WATER SAFETY MANAGEMENT, LEGIONELLA PREVENTION AND RISK MANAGEMENT IN HOSPITALS: A FRAMEWORK FOR ESTATES AND FACILITIES MANAGEMENT IN ENGLAND

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Glossary

Aerosol	A suspension in a gaseous medium of solid particles, liquid particles or solid and liquid particles having negligible falling velocity.
Air-conditioning	A form of air treatment whereby temperature humidity and air cleanliness are all controlled within limits determined by the requirements of the air-conditioned enclosure.
Augmented care units	Primarily paediatric and adult critical care, neonatal and burns units. A local risk assessment is required to establish if other areas such as renal, transplant and haemato-oncology units should be designated as 'augmented care units'.
Bacteria (Singular bacterium)	A microscopic, unicellular (or rarely multicellular) organism.
Biocide	A substance which kills micro-organisms.
Biofilm	A community of bacteria and other microorganisms, embedded in a protective layer with entrained debris, attached to a surface.
Calorifier/Plate Heat Exchanger	Apparatus used for the transfer of heat to water in a vessel by indirect means, the source of heat being contained within a pipe or coil immersed in the water.
Cold Water Service	Installation of plant, pipes and fitting in which cold water is stored, distributed and subsequently discharged
Dead end/dead leg/blind end	A length of pipe closed at one end through which no water passes. Pipes leading to a fitting through which water only passes when there is draw-off from the fitting.
DIPC Director of Infection Prevention and Control	The Trust lead on all infection control matters.
Disinfection	A process which destroys or irreversibly inactivates micro-organisms and reduces their number to a non-hazardous level.
Distribution circuit	Pipework which distributes water from hot or cold water plant to one or more fittings/appliances.
Domestic Water Services	Hot and cold water services intended for personal hygiene, culinary, drinking water or other domestic purposes.

Hot water service	Installation of plant, pipes and fittings in which (HWS) water is heated, distributed and subsequently discharged (not including cold water feed tank or cistern).
Legionella pneumophila	One of the causative bacteria of Legionnaires' disease.
Legionella	Type of aerobic bacterium which is found predominantly in warm water environments (Singular of legionellae)
Legionellae	The genus legionella belongs to the family Legionellaceae which has over 40 species. These are ubiquitous in the environment and found in a wide spectrum of natural and artificial collections of water.
Legionellosis	Any illness caused by exposure to *Legionella*.
Legionnaires Disease	A form of pneumonia caused by legionella bacteria
Pontiac fever	A disease caused by species of *Legionella* an upper respiratory illness less severe than Legionnaires disease.
Pseudomonas aeruginosa	A Gram-negative bacterium, commonly found in wet or moist environments. It is commonly associated with disease in humans with the potential to cause infections in almost any organ or tissue, especially in patients compromised by underlying disease, age or immune deficiency.
Risk assessment	Identifying and assessing risk from Legionellosis / *Pseudomonas aeruginosa* from work activities and water sources on premises and determining any necessary precautionary measures.
Sentinel taps	For a hot water service – the first and last taps on a recirculating system. For cold water systems (or non-circulating hot water systems), the nearest and furthest taps from the storage tank. The choice of sentinel taps may also include other taps which are considered to represent a particular risk.
Stagnation	The condition where water ceases to flow and is therefore liable to microbial growth.
Strainers	A coarse filter usually positioned upstream of a sensitive component such as a pump control valve or heat exchanger to protect it from debris.
Thermal disinfection	Heat treatment to disinfect a system.

Thermostatic mixing valve	Mixing valve in which the temperature at the outlet is pre-selected and controlled automatically by the valve.
Total viable counts	The total number of culturable bacteria (per volume or area) in a given sample (does not specifically include *Legionella*).
Water Regulation Advisory Scheme	A conformance mark that demonstrates that an item complies with high standards set out by water regulations.
Water Safety	Aspects of the chemical, physical and microbiological condition of water supplied for domestic purposes (including consumption) and process requirements which has the potential to cause harm to human health
Water Safety Group	A multi-disciplinary group formed to undertake the commissioning and development and on-going management of the water safety plan (WSP). It also advises on the remedial action required when water systems or outlets are found to be contaminated and the risk to susceptible patients is increased
Water Safety Management Plan	The document that is produced by WSG and Estates Department to manage the water systems.
Water Safety Plan	A risk-management approach to the microbiological safety of water that establishes good practice in local water distribution and supply. It will identify potential microbiological hazards caused by P. aeruginosa and other opportunistic pathogens, consider practical aspects and detail appropriate control measures. WSP's are working documents that need to be kept up-to-date and reviewed whenever organisations make changes to water supplies, use of water and control measures.
Waterborne pathogens	Microorganisms capable of causing disease that may be transmitted via water and acquired through ingestion, bathing, or by other means.

Acronyms

ANSI	American National Standards Institute
AOC	assimilable organic carbon
ASHRAE	American Society of Heating, Refrigerating and Air-Conditioning Engineers
ASTM	American Society for Testing and Materials
BAC	British Accreditation Council
BREEAM	Building Research Establishment Environmental Assessment Methodology
CDC	Centers for Disease Control and Prevention
CfU/l (or CFU/l)	Colony forming units
CMS	Centers for Medicare & Medicaid Services
COSHH	The Control of Substances Hazardous to Heath
DNA	deoxyribonucleic acid
DWPS	drinking water plumbing systems
ECDC	European Centers for Disease Control
EEA	European Economic Area
EWGLI	European Working Group for Legionella Infections
FM	Facilities Management
HSE	Health & Safety Executive
HSG	Health & Safety Guidance
HTM	Health Technical Memorandum
ICU	intensive care unit
IHEEM	Institute of Healthcare Engineering and Estate Management
ISO	International Organization for Standardization
LCA	*Legionella* Control Association
LD	Legionnaires' Disease
Legionella spp.	*Legionella* species
Lp	*Legionella pneumophila*
NEAT	NHS Environmental Assessment Tool
NHS	National Health Service

NSF	National Science Foundation
PCR	polymerase chain reaction
PDCA-WSP	Plan-Do-Check-Act Water Safety Plan
PHE	Public Health England
POE	point of entry
POU	point of use
POWW	point of water withdrawal
PPM	Planned Preventative Maintenance
PVC	polyvinyl chloride
RNA	ribonucleic acid
RSPH	The Royal Society for Public Health
SBT	Sequence-based typing
TOC	total organic carbon
UV	ultraviolet
VBNC	viable-but-not-culturable
VHA	Veterans Health Administration
WHO	World Health Organization
WMSoc	Water Management Society
WRAS	Water Regulation Advisory Scheme
WSMP	Water Safety Management Plan
WSP	Water Safety Plan

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Now I do hope that the following work will contribute to the understanding and handling of *Legionella* in drinking water systems in hospitals.

Abstract

This study is the first to evaluate water safety and *Legionella* prevention from a management level perspective. It is an organisation's duty to prevent any harm or risks potentially threatening the health of people. For that, certain processes are essential to be applied. They should be known by the people responsible and those, who are involved in any process serving to maintain health and safety, and to reduce known hazards. This thesis's purpose is to create a significant contribution to knowledge by creating the first ever suggested framework for England. It makes a distinct and original contribution to knowledge as it is easy to understand and provides schemes and document templates for reference and for application.

The specific aim of this research is to systematically identify the present situation of water safety and *Legionella* prevention in water systems in healthcare organisations, i.e. hospitals and hospital trusts in England. It seeks to create a framework guiding management processes to people responsible to identify and better understand roles and processes to properly take action for the prevention of water system related infections caused by *Legionella*. The focus of the research lies in organisational structures from the point of view of Estates and Facilities Management. It analyses the current state of the process of *Legionella* prevention with a focus in England and with a different way of looking at the problem. In research papers the topic is neither very prevalent nor easily accessible at management levels. Methodology is built on a mixed methods research design and a multilevel triangulation approach. An embedded design applies cases for analysis, that have been empirically collected during an exploratory first phase with cases in the UK, Germany and Switzerland. A consecutive country-specific phase fosuing the research more specific was applied for England. Data from interviews and documents was collected and analysed during the exploratory phase, which had a focus on taxonomy and to explore job descriptions and factors in hospitals that have a thematic connection to *Legionella,* risk management and water systems for the purpose of water safety management. This phase was also necessary to test the fluency of the procedures selected for data collection and verify and confirm the case strategy chosen. Research of the following phase collected and analysed data from interviews, a survey and documents. The specific focus of this phase was to find patterns, define coding structures, build categories, analyse and compare content by applying cycles of content analysis to find levels of abstraction to create a draft version of a framework, which underwent a validation step in a final focus group by experts in the field of risk management and water safety.

Throughout the research process, the findings present a systematically reviewed and analysed picture of procedures of water safety management. It applies stakeholder analysis as well as process analysis, demonstrating levels of collaboration, risk management procedures, process management, quality management, environmental management and knowledge management.

The dissemination of the research's output is a framework titled "Water safety management, *Legionella* prevention and risk management in hospitals: a framework for Estates and Facilities Management in England". It aims at closing the gap between theory and practice and complies with best practice. It translates given obligations into the professional field of Estates and Facilities Management and should be made available for transferring knowledge.

1 Introduction

At the very beginning of this research it is crucial to understand the subject of interest. This research may be denoted as a journey which requires investigative skills to chase hazards invisible to the eye. Those hazards are caused by a certain type of bacteria, termed *Legionella*. We may not forget that we, humans, are only one part of the whole eco-system on the shared environment of earth, in which certain bacteria are essential to life and others are not. Humans and bacteria share a common environment and interact. Humans are the result of their environment. Thus, a responsible and aware intercourse should guide and determine the way they act.

Becoming aware of that, J.P. Frank and M. von Pettenkofer constituted the science of hygiene at the end of the 18^{th} century. It is defined as the entirety of all efforts and measures to prevent diseases and any damage to health of individuals and of the community (GBE, 2016). It includes infectious diseases and epidemics, which are caused by social coexistence. Furthermore it includes occupational hygiene, which considers emerging or impending diseases. Hygiene is closely linked with microbiology, which applies certain subject-specific terms and expressions. Some essential terms are explained in the glossary of this thesis.

1.1 Research Context

The research context is in health care. It is rooted in the topic of the presence and prevention ot the potential pathogeneous bacteria *Legionella* in drinking water systems. The research contextualises in an exploratory first phase cases present in England, Germany and Switzerland. A consecutive country-specific phase fosuses the research topic more specifically for England only, as a consequence of preliminary findings and the aim of creating a specific framework for England. Framing elements specify hospitals, infection prevention, business management, estates and facilities management, stakeholder management, process management, water safety management, risk management and knowledge management.

1.2 Problem

There is no evidence-based research focusing on the process of *Legionella* prevention in water system management in hospitals, seen from the Estates and Facilities Management or Facility Services perspective, in the context of management levels. As monitoring strategies in health care organisations have moved on from considering only *Legionella* from a water system management perspective, the output of this work may also be contextualised to extending management practice for *Legionella* prevention to water safety per se (to include for example *Pseudomonas aeruginosa* and environmental myco-bacteria). Where possible, levels of abstractions took general management considerations in order to raise awareness for water safety management issues. Nevertheless, the focus of this research will be on *Legionella*. Since the introduction of the new Health Technical Memorandum in the context of the United Kingdom, the focus has changed from a management perspective to the multidisciplinary water safety group and water safety plan. Though the interpretation of what is required is not standardised. Based on the apparent research problem, the following research question was proposed.

1.3 Research Question

By iteratively answering four defined subquestions (SQ1-SQ4), decisive elements will be investigated and help guiding through the research process and the procedures of analysis as well to answer the research question (RQ).

Four subquestions

- SQ1: Are there processes defined in hospitals in terms of *Legionella* prevention in water systems?
  - Explanations to SQ1: It may consider governance underpinned by policies at Trust or hospital level for water management. It may also cover operational procedures as separate processes.
- SQ2: Who are the process owners and what are their roles and duties from the perspective of Estates and Facilities Management and Facility Services processes?
- SQ3: Are there points of overlapping duties and how can they be identified or be characterised?
  - Explanations to SQ3: There might be a need for evidence in clarifying duties or responsibilities / lines of accountability or operationally.
- SQ4: Are there management strategies comparable between organisations (hospitals)?

Research question

- RQ: With the perspective of Estates and Facilities Management and Facility Services, is there a possible generalisable or transferable «process» of *Legionella* prevention in water systems in hospitals or is risk management subject to parameters or criteria specific to each organisation?

1.4 Research Aim

The aim of this research is to systematically reveal the present situation of *Legionella* risk management and prevention in water systems in selected organisations (hospitals) in healthcare and create a framework guiding people responsible for Estates and Facilities Management in healthcare organisations to identify, understand and properly take action on *Legionella* prevention and risk management for water safety.

1.5 Research objectives

This research aims at achieving the following research objectives:
(1) to identify stakeholders involved in the process of water safety management, *Legionella* prevention and risk management in hospitals,
(2) to analyse fields and functions of responsible management in the process of water safety management, *Legionella* prevention and risk management in hospitals,

(3) to identify and analyse processes in water safety management, *Legionella* prevention and risk management in hospitals from the perspective of responsible management, with special interest in Estates and Facilities Managementand stakeholders (focus: non-clinical),
(4) to review and consider current state and conformity to standards, legislation and regulations. The discussion therefore spots on risk management from an Estates and Facilities Management perspective,
(5) to identify points of overlapping duties in the process of *Legionella* prevention in water systems,
(6) to identify similarities and differences between hospitals in the process of water safety management, *Legionella* prevention and risk management with respect to management responsibilities by roles, commitment to role, and process elements.
In order to achieve the objectives, the following concept of the empbedded reseach design with cases will be applied (Figure 1-1). As the framework will be an output guided by the objectives, it is essential to refer to the logic given by the sequential exploratory mixed mehods research for understanding the steps of analysis and interpretation (Figure 6-3). The systematic way of how the objectives feed answers to the research subquestions, applying different research procedures, are presented in Table 6-15, Table 6-16, Table 6-17, and Table 6-18. Specific strategies of selected phases of how analysis of questions deliver answers to research subquestions are presented in Table 6-19, Table 6-20 and Table 6-21.

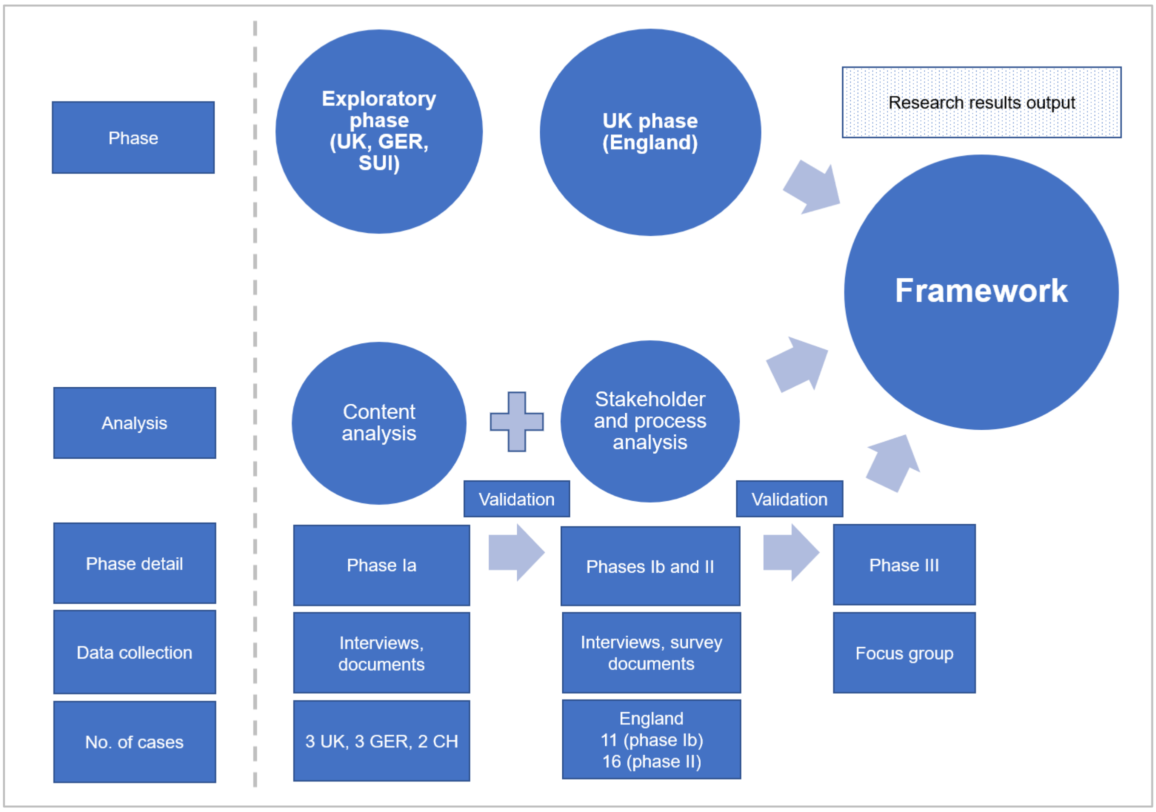


Figure 1-1: Concept of embedded research design with cases

1.6 Purpose

There are two joint purposes with the research. The first is to identify, qualify, quantify and understand the existing process and the process owners and suggest a concise, yet fully elaborated best practice guidance. The second purpose is to develop a process-based framework for estates and facilies management. This framework intends to give guidance for management levels, explaining by a process-map and stakeholder analysis as core elements, the *Legionella* water safety risk management and prevention process in healthcare facilites in England, taken from the perspective of practitioners in hospitals being responsible for estates and facilites management. It shall further be possible to measure compliance to the framework by benchmarking practices. Through the encouragement of people responsible for measuring their level of compliance against the given framework may bring more transparency and motivation into competing with the sometimes underestimated and multifaceted topic of the presence of *Legionella* in the built environment.

1.7 Significance of the research

This framework closes the gap between the identified need for guidance on *Legionella* prevention in hospitals at management level from the perspective of Estates and Facilities Management, detected in the literature review. Thus, the study is the first to evaluate water safety and *Legionella* prevention from a management level perspective. The dissemination of the research's output is an original framework, closing the gap between theory and practice whilst complying with best practice. This research represents a significant contribution to the body of knowledge of the research field by enhancing the understanding of the process of *Legionella* prevention and risk management, seen from an estates and facilities managment perspective. It provides evidence of originality as it faces a topic of practical relevance, which is rooted not solely in the core facilites management business, but, as it is typical for estates and facilites management, is closely connected with different requirements, disciplines, stakeholders and processes of the organisation. It is strongly interwoven with risk management, safety and security, quality management, environmental management and maintenance issues in the healthcare sector, specifically with hospitals. Furthermore, it debates the role of estates and facilites management in the area of tension between clinical and non-clinical processes. It utilises predominant theories and methods of case study research and business research to create a framework for estates and facilites management, sharing evidence from a practitioners' perspective. The work will aid responsible management persons and generate new significant knowledge about processes. It translates given obligations into the professional field and should be made available for transferring knowledge. It is especially designed for hospitals in England, as data for the development of the framework content refers to that national context.

1.8 Limitations

This research project has the following limitations:

- Research is a mix of case study research and survey study research with the aim of finding generalisations, but a statistically reliable generalisation it is not possible. In this research transferability was favourably considered instead of trying to achieve generalisation. Nevertheless, an output document "framework", based on the results of the research phases, is being compiled as a potential first step towards more generalisation. It shall be understood as a guiding document for professionals to critically review and question their own processes.

- Case definition is tailored to the business environment of hospitals.
- Research is, in its ultimate output, limited to the national context of the United Kingdom, with a focus on England.
- This research project may also raise awareness as a “active researcher” project as each scientific discussion, presentation, publication, interview, where the researcher tested and shared growing expertise, sensitised third parties. This effect cannot be measured, but is a possible hypothesis because of the duration and magnitude of the researcher’s explorative progress.

1.9 Delimitations

There has been no interruption in the course of research. An embedded design applies cases for analysis, that have been empirically collected during an exploratory first phase with cases in the UK, Germany and Switzerland. This was due to the fact that the researcher had directed his interest in recent years primarily towards German-speaking countries and now wanted to widen the focus on the English-speaking country of England. To better understand the real cases, experience was made and data collected in a pilot study and in three different countries to compare given situations and learn about the perspectives of responsible management and practitioners. Being equipped with business perspectives research focuses in the next step on the context of interest, which is England. In order to become aware of and to get to know the differences ot the topic of interest present in the different countries including technical, constructional and organisational standards and cultures, phase Ia was necessary, helpful and gave orientation. Phase Ia was also specifically for testing the fluency of the procedures selected for data collection and verify and confirm a case strategy chosen (see chapters 6.5 and 6.9.2). Consecutive country-specific phases Ib, II and III set the focus of the research specifically on England, where data for analysis following the research phase Ia originated. The final output of the research project is thus reduced to the national context of England.

1.10 Organisation of the thesis

Where considered appropriate, chapters close with a summary or with conclusions and recommendations that synthesise statements that have been brought up within the body of each chapter.

Chapter 1, as already presended, introduced the research context and outlined the research problem. After highlighting the research question, the research aim, objectives and purpose have been presented. The significance of research as well as delimitations and research interference were commented on.

Chapter 2 discusses the diagnosis of Legionnaires’ disease and common exposure pathways in clinical and non-clinical areas of healthcare. These active areas of research will require continued investment in order to improve the management of *Legionella* in water systems. The chapter also takes a focus on the surveillance of Legionnaires’ disease in selected countries, as well as the environmental monitoring of *Legionella* that is becoming more common in built water systems. The quantitative threshold of *Legionella* concentration, above which action must be taken, and the role of quantitative microbial risk assessment, are extensively examined in this chapter.

Chapter 3 contextualises the built environment and directs the perspective on Estates and Facilities Management of hospitals and hospital Trusts. The chapter considers existing strategies used to control *Legionella*, including the use of heat, biocides, flow control, aerosol formation prevention, and distal devices, along with their application in several typical built environments. The chapter also describes what is known about the efficacy of different control methods and their potentially unintended consequences.

Chapter 4 reviews the array of laws, regulations, codes, standards, and guidance documents that relate to *Legionella* management, both in the countries in which the research was based and abroad. It includes monitoring parameters and reflects how these various policy tools can be applied to better protect the public from legionellosis.

Chapter 5 summarises essential findings from the literature review of chapters 2, 3 and 4, and bulletpoints focus topics of this research. This chapter is therefore a condensation of chapters 2, 3 and 4, which breaks down the focus of the research project to a few key terms and main fields of interest.

Chapter 6 introduces the methodology chosen for achieving the research objectives. It begins with an introduction of a summary table to present a picture on core elements of methodology applied. A specific reference to standards for reporting qualitative research is considered in order to organise a structure for the methodology chapter and to achieve completeness. Each chapter explains what is applied in the research design of this research. Data triangulation and transferability of the findings into the environment under investigation, ethical considerations, and reflections made by the researcher close chapter 6, with a summary.

Chapter 7 presents the results and analyses structured for each research phase. Results are presented in different ways for qualitative and quantitative data visualisation. An aggregated analysis combines findings over different research phases and puts a focus on process and stakeholder identification and analysis. An early version of the framework has been developed, presented to and critically reviewed by a focus group. According to comments revisions were made.

Chapter 8 describes the final research output compilation, a framework titled "Water safety management, *Legionella* prevention and risk management in hospitals: a framework for Estates and Facilities Management in England". The framework has been complemented according to the commented and intended revisions of chapter 7.7.

Chapter 9 presents the conclusion with a review on the research process, a review on the research objectives, and the answer to the research question. The applicability of the framework is evidenced by comments from the validation phase, followed by highlighting the significant contribution to knowledge of this research.

Chapter 10 puts the view beyond and brings up ideas for further research.

Chapter 11 lists all references used in this thesis.

Chapters 12-17 presents the appendices, providing futher details and additional information about what has has been referenced to elsewhere in the text body of this thesis.

2 Background one - *Legionella*, infection, healthcare

This chapter introduces the complex ecology niche of *Legionella* in both natural and built water environments, and common exposure pathways in clinical and non-clinical areas of healthcare.

2.1 Legionella - a ignificant topic

After a brief characterisation of pathogens and *Legionella*, this chapter presents aspects on the surveillance of Legionnaires' disease and the role of quantitative microbial risk assessment.

2.1.1 Pathogens

There exist different hygienically relevant microorganisms in drinking water systems. Two categories of hygienically relevant microorganisms can be distinguished:

> (I) Microorganisms with pathogenic properties which have been shown to be associated with water-related illness and outbreaks, and
>
> (II) Bacteria which are primarily used as index and indicator organisms in water analysis, indicating the presence of pathogenic organisms of faecal origin (index organisms) or indicating the effectiveness of water treatment processes as well as integrity of water distribution systems (indicator organisms) (WHO, 2006).

Quite a few opportunistic bacterial pathogens naturally occur in aquatic environments. These bacteria include *Aeromonas* spp., some coliforms (*Citrobacter* spp., *Enterobacter* spp., *Klebsiella pneumoniae), Legionella* spp., *Mycobacterium* spp. and *Pseudomonas aeruginosa*. They are able to persist and grow in biofilms of drinking water systems, sharing a microbiological microcosmos as a niche of life provided in biofilms (Wingender and Flemming, 2011).

2.1.2 *Legionella* – epidemiological considerations

The following chapter summarises basic characteristics to better understand the ecology niche of *Legionella*, its infection of people, the transmission, identification and detection of sources.

2.1.2.1 *Legionella* - bacteriology, ecology and environmental sources

Legionella spp. – 'spp.' is an abbreviation for 'species' (pl.) in biology (spp., (n.d.)) - are Gram-negative, rod-shaped, non-spore-forming bacteria. Legionellae are obligate aerobes and seem to be able to appear anywhere in places of advantageous conditions (Bartram et al., 2007 p.29). They can survive in moist environments for long periods of time and they can also resist temperatures of 6-60 °C and a pH range of 5.0-8.5 (Diederen et al., 2007) (HSE, 2013). Growth seems to be favoured by water temperatures between 20 and 42 °C. Below 20 °C the organisms do not seem to multiply. Above 60 °C they will not survive in the environment.

Although it is commonly accepted that legionellae start proliferation at temperatures above 20°C, their growth rate at temperatures below 25°C is still very low. In cool water they may, however, remain inactive up to the point when water temperatures reach a suitable level for growth (HSE, 2013). Water systems of hot and cold water in buildings operate within a temperature range that matches thermal growth conditions of *L. pneumophila*. A proliferation inside the water system and a potential threat to the health of people cannot be excluded when the bacteria is being released from the system. The bacteria may exert its pathogenic potential in a host under certain circumstances.

2.1.2.2 Historical facts on Legionnaires' disease

Legionnaires' disease was first identified following a large outbreak of pneumonia among people who attended an American Legion convention in Philadelphia in 1976. The outbreak caused 29 deaths of people (McDade et al., 1977). The outbreak was characterised by a large number of cases of pneumonia that can be associated with generalised sepsis. A bacteria was identified as the causative agent and subsequently termed *L. pneumophila* (McDade et al., 1977).

Legionnaires' disease is an important but relatively uncommon respiratory infection that can cause substantial morbidity and mortality. First recognised more than three decades ago, only modest progress has been made in the investigation, clinical and incident management, and public health response to cases and outbreaks (Fraser et al., 1977).

2.1.2.3 Transmission and risk factors

The transmission of Legionnaires' disease is usually by inhalation of aerosols or aspiration of water containing *Legionella* spp. There is no evidence found of a person-to-person transmission (Correia Ana M. et al., 2016). Susceptibility to Legionnaires' disease is associated with smoking, older age, chronic cardiovascular or respiratory disease, diabetes, alcohol misuse, cancer, and immunosuppression (Den Boer et al., 2006, Plouffe and Baird, 1981, Rosmini et al., 1984, Marston et al., 1994). For infected people a mortality rate of 8-12 % is typical but might be higher in people belonging to certain risk groups. Those are for example people who are elderly, those who have pre-existing medical conditions, smokers, nosocomial cases, or people who suffer a delay or miss a correct diagnosis and treatment of their disease (Dominguez et al., 2009). The average case-fatality rate is 10 % in Europe (ECDC, 2013, CDC, 2011). In nosocomial cases the case-fatality rate is higher and ranges between 15 % and 34 % (ECDC, 2013, CDC, 2011).

2.1.2.4 Identification and diagnostic in patients

For a period of several decades the consensus was that serology offered a reasonably sensitive and specific primary diagnostic method. The method is characterised by standardised reagents and appropriate control sera. However, the diagnostic method is subject to controversies about (a) the choice of the method for antigen preparation and (b) the question whether whole or subclass-specific immuno-globulin concentrations should be measured (Wilkinson et al., 1983, Harrison et al., 1987).

Not long after the outbreak of Legionnaires' disease in 1976, the detection of *L. pneumophila* in the urine of patients was first described as a diagnostic method (Farshy et al., 1978). It was not widely accepted as a routine diagnostic method and thus not incorporated in international case definitions until the mid 1990s (Plouffe et al., 1995). In the UK, the prevalent assays between the early 1980s and mid 1990s were the indirect IFAT and the rapid microagglutination test.

Phin et al. (2014) conclude that most positive results obtained with commercial kits are of no diagnostic value. Data estimate a positive predictive value of only about 50% with even the best commercial assay (Elverdal et al., 2013). In contrast, several reasonably reliable commercial kits are available for routine use (Harrison and Doshi, 2001), (Domínguez et al., 1999). In 2014 Phin et al. find, that Urinary antigen detection accounts for 70-80 % of cases that are diagnosed in Europe and the USA (ECDC, 2013, CDC, 2011). Reliance on urinary antigen detection has limitations. The most substantial limitation of assays is the poor sensitivity for legionellosis caused by non-*L. pneumophila* strains. Sensitivity in routine use is, at best, 80-90% for the diagnosis of community-acquired Legionnaires' disease caused by *L. pneumophila* serogroup 1 strains. In contrast, sensitivity for Legionnaires' disease caused by other *L. pneumophila* strains is less than 50 % (Helbig et al., 2003, Svarrer et al., 2012).

It is observed that sensitivity of culture varies widely among different laboratories. But in cases in which clinical awareness is high, it is in the order of 50-80 % (Winn, 1993, Harrison et al., 1987, Mentasti et al., 2012). When seen from a global perspective, most cases of Legionnaires' disease relate to *L. pneumophila* and serology or PCR might be used as primary diagnostic test (Phin et al., 2014). The diagnostic 'gold standard' is culture and isolation of legionellae from clinical specimens. Importantly, isolation of the infecting strain allows epidemiological typing to be done, which provides valuable data for the control and prevention of further cases (Phin et al., 2014).

The number of *Legionella* species and serogroups known increases continuously. There are currently known more than 50 species comprising 70 distinct serogroups (WHO, 2011). There have been documented about twenty species of *Legionella* as human pathogens (Diederen et al., 2007). This characterisation for being pathogenic is on the basis of their isolation from clinical material. *Legionella* can be enumerated by applying specific methods (ISO, 2017a). Some species of *Legionella* are a common cause of infection, others are only isolated from the environment and do not bear a potential of infection. By nature, *Legionella* spp. is a ubiquitous bacterium. They can be found in natural aquatic environments such as streams, rivers, ponds and lakes. Furthermore they may be present in moist soil or in mud, where they occur in relatively low numbers, but are also present in built environments, e.g. water supply in buildings (WHO, 2011).

2.1.2.5 Transmission and spread with epidemiological relevance

An Infection with *Legionella* in humans is caused by inhaling contaminated airborne small-size water droplets, termed aerosols (Duncan et al., 2011, Fields et al., 2002). In the context of buildings those droplets origin from different aerosol-producing reservoirs such as air-conditioning units, cooling towers, sink taps, whirlpool spas, and showerheads (Reuter et al., 2013). Outbreaks of Legionnaires' diseases caused by exclusive aerosol transmission can be read in numerous examples as reported by Phin et al. (2014) presenting a selection of notable worldwide outbreaks of Legionnaire's disease from 1976 to 2012. Especially in epidemics where a cooling tower, water spa, water fountain, or water mister were identified as the source of disease (Fields et al., 2002). Legionellae are able to proliferate in humans. This is closely linked to the virulence character of legionellae. Therefore, the virulence of *L. pneumophila* not only causes an infection, an infection can also depend on the susceptibility of the host (Bartram et al., 2007).

Although uncommon, Legionnaires' disease continues to cause disease outbreaks of public health significance. Legionnaires' disease is an important cause of community-acquired and hospital-acquired (=nosocomial) pneumonia. The disease is caused by any species of the Gram-negative aerobic bacteria belonging to the genus *Legionella*; *Legionella pneumophila* serogroup 1 is the causative agent of most cases in Europe (Phin et al., 2014).

Various efforts are in place to counteract, to learn and to sensitise the people about interactions between pathogens and the shared environment. The endeavour of the European Working Group for Legionella Infections (EWGLI) is to better protect the health of people in European countries by improving detection and control of infection sources (Ricketts et al., 2010). In Europe, there is a coordinated surveillance scheme for Legionnaires' disease operating since 1995. The European Centre for Disease Prevention and Control (ECDC) publish annual reports on Legionnaires' disease. It is recommended that national surveillance units consider ways of raising awareness amongst front-line clinical staff. In 2011 the age-standardised notification rate of Legionnaires' disease was 9.2 per million people within Europe. Among the countries there was a wide variation with a reported range between 0.0 and 21.4 per million people (ECDC, 2013). These rates have not changed since 2005, except for small year-on-year variations (ECDC, 2013). The highest numbers of reported cases are consistently observed in France, Italy, and Spain (ECDC, 2013, ECDC, 2011, ECDC, 2012).

For the year 2012, the surveillance report from the ECDC states, that 5'852 cases of Legionnaires' disease were reported by EU Member States, Iceland and Norway. Of the 29 countries involved, six countries accounted for 84 % of all notified cases. Interestingly these countries practise a certain level of awareness and run reporting systems on *Legionella* (ECDC, 2014). 69 % of the notified cases were community-acquired, 20 % were travel associated and 8% were linked to healthcare facilities (ECDC, 2014). Healthcare facilities are usually visited by immunocompromised people or people who need a medical operation. Thus they constitute a risk group whose environment should meet certain requirements of hygiene, monitoring and risk assessment to contribute to preventive measures. In Europe, approximately 70 % of *Legionella* infections are caused by *Legionella pneumophila* serogroup 1. Other serogroups count 20-30% of *Legionella* infections. Between 5 and 10 % of *Legionella* infections are caused by non-pneumophila species (Bartram et al., 2007, Mencacci et al., 2011). However, Borella et al. report that *L. pneumophila* serogroups 2–14 and other species prevail in the environment, including hospitals (Borella et al., 2004, Borella et al., 2005). The question of why *L. pneumophila* serogroup 1 is so predominant among clinical isolates is unknown (Spagnolo et al., 2013). Taking the view towards the distribution of *L. pneumophila* serogroups in the environment little is known about influencing ecological factors.

2.1.2.6 Epidemiological typing

Epidemiological typing is extremely important for linking cases to a specific source and to take measures against the outbreak. However, if not done carefully, false conclusions incorrectly link a potential source to a case. Epidemiological typing can also identify 'pseudo-outbreaks' (Maini et al., 2012, PHW, 2011). If clinical samples are not available, or access to this information is refused, it is still useful to collect environmental samples. They give a good basis for an assessment to confirm or rule out the presence of *Legionella* spp. In combination with a complete risk assessment, the information about the environment can help assess the likelihood of any suspicious system as a potential source. Spatial analysis and mathematical modelling techniques may assist in directing investigations. Such methods include cluster analysis, infection window analysis or attack ratio analysis. They are recognised as a good chance to enhance traditional investigation techniques. However, they require good case data to rely on (Den Boer et al., 2002, Sansom et al., 2013, Egan et al., 2011, White et al., 2013). Most Legionnaires' disease is caused by a relatively small subset of all *Legionella* strains recovered from the environment. Some strains are widespread (e.g. strain ST1), others seem to be restricted to particular regions, e.g. strain ST47, which is observed in northern Europe (Harrison et al., 2009, Kozak-Muiznieks et al., 2014).

2.1.2.7 Clinical manifestations and diagnosis of legionellosis in patients

In clinical contexts Legionellosis presents as two distinct clinical forms (Boshuizen et al., 2001):

- Legionnaires' disease (or legionellosis): a severe multisystem disease involving pneumonia
- Pontiac fever: a self-limited flu-like illness

2.1.2.8 Clinical Presentation and Management of Legionnaires' disease

Legionnaires' disease is a notifiable disease in many countries and cases should be reported immediately to the public health authorities. Although Legionnaires' disease can occur in healthy individuals, it occurs more frequently in those with predisposing risk factors.

Because of the high mortality and morbidity associated with untreated Legionnaires' disease, priorities to be set for clinical management are (Viasus et al., 2013, Chidiac et al., 2012, Eliakim-Raz et al., 2012, Mandell et al., 2007, Levy et al., 2009, Levy et al., 2010, Zumla et al., 1988, Cunha, 2008):

- early diagnosis and prompt treatment with effective antibiotics
- appropriate management of complications (such as respiratory failure, renal failure, and CNS involvement)
- the management of underlying co-morbidities and risk factors.

An effective management is dependent on clinical physicians who consider the possibility of Legionnaires' disease in patients. Especially in patients presenting with pneumonia or a multisystem illness with fever at all points of care (Viasus et al., 2013, Mandell et al., 2007). Due to the fact that Legionnaires' disease presents as a range of clinical manifestations and symptoms, it cannot claim to be with defining clinical features that can be identified and specifically be connected with a precise case definition (Viasus et al., 2013, Levy et al., 2009, Levy et al., 2010, Cunha, 2008). A single diagnosis of Legionnaires' disease, or at least suspicious facts, should alert the physician to the possible existence of other cases related in place or time. This key moment might be crucial for the early identification of a potential source of infections (Zumla et al., 1988). For this reason, tracing and uncovering historical information that might contribute to the management of the case(s), should include a detailed enquiry. A link to an exposure to aerosolised water droplets that potentially came from the environmental setting in a period of the previous 10 days coild be one trace.

Furthermore, a detailed history of the recent movements of the patient is recommended. Following those traces contributes to the epidemiological follow-up.

2.1.2.9 Investigation of outbreaks of *Legionella*

Most cases of Legionnaires' disease have a sporadic nature of occurrence. Nevertheless, clusters warranting investigation and point source outbreaks can occur. It is reported that sometimes those outbreaks may have substantial implications for public health (García-Fulgueiras et al., 2003). There is an explicit motivation for investigation of Legionnaires' disease outbreaks, considering that a single point-source has the potential to release contaminated aerosols over a wide area to which large numbers of the population might be exposed to. Several outbreaks of broadly investigated exposures are reported (García-Fulgueiras et al., 2003, Bennett et al., 2013, Castilla et al., 2008). In some of them the particular cause was seen in cooling towers. Outbreak investigations report evidence of a distant source of infection up to 15 kilometers from cases (Phin et al., 2014, Nygård et al., 2008, Nhu Nguyen et al., 2006, White et al., 2013). However, many outbreaks show a shorter distance of dispersion (García-Fulgueiras et al., 2003, Castilla et al., 2008). Environmental conditions as well as physical geography may play a role in determining the shape of an outbreak's dispersion (Phin et al., 2014).

The implementation and operation of effective surveillance and notification systems are fundamental and aid an early identification of notable outbreaks to reduce the fatality rate and identify suspected sources (Phin et al., 2014 p.1016). The explosive character of the spread of Legionnaires' disease, which can produce hundreds of cases within days, experiences a shift to monitoring and professional management, which contributes to civil protection (García-Fulgueiras et al., 2003, Den Boer et al., 2002, Castilla et al., 2008). An effective control of outbreaks of Legionnaires' disease relies on a short delay in ascertainment of descriptive epidemiological (clinical and environmental) data. It requires links to microbiological information to reliably identify the actual source and implement control measures.

Rapid investigation with appropriate methods and the implementation of control measures result in lower case-fatality rates. This development has been attributed to several outbreaks (Castilla et al., 2008, McCormick et al., 2012). To draw an entire epidemiological picture and identify links in time and location, detailed case histories are necessary. This would need the systematical collection of information, complemented by standardised questionnaires, which seem necessary and are seen as an effective tool.

2.1.2.10 Underreporting of cases

In the 2014 ECDC report (ECDC, 2014), which summarizes statistical data of 2012, it was stated that there are two main reasons why Legionnaires' disease is thought to be underreported for the countries mentioned: (a) insufficient diagnosis by clinicians, and (b) failure to notify health authorities. This is interesting against the backdrop of the disease being registered in all European Union (EU) and European Economic Area (EEA) countries. In 2012, there were 401 reported cases for the UK and 412 in the year 2015. For Germany the report presents 628 reported cases in 2012 and 867 in 2015 (ECDC, 2018).

In many countries, the total number of cases is probably higher than notification data. This assumption arose from present underdiagnosis and definition and surveillance issues (Phin et al., 2014). Any transmission and infection occurs via inhalation from aerosols coming, for example, from showers. In hospital environments, respiratory therapy devices, warm-mist humidifiers or ventilators may provide pathways of transmission (Hines et al., 2014). While measures to prevent hospital-associated legionellosis have been in place for some time, the majority of recent cases of Legionnaires' disease have been reported to come from the community (Beauté et al., 2013, CDC, 2013). But hospitals represent ideal locations for Legionnaires' disease transmission as we can read in chapter 2.3.

2.2 Hospital trust and the NHS

According ot Oxford learner's dictionaries, a hospital trust is "an organization that runs a public hospital for the National Health Service in Britain" (Hospital-trust, (n.d.)). It was a decision made by the British government to make hospitals responsible for their own management and financial affairs. "In 2004 the government introduced a new type of organization in England called the foundation trust or foundation hospital. Hospitals that achieve a high level of service can apply for foundation status, which gives them the right to raise their own finances, for example, by selling assets or borrowing money" (Hospital-trust, (n.d.)).

The Trust as employers have a general duty under The Health and Safety at Work Act etc. 1974 (HSWA) to ensure so far as is reasonably practicable, the health, safety and welfare of all their employees.

HSWA 2(1) requires employers to:

- provide and maintain plant and systems of work that are safe and free from health risks
- make arrangements for ensuring safety and the avoidance of health risks in connection with the use, handling, storage and transportation of articles and substances [HSWA 2(2)b]
- provide such information, instruction, training and supervision to ensure the health and safety at work of their employees [HSWA 2(2)c]
- provide a safe working environment [HSWA 2(2)e]
- those in control of premises must ensure that they are safe and that any plan or substance do not endanger health of all persons at work and the general public [HSWA 4]

As laid down in 'Legionnaires' disease - The control of *Legionella* bacteria in water systems', Approved Code of Practice and guidance on regulations L8 (Fourth Edition) 2013 (chapter 4.5.3) and Health and Safety Guidance 274 Parts 1-3 2013 (chapter 4.5.4), the Trust management is required to:

- Identify, review and assess sources of risk of infections from *Legionella* bacteria
- Prepare a scheme for the continuing prevention/control of the prevailing risk
- Review, revise, implement and manage precautions
- Keep records (for at least five years) of the precautions implemented
- Appoint competent person(s) to help take measures to comply with the law

To get these demands realised in a Trust or a hospital becomes even more challenging. Increasing numbers of NHS providers are facing financial difficulties. The latest numbers for 2018/2019 show that 48 per cent of all trusts are planning to end the year in deficit (TheKingsFund, 2019b). A shift in national policy towards providing care outside of hospital has seen a reduction in the number of hospital beds (TheKingsFund, 2019a). Hospital beds are only one component of health care. Most health care is delivered without using a hospital bed, because beds rely on staff and associated equipment [and also the built environment and infrastructure] to deliver care (TheKingsFund, 2017).

2.3 The hospital environment

It is crucial to understand that safe water in the hospital environment was, is, and will be vital to ensure patient safety and reduce costs for the organisation. One might ask why it may reduce costs. The answer can be found when focusing on waterborne infections and must be considered in a long-term perspective. Waterborne infections might occur seldom compared to other disease outbreaks. But when they appear, they cause increasing morbidity, mortality and treatment costs due to extended hospital stays and impending compensation claims.

Furthermore, the image and trustworthiness of an organisation might be damaged, when an outbreak was referred to building-specific defects of their own organisation and there was not everything possible done in terms of risk management, control and prevention.

2.3.1 Occurrence of *Legionella* and the healthcare context

Infections caused by non-pneumophila species of *Legionella* and non-serogroup 1 *Legionella pneumophila* are frequent in hospitals (Lin et al., 2011b). The manifestation of Legionnaires' disease ranges from a mild respiratory illness to a rapidly fatal pneumonia. Incubation period ranges between 2 and 19 days, but shows a median of 6 days (Bull et al., 2012). Death occurs through progressive pneumonia with respiratory failure and/or shock and multi-organ failure (McDade et al., 1977). Certain risk factors promote an infection with *Legionella*. According to Wright et al. (2012) the major mode of transmission of *Legionella* is aspiration. Thus, some patient groups are at a greater risk than others, especially when having a chronic lung disease (e.g. chronic respiratory) or when undergoing a surgery which requires general anaesthetic. Seen from a global viewpoint, the age and sex distribution of cases of Legionnaires' disease are similar between countries. Most cases are reported for older people, which are 74-91% of patients aged 50 or older. In most of the cases males are infected. Per female patient there are 1.4-4.3 male patients registered (ECDC, 2013, CDC, 2011, Ng et al., 2009, Graham et al., 2012, Ozeki et al., 2012, Lam et al., 2011). Other groups with a higher risk of infection may be seen in smokers and people with certain occupations (Bull et al., 2012). Benin et al. (2002) differ the occurrence of legionellosis into (a) sporadic, (b) nosocomial or (c) large outbreaks or parts of lager outbreaks.

2.3.2 Infections in healthcare facilities

Legionnaires' disease can be caused by inhalation of contaminous aerosols or by aspiration of contaminated water (Heesemann, 2012). Aerosols can occur both inside and outside buildings. Their presence is typically associated with water systems of cooling towers, heat exchange systems, showers, swimming pools, thermal spa or similar situations that create small-size water droplets accessing the environment (Laganà et al., 2014). When being distributed, aerosols find easy access to individuals via their airways. If aerosols contain *Legionella*, they potentially infect people. People go to healthcare facilities induced by a certain motivation, e.g. poor health. As a necessity for infection prevention, indoor environments should be subjected to high standards of hygiene and prevention control (Haupt et al., 2012). In some cases a high level of hygiene is realised for the proximity of certain working environments. This is seen necessary to fulfil organisation-specific standards, rules and demands of legislation. Neglected might be 'non-obvious' or 'unconscious' risks.

Some problems of water systems in facilities are, that they are part of a building, possess defined functions, must fulfil criteria subjected to certain functional demands, and potentially are connected amongst each other via (complex) pipe-distribution systems. Even in healthcare, a field of high-level hygienic risk control, the phenomenon of a lack of precautions for certain in-house systems is present (Fragou et al., 2012, Spagnolo et al., 2013). This represents potential hazards to patients, visitors, staff or other groups of building users.

Dentistry is a specific field in health care everyone can imagine. Aerosols are produced by various instruments used in dentistry, such as turbines, micro-motors, air-water syringes and ultrasound scaler (Cristina et al., 2009, Perdelli et al., 2008). In dentistry we easily find situations where:

- aerosols might be emitted by water-associated instruments of dental chair units (DCUs)
- aerosols potentially contain *Legionella* arising from the dental unit waterlines (DWULs)
- patients and working personnel are exposed to aerosols.

Both patients and dental staff might be infected by due to aspiration of aerosols that were created and released during dental treatment (Fotos et al., 1985). Any other hospital equipment is of particular concern for both inhalation of droplets and infection of wounds (Cristina et al., 2008). In healthcare settings technical systems are used that can disseminate legionellae into the lower respiratory tract (Marrie et al., 1991). Examples for such medical devices are: medical humidifiers, inhalation devices and respiratory therapy equipment. The entirety of such healthcare facilities include hospitals, health centres, hospices, residential care facilities and dialysis units (Bartram et al., 2007).

2.3.3 Classification of nosocomial Legionnaires' disease

About 10 years ago the WHO defined three classes to precisely distinguish between cases of nosocomial Legionnaires' disease (Bartram et al., 2007):

(1) Definite nosocomial: in a person who was in hospital for 10 days before the onset of symptoms.

(2) Probable nosocomial: in a person who was in hospital for 1-9 of the 10 days before the onset of symptoms, and either (a) became ill in a hospital associated with one or more previous cases

of Legionnaires' disease, or (b) yielded an isolate that was indistinguishable (by molecular typing methods) from isolates obtained from the hospital water system at about the same time.

(3) Possible nosocomial: in a person who was in hospital for 1-9 of the 10 days before the onset of symptoms in a hospital not previously known to be associated with any case of Legionnaires' disease, and where no microbiological link has been established between the infection and the hospital.

2.3.4 Nosocomial infections with *Legionella*

In many cases Legionnaires' disease is a hospital-acquired (nosocomial) infection. The building stock and the built environment of hospitals represent ideal conditions and locations for transmission of Legionnaires' disease. Fields et al. (Fields et al., 2002) mention some which are the presence of:

- at-risk individuals in large numbers (immunocompromised people)
- rather old and complex plumbing systems
- often reduced water temperatures to prevent scalding of patients

A crucial measure for the management of the disease is an early clinical diagnosis, accompanied by the immediate delivering of appropriate antibiotics for *Legionella* spp. When talking about the control of Legionnaires' disease outbreaks, big effort relies on rapid ascertainment of descriptive and available epidemiological data. Together with microbiological information it helps identifying the source and directs for taking appropriate measures. There are numbers of reasons which emphasise the need for further research to support early diagnosis and improve clinical or outbreak management. Those to be mentioned are (Coetzee et al., 2012, McCormick et al., 2012):

- the substantial morbidity associated with Legionnaires' disease
- the widespread occurrence
- major outbreaks

Phin et al. (Phin et al., 2014) critically reviewed and summarised the global epidemiology of Legionnaires' disease as well as its diagnosis and management.

2.3.5 Variety of hospital-acquired Legionnaires' disease

The first reported outbreak of hospital-acquired Legionnaires' disease took place in a psychiatric hospital at St Elizabeth's in Washington, DC, in 1965. A number of 81 patients contracted an uncommon pneumonia of which 15 people died. This outbreak was linked with Legionnaires' disease only in 1977 (Thacker et al., 1978).

The largest outbreak of hospital-acquired Legionnaires' disease occurred at the Wadsworth Veterans' Administration Medical Center (VAMC) in Los Angeles. Between 1977 and 1982 at least 218 confirmed cases constituted this outbreak. Up to 2002 more than 300 reports of hospital-acquired Legionnaires' disease have been published in peer-reviewed literature and public-health reports (Sabria and Yu, 2002), ranging from small to major (large) outbreaks. Small outbreaks of nosocomial-related Legionnaires' disease, which are characterised by occurrence over a short period of time, indicate an exposure to legionella-contaminated potable water.

Those outbreaks often occur as a result of stagnant water in pipes of the facility or are related to water pipes or water systems in or near the facility. In contrast to the characteristics of small outbreaks, a sudden appearance of large numbers of Legionnaires' disease cases, which occur over a short period of time, suggests airborne spread. Potential sources, for example, can be seen in legionella-contaminated water towers (Cunha et al., 2011).

There is evidence, that healthcare-acquired Legionnaires' disease occurs due to the exposure to *Legionella* spp which has colonised hospital water distribution systems (Casini et al., 2008). In that specific context, potable water has been identified as the environmental source for almost all reported hospital outbreaks (Sabria and Yu, 2002, Ozerol et al., 2006, Stypułkowska-Misiurewicz et al., 2007). The degree of *Legionella* colonisation of water systems determines the threat on a point of release of *Legionella* contaminated aerosols.

2.3.6 Healthcare acquired Legionellosis, outbreaks, water and the environment

Tobin et al. and Stout et al. (Tobin et al., 1981, Stout et al., 1982, Lin et al., 2011a) first made epidemiological links between the presence of *L pneumophila* in hospital drinking water and the occurrence of hospital-acquired legionellosis. In the context of hospitals only a few reports of outbreaks have been linked to a cooling tower.

2.3.7 Water testing and variability of *Legionella* counts

The variability of *Legionella* presence within a DWPS at (a) consistent sampling points, (b) standard operating conditions and (c) at short time intervals (e.g. within hours or weeks) has rarely been studied. Napoli et al. (Napoli C. et al., 2009) showed the variability of *Legionella* present in the water system within a single hospital. They took water samples from 21 taps in different wards at the same time for each of 5 consecutive days. However, the data did not show variances in log-steps regarding the issue of *Legionella* variability over time as presented in a different study (Völker et al., 2016), even within hours. They argue that if there was already existing data being collected by building owners or health authorities, it would enhance the repeatability of their results.

The variability of *Legionella* presence in water samples can be explained in different ways. One explanation is the abrupt break away of parts of an existing biofilm, which hosted *Legionella*. During sampling, this amount, which used to be 'bound' in the biofilm system, gets into the sample. The result is a *Legionella* count exceeding the level many times over a sample which contains the 'regular' sample water of the system without parts of the biofilm (Wingender and Flemming, 2011). Another explanation is the so called VBNC state (viable but non-culturable), which describes, that *Legionella* can outlast certain conditions. *Legionella* enters and leaves this state depending on surrounding conditions for accumulation. There are well-known problems of detecting *Legionella* cells with culture methods in the laboratory. Thus additional molecular methods for *Legionella* detection are advised (Flemming et al., 2014). Allegra et al. (Allegra et al., 2011) compared *Legionella* detected from hospital water systems using culture and a flow cytometry assay to identify VBNC cells and found that VBNC cells varied from 4.6 to 71.7 %.

The problem with the presence of VBNC *Legionella* is that using the viable culture method of detection a negative result does not necessarily mean that Legionella is not present. This has serious ramifications for public health protection using routine sampling (Whiley et al., 2014).

2.3.7.1 Environmental sources and ecological niches

Legionella can proliferate in certain human-made water environments, such as water-cooling devices (cooling towers and evaporative condensers), hot water distribution systems, taps and whirlpool spas. Very low concentrations of *Legionella* from natural habitats can find favourable conditions in a man-made hot water system. It may provide suitable conditions for proliferation and thus occurrence may increase strikingly. Types of engineered water systems like piped drinking water, cooling towers, fountains and humidifiers are known to be important sources for cases of Legionellosis and outbreaks (Craun et al., 2010). Kruse et al. suggest that there is a substantial degree of potential exposure to *Legionella* spp in the community. In their study they found at least a medium level of contamination of water systems for 20 % of the buildings tested. The bioburden embodies a hazard of being a potential source of infection.

Contamination levels succeeding a certain threshold level guide people responsible how to risk assess and enforce further measures. Such specific threshold levels are for example published by national legislation or recommendations for decision making in classifying the level of contamination from a source. It must be kept in mind that the risk of an infection depends on a number of different factors and different perspectives. Those perspectives concern both the population at risk and the design of the water system (O'Neill and Humphreys, 2005).

Legionella can find ecological niches within ecological systems. Overall, these niches favour persistence and growth of *Legionella*. Considering the different potential points of use, every outlet of the water system can be regarded as an ecological niche for *Legionella* (Marrie et al., 1992). According to the report from ECDC (2017b p.17), the distribution of sampling sites testing positive for *Legionella* come from 90% ‘water systems’, 5% ‘cooling tower’. 3% ‘pool’ and 2% ‘other’. The distribution of sampling sites testing positive for *Legionella* and matching with clinical isolates come from 83% ‘water systems’, 5% ‘cooling tower’, 10% ‘pool’ and 2% ‘other’.

2.3.7.2 Water systems in the (built) environment

Legionella spp can be found in specific (drinking) water systems of private and public buildings such as homes, hotels and hospitals. There are reported prominent cases of contaminated ‘typical’ water systems such as water installations (see also chapter 2.3.7.1), or other types of engineered systems, such as HVAC systems or cooling towers (Exner et al., 2005) (Buse et al., 2012) linked to facilities and premises, but also other sources of *Legionella* in systems of the (built) environment, such as room humidifiers, wastewater/ waste water treatment plants, fountains, baths, potting soil/compost (van Heijnsbergen et al., 2015).

One aspect of monitoring strategies ist the control of compliance on temperature levels. Different authorities suggest different temperature regulations (Bédard et al., 2015). Some regulations are summarised in Table 2-1.

In the first column, the authority (organisation or country) is listed, in the second column, the required temperature at the water heater is listed, in the third column, the required temperature at the return loop, and in the fourth column, the required temperature at the point of use is listed.

Table 2-1: Comparison of temperature regulations by different authorities, adapted from Van Kenhove et al. (2019 table 4), modified

	Water heater	Return loop	Point of use
WHO	≥60°C	>55°C	≥50°C (after 1 minute)
EWGLI	≥60°C (1 hour a d/wk)	≥55°C	≥55°C (70°C should be possible)
UK	≥60°C	≥50°C/loop	≥55°C (health care)
France	>55°C	>50°C	≥50°C
USA	≥60°C	≥51°C	≥43.3°C to 49°C

In practice, the precision, accuracy and effectiveness of ways of estimating the risk of *Legionella* contamination, for example promoted by temperature, stagnation, pipe materials, etc., have only rarely been assessed empirically. With respect to the surveillance of DWPSs and correspondingly the identification of risk areas, there is a need for an early estimation of the risk of *Legionella* contamination within a building. This requires efficient and assessable variables to identify threats, estimate hazards and to prioritize risks.

2.3.7.3 Occurrence of *Legionella* in engineered systems

In a review in 2008 Diederen issued, that “in the US *Legionella* bacteria causes thousands of nosocomial Legionnaires’ disease cases each year, not only affecting patients, but resulting in expensive lawsuits, emotional stress, wasted time, and damaging press” (Diederen, 2008).

He further outlines, that pathogens have been detected in different contexts, environments or technical systems. Diederen gives specific examples, enumerating potable water, cooling tower water, distilled water, nebulizers, contaminated respiratory therapy solutions, room humidifiers, vaporizers, mist tents, sinks, hydrotherapy pools, whirlpools, lithotripsy therapy tanks, dialysis water, eyewash stations, endoscopes, and flower vases. As a result, people (e.g. patients, visitors, occupants, working staff) in the proximity, who move inside or outside the built environment of any building, may be exposed to pathogens. They may be infected by direct contact with contaminated water, ingestion, inhalation of aerosols, aspiration, or indirect transfer from moist surfaces (e.g., by health care workers’ hands) or medical devices (CDC, 2003).

2.3.7.4 Gguidance for healthcare buildings

Health building notes (HBN) give best practice guidance on the design and planning of new healthcare buildings and on the adaptation or extension of existing facilities. They provide information to support the briefing and design processes for individual projects in the NHS building programme.

For identifying added value for achieving excellence, there are three main components of the design brief for healthcare buildings mentioned in 'HBN 00-01 General design guidance for healthcare buildings' (DH, 2014), which are 1) Functionality, 2) Impact, 3) and build quality. Each of them forms specific targets affecting 'water', 'risk', 'quality' and 'safety'. Applicability is for the design and planning of new healthcare buildings as well as for the adaption or extension of exisiting facilities. With each of these four dimensions measures and actions are closely linked in order to achieve best practice. They are described more detailed in the next sections. Figure 2-1 presents a generic illustration.

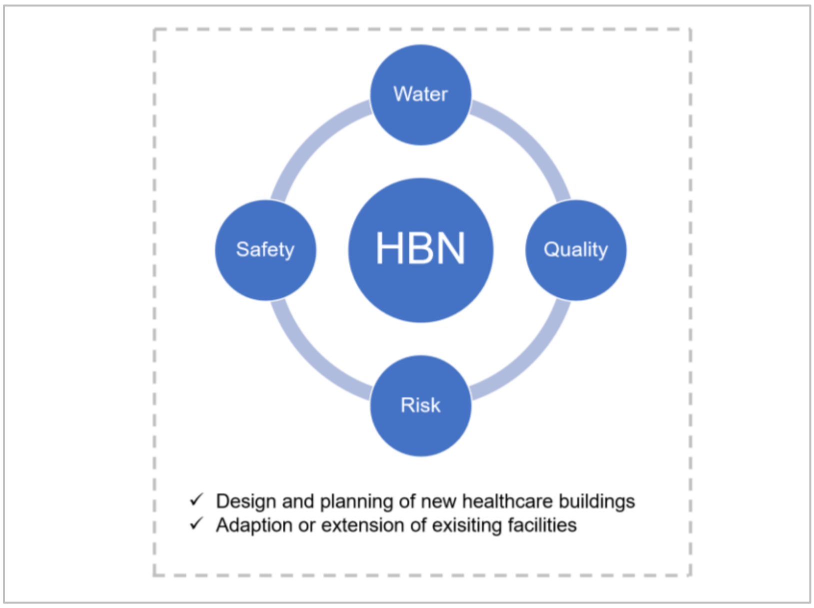


Figure 2-1: Four dimensions in HBN

The four dimensions will be considered for research and inform elements for the final framework. Therefore the HBN have been reviewed and a summary of the notable content for each of the dimensions is presented in keywords hereafter.

With respect to the research context HBN holds specific topics linked with 'water'

- *Form and materials*: Composition. The building's form should be pleasing and well-composed. Issues to consider:
  - the integration of service elements such as rainwater pipes, flues, grilles, plantrooms, refuse bays.
- *Engineering*: Specialist engineering systems. Set out the brief, requirements and standards to be followed for specialist systems including:
  - cold water storage
- *Engineering*: Emergency backup systems. The emergency backup systems should be designed to minimise disruption. Set out emergency backup requirements and standards. Issues to consider:
  - hot water
  - cold water storage
- *Engineering*: Hot water and steam/operational engineering systems. Issues to consider:
  - flexibility and efficiency of engineering systems

    - economy in use of resources.
- *Engineering*: Water and drainage system. Set out requirements and performance standards (refer to specific guidance as appropriate). Issues to consider:
    - flexibility and efficiency
    - minimising the use of resources
    - capacity of the water supply system to provide safe potable drinking water
    - adequacy of water pressures for clinical processes

With respect to the research context HBN holds specific topics linked with 'risk'

The World Health Organization defined "health" as "a state of physical, mental and social wellbeing and not merely the absence of disease or infirmity" (WHO, 1948). Healthcare facilities should provide a therapeutic environment in which the overall design of the building contributes to the process of healing and reduces the risk of healthcare-associated infections rather than simply being a place where treatment takes place. In turn, the healthcare planning and design process therefore needs to be correspondingly broad enough to include not only the issues surrounding the treatment of disease, but also the promotion of health and prevention of disease - essentially the creation of a safe and therapeutic care environment.

- Section 1.5 of HBN 00-01: Regulation 15 of the Health and Social Care Act 2008 (Regulated Activities) 2010 states that patients must be "protected against the risks associated with un-safe and unsuitable premises, by means of …. suitable design and layout … maintenance and ….operation".
- Sections 1.11 to 1.14 of HBN 00-01: The NHS has developed, with the support of DH, the NHS Premises Assurance Model (NHS PAM), whose remit is to provide governance and assurance to boards of organisations that patients, staff and visitors are protected against risks associated with hazards such as unsafe premises. It has been designed to apply across the range of estates and facilities management services.
  Although not mandatory, NHS PAM allows organisations that provide NHS-funded care and services to better understand the effectiveness, quality and safety with which they manage their estate and facilities services and how that links to patient experience and patient safety. Key questions are underpinned by prompt questions which require the gathering of evidence. Healthcare organisations need to prepare and access this evidence to support their assess-ment of the NHS PAM. The model also includes references to evidence and guidance (for example, HBNs and HTMs) to assist in deciding the level of NHS PAM assurance applicable to a particular healthcare organisation.

With respect to the research context HBN holds specific topics linked with 'quality'

- *Performance:* Air quality:
    - Air quality should be fresh for patients, staff and visitors. Issues to consider:
        - quantity of space with natural/artificial ventilation and/or air-conditioning
        - access by occupants to natural ventilation
        - an appropriate level of control by occupants of heating and ventilation.

Section 1.26 of HBN 00-01: The Common Minimum Standards (CMS) for the procurement of built environments in the public sector set a requirement that: “All clients will aim to deliver design excellence in accordance with the principles set out in the Government Construction Strategy” (CMS 4.1).

Compliance is expected, although the CMS do make provision for practicality, achievability and value for money to be considered in certain circumstances. Details on the CMS can be found on the Common Minimum Standards web page.

Section 1.27 of HBN 00-01: The CMS recommend that Design Quality Indicators (DQIs) are used as part of ensuring all stakeholders, including end-users, are involved in the development of the output specification, design brief and in the assessment of project success. The DQIs for the health sector have been developed by the UK Construction Industry Council as a five-stage facilitated and accredited process. This replaces the Achieving Excellence Design Evaluation Toolkit originally produced by the Department of Health, which has been archived and is no longer supported.

Section 1.28 of HBN 00-01: The CMS document also recommends that an appropriate environmental assessment process such as BREEAM, or an equivalent process appropriate to the size, nature and impact of the project, should be carried out on all projects. BREEAM for healthcare buildings replaces NEAT (NHS Environmental Assessment Tool) as the preferred environmental assessment method and certification scheme for healthcare buildings in the UK.

Section 5.1 of HBN 00-01: The design brief is one of the important elements that form part of the overall process in creating a healthcare project. It is essential that the brief is developed in the context of the total lifespan of the project. The brief will:

- describe clinical service needs and design vision/objectives;
- define environmental quality and sustainability objectives, whole hospital policies and departmental policies; and
- detail technical requirements and schedules of accommodation.

With respect to the research context HBN holds specific topics linked with ‘safety’

Section 5.5 of HBN 00-01: Of particular importance in the context of health care buildings is the need for the design brief to incorporate policy, guidance and best practice in relation to reducing health care associated infections (HCAIs). It is vitally important to have a clear understanding of how the briefing, planning, design, procurement, construction, commissioning and ongoing maintenance of health care property can contribute to the prevention and control of HCAIs.

Section 5.58 of HBN 00-01: The project team should refer to the growing body of research material indicating that the design of the healing environment impacts on patient recovery and on staff, and that good quality environments impact positively on patient care and vice versa.

2.4 Summary background one

This chapter highlights gaps in research and scientific reporting due to the delicate nature of the topic with respect to management, process, duties and stakeholders involved. The previous chapter extensively informed about *Legionella*, infection and healthcare. Specifically some arguments which are seen to be of utmost importance for this research are summrised by:

- Infections caused by non-pneumophila species of *Legionella* and non-serogroup 1 *Legionella pneumophila* are frequent in hospitals (Lin et al., 2011b).
- Immunocompromised people in healthcare facilities constitute a risk group whose environment should meet certain requirements of hygiene, monitoring and risk assessment to contribute to preventive measures.
- In 2012 there were 401 incidences of notification of Legionnaires' disease for the UK (ECDC, 2014)
- Legionnaires' disease is thought to be underreported (ECDC, 2014).
- In a study including 233 buildings (32.7 %) with potable water systems, Kruse et al. (Kruse et al., 2016) identified *Legionella* spp., where 148 (63.5 %) of them revealed a medium or higher level of contamination.
- *Legionella* spp. can contaminate parts of or even the whole (drinking) water system in the presence of favourable conditions (RKI, 2013).
- Indoor environments should be subjected to high standards of hygiene and prevention control (Haupt et al., 2012).
- Even in healthcare, a field of high-level hygienic risk control, the phenomenon of a lack of precautions for certain in-house systems is present (Fragou et al., 2012, Spagnolo et al., 2013).
- Both patients and staff might be infected by due to aspiration of aerosols that were created and released (Fotos et al., 1985).
- Any hospital equipment is of particular concern for both inhalation of droplets and infection of wounds (Cristina et al., 2008).
- In the environment of hospitals, Fields et al. (Fields et al., 2002) mention a) at-risk individuals in large numbers (immunocompromised people), b) rather old and complex plumbing systems, and c) often reduced water temperatures to prevent scalding of patients.
- There are numbers of reasons which emphasise the need for further research to support early diagnosis and improve clinical or outbreak management. Those to be mentioned are (Coetzee et al., 2012, McCormick et al., 2012): a) the substantial morbidity associated with Legionnaires' disease, b) the widespread occurrence, c) major outbreaks.
- Up to 2002 more than 300 reports of hospital-acquired Legionnaires' disease have been published in peer-reviewed literature and public-health reports (Sabria and Yu, 2002).
- Potential sources can be seen in legionella-contaminated water towers (Cunha et al., 2011)
- Healthcare-acquired Legionnaires' disease occurs due to the exposure to *Legionella* spp which has colonised hospital water distribution systems (Casini et al., 2008).

- Potable water has been identified as the environmental source for almost all reported hospital outbreaks (Sabria and Yu, 2002, Ozerol et al., 2006), (Stypułkowska-Misiurewicz et al., 2007).
- Garbe et al. (Garbe et al., 1985) report on an outbreak, including clinical and environmental samples, that a cooling tower has been heavily contaminated with *Legionella pneumophila*, serogroup 1. In a different outbreak of legionellosis the cooling towers were disinfected a second time (Sabria and Yu, 2002).
- Outbreaks may have substantial implications for public health (García-Fulgueiras et al., 2003)
- Large outbreaks of Legionnaires' disease have been associated with contaminated cooling towers, (García-Fulgueiras et al., 2003, Greig et al., 2004, Bennett et al., 2013) hot and cold water systems, and whirlpool spas (Colville et al., 1993, Den Boer et al., 2002). Common to all sources mentioned is, that they represent engineered, technical systems, in which water is transported and/or manipulated for a specific purpose.
- Contaminated drinking water plumbing systems (DWPS) are common in public buildings (Völker et al., 2010). The survey reported by (Völker et al., 2010) points out that approximately a) every second monitored hospital, b) every fourth nursing home, and c) every seventh sports facility was contaminated with *Legionella* at least once between 2003 and 2006.
- Incomplete cleaning and disinfection may also be the cause for an outbreak, as well as the multiple use of reusable oxygen humidifiers for several patients, probably posing a reservoir for *Legionella pneumophila* (Bou and Ramos, 2009).
- Outbreaks reported were associated with the exposure to decorative fountains located in the public area of the hospital (Lin et al., 2011b, Haupt et al., 2012).
- Investigations of evaporative condensers mainly found in hospital areas found high concentrations of *Legionella pneumophila* (Pleischl S. et al., 2002). Contamination was due to insufficient cleaning and disinfection, and messy maintenance of the evaporative condensers.
- Because of the high mortality and morbidity associated with untreated Legionnaires' disease, priorities to be set for clinical management are a) early diagnosis and prompt treatment with effective antibiotics, b) appropriate management of complications, and c) the management of underlying co-morbidities and risk factors (Viasus et al., 2013, Chidiac et al., 2012, Eliakim-Raz et al., 2012, Mandell et al., 2007, Levy et al., 2009, Levy et al., 2010, Zumla et al., 1988, Cunha, 2008).
- An entire DWPS can, in most cases, be regarded as an open ecological system with incoming and outgoing microorganisms. The highly variable counts of culturable *Legionella* cells and the variable types of *Legionella* species (pneumophila, non-pneumophila and different serogroups) within a building and at single outlets suggest that the water system is highly dynamic and sensitive. It needs precise understanding of building-specific and water system related information as well as a deep understanding of potential causes or weak points. Its complexity calls for experts' interdisciplinary endeavour and provision of essential resources. *Legionella* can find ecological niches within these ecological systems, which favour their persistence and growth. Regarding the points of use, every outlet of the system can be regarded as an ecological niche for *Legionella* (Marrie et al., 1992).

- The risk of an infection depends on a number of different factors and different perspectives. Those perspectives concern both the population at risk and the design of the water system (O'Neill and Humphreys, 2005)
- According to the report from ECDC (2017b p.17), the distribution of sampling sites testing positive for *Legionella* come from 90% 'water systems', 5% 'cooling tower'. 3% 'pool' and 2% 'other'. The distribution of sampling sites testing positive for *Legionella* and matching with clinical isolates come from 83% 'water systems', 5% 'cooling tower', 10% 'pool' and 2% 'other'.
- In order to achieve and maintain control over water systems at safe levels in healthcare facilities, fundamental aspects have to be considered. Microbiological monitoring plays an important role, but is only one part of the whole puzzle. It should be performed not only for identifying risks and being part of the risk assessment, but also to help in ensuring compliance with statutory regulations/guidelines on an operative viewpoint of daily business. Even the presence of various minerals in water is considered as a risk indicator for bacterial colonization and biofilm development (Borella et al., 2003).
- According to 'HBN 00-01 General design guidance for healthcare buildings' (DH, 2014) there are specific targets affecting 'water', 'risk', 'quality' and 'safety' applicable for the design and planning of new healthcare buildings as well as for the adaption or extension of exisiting facilities.

Taking into consideration the aforementioned facts, awareness, compliance and appropriate structures in organisations need more attention by responsible people to act responsible. The confirmation of an outbreak happens on basis of clinical and environmental samples. On the basis of case histories, potential sources should be localised and risk assessments be done. Even the aspect of communicating to health authorities and to the public should be considered on basis of clear facts and decisions while meeting existing law. Those activities guide and prioritise ongoing investigations and define measures to be taken. The microbiological aspect of any investigation is to seek evidence for linking the source of the outbreak to the case(s). A central point in doing this is the comparison of *Legionella* isolates in environmental samples with those from patients. In this context of investigating and assessing a potential outbreak situation, potential overlapping duties of different roles involved within an organisation may be existing.

The target of a well working self-control in the sense of prevention, which is rather a proactive than a reactive principle, is to get the situation manageable and transparent from top-down the management levels of an organisation. Only when the responsible person can fully assess the given situation of an outbreak or case clarification by evidence, appropriate measures can be taken into action. In organisations decision-making usually is realised by responsible functions of management.

Taking everything of this chapter into consideration, people responsible for healthcare buildings have a long list of targets and duties to fulfil. For that it is important to give guidance in this specific topic for a specific group of stakeholders to meet all detected necessities and gaps reported by literature.

The guidance should be specifically made for the FM industry and be applied by people responsible in hospitals managing water safety and taking responsibility on risk management and *Legionella* prevention. Therefore the next chapter characterises the FM industry and highlights specific management procedures.

3 Background two - Estates and Facilities Management

In order to understand the rather microbiological topics of the previous chapter in the research context correctly and raise awareness about the research problem, it is necessary to introduce and explain management practice and mechanisms of Estates and Facilities Management.

3.1 Estates and Facilities Management

The British Institute of Facilities Management (BIFM) formerly defined the FM profession in the UK as: “Facilities Management is the integration of multi-disciplinary activities within the built environment and the management of their impact upon people and the workplace” (Wiggins, 2010). The European standard defines FM as: “the integration of processes within an organisation to maintain and develop the agreed services which support and improve the effectiveness of its primary activities” (BS, 2011b). This standard, consisting of seven parts, has been adopted and brought into national level in the United Kingdom (BS EN 15221-1 to BS EN 15221-7), Germany (DIN EN 15221-1 to DIN EN 15221-7) and Switzerland (SN EN 15221-1 to SN EN 15221-7). The European standard EN 15221-Family and ISO 41000 gives relevant terms and definitions in the area of Facility Management.

Another Facilities Management Definition is “An organisational function which integrates people, place and process within the built environment with the purpose of improving the quality of life of people and the productivity of the core business” (ISO, 2017b).

According to the standard, FM encompasses multi-disciplinary activities within the built environment and the management of their impact upon people and the workplace. Effective FM combines resources and activities likewise and is vital to the success of any organisation (BIFM, 2015). At a corporate level, it contributes to the delivery of strategic and operational objectives. On a day-to-day level, effective FM provides a safe and efficient working environment, which is essential to the performance of any business – whatever size and scope.

FM is capable of covering different support processes (facility services), of which the element of service delivery is described in a written statement, and perhaps measured by key performance indicators (KPIs) (CEN, 2006 p.8). Any service incorporates a series of duties, depending on the context of the mandate. Support processes, as characterised by EN 15221, can for example be assigned to roles (and linked with duties) in tasks on ’building maintenance’, ‘operational’, ‘business continuity planning’ or ‘health and safety’, which each can contain risk areas. The FM department in an organisation is required to control and manage safety related issues.

Failure to do so may lead to injury, loss of business, prosecution or insurance claims. Even more, the confidence of customers and investors in the business may also be affected by adverse publicity (Atkin and Brooks, 2009).

Generally speaking FM is the management and maintenance of commercial buildings, encompassing everything required to keep people alive and safe. FM may include different services, such as building maintenance, catering, cleaning. Some more examples for the two categories are summarised in Table 3-1.

Table 3-1: Examples of hard and soft FM

Examples of hard FM	**Examples of soft FM**
Building Maintenance, CCTV Systems, Access Systems, Air Conditioning, Fire Safety, Structural Maintenance, Heating & Ventilation Systems, Mechanical & Electrical Services.	Pest Control, Cleaning Services, Grounds Maintenance, Security Services, Catering & Vending, Janitorial Services, Waste Management, Concierge & Reception Services.

Hard and soft FM elements in combination are important to ensure a specific building is running as smoothly as possible. As is the problem with many other services, FM may tend to go unnoticed until a certain event demonstrates something went irregular.

Given the wide range of services included in FM, the decision to outsource these services to one dedicated service provider will relieve a facilities manager of all the challenges that come along with maintaining a building. FM can:

- Reduce costs and optimise investments
- Improve operational utilisation, availability and flexibility
- Address environmental standards and concerns
- Maintain regulatory compliance
- Enhance safety and reduce risk
- Provide engaging, productive environments

FM in general, and FM in healthcare specifically, usually makes necessary numbers of services. These are mainly categorised into 1) hard and 2) soft FM. Hard FM relates to management and maintenance of property, while soft FM includes the management of support services (Hinks et al., 2003). The built environment, including infrastructure facilities such as estate and property, indoor air, structure and fabric, water supply, electricity and telecommunication systems belong to the first category (hard FM). Catering, cleaning, waste management, security, and laundry are part of soft FM. By definition, it is Estates which covers the water safety aspect. Thus, the information and data required for this research is located there. Essentially the right people need to be involved.

‘Estates and Facilities Management’ in the UK-context is often used as a combined term for management levels in organisations, such as hospitals. Although both terms differ in content by definition, they help in allocating responsibilities, and thus, processes and tasks. They organise the organisation. Aspects of hard FM could, by definition, be understood as ‘Estates’ or even ‘Property’, when spotting the focus on structural maintenance, or maintenance and repair work, that may have an impact on structural elements (e.g. remedial work). Any building is assigned a function. Its entirety must make it possible to manage the planned processes, persons and structures permanently, efficiently and securely. An infected water system is a serious damage to a building and a risk for the organisation, that must be remedied. In a combined view, the two terms make the hospital a working environment.

The reason why both terms ‘Estates’ and ‘Facilities Management’ are to be contextualised for water safety management is, that the topic water safety management, with its potential impact and consequences for the building and the built environment, must be considered equally with respect to process and risk management, where the boundaries are not strictly set and depend on the angle of vision.

There is also the former term ‘building management’, wich was understood as a sub-area of facility management that deals with the management of existing buildings and technical facilities (GEFMA, 2004a). With this distinction given, one also speaks of operational facility management, concentrated on the utilisation phase (Preuß and Schöne, 2010). A subdivision can be made into the areas of technical, infrastructural and commercial facility management (Krimmling, 2017) (Teichmann, 2009 p.20). The aim of building management is the functional maintenance of buildings, taking into account the requirements of the owner, the user and the (real estate) market. Technical building management comprises all activities in a building in connection with maintenance, inventory care and modernisation (Hellerforth, 2001). Among other things, risk and quality management are important elements for a performance management system in building management (Teichmann, 2009 pp.105-107).

3.2 Estates and facilities management in hospitals

By considering the topic of water hygiene there is a variety of stakeholders working on a common process of Legionella prevention (Gamage et al., 2016; Leiblein, Tucker, et al., 2017; Spagnolo et al., 2013). This includes internal and external people, who collaborate and work on a common process. Certainly, law and duties vary from country to country which is, of course, not unusual to deal with for a locally or globally acting Corporate Real Estates, Facilities Management or Facilities Services Provider business. However, the legal framework, standards or even potential threats are not always obvious to people responsible (Leiblein, Füchslin, et al., 2017). An infected water system is a deficiency in a building and reduces the value of a facility. Above all, the hazard to people and the liability of duty holders may be two even stronger arguments. Because of the critical importance and complexity of the topic, professionals with operational duties must bear this in mind. Especially in working environments with people who are in the need of protecting their health.

3.3 Management interwoven in the organisational structure

The management of an organisation can just be as good a the stakeholders being involved as well as the structures and quality of collaboration and communication.

3.3.1 Organisation, Stakeholder theory and stakeholder analysis

A stakeholder analysis can be used in many circumstances such as a procurement exercise, development of a specific project, or as in this case process and process owner (stakeholder) identification. The involvement of the right people not only ensures that they are engaged with the process, it also maximises the potential for the widest range of issues and options to be considered as part of an interdisciplinary endeavour/collaborative approach (as is the case with *Legionella* prevention and water safety).

The matrix opposite visualisation method is often used by project managers to group stakeholders into areas of importance by considering ‘power’ to influence the process and ‘interest’ in the outcome. Although it can appear slightly crude it can prove quite useful to highlight the stakeholders that need to be most closely engaged with the process (see chapter 6.10.2.5).

3.3.2 Management instruments

From the manager’s perspective there are different driving forces, or ‘motivators’, for organising work and applying certain instruments to manage and delegate. In the context of this thesis the focus should be set on the two aspects, namely ‘extrinsic’ and ‘intrinsic’. Both have implications on the organisational procedures as they may be the source for applying certain management instruments for implementing, decision making, announcing, enforcing and to delegate.

3.3.2.1 Extrinsic motivation

Influencing documents from the outside of an organisation, such as acts, standards, statutes, policies, frameworks, best practice.

3.3.2.2 Intrinsic motivation

From a manager’s cockpit perspective of the organisation strategically applying and implementing management instruments for achieving the realisation of a visions by, for example, governance arrangements scheme, stakeholder matrix, responsibility assignemt matrix (RAM), linear responsibility chart (LRC), accountability chart (AC), audit report, verifying report, review, risk assessment, process map, workflow charts, standard operating procedure (SOP), action plan, policy, training program, job descrition, checklist. Some of these may be documents relevant for processes.

3.4 Drivers for *Legionella* prevention in Estates and Facilities Management

The International Facility Management Association’s (IMFA) guidelines define the competencies of the professional field in FM. In 2013 the chapters “Emergency Preparedness and Business Continuity” and “Environmental Stewardship and Sustainability” were added to these guidelines. Thus, the management competencies of FM now include hazard prevention requirements in certain areas. Hazards might, for example, arise from microbiological contamination with species of *Legionella*. The facultative pathogen *Legionella pneumophila* (Heesemann, 2012), a species of *Legionella*, accounts for 85-98 % of confirmed cases, depending on the testing method used (ECDC, 2014). In community and in healthcare organisations, the potential consequences of a case of *Legionella* are particularly profound. In healthcare not only the health of patients and staff might be affected (working people such as doctors, care personnel, cleaning personnel, and service personnel), but also the performance of and confidence in the organisation (Diederen, 2008, Freije, 2005). Quality, performance and knowledge management (Liyanage and Egbu, 2005, Liyanage and Egbu, 2006, Liyanage and Egbu, 2008) are key drivers for quality service delivery in FM businesses.

3.4.1 Risk management

Persons or companies responsible for renting domestic property (e.g. property agents or landlords) must control the risk of *Legionella* contamination which can cause legionnaires disease (HSE, 2019). *Legionella* bacteria can be found in water tanks and systems – these require a legionella risk assessment to be conducted in order to comply with Health & Safety law. Compliant *Legionella* risk assessments must be carried out by a competent *Legionella* risk assessor.

3.4.1.1 Hospital building systems at a higher risk

Water systems, cooling towers/condensers, respiratory devices and humidifiers, but also point of use, e.g. specific rinsing medical equipment, baths, showers and hand washing (Ortolano et al., 2005) should be part of an integrated risk management supporting control strategies and thus prevention of nosocomial infections. Within healthcare buildings, particularly those which have been around for some time, or water systems that had parts that have not been removed over the years with pipework disappearing and reappearing, embedded in water sampling, there may be deadlegs or other causes leading to stagnation or inappropriate water use.

In healthcare, there are more different actors which can have an impact on water quality than in non-healthcare sectors. It’s not just Estates. The water quality and water systems seem to be considered as to be an Estates problem and not a hospital-wide problem. But Infection Control, specialists, and those users, which require specialist water quality such as dialysis and hazardous events which may lead to increases in hazards (e.g. *Legionella*), carefully need to consider:

- There are different actors/roles compared with utilisation and non-healthcare systems
- There are multiple water systems not just for normal uses but also for treatment and diagnosis
- There are often old buildings with complex water systems which have evolved over time. Potentially they have long and unknown piperuns, many deadlegs and blind ends, multiple wash hand basins, en-suites which may not be used, many complex components (Thermostatic mixing valves, electronic taps etc.).

Water safety plans (WSPs), which describe a ‘scheme for preventing and controlling the risks’ are a component of the WHO’s framework for safe water. It includes three elements, namely ‘system assessment’, ‘monitoring’, and ‘management and communication’ and stimulates the motivation of people responsible to think about safe limits for achieving health-based targets (Lee, 2017 p.23). Potential scenarios of a large contamination infestation, a failure or downtime situation may also be a considerable argument for management with focus on business continuity management.

A control programme should be reviewed and this facility plan be developed or improved and then implemented to minimize all risks associated with water use. And it should be made sure that they are managed effectively and monitoring targets are easily measurable in the whole time. For example, temperature, target levels of disinfectant are maintained within the system, pH, turbidity, AOC and faecal indicators. The delivery quality of incoming water is also a useful monitoring parameter.

The individuals involved in the management's operational control measures also need to be trained and competent. It is essential that the WSP is managed and communicated effectively with supporting programmes to ensure good communication.

Once *Legionella* has colonized a water system, eradication is usually unachievable (Marchesi et al., 2011, García et al., 2008, Zhang et al., 2007). But risk management for existing water systems qualifies people being responsible to act responsibly and adequately to the issue. Activities include monitoring and definition of measures for preventive actions. It should be kept in mind that it is aerosol exposure that usually constitutes the actual risk for transmission of legionellosis. The questions arising from the gap that occurs, when estimating the level of exposure from the level of contamination of the system, are challenging, especially in the context of hospitals (Hines et al., 2014).

Developing a risk reduction strategy requires certain key issues. A proactive approach that aims to minimize pathogens, such as *Legionella,* in water systems is one way to pursue. Another option can be seen in a reactive approach that considers environmental measures only after a disease is identified and confirmed. For a given pathogen this issue must be considered on the basis of severity of the associated illness, sources of contamination, data on preventative measures, available detection methods, remedial technology, and legal issues (Freije, 2005).

Because of the ubiquity of the bacteria *Legionella*, it requires measures that help preventing favourable conditions for colonizing and growth in operating and used systems, which might affect people. The primary task is not to identify whether or not the bacteria are present, but to identify which circumstances present risk factors promoting growth of the bacteria (Hoebe and Kool, 2000). Yet it must be noted that appropriate risk management of water systems includes control and monitoring tasks.

Risk assessment combined with environmental monitoring has been effective in predicting risk. This can be read in studies in countries like Italy, Spain or USA (Lin et al., 2011a, Sabrià et al., 2005, Squier et al., 2005, Boccia et al., 2006). Most European countries mandate routine culturing of the hospital drinking water for *Legionella* spp. For cooling towers and evaporative condensers in healthcare facilities a risk assessment should take into account the proximity of cooling exhausts to the air inlets for wards housing high-risk patients (e.g. such as those who have just had a renal transplantation) (Pleischl S. et al., 2002). As part of their study Völker et al. discuss that it may be difficult for hygiene specialists, technical staff and public health practitioners to decide about the specificity of health protective measures to be taken for *Legionella* control. They point out that microbiological counts below the TTL do not conclusively indicate there is no health risk and therefore no need for intervention (Völker et al., 2016). Their longitudinal approach in the study showed that taking a sample at a specific time (cross-sectional sampling results) only provides a snapshot of the current microbial situation. Furthermore, infections risk emerging from only parts of the DWPS are assessed and thus not representing the whole picture or reflecting the whole situation. A longitudinal sampling approach and a better risk assessment for any operating outlets within a building could increase the degree to which the sample results represent the real DWPS situation. For that hazards must be identified though a hazard analysis.

3.4.1.2 Hazards

According to McCoy (2006) “a hazard analysis and control plan (either WSP or HACCP) should be part of the water management plan for every facility because expenses are high, and a duty exists to provide hazardfree water. Acquiring water and then disposing of it is a significant part of every facility budget. Unfortunately, most facility managers budget little or nothing for water safety plans.”

3.4.1.3 Water safety risk assessment

Legionellosis management and control risk assessments are a statutory requirement under current guidelines and legislation; they should be carried out as part of a total “Management Systems Controls” package for the trust and should not be carried out just to comply.

An adequate sufficient *Legionella* risk assessment compliant with BS8580:2019, ACoP (L8) and HTM04-01 shall be carried out by the trust's externally appointed specialist independent advisor on all buildings currently owned or occupied by the trust, in order to identify and assess the risk of Legionellosis and water quality issues from work activities and water sources on the premises and organise any necessary precautionary measures. The assessments shall be reviewed and/or updated when there are significant changes to statutory standards, operational requirements and when there are significant changes to a building’s domestic water and wet air systems.

Where the assessment demonstrates that there is no reasonably foreseeable risk or that risks are insufficient and unlikely to increase, no further assessment or measures are necessary. However, should the situation change, the assessment should be reviewed and any necessary changes be implemented. The assessment will be reviewed whenever there is reason to believe that the original assessment may no longer be valid or in accordance with the schedule detailed above. This may be because of:

- changes to the plant or water or its use;
- changes to the use of the building in which it is installed;
- the availability of new information about risks or control measures;
- changes to key personnel;
- the results of checks indicating that the control measures are no longer effective.

The risk assessments will be issued to the WSG and an action plan derived by the group. Risk assessments shall be reviewed on a regular basis by the WSG to determine if there is a need to carry out a re-assessment. This would be based on an assessment of change or known issues.

McCoy and Rosenblatt (2015 p.519) provide a systematic comparison of HACCP-based programs for building water system management. They compare the presence or absence of the following components of four different programs (NFS Int’l 444, WHO WSP, VHA Directive 1061 and ASHRAE 188):

- Interdisciplinary team with authority and responsibility
- Water system description (process flow diagrams)
- Hazard analysis and risk characterisation based on water system description
- Critical control points are selected based on hazard analysis and risk characterisation

- Critical limits are specified and monitored; Corrective actions are required
- Confirmation that the plan is being implemented according to design (verification) is required
- Confirmation that controls, when applied according to plan, are effectively controlling hazards (validation) is required

Mitigating risks, in general, could also be achieved by applying a generalistic and holistic concept for hospital hygiene, considering aspects of infection prevention and control (Exner et al., 2001). According to the authors this might for example be institutionalised by:

- ensuring structural and process quality
- quality assurance and audits/inspections
- identification and surveillance
- incident and outbreak control management

3.4.2 Process management - meaning and importance of processes

According to Arndt (2006 p.77) a process is "an assorted order of activities, which transform a defined input into a defined output." For Rummler et al., (2010) p. 215 as cited Krampf (2016 p. 3) "Processes are the mechanism that link and combine the functional capabilities across the organization to create value for the business and customers." These two definitions underline that there is a certain kind of order, structure and activity inherent in a process. It can be referred to business activities and business requirements. EN ISO 9001:2008 delivers a more detailed definition of processes. It explains: "processes consist of inputs, the workflow and outputs. In guidance on the concept and use of the process approach for management systems the outputs, as a result of the processes, are considered as satisfied requirements" (BS, 2011a p.11). Therefore, it is essential that processes are defined precisely in order to emphasize clarity in repeatable, controllable and improvable performing. Any process is built by a number of sub-processes.(BS, 2011a p.9). For that, the identification, analysis and description of business processes and business process maturity is essential (Looy et al., 2014).

An illustration of an abstracted process model consisting of different hierarchial levels in a service process in hospitals is shown in Figure 3-1. This structure could be used as a guiding template for mapping processes.

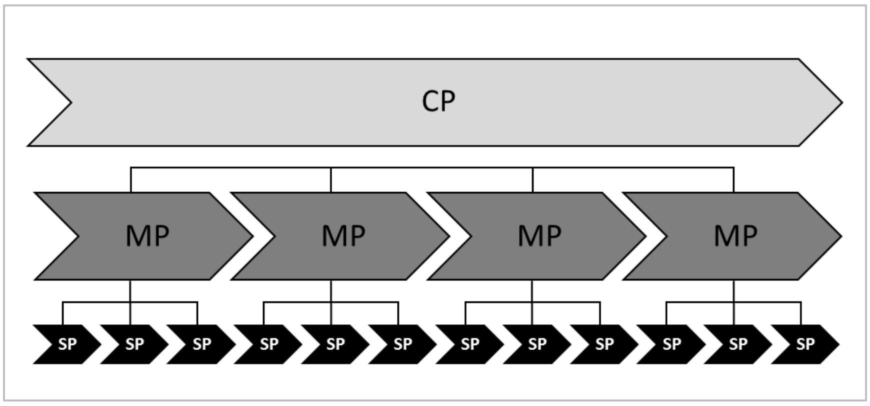


Figure 3-1: Hierarchic process structure for hospital processes containing core processes (CP), main processes (MP) and sub processes (SP), adapted from (Hessel, 2004), translated and modified.

As mentioned in chapter 3.1 the definition of FM is strongly related to the concept of processes. Effective FM processes are according to BS (2011a p.16) processes which can be adopted easily, are adjustable and which the core business with its core processes can rely on. In addition, effective FM processes are well connected with any other processes. Their different outputs, then, are in some cases inputs for subsequent processes (BS, 2011a p.16) (Interdisziplinärere Normenbereich, 2011 p. 16). Furthermore BS (2011a pp.9-10) states that "FM processes influence the effectiveness of the primary processes." Process maps are in most cases the visualisation of processes and how they are structured" (BS, 2011a p.14, Interdisziplinärere Normenbereich, 2011 p. 14). In addition, process mapping is an important application to evaluate and design processes (Johnston et al., 2012 p. 206). Related to the FM context there are process levels such as 'operational', 'tactical' and 'strategic' recognised as horizontal levels or even interpreted in a vertical hierarchy, when connecting over different levels (BS, 2011a p.14).

An essential element of high interest is, that processes should be balanced between high standardisation and high flexibility (Kukla, 2015). For Wagner & Käfer (2008 p. 38) as cited in Kukla (2015 p. 21), process management contains planning, organisation, management, financing, controlling, steering and contiuous improvement. According to Tenner and DeToro (1997 p. 7) there are three approaches for achieving process improvements:

- Continuous improvement on an ongoing basis for incremental gains,
- Benchmarking periodically for larger gains, or
- Re-engineering selectively to achieve dramatic breakthroughs.

The business process re-engineering approach is a change management process with fundamental rethinking and radical changes within an organisation to gain benefits like quality and productivity improvements (Tennant and Wu, 2005, Hammer and Champy (1993) as cited in Hurst et al., 2008 p. 290). The idea behind it is to identify the processes which add value and those process steps which do not add value at all (Hurst et al., 2008). Based on these insights the process then can be (re-)designed (Hurst et al., 2008), and tailored to the organisation's needs. These approaches are for the improvement of processes. According to Arndt (2006 p. 78) “the process optimisation tries to improve current processes by critical questioning and new designing”.

Taking everything into consideration, people responsible at management level decide on the necessity, complexity and influence of processes. It is clear that these elementary decisions need to be thought about in detail and linked with the overall strategy of the organisation. For good reason helpful specific management approaches are needed to identify processes and set the right focus. The creating of a framework as an output of this research tries to change meanagement process in order to initiate the (re-)engineering of a commonly recognised process of water safety management, *Legionella* prevention and risk management in hospitals with a specific focus seen from Estates and Facilities Management in England.

3.4.3 Quality management

Since the early 1980s many epidemiological studies demonstrate that nosocomial outbreaks of Legionnaires' disease have almost always been linked to potable water (Sabria and Yu, 2002). Therefore a structured water quality management and sufficiently operating control and intervention systems have to be established for the prevention of this disease. Essential pillars for achieving quality in FM in healthcare contexts, with focus on services in infection control, are knowledge management (KM) and performance management (PM) Figure 3-2.

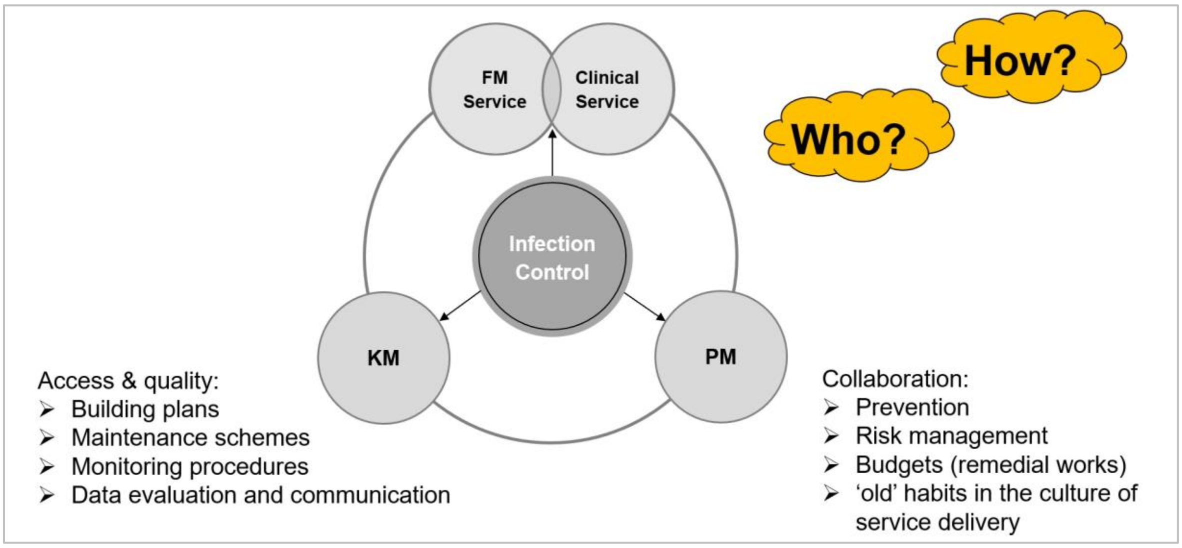


Figure 3-2: HAI and the role of FM in achieving quality, adapted from (Liyanage and Egbu, 2005 p.201) "Three dimensions of infection control", modified.

3.4.4 Environmental management and maintenance issues

Motionless water is defined as stagnation. In a water system missing a circulation pump, the water remains in pipes for as long as fittings, valves or any other type of outlets are used, which disperses stagnant water. Water stagnation may be just one cause for proliferation of *Legionella* spp in PWH (potable water hot) systems. It allows bacteria time to grow. Furthermore there persists difficulty of maintaining high temperatures and disinfectant concentrations (Bartram et al., 2007). Permanent stagnation zones, caused, for example, by hydraulic or physical dead legs, are ecological niches for bacterial growth. When the formation of biofilm was supported by favoured growth conditions prior, the impact of biological stress to the biofilm system may cause a major detachment of bacteria into the water. Biological stress is given, for example, in the case of reduced oxygen and nutrient supply (Flemming et al., 2014). To control the proliferation of *Legionella,* numerous regulations call for the removal of any stagnation areas and other structural factors causing stagnation within DWPS (Bédard et al., 2015).

Several conditions contribute to a potential risk. Studies have shown a statistical correlation between the operating temperature in DWPS, *Legionella* incidence, and growth. *Legionella* finds optimal conditions at a temperature range between 35°C and 46°C (Buse et al., 2012). When the temperature consistently exceeds 60°C growth and detection of Legionella is inhibited (Flannery et al., 2006, Völker et al., 2010).

In contrast, PWH temperatures under 50°C (Borella et al., 2004) or 55°C (Mathys et al., 2008, Völker and Kistemann, 2015) significantly encourage growth of *Legionella*. Recent studies and guidelines stress the importance of appropriate hydraulic balance to ensure homogenous temperature regimes throughout water systems (Bédard et al., 2015).

A selection of existing decontamination methods are listed hereafter.They were, inter alia, compiled through studying different publications (Spagnolo et al., 2013, Gollnisch et al., 2003, BAG/BLV, 2018, Marchesi et al., 2011, Lin et al., 2011a, Ngwenya et al., 2013). Their application is subject to the countrys' national legislation:

- Shock heat treatment with flushing
- Chlorine dioxide (Marchesi et al., 2011)
- Monochloramine
- Point-of-care or point of use (POU) (Lin et al., 2011b)
- Copper-silver ionization
- Hyperchlorination
- Ultraviolet light

3.4.5 Maintenance and business focused maintenance

According to ECDC (2018) the United Kingdom has had an unusually large proportion of cases of Legionnaires' disease. This is partly due to the vigilance of the public health laboratories working effectively with medical authorities, and partly due to poor building maintenance (Brundrett, 2003). It is well-known that water systems are not always up-to-date with current demands or technical standards. Although microbiological risk assessment remains a (not only costly) challenge, there are given many reasons for monitoring for pathogens like *Legionella*. Particularly, whenever there are environments where water is used/consumed and, as a consequence, getting into contact with people. Concequently the technical services department or those responsible for maintenance or business focused maintenance should keep an eye on that (Harris, 2016).

Mains water supply to a building is realised through pipes of larger diameters. After entering a DWPS, smaller pipe diameters are used for further distribution to the water consumers. They potentially favour the development of biofilms to a greater extent, due to flow variability and variations in use patterns. These effects increase the potential microbial bioburden (Exner et al., 2005).

Bédard et al. (2015) distinguishes between three different types of vertical and horizintal hot water distribution systems, which are a) recirculation before the last tap, b) recirculation connected after each device, and c) recirculation connected after the last device. In the case of poorly designed DWPS, stagnation of water can be caused, which provides a suitable environment for the proliferation of legionellae. Furthermore, the growth of *Legionella* spp is supported by accumulation of sludge, scale, rust, algae or slime deposits in the water distribution systems (Exner et al., 2005). Therefore systems that are kept clean and the water flowing are less likely to support excessive growth of *Legionella* spp.

The point of water withdrawal (POWW) in any facility is realised in a different way. Several studies (Sydnor et al., 2012, Halabi et al., 2001, Leprat et al., 2003) found for example, that (electronic) non-touch fittings were contaminated more frequently with bacteria (including *Legionella* spp.) than were conventional fittings. This might be a result of the low amount of water that flows out. Another reason is recognised in the low water pressure and the steadily persisting column of water with a temperature of about 35°C (hot water). Völker et al. (Völker et al., 2016) warn that that if only considering temperature as an influencing factor for assessing contamination risk of a DUWL, there may be other important factors neglected, which are part of the water system. But those can have a decisive influence when thinking about possible stagnation problems (e.g. caused by dead ends) at an outlet. Even in the case of high water temperatures over 55°C, as mandated by guidelines (Bartram et al., 2007, EWGLI, 2017, DVGW, 2015, VDI/DVGW, 2013), outlets with additional risk factors will still have a higher degree of contamination risk.

There are interactions of the piping system materials, the water as carrier, and the components in the water, as well as interaction between bacteria (e.g. *Legionella*), mycobacteria, amoeba and biofilm in the piping network, causing food and host situations. This might cause biofilm aggregation in water piping systems (Wang et al., 2012). Whenever possible, the temperature should be kept outside the range where *Legionella* favourably grows. Some authors point out the difficulty in maintaining constant water temperature levels throughout the water system of facilities (Cristino et al., 2012). This might be due to long distribution ways through pipes, and demand-orientated modifications of sub-systems. Another factor, which should be taken care of, is recognised in the selection of appropriate plumbing materials that support neither microbial growth nor the development of biofilms (Lin et al., 2011b).

Additional to the facts mentioned before, is the presence of certain materials in the fittings, such as rubber or PVC. These facilitate the adhesion of micro-organisms and contributes to the formation of biofilms (Wingender and Flemming, 2011, Flemming et al., 2014).

A study by Demirjian et al. (2015) reports about the importance of clinical surveillance and on risk factor and technical assessment. For that they focused on a group of 19 buildings that had at least medium levels of contamination at the primary sampling. The authors categorise their study as being a prevalence survey and risk factor analysis focusing on the water systems rather than the users. They found:

- that nearly all buildings had considerable technical difficulties
- increasing the temperature of the central calorifier had little, or next to no, effect in the peripheral system, but sometimes increased the temperature difference between the central supply and the most-removed outlet to >30°C
- Pressure valves were commonly lacking or not functioning properly
- there was no sufficient hydraulic control
- in older buildings there were often numerous changes and additions to the system but no plans showing the actual extent of the hot water system
- Maintenance was usually restricted to the calorifier

- the condition of either the pipes or the insulation throughout the system was largely unknown as long as no pipe burst or flooding occurred.

The authors suggest that for buildings in which *Legionella* contamination at medium level or above is detected, seizing the opportunity to perform a technical assessment of the water system with identification and removal of critical points, as well as the implementation of risk control measures and maintenance, may be worthwhile. However, they argue that it was not possible to compare the exposure in the buildings surveyed to the actual occurrence of clinical cases of legionellosis.

It seems to be important, however, to include outlets which are furthest away from the calorifier within a building's DWPS. Outlets of that kind usually represent hydraulically disadvantaged locations. Nevertheless, the surveillance and identification of true risk areas (conceptional, systematic approach) and determining factors is rather more important than relying on just sampling the furthest outlet (Bartram et al., 2007, EWGLI, 2017, DVGW, 2015, VDI/DVGW, 2013).

Finally, when measuring and monitoring *Legionella* contamination in potable water systems, there is always an amount of uncertainty due to a wide variation in bacterial concentration over time (Rodríguez-Martínez et al., 2015, Napoli C. et al., 2009, Völker et al., 2016). Although care may be taken to standardise sampling, there may have been influences from external sources (e.g., user behaviour or construction works) existing environmental influences, knowledge and cooperation of people or institutions being involved, having a decisive effect on the result of the analysis and the outcomes of risk assessment. Generally speaking, a number of uncertainties remain in exposure assessment, risk assessment, and the development of adequate prevention and control strategies for *Legionella* in any building / organisation (Whiley et al., 2014).

3.5 Summary background two

In order to provide clarification of how the two terms 'Estates' and 'Facilities Management' shall be understood in this research context, the author suggests the following simplification, which is in line with the definitions of FM presented early in chapter 3:

- Estates: the building structure and the environment that is defined by the building
- Facilities Management: managing the equipment and services, that are necessary for the proper operation of a building.

Taken from literature, the following highlighted aspects present gaps in the current water safety management principles, for which Estates and Facilities Management is responsible for:

- In healthcare not only the health of patients and staff might be affected (working people such as doctors, care personnel, cleaning personnel, and service personnel), but also the performance of and confidence in the organisation (Diederen, 2008, Freije, 2005).
- Quality, performance and knowledge management (Liyanage and Egbu, 2005, Liyanage and Egbu, 2006, Liyanage and Egbu, 2008) are key drivers for quality service delivery in FM businesses.
- Water safety plans (WSPs), which describe a 'scheme for preventing and controlling the risks' are a component of the WHO's framework for safe water. It includes three elements, namely 'system assessment', 'monitoring', and 'management and communication' and stimulates the motivation of people responsible to think about safe limits for achieving health-based targets (Lee, 2017 p.23).
- Once *Legionella* has colonized a water system, eradication is usually unachievable (Marchesi et al., 2011, García et al., 2008, Zhang et al., 2007).
- The actual risk for transmission of legionellosis: The questions arising from the gap that occurs, when estimating the level of exposure from the level of contamination of the system, are challenging, especially in the context of hospitals (Hines et al., 2014).
- For a given pathogen it must be considered on the basis of severity of the associated illness, sources of contamination, data on preventative measures, available detection methods, remedial technology, and legal issues (Freije, 2005).
- Risk assessment combined with environmental monitoring has been effective in predicting risk. This can be read in studies in countries like Italy, Spain or USA (Lin et al., 2011a, Sabrià et al., 2005, Squier et al., 2005, Boccia et al., 2006). Most European countries mandate routine culturing of the hospital drinking water for *Legionella* spp. (Pleischl S. et al., 2002).
- In the UK (England) an adequate sufficient *Legionella* risk assessment compliant with BS8580:2019, ACoP (L8) and HTM04-01 shall be carried out by the trust's externally appointed specialist independent advisor on all buildings currently owned or occupied by the trust.
- By taking a focus on the healthcare sector, effective and efficient processes are of high importance, especially with respect to the primary mission of hospitals. Therefore process management is an important approach to allocate competences and responsibilities in order to ensure high quality in processes (Kukla, 2015).

- Hot potable water is the most common source of nosocomial and community-acquired legionellosis worldwide. The water is dispersed by shower-heads, fittings, etc., and there are numerous reports of colonization of warm water systems in different types of buildings (e.g. hospitals, nursing homes). The complex structure of warm water systems is believed to provide favourable conditions for the growth of bacteria (Mathys et al., 2008).
- Various direct or indirect risk factors, coming from the built environment, can be found in research. The distance of an outlet can be an indirect risk factor. Risk factors can result from the furthest outlets within a DWPS. Some of them are stagnation, temperature loss, and increased biofilm formation (Borella et al., 2004). Flannery et al. (Flannery et al., 2006) identified the height of a building of over 10 floors as a risk factor.
- Borella et al. (Borella et al., 2004) and Mathys et al. (Mathys et al., 2008) identified the age of a plumbing system as a crucial risk factor. Current regulations rely on culture-based methods to assess the presence of *Legionella* in DWPS. Control focuses on detecting and eliminating favourable conditions for *Legionella* growth, by which risk factors may decrease.
- A decisive factor in the control of *Legionella* growth is appropriate maintenance of water distribution systems. Temperature, for example, is an important parameter that helps in controlling *Legionella* colonisation.
- Another factor, which should be taken care of, is recognised in the selection of appropriate plumbing materials that support neither microbial growth nor the development of biofilms (Lin et al., 2011b).
- Although care may be taken to standardise sampling, there may have been influences from external sources (e.g., user behaviour or construction works) existing environmental influences, knowledge and cooperation of people or institutions being involved, having a decisive effect on the result of the analysis and the outcomes of risk assessment. Generally speaking, a number of uncertainties remain in exposure assessment, risk assessment, and the development of adequate prevention and control strategies for *Legionella* in any building / organisation (Whiley et al., 2014).
- A focus on checking up on and controlling the condition and correct operation of the hot water system in residential and other buildings is warranted (Demirjian et al., 2015).
- Risk assessments will be issued to the WSG and an action plan derived by the group. Risk assessments shall be reviewed on a regular basis by the WSG to determine if there is a need to carry out a re-assessment; this would be based on an assessment of change or known issues.

In order to be compliant, people responsible must be aware of and take on responsibility. For that specific guidance and the national legislation frame with standards and mandatory duties to be fulfilled are important to know. This will be part of the next chapter.

4 Background three - Legislation, standards, guidance

The previous chapter presented the professional fied of Estates and Facilities management. Stakeholders who work in or collaboratively with that specific field must be oriented and receive guidance in terms of water safety, *Legionella* prevention and risk management of water systems in hospitals. For that, the following sections of this chapter will provide a comprehensive overview, relevant to the research context.

4.1 The role of national laws, standards and regulations

Organisations, such as hospitals, are covered by a series of mandatory documents. They include laws, regulations, or any other authority enforcing organisations to do everything in their power to protect building occupants from potential or known hazards. It comprises different focuses, according to the area of interest and to national bodies of authority. For safety and health issues of occupants, for example, the Health and Safety Executive in the United Kingdom (HSE, 1974), the “Arbeitsschutzgesetz/ArbSchG” in Germany (FMJCP, 2015), and the Staatssekretariat für Wirtschaft SECO in Switzerland (SECO, 2015) set national frameworks for responsibility. As the research of phase Ia focuses on the countries Germany, The United Kingdom and Switzerland, country-specific documents with focus topics on these countries are given a special attention.

As stated in the literature, legionellosis qualifies as a known hazard. Underlying existing standards mean that organisations are consequently much more likely to be found guilty of negligence in a lawsuit, if a simple analysis proves that appropriate preventative measures were not taken (Taylor, 2014). In the context of hospitals, the incidence of clinical cases of legionellosis is estimated at between 1/10,000 and 1/100,000 of the population (Parr et al., 2015). This is interesting in the light of the fact that the potential exposure to aerosols is substantial. Due to under-diagnosis and under-reporting the true incidence is largely unknown. Data from Norway report that *Legionella* spp. could be detected from 6% of patients hospitalised for community-acquired pneumonia (Røysted et al., 2015). Probably a larger challenge for physicians and people responsible is, that the actual infectious dose for *Legionella* spp. still remains uncertain (Whiley et al., 2014). This should be kept in mind. When counts of *Legionella* spp. exceed the threshold level of 1,000 CFU/L, European and Italian guidelines advocate increased clinical and environmental surveillance. Casini et al. recommend disinfection measures, when one or more cases of healthcare-acquired Legionnaires’ disease are observed or when counts exceed 10,000 CFU/L (Casini et al., 2008).

Even the presence of guidelines at a local level can be observed. Allegheny County (Pennsylvania, USA) guidelines (Squier et al., 2005), for example, constitute that the risk of nosocomial transmission is more related to the extent of colonisation (i.e. percentage of positive cases) of sites which are at a distance to water, than to quantitative measurement of *Legionella*. The guidelines recommend that environmental surveillance should be performed annually at least, whereas transplant centres, oncology and neonatology should be tested more frequently. Guidelines furthermore suggest considering disinfection measures for a hospital in the case of exceeding 30% for distal sites being tested positive (BAG/BLV, 2018 p.79). This should be mandatory due to the particular need for protection of the persons concerned, even in the absence of nosocomial legionellosis.

There may be different categories that guide and reflect the ambitions of legislation, liability and guidance. According to BIFM (BIFM, 2015) they comprise:

- Regulatory requirements
- Organisational responsibilities
  - The process (i.e. water safety risk management and prevention)
  - The subject (i.e. *Legionella*)
  - The organisation (i.e. hospital / Trust)
  - The people (i.e. those responsible at management levels)
- Personal responsibilities
  - Control (i.e. measurement of compliance; detection)
  - Transparency (i.e. processes, policies and procedures)
  - Accountability (i.e. responsibility of individuals for their scope of duties)
  - Awareness (i.e. training; education)
  - Prevention (focus on acting resonsibly; risk management, quality management)
  - Management (good management practices adopted, actively lived processes)

4.2 Drinking water governance and management challenges

The Council Directive of the European Union states that water supplied from a distribution network should fulfill quality requirements (including microbiological parameters) "at the point, within premises or an establishment, at which it emerges from the taps that are normally used for human consumption" (EU, 1998). Bereskie et al. (2017 p.252) discovered a list of themes on the basis of a literature review. The list summarises challenges associated with the water governance structure in managing drinking water in Canada. These themes found for Canada may also be thematised in other countries. Thus, this list could generally be contextualised with with other countries.

They presented the following themes, which will be considered for framework creation in the commented way:

- Fragmentation across political boundaries (Hill et al., 2008, Dunn and Bakker, 2009, Simms and de Loë, 2010, Bakker and Cook, 2011).
- Governance gaps, overlapping responsibilities, duplication of efforts (Dunn and Bakker, 2009, Simms and de Loë, 2010, de Loë and Murray, 2012, Bakker and Cook, 2011).
- Discrepancies among the mandates and administration leading to confusion surrounding leadership responsibilities and inconsistent resource allocation (Simms and de Loë, 2010).
- Lack of accountability and coordination between tiers of governance (Bakker and Cook, 2011).
- Inadequate monitoring and enforcement (Dunn and Bakker, 2009, Bakker and Cook, 2011).
- Resistance to change and barriers to learning (Simms and de Loë, 2010).
- Failure to integrate activities at spatial and temporal scales (Dunn and Bakker, 2009, Simms and de Loë, 2010).
- Difficulties in evaluating performance (Simms and de Loë, 2010).

- Tension between harmonization (i.e., the selective standardization of laws, rules and norms) and subsidiarity (i.e., the delegation of decision-making and policy implementation to the lowest-appropriate scale) (Bakker and Cook, 2011).

According to a literature review there is an existing under-representation in the literature about specific focus topics in water safety management practices in Estates and Facilities Management in hospitals (Leiblein et al., 2016). Therefore, a focus on the aforementioned themes is given space in this thesis. It will be considered throughout the overall process of elaboration of the present research.

To bring together a better understanding and awareness of governance and management challences in the context of the current research, a deeper look at current legislation, standards and guidance becomes necessary.

The following sections aim at setting the focus of the research by reviewing and bringing together official documents on drinking water hygiene. They cover likewise topics of water protection and water safety management legislation, policies, associated quality management frameworks, and other requirements. The documents are referenced within their country-specific relevance and are classified into the respective document category. Selectively excerpts are made on focus-topics with relevance to the research context scope. This is done especially for the United Kingdom and England (chapter 4.3.3 and 4.5), as it is the main research focus. Furthermore it will be done for Germany (chapter 4.3.4) and Switzerland (chapter 4.3.5), as they are considered in the exploratory phase Ia.

Reviewing law, regulations and best practice brings together and presents relevant information to which this research wants to contribute. Nevertheless, other countries have been considered during the literature review process, too, which can be characterised as an ongoing literature review and comparison process, as legislation, standards, guidance, recommendations underwent official revisions from their editing bodies, or have become outdated by changes in legislation during research. It took enormorous effort to deal with such changes in legislation, as the research is oriented to be a practice oriented one, with a final framework output relevant for the present situation England.

Different acts face the topics ‘water safety’ and ‘water safety management’, when regulating the quality of (drinking) water coming from from the source, being delivered to the local provider, and being brought to the consumer/end user. Along the way of the water there may occur potential hazards emerging from different sources, such as contamination with bacteria (*Legionella, Pseudomonas*). Service providers, building owners, businesses and industry must cope with all of them.

For Europe, the European Working Goup for *Legionella* Infections has proposed measures for certain concentrations of Legionella pneumophila in water samples (Table 4-1).

Table 4-1: The critical *Legionella* pneumophila concentrations and associated measures, according to (EWGLI, 2011, EWGLI, 2017)

Concentration limit		**Measure**
Between 1,000 and 10,000 CFU/L	<20% of samples	Resampling if necessary If, after resampling, a similar number of samples are infected, it is recommended to take measures to lower the concentration
	>20% of samples	Obigation to take measures to decrease concentration Disinfection should be considered
More than 10,000 CFU/L		Resampling necessary Take immediate action to lower concentration (for example, disinfection)

For identifying similarities or differences of country-specific contexts of the application of the proposed EWGLI critical concentration limits, and for summarising regulations of different countries, for different objects of regulatons, critical levels, the context of regulations and relevant documents, Appendix A

Table Appendix A-1 summarises relevant information. Common is the different use of drinking water for different purposes, such as spa pools, swimming pools, showers, cooling towers, air conditioning systems or process water applications. Risk arises, when aerosols might be released when operating a water system.

As can be read in legislation, regulation or guidance documents of different countries, there exist different contexts of regulation, values for PWC, PWH, PWH-C as well as different action values and recommendations. For selected countries

Table Appendix A-2 compiles international regulations on drinking water requirements in building installation systems to reduce the growth of *Legionella*.

Not only temperature is regarded a parameter for continous monitoring and testing in order to enable effective prevention, but also sampling, sampling methods and limit values for *Legionella* concentration were discussed. They differ from country to country (Table Appendix A-3).

4.3 Comment on international references

Differences in current regulations are in line with findings from Van Kenhove et al. (2019). Although there may be multiple similarities, it can be noted that current *Legionella* regulations and guidelines have some differences. It is interesting, that the target group is often very specific. A large proportion of documents are applicable to a limited group of buildings (healthcare) or specific contexts of application (cooling towers, HVAC). The European Centre for Disease Prevention and Control (ECDC) publish reports and guidelines to continuously inform about recent cases of Legionnaires' Disease and current best practice available (ECDC, 2017a). In healthcare environments the risk of infection is higher due to the potential higher concentration of elderly or immunocompromised people.

It is evident that the definition of what constitutes a dangerous *Legionella* concentration level varies between countries. It may even be up to a factor 100 in difference. Non-European documents (e.g. ASHRAE [American Society of Heating, Refrigeration and Air Conditioning Engineers]) do not include critical levels, nor do they provide a large amount of guidance on testing limits. Most guidelines and regulations talk about *Legionella* in general, but if *L pneumophila* is what is actually meant, this could be specified in future updates and a unification of the guidelines.

The likelihood of illness depends on the concentration of *Legionella* in the water source, the production and dissemination of aerosols, host factors such as age and pre-existing health conditions, and the virulence of the particular strain of *Legionella*. At the same time, it has to be recognized that most exposures do not cause illness (WHO, 2018).

4.3.1 The United States of America (Standard ASHRAE 188)

The former draft of ASHRAE-Standard 188P entitled "Legionellosis: Risk Management for Building Water Systems" puts forward criteria to help facility managers understand building water systems. The target is avoiding amplification and dissemination of *Legionella*. With respect to the design and operation of the building water systems, the standard aims to provide practical guidance to control exposure. It includes design, maintenance and operational procedures throughout the life-cycle of a building (Martin, 2012, Scott, 2014). The topic *Legionella* and water safety might be discussed comprehensively in the ASHRAE Standard on *Legionella* Prevention (Freije Matthew, 2014). Publication of the Standard was planned for midyear 2015, but it had been postponed several times. Nevertheless, national contexts and authorities determining regulatory and technical standards need to be considered.

The ASHRAE guideline 12-2000 (for industry) "Minimizing the risk of legionellosis associated with building water systems," provides specific environmental and operational guidelines for minimising the risk of *Legionella* infection in building water systems (ASHRAE, 2000). In 2015, ASHRAE released a standard for *Legionella* risk management.

This was the first *Legionella* standard in the United States. American National Standards Institute (ANSI)/ASHRAE Standard 188-2015, "Legionellosis: risk management for building water systems," provides minimum legionellosis risk management requirements for the design, construction, commissioning, operation, maintenance, repair, replacement, and expansion of new and existing buildings and their water systems and components (Lindahl et al., 2015). The publication includes a description of environmental conditions that promote *Legionella* growth and the creation of a risk management process to be implemented by building owners or managers. The applicability of the standard depends on a survey of the building's risk factors (based on listed criteria) and provides a basis for identifying systems that pose a risk of legionellosis. If the building has one or more risk factors, then application of the standard is dependent on the nature and number of risk factors identified. In some cases, it also requires the site manager to develop a water management program. There is also a particular section that provides specific guidance for health care facilities. The standard does not provide a large amount of guidance on temperatures, water treatment strategies, or testing limits, and no critical levels of concentration are mentioned.

However, after a series of public drafts reviews released by the Board of Standards (BSR)/ASHRAE since the first draft in 2010, in the Standard 188P "Prevention of legionellosis associated with building water systems," water temperature recommendations for *Legionella*, controls are set as follows: the hot water heater outlet temperature should be at or above 60°C; the hot water temperature at the coldest point in the hot water heater, storage tank, or distribution system should be at or above 51°C; and the cold water temperature in any part of the system should be at or below 25°C. If the hazard analysis and critical control point team determines that these temperatures cannot be achieved, then it may conclude that additional hazard control measures are required. In 2018 ASHRAE has finally worked on revisions from the publicly reviewed draft of the standard (Kelechava, 2018). In the United States, there were only guidelines, and no regulations, until 2015. In 2015, the first official requirement to test for *Legionella* in cooling towers was released. This was followed in 2016 by the requirement to test for *Legionella* in health-care facilities (Stout, 2017).

The American Society for Testing and Materials (ASTM) and Centers for Disease Control and Prevention (CDC) guidelines exist for the prevention of and reaction to outbreaks (CDC, 2019) (CDC, 2005) (CDC, 1997). There is a toolkit available on their website that is very useful for developing a *Legionella* water management program (Cooley, 2017, CDC, 2017a). There is also the Industrial Hygiene Association guideline (IHA), with recommendations for *Legionella* testing. The ASTM "Standard guide for the inspection of water systems for *Legionella* and the investigation of possible outbreaks of legionellosis," dates from 2015 (ASTM, 2015). The guide explains appropriate responses by employers, building owners and operators, facility managers, health and safety professionals, public health authorities, and others to the concern that a water system may be infected with *Legionella* and to the identification of one or more cases of legionellosis (i.e. Legionnaires disease or Pontiac fever) (Russotti, 2015).

4.3.2 The United States of America: Centres for Disease Control

In 2016, *Legionella* made the drinking water contaminants list of the United States Environmental Protection Agency (EPA). In 2017, the Centers for Medicare & Medicaid Services (CMS) released a mandate requiring all certified hospitals to have potable water testing and water management plans that meet American Society of Heating, Refrigerating and Air-Conditioning Engineers (ASHRAE) industry standards to reduce *Legionella* risk (Van Kenhove et al., 2019).

To avoid a citation and receive Medicare or Medicaid reimbursements, hospitals and long-term care facilities must “demonstrate measures” that show compliance with the June 2017 Centers for Medicare & Medicaid Services (CMS) “Requirement to reduce *Legionella* risk in healthcare facility water systems to prevent cases and outbreaks of Legionnaires’ disease (LD)”. A guidance is the CMS memorandum titled ‘S&C 17-30-*Hospitals/CAHs/NHs*’. But it does not give prescriptive, detailed procedures to follow. It simply requires a water management program (WMP) that minimises the risk of Legionnaires’ disease, giving the facility flexibility in the policies and procedures toward that outcome provided the program “considers the ASHRAE industry standard and the CDC toolkit, and includes…environmental testing for pathogens” (Freije, 2018).

“Even the ASHRAE standard (ANSI/ASHRAE Standard 188) and CDC toolkit to which the CMS memorandum refers outlines only a framework for a WMP, still requiring the facilities to determine the specific policies, procedures, and control measures with which to fill the framework. Decisions about those details are crucial. Ideally, hospitals and nursing homes will implement an effective WMP, one that truly reduces *Legionella* risk, without wasting money on unnecessary procedures. Inspections of hospitals and nursing homes will be a key to success (real prevention at a reasonable cost) of the CMS requirement. Assuming the inspections are short, surveyors will have limited time to determine whether the facility has established and implemented an effective WMP, so they should ask clear and objective questions that reveal whether crucial criteria have been met. The checklist should be consistent from state to state, facility to facility” (Freije, 2018).

Matt Freije’s proposed 11-point checklist, based on wording in the CMS memorandum (CDC, 2017b), might provide a starting point (Freije, 2018). The list suggests the following questions to be answered, but it is commented that the list may be expanded and refined as surveyors get more experience:

1. Has the facility conducted a risk assessment to identify where *Legionella* and other opportunistic waterborne pathogens (e.g. Pseudomonas, Acinetobacter, Burkholderia, Stenotrophomonas, nontuberculous mycobacteria, and fungi) could grow and spread in the facility?

Based on ASHRAE 188 and the CDC tool kit, a facility’s risk is based primarily on the types of water systems it has. Does the WMP document list a brief description of each one of the following types of water systems on the property (Table 4-2)?

Table 4-2: Property checklist ‘number and description of water systems’

Type of water system	**No. of systems on the property**	**Each described?**
Domestic cold water		

Domestic hot water		
Cooling tower or evaporative condenser system		
Decorative fountains		
Whirlpool spas		

2. Has the facility established a water management program (WMP) for the water systems listed in #1?

3. Does the WMP list specific preventative measures (control measures) for the operation and maintenance of the types of water systems listed in #1 (e.g., physical controls, temperature management, disinfectant level control, visual inspections)? How many control measures are listed for each system type (Table 4-3)?

Table 4-3: Property checklist ‘number of control measures’

Type of water system	**No. of control measures**
Domestic cold water	
Domestic hot water	
Cooling tower systems	
Decorative fountains	
Whirlpool spas	

4. Does the WMP include *Legionella* control measures for the design, specification, construction, and commissioning phases of new building and major renovation projects?

5. Does the WMP outline specific steps for responding to incidents such as water main breaks, and for planning temporary system shutdowns?

6. Per ANSI/ASHRAE Standard 188-2015 and the CDC toolkit, does the WMP list performance criteria (control limits) for each control measure, a monitoring procedure for determining control measure performance, and corrective actions to take if the control measure is not performed within the control limit?

7. Does the WMP outline specific steps for responding to a suspected or confirmed case of Legionnaires’ disease?

8. Does the WMP outline specific and meaningful validation procedures? The facility should be able to provide brief and clear answers to the following questions:

a) What are the specific method(s) of validating its WMP for effectiveness in controlling *Legionella*?

b) Why are the validation methods reliable in indicating whether the WMP is effective in controlling *Legionella*?

c) How can the validation method(s) help the facility improve its water management practices for reducing waterborne pathogen risk?

9. Is the facility validating its WMP by environmental testing for *Legionella* or other pathogens? If so:

a) For what pathogen(s) is it testing samples from the water systems?

b) Which water systems are being sampled?

c) On what criteria is the facility interpreting test results?

d) Does the facility have a specific plan for responding to test results?

e) Does the facility have tools (e.g., spreadsheet or database) for monitoring test result trends?

10. Does the WMP include a written plan for communication and notification (e.g., of test results)? Are all necessary departments (e.g., facilities engineering; infection control) included?

11. Did the facility show documentation to verify that the WMP control measures, validation procedures, and corrective actions have been implemented for the past 12 months?

4.3.3 Orientation for people responsible in England (UK)

Table Appendix A-4 to Table Appendix A-8 list UK specific legislation, regulations, standards, industry guidance and BSRIA guidance on water safety management. Not complying with the ACoP L8 can bring prosecution under health and safety legislation. Duty holders must carry out or initiate risk assessments. There is the requirement to ensure understanding of all rules concerning buildings or activities where water is used or stored and where there is a means of creating or transmitting water droplets or spray (aerosols) which may be inhaled by occupants. Noting of cross references to HSG274 parts 1, 2 and 3. HTM 04-01 Parts A, B, C and annex D08 should be read in conjunction with the HSE's Approved Code of Practice (L8) and HSG274 Part 2. It is equally applicable to both new and existing sites.

There could also be influences by potential effects of Climate Change Act 2008 which is in place for reducing energy consumption. Section 1.18 of HBN 00-01 explains that healthcare organisations need to be mindful of the Climate Change Act and the resultant measures that need to be taken, particularly with regard to flooding, drought, hot weather and freezing temperatures (for further guidance, see Health Building Note (HBN) 0007 – 'Planning for a resilient healthcare estate'). Section 1.19 of HBN 00-01 states that one of two main areas of focus for action with respect to climate change is mitigation, which reduces the impact of business functions on the climate through the lowering of carbon emissions from energy use, the reduction of water consumption, improved efficiency of transport etc. Under the Climate Change Act, the government has set up the CRC Energy Efficiency Scheme, which requires large public and private sector organisations to achieve energy-saving targets. Such programmes may have a direct effect on energy consumption, and thus, for example temperature levels of hot water systems.

During a specific conference on *Legionella*, held in Glasgow on March 28th 2019, it was pointed out by a representative of Health Facilities Scotland (HFS), that in healthcare projects, client briefing is very often unclear. The following section highlights some content, which was published in the event report (Maynard, 2019a, Maynard, 2019b). It was described that there is almost no learning from previous projects, no specification of materials or quality considered, and no specification of deliverables at handover nor checks at project milestones. Estates, FM and Infection Prevention and Control (IPC) are not involved early enough in projects and there are often insufficient technical skills in design teams. This could mean, for example, the selection of taps and basins on aesthetics, and not on engineering and infection control benefits. There are also examples of avoidance of guidance to save money, value engineering, derogations. The HFS representative noted that a) poor supervision of installation, b) contractors not trained in healthcare specifics, c) designers not attending site during installation, d) commissioning poor, e) the use of chemicals to "disinfect" systems, causing invalidation of the warranty of taps and other components - he argues that water systems should ideally be kept uncontaminated, f) failures not challenged, and g) Insufficient adequate safe access for all services/ maintenance. The speaker critically summarised that project success is measured only as a function of time and money, not quality. Furthermore there is also a lack of training for all stakeholders. For the post-occupancy phase he found that a) the contractor does not take on responsibility for managing systems, b) maintenance is not to best practice, c) water management is poor or non–existent, d) there's no seasonal commissioning, e) FM teams are not sufficiently competent, f) infection control issues need handover checklists, and g) a lack of training. He concluded that there should be a review of construction management guidance to establish how it can provide assurance that similar issues will not occur in future projects. Her further recommends consideration to be given to the production of updated “standard” Employer’s Requirements (also known as Authority Contract Requirements (ACR) or Board Contract Requirements (BCR) as a National resource for all Boards. Finally he proposed the consideration for updated water and other guidance to include: a) thermal disinfection in sections of water distribution systems, b) handover checklists, c) contract management procedures, d) design guides to eliminate thermal pickup in cold water systems, e) update advantages and disadvantages of chemical disinfection techniques, f) the organisms that should be tested for and action to take on a defined level, g) drain cleaning regimens, and h) biofilm growth in drainage systems.

4.3.4 Orientation for people responsible in Germany

Guidance to landlords or management responsible in estates or FM, who are in charge of premises can be found in a wide range of national publications. But one of the weaknesses is risk assessment (Bartz, 2017 p.43). The common sense basis is that a possible health threat is given when the presence of *Legionella* in higher proportions in any water sample is proven positive (Hoebe and Kool, 2000). *Legionella* outbreaks have resulted in the classification of the disease as a public health priority in Germany.

Hereby a technical threshold level (TTL) for *Legionella* spp. is specified in the German drinking water ordinance (BMG/FMH, 2016). The limit defines drinking water may not exceed 100 colony forming units CFU/100 mL. Samples exceeding this level are classified as ‘contaminated’ (DVGW, 2004). The TTL is regarded as a minimum level, above which technical interventions are required.

In Germany legislation on *Legionella* and drinking water was introduced in 2011. Suddenly the monitoring for *Legionella* spp. became mandatory in all public, commercially operating and private buildings operating hot water systems of a certain size and of certain criteria (Bartz, 2016). The German drinking water ordinance aims to give orientation in assessing the exposure risk to *Legionella* spp. throughout the population caused by water systems of facilities and building stocks. If seen necessary appropriate protective measures should be applied (BMG/FMH, 2016). The strict policy is the consequence of the lack of a reliable dose-response model which can reliably identify an unacceptable risk of infection. A proposed cut-off level of 30% positive samples to estimate the risk of *Legionella* in drinking water plumbing systems (DWPS) (Lin et al., 2011a) has been questioned because it is not sufficiently precise or sensitive (Pierre et al., 2014).

In Germany, there is the Technical Rule W551 (2004) and the worksheet W556 (A) (2015) for drinking water installations, which recommend some best practice for drinking water installations to keep a high water quality in the drinking water system. Generally they can be summarised by (Suchenwirth, 2017, Pleischl, 2017):

- Keeping the stored water volume small
- Keeping hot water temperature above 60°C when leaving the tank and at or above 55°C in circulation distribution pipes. This is in accordance with DIN 1988-200, section 10.2.3
- Keeping non-circulating (like end-use) pipes short
- Avoiding stagnation
- Regular maintenance and inspection of the system
- Rehabilitation, such as the use of insulation and the use of electronic self-flushing taps
- Perform hygienic-microbiological examinations

A journal article (Leiblein et al., 2018) describes situations of *Legionella* prevention in drinking water systems in buildings, argued from practice and reflected in the legal situation in Germany. Along with presenting a summary of current statutes, standards and guidance (Table Appendix A-9), the authors present well documented court decisions and highlight proper execution of sampling, independency, risk assessment and hazard analysis in the context of water safety management. Non-conformity in service delivery may not also endanger persons, but may result in compensation payment for pain and suffering. The idea behind the article is to sensitise those people responsible for the topic. A goal of this article is described to raise consciousness about consequences in circumstances not complying with given regulations (law), and rules or standards, which are often referenced as “generally accepted rules of technology” and to which the law references.

4.3.5 Orientation for people responsible in Switzerland

Guidance to landlords or people responsible in FM, who are in charge of premises in Switzerland, can be found in national publications such as Swiss Norms (e.g. SIA 285-1, SIA 385-2) or in the regulations of the SVGW, the Swiss Society for the field of Gas and Water. Within the publications from the SVGW, normative technical rules such as the ‘W3’ guidance sheet can be found specifically for the topic area covering water management.

The FOPH has published guidelines for testing of *Legionella* for several types of facilities. There it can be read that facility water systems in private and public facilities in Switzerland are subjected to different thresholds regarding the risk assessment of a potential contamination (FOPH, 2009). Obtained from the recommendations, limits for concentration of *L pneumophila* in the water system are used for orientation, but are missing legal enforcement. In module 13, “Special case hospitals and care homes”, limits for *Legionella* in the water systems of hospitals are presented. A report (FOPH, 2008) concluded that the incidence of legionellosis in Switzerland is relatively high compared with other countries in Europe. FOPH’s ongoing statistics on the number of cases registered, document an increasing number of deaths caused by legionellosis. The numbers represent all cases notified to the FOPH. Statistics are listed consecutively due to the fact that in Switzerland legionellosis is a notifiable disease since 1988. In a module-based document the Swiss authority reports on different perspectives on *Legionella* and prevention strategies. Special cases are seen in hospitals and care units (FOPH, 2009). The Swiss regulations on drinking water – including Foodstuffs and Consumer Goods Regulations, Hygiene Regulations and Regulations on Drinking Water, Spring Water and Natural Mineral Water – made no mention about *Legionella* for many years. However, pathogens are tolerated up to a limit to 300 microbes per millititre. Legislation modified in 2016 and recommendations of the FOPH, which have been revised in 2018, emphasize a stronger focus on self-control of healthcare facilities to be ensured by their own risk management programmes. Now they even include threshold levels for *Legionella* contamination in a drinking water system.

With regard to operator responsibility and duties the legal situation for Switzerland can currently be summarised as follows (Table Appendix A-10):

- According to Art51 of the Federal Act on Foodstuffs and Consumer Goods of 20 June 2014 (FC, 2014), the cantonal chemist implements the Foodstuffs Act in the field of foodstuffs and utility articles. Shower water is defined as a "commodity" and must meet the legal requirements of the Ordinance of the Federal Department of Home Affairs on drinking water in publicly accessible baths and shower facilities of 16 December 2016 (FC, 2016b).
- On the basis of Articles 15 and 33 of the LMG and Article 72 of the Ordinance of 16 December 2016 on Foodstuffs and Utility Articles (TBDV) (FC, 2016a) in conjunction with Articles 9 and 13 of the TBDV, water samples and thus sampling points of a water system can be objected to in the event of a corresponding laboratory finding.
- Within the framework of the legal obligation to self-inspection pursuant to Article 26 of the LMG and Article 73 et seq. of the Ordinance on Foodstuffs and Consumer Goods, all processes relating to shower and bath water in an establishment (hospital/nursing home) must be checked for defects. If necessary, appropriate measures must be taken to sustainably improve the microbiological situation of the water in the shower facilities. Information on the procedure can be found in the document *Legionella* and Legionellosis, BAG/BLV Recommendations, August 2018, Modules 11 and 12 (BAG/BLV, 2018).

4.4 The World Health Organisation and the Water Safety Plan

For the purpose of providing safe water, experts and the World Health Organisation (WHO) have developed the Water Safety Plan (WSP). It constitutes a scheme for preventing and controlling potential risks through system assessment, monitoring, surveillance and management/communication (Bartram et al., 2007). That systematic approach is required to secure microbial safety of water by which health outcomes can be improved. It is this important milestone that set going the improvements that can be recognised today in different characteristics, which all strive for protecting the health of people and providing a conscious handling of one of the most precious elements for human life: water.

The objectives of a water safety plan are to ensure safe drinking water through hazard analysis, HACCP based risk assessment, management and monitoring plans backed up by supplementary programmes; including training, surveillance and communication.

4.4.1 The Water Safety Plan of the World Health Organisation

National legislation differs from country to country, but water-associated risks are common to all. One of these risks can be interpreted in the presence of the bacteria *Legionella* in water. Thus, the water distribution systems might be seen a potential source of risk, which is aimed to be controlled, monitored and managed properly over time.

To reduce the risk of damage to health, the World Health Organisation's guidelines for drinking water quality recommend that health care facilities adopt a water safety plan (WHO, 2011) to practise as a substantial part of their risk management. The water safety plan (WSP) represents a "scheme for preventing or controlling the risks" that considers a) system assessment, b) monitoring and c) management and communication (Stanwell-Smith, 2014). The use and provision of microbiologically clean (hygienic) water also complies with the generally accepted principles of preventing infection in industrialised countries. Not only assessing potential hazards is crucial for *Legionella* prevention (KRINKO, 2006), but also raising awareness for potential sources of contamination, the source of contamination itself, the water lines/water systems of any facility as well as the knowledge about the latter should bring motivation to people being in duty.

"Ideally, prevention or minimising the risk of waterborne infection should occur at the design and commissioning stages" (Stanwell-Smith, 2014). But this situation is not always available and the existing facilities in the buildings must be considered appropriately. For that, the WHO has advocated the application of WSPs to water systems in buildings and specialised equipment as well as to the potable water supply. The drivers to implement these applications need to come from Government and regulators (Bartram et al., 2007). Nowadays the requirements and strain on resources become much more competing. In this dynamics the cost of water system maintenance can drop down, or be crossed out of the list of priorities (Stanwell-Smith, 2014). Seen from a global perspective, increasing national and international outbreak incidents have probably contributed to instigating legal improvements and to develop a legal framework.

Regulations and guidance documents require a detailed description of the characteristics of the plumbing system along with environmental monitoring as first steps to assess and to evaluate the risk for *Legionella* contamination in the PWH system (Bartram et al., 2007). Data, coming from a DWPS description plan, is the cornerstone for identifying risk areas and interpreting monitoring results. Furthermore, effective monitoring requires contemporary, approved and acknowledged sampling methods and diagnosis.

4.4.2 Steps in the development of a WSP

To all hospitals, and also other healthcare facilities, the WHO guidelines for drinking water quality (WHO, 2011) recommend adopting a WSP as part of their infection control programme (Figure 4-1). Appropriate measures must be considered and realised in order to reduce the number of healthcare-associated infections. This includes *Legionella* spp, potentially acquired from water (Williams et al., 2013).

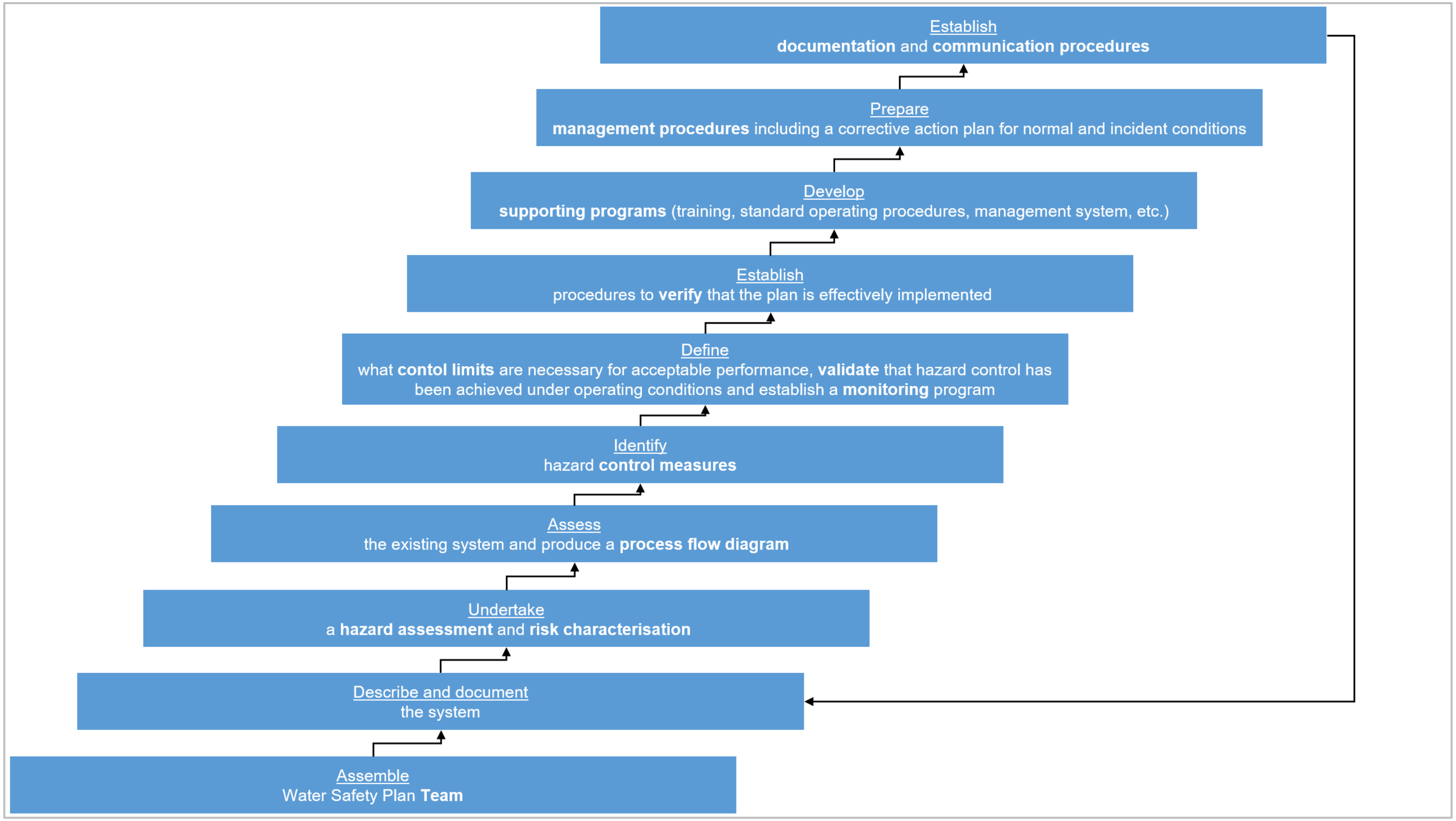


Figure 4-1: Steps in the development of a WHO Water Safety Plan, according to McCoy and Rosenblatt (2015 p.520), modified

A WSP is part of a framework for safe water quality (Figure 4-2) that also includes health-based targets and surveillance. Action should be taken towards performing a water system assessment for the facility, monitoring microbial counts for organisms of interest (including *Legionella* spp), disseminating information, communicating recommendations, and maintaining surveillance activities over time. The WSP of a healthcare facility must include both prevention and control measures for infectious diseases that can be associated with originating from water. The implemented plan should address issues specific to the facility, including treatment requirements, protocols for the cleaning of specialized equipment used by the facility and the control of microbial growth in water systems and equipment, which is being connected to the water systems (waterlines).

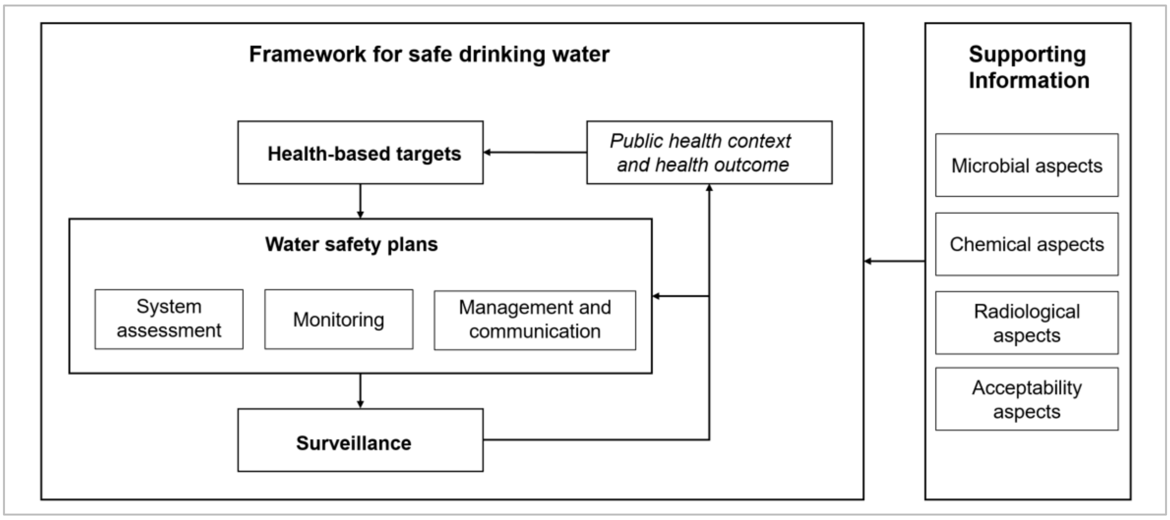


Figure 4-2: Framework for safe drinking water , adapted from WHO (2011 p.165), modified

But, as for every other endeavour, WSP implementation can neither guarantee success nor is it a self-runner (Setty et al., 2018). Nevertheless Dyck et al. (Dyck et al., 2007) observed no new case of nosocomial *L pneumophila* after the successful implementation of a WSP, even with screening each case of pneumonia for *Legionella* spp.

4.5 Commenting UK references with focus on water safety / *Legionella* prevention

Building regulations are nowadays closely linked to energy conservation and the health, safety and welfare of the occupants are cared for by the Health and Safety at Work Act. This Act is supplemented by detailed guidance on individual topics.

4.5.1 HSE – Health and Safety Executive

HSE guidelines require all employers to review their water services and, if needed, prepare an action plan for remedial work. Staff training and written record keeping are also required. This note reminds employers of their obligations (Brundrett, 2003). Each of the 22 items (Table 4-4) is quested for whether or not the risk assessment contain details which fulfil the HSG 274 requirements.

Table 4-4: Guidance Checklist of Appendix 1 in HSG 274 (HSE, 2014)

Item no.	Advised requirement detailed in the HSG 274 document Appendix 1
1	Details of management personnel who play an active role in the risk management process, to include names, job titles and contact information for:
2	An assessment of the competence of those associated with risk management, including their training records.
3	Identification of roles and responsibilities, to include employees, contractors and consultants.
4	A check to confirm that consideration was given to preventing the risk by elimination or substitution before implementing appropriate control measures.
5	The scope of the assessment, i.e. the details and entirety of the plant being assessed.
6	Assessment of the validity of the schematic diagram which should include all parts of the water system where water may be used or stored.
7	Details of the design of the system, including an asset register of all associated plant, pumps, strainers, outlets and other relevant items.
8	Assessment of the potential for the water system to become contaminated with *Legionella* and other material.
9	Details of any water pre-treatment process.
10	Assessment of the potential for *Legionella* to grow within the system and effectiveness of control measures: • Chemical and physical water treatment measures; • Disinfection and cleaning regimes; • Remedial work and maintenance.
11	Evidence of corrective actions being implemented.
12	Evidence of proactive management and follow-up of previous assessment recommendations or identified remedial actions.
13	Evidence of the competence of those involved in control and monitoring activities.
14	A review of the *Legionella* control scheme, including management procedures and site records or logbooks, which include: • System maintenance records;

	• Routine monitoring data; • Water treatment and service reports; • Cleaning and disinfection reports; • *Legionella* and other microbial analysis results.
15	Quality of the supply water – where this is not wholesome, additional risks and measures to mitigate the risk must be included in the risk assessment process.
16	Examination of tanks for configuration, flow pattern, protection against contamination, materials of construction, condition, temperature, size in comparison to water consumption and and cleanliness or contamination.
17	Any points in the system where there is a possibility of low or no flow, such as blind ends, dead legs and little used outlets.
18	Any parts of the CWDS susceptible to heat gain to an extent that could support the growth of *Legionella*.
19	Any parts of the system with low water throughput including, e.g. low-use fittings in unoccupied areas or oversized tanks that may lead to stagnation.
20	Any parts of the system which are configured in parallel with others and where the water flow could be unbalanced.
21	Hot water system return pipes – stagnation often occurs, particularly at points furthest away from the water heater, where circulation has failed and the hot water has cooled.
22	Timely, appropriate remedial action to poor temperature or monitoring results and using this as an indicator of the effectiveness and adequacy of the management controls in place.

4.5.2 COSHH – Control of Substances Hazardous to Health

COSHH Regulations 1999

According to Wiggins (2010 p.286) the COSHH Regulations 1999 require the FM to carry out an assessment of the risks in the premises. It comprises risks arising from exposure to legionella bacteria from all water systems. If the organisation employs five or more people, a written record of the risk assessment is required. Prosecution may be a consequence in case of failure fulfilling this demand. It especially impends if an incident has occurred that could have been reasonably anticipated, based on a prior formal risk assessment. If there was the specific case that an occupant is a tenant in a managed building, it is the landlord's field of responsibility to ensure a risk assessment is carried out. However, the tenant and the landlord do have overlapping duties of care towards the occupants. In addition, people responsible (e.g. in the field of Estates and FM) also need to judge whether or not the current control measures are suitable and sufficient. The control measures aim at either eliminating or controlling adequately the risks identified. In places where additional and essential measures or controls were identified and are seen as necessary, precautions will protect work colleagues, all employees, staff, visitors, the public and the business itself.

4.5.3 ACopL8

The Approved Code of Practice and Guidance L8

The Approved Code of Practice - L8 gives advice on the requirements of the Health and Safety at Work Act 1974 etc. and the Control of Substances Hazardous to Health Regulations 2002 (COSHH, chapter 4.5.2). In particular it gives guidance on sections 2, 3, 4 and 6 of the HSW Act and regulations 6, 7, 8, 9 and 12 of COSHH, as does HSE leaflet 'IACL27(rev2) – a guide for employers'. ACoPs are approved by the Health & Safety Executive Board with the consent of the Secretary of State.

The Approved Code of Practice and Guidance L8, "Legionnaires' Disease - The Control of *Legionella* Bacteria in Water Systems" (ACoP L8) outlines that in the meantime there is much legislation and guidance concerning the safety of water systems in buildings. As can be read in Wiggins (2010), two important documents have been published by the Health and Safety commission. Namely they are the guidance document HSG274 and the ACoP L8-Legionnaires' disease, mentioned above. Both these documents offer essential practical advice on maintenance, water treatment and requirements for monitoring. They give advice on the competence and training for staff being responsible for implementing risk management activities. It comprises developing, managing and conducting risk assessment on related activities as well as implementing control measures and requirements for intervention. Furthermore, the ACoP L8 emphasises carrying out work effectively and safely underlining existing duties of suppliers of products and services. Its content primarily addresses water treatment contractors to help them improve their standards. If there is a reasonably foreseeable risk of legionellosis due to a potential presence of *Legionella*, the ACoP L8 applies to any workplace or work activity where water is used or stored (Wiggins, 2010 p.283-284).

Clause 38 of the ACoP L8 specifies that risk assessment should be reviewed regularly. Due to changes or whenever there is reason to suspect that the present assessment is no longer valid, the assessment should be corrected to meet the current state. Revision should be done at least every two years. Contents of what is on the review list of the assessment, and when, should also be recorded (refer to Appendix B of the Water Services Manual). Demands for changes may result from different issues. To mention some, Wiggins lists: (a) changes to the water system or its use, (b) changes to the use of the building in which the water system is installed, (c) the availability of new information about risks or control measures, (d) the results of checks indicating that control measures are no longer effective, (e) a case of Legionnaires' Disease / Legionellosis is associated with the system.

Water quality legislation in the UK comprises Water Supply (Water Quality) Regulations 1989 and the Water Supply (Water Quality) (Scotland) Regulations 1990 (Wiggins, 2010). According to these regulations drinking water should have no unpleasant taste, colour, odour or turbidity. Drinking water should also not exceed limits set for chemicals and microorganisms, such as coliform, *Escherichia coli* or *Pseudomonas aeruginosa* bacteria.

This early legislation was later enforced by the Workplace (Health Safety and Welfare) Regulations 1992 which explicates that every employer has the duty to supply 'wholesome' drinking water. Furthermore Report 71 (The Microbiology of Water 1994, Part 1 – Drinking Water) advises that coliforms, *E. coli* or *P. aeruginosa* are absent in a 100 mL sample of drinking water.

4.5.4 HTM04 – Safe water in healthcare premises

NHS trusts or government organisations should meet all the constraints of ACoP L8. HTM 04-01 is really not required. Although what it does do, is that it gives a lot more detail around healthcare premises than the ACoP L8. In front of HTM 04-01, it states that: "an NHS organisation should meet all the requirements of L8 and HSG274". So, in reality, HTM 04-01 is not really required, although it is much more detailed around water hygiene issues, or water safety within healthcare premises.

4.6 Actors in the United Kingdom and England context

There can be identified numbers of organisations or interest groups providing guidance on water safety and *Legionella* to their members (Figure 4-3). Among those there might be standards or specific industry guidance, as presented in chapter 4.3.3. In order to briefly introduce those interest groups, to which this research wants to inform, and which were considered for the survey during the research (see chapter 6.9.7.3), the following paragraphs summarise their character, mission, aim or vision that have been available from their web-presentation.

Figure 4-3: Organisations with guidance for the context of hospitals

4.6.1 NHS – The National Health Service

The NHS tries to educate people engage with their health, care and wellbeing so they can stay healthy and help manage any long-term health conditions. For any further details in the specifcs mission regarding water safety management, be advised to read chapter 2.2

4.6.2 RSPH – The Royal Society for Public Health

The Royal Society for Public Health (RSPH) is an independent health education charity and the world's longest-established public health body. Their vision is that everyone should have the opportunity to optimise their health and wellbeing.

4.6.3 WMSoc – The Water Management Society

The Water Management Society (WMSoc) is a not-for-profit membership organisation that has been providing practical and technical training solutions to individuals and companies within the water management industry for over 40 years. Their expertise in *Legionella* awareness, *Legionella* and water hygiene training enables them to give the most up-to-date instruction on how to prevent Legionnaires' and other waterborne diseases within various water systems, including cooling towers. The WMSoc will continue to maintain and improve standards within the industry. In the WMSoc 'Code of Conduct' there is a clear focus set to develop and enhance the WMSoc, its values and its members, to promote a safer, cleaner water industry.

4.6.4 LCA – *Legionella* Control Association

The *Legionella* Control Association (LCA) is a voluntary organisation whose membership comprises providers of services and products concerned with the control of legionella bacteria in water systems. The primary aim is to keep water systems safe and minimise the risk of cases of Legionnaires' disease caused by poorly maintained systems.

4.6.5 IHEEM – Institute of Healthcare Engineering and Estate Management

The Institute of Healthcare Engineering and Estate Management (IHEEM) is an international professional engineering institute, specialising in the healthcare estates sector. IHEEM's primary purpose, as a professional development organisation, is to keep members up to date with developing technology and changing regulations within the industry.

4.6.6 CIBSE – Charteted Institution of Building Services Engineers

The professional body with responsibility for services on *Legionella* case identification and providing services to reduce *Legionella* contamination is the Chartered Institution of Building Services Engineers (CIBSE). They were among the first to publish advice for designers over twenty-five years ago. Over 15 Years ago they issued a Technical Memorandum. However, cases continued, and so more binding measures were required, which led to today's set of legislation and guidance.

4.6.7 BIFM

Formerly known as the British Institute of Facilities Management (BIFM) the body maintained 'Special Interest Groups' for certain topics, with their own series of guidance documents called 'BIFM Guidance'. BIFM was replaced by the Institute of Workplace and facilities Management (IWFM), which was established in 2018. It builds on the heritage of 25 years of the British Institute of Facilities Management and is the professional body for workplace and facilities practitioners. The IWFM "exists to promote excellence among a worldwide community by advancing professional standards, offering guidance and training, developing new insights and sharing best practice" (IWFM, 2019).

4.6.8 BSRIA - Building Services Research and Information Association

BSRIA is an ISO 9001 registered test, instruments, research and consultancy organisation, providing specialist services in construction and building services. As a non-profit distributing, member-based association, clients can be assured of an independent approach and authoritative reputation. Any profits made are invested in an on-going research programme, producing industry recognised best practice guidance.

'BG' BSRIA guides (see chapter 4.3.3, Table Appendix A-8) includes guidance on commissioning air systems, commissioning water systems, domestic ventilation airflow rate testing, seasonal commissioning, pre-commission cleaning of pipework systems and commissioning management. A maintenance construction information service (CIS) guide focuses on business focused maintenance, exemplifying responsible people, budget limitations, business consequences and rate impacts and consequences of maintenance regimes. Business-focused maintenance provides the built environment industry with a methodology for utilising maintenance budgets more effectively. Assets critical to the business are maintained, while other less critical assets are managed as well as possible within the available budget. The BSRIA Topic Guide 'TG' *Legionella*' (see see chapter 4.3.3, Table Appendix A-8) is designed to be an 'at-a-glance publication' introducing readers to key industry topics and suggesting further reading. The guide is aimed at those looking for basic information about *Legionella* including definition, history and prevalence. There is also guidance on the relevant legislation and supporting documentation alongside some risk management tips to ensure compliance.

4.6.9 CIS – The Construction Information Service

The Construction Information Service brings together a comprehensive collection of essential technical documents from a wide range of publishers. Covering all aspects of building, engineering, design and construction, it provides its users with a single source for all their technical information needs.

4.7 Summary background three

Key factors of given regulations with an international background are summarised in Table 4-5, according to Van Kenhove et al. (2019) p. 974. In the first column, the table lists the authority (organisation or country). In the subsequent columns, there are answers on the question whether or not *Legionella* being a reportable disease, the presence of any testing guidelines, existing action levels for sampling results, maintenance strategies, and corresponding mitigation plans.

Table 4-5: Key factors of regulations, according to Van Kenhove et al. (2019) p. 974, modified.

Authority	**Reportable disease**	**Presence of testing guidelines**	**Action levels for sampling results**	**Preventative maintenance strategies**	**Mitigation plans**
WHO	In some countries	Testing is recommended; requirements and frequencies are included	Only for cooling water systems	Temperature. Hot water temperature should be maintained	Disinfection, cleaning, monitoring and regular service and maintenance
EWGLI	In some countries, e.g. United Kingdom; reporting of travel-associated cases	Testing is recommended; requirements and frequencies are included	Different actions required between 1,000 and 10,000 and above 10,000 CFU/L	Temperature. Chlorination in Italy.	Risk assessment and management plan in combination with regular measurements
USA	Reportable	Recommendations for *Legionella* resting	Not included	Temperature. Standard chlorination	Creation and implementation of a risk management process and *Legionella* water management program

There are national differences existing according to legislation and to explanations of generally accepted engineering standards, i.e. norms, recommendations, or technical and guidance documents. But there are recommendations written on paper. For the people responsible, who may be assigned to the professional field of Estates and Facilities Management, there are undeniably aspects of water hygiene that could enforce criminal and civil law obligations. A context specific review provides support in detecting deficiencies and thus avoid potential lawsuits. For that, a systematically tabulated collection of statutes, standards and other documents guiding design, operation and maintenance to minimise risks caused by *Legionella* in building (drinking) water systems have been presented in chapter 4. Professionals can apply these for reviewing the processes and procedures within the organisation they are responsible for.

In this chapter there have been identified gaps in the form that:

- a focus on the hospital (healthcare) perspective is not everywhere there

- although technical guidance is there, guidance for implementing processes are missing. The concrete guidance of management is not there
- (Old) systems that have to be managed are there

For that, specific knowledge about the process is important. It needs to be developed a guideline developing guidance. This research is therefore an approach that considers a different way of looking at the problem. High incidence on *Legionella* cases is attributed partly to the poor maintenance of building water services (Brundrett, 2003 p.275). Here a focus must be set on.

According to Wiggins (2010 pp.285-286) "various agents and organisations have developed the WMSoc Code of Conduct. They include the Water Management Society, the Health and Safety Executive (HSE) and the British Accreditation Council (BAC). The code is promoted by the *Legionella* Control Association. It is designed to help building owners and operators select competent service providers out of a rising number of businesses. Furthermore, the code specifies that there must be a written agreement between the service provider and the client. It shall precisely declare individual responsibilities of both parties involved. An adequate and up-to-date monitoring and treatment will also be essential. Records should be kept stored for at least 5 years. When there are service providers involved in water management processes, they will have signed up to the Code of Conduct. Among them, the competent ones will be able to provide their client or FM with a copy of their certificate. The code highlights six critical areas, which have to be considered:

- Allocation of responsibilities,
- Training and competence of personnel,
- Control measures,
- Communication and management,
- Record keeping, and
- Reviews."

These critical areas will take a central role in the further development of topic under investigation.

5 Summary of literature review

The main points of the literature review summaries presented in chapters 2.4, 3.5 and 4.7 are now reflected and narrowd down to the key terms and elements. They show the identified gaps in knowledge and provide a starting point for research.

- Chapter 2.4 *Legionella*, infection, healthcare

There is undoubtedly a need for something to make *Legionella* control easier, particularly for the layman in the care sector, if not the healthcare sector itself. But also for management level, as they need orientation about the extent of their management activities.

- Chapter 3.5 Estates and Facilities Management

In certain points Estates and Facility Management servig hospitals are responsible for water safety management and *Legionella* prevention. It needs awareness, orientation, resources, clear structures and the support of senior management to meet all the obligations in their job demanded by governmental (perspective on the organisation from outside) and structural (perspective inside the organisation) conditions.

- Chapter 4.7 Legislation, standards, guidance

References can be made on selected main points not only found in HTM04-01, HSG274, AcoP L8, WMSoc and BSRIA for the United Kingdom and England. The WHO water safety plan constitutes a scheme for preventing and controlling potential risks through 'system assessment', 'monitoring', 'surveillance and management/communication'. The key concepts in the WSP hazard analysis and control system are: 'Team', 'hazard assessment and risk characterisation', 'process flow diagram', 'control measures', 'control limits', 'validation', 'monitoring', 'verification', 'supporting programs', 'management procedures', 'documentation and communication'.

Put into a meta-level it is fundamental to understanding the functioning of the own organisation wih regard to:

- Stakeholders / duty holders / process managers or process owners
- Processes, process elements, process steps, process maps, process architecture

Aforementioned threefold need for advice could be made transparent in form of a framework and well feed back into regulations. As stated by Van Kenhove et al. (2019), “Comparing frameworks can be a first step on the path to future unification of *Legionella* regulations. Current regulations involve a wide range of climatological circumstances. Still, the same measures are recommended in different environmental circumstances worldwide because it is the characteristics of the DHW system that dominate over different climatic conditions. Clearer and more uniform and unambiguous regulations will facilitate their implementation.” They ask the question “Do we have clear, uniform, and unambiguous *Legionella* guidelines and regulations?” and conclude that obviously we do not. “However, despite different regulatory frameworks, there is a broad unification of principles”.

For England (in the UK), those principles could be given a ‘home’ in a framework guiding people in Estates and Facility Management of hospitals responsible for water safety management and *Le-*

gionella prevention. As a result from the evaluation of an intense, overarching and continuous literature review regarding the research focus (chapter 4), the research problem (chapter 1.2) was finally figured out, which led to the research question and sub questions described in chapter 1.3.

Their answer shall give orientation and provide support to people responsible for water safety management and *Legionella* prevention in hospitals in England, with a specific perspective from Estates and Facilities Management. Together with answering the research question, the proposed need for guidance in form of a framework (chapter 6.14) will be covered by a framework output (chapter 8), giving fully the justification and need for research in this topic.

The next chapter 6 describes the methodology of how this goal will be achieved.

6 Methodology

The previous chapters focused on presenting the thematic environment in which this research is embedded. Chapters 5 highlighted the most important aspects of an extensive literature review, hereby giving the fundament for the elements in focus. These are necessary to approach and to narrow down the objects of research to collect and analyse data about the present situation in hospitals about water safety management, *Legionella* risk management and preventative action. Given the aim and objectives described in chapters 1.4 and 1.5, the research claims for itself an orientation on present, relevant and highly interdisciplinary aspects with focus seen from a managerial level in the field of estates and facilities management. It consequently considers thoroughly the business of management in hospitals including operational and strategic levels in a specific range of duty.

In order to determine whether stakeholders and processes can be identified, ordered, mapped and be compared for similarities, a research methodology becomes necessary that is tailored to this specific setting with sensitive topics. Based on the findings, which result from applying scientifically recognised research methodologies, a framework should be drawn up as a final output, which adequately discusses, includes and recognises findings characterising processes and stakeholders.

This chapter outlines the research methodology. As the research applies different types of methodologies with different types of data collection, in which the researcher interacts and communicates with individuals, the research journey may also include a motivation of committing to contribute to organisational improvement and thus, effectiveness. A researcher is a highly educated communicator, and in a communication context, (Du Plooy, 1996 p.30) describes methodology as the "principal ways in which communicologists act on their environment, that is, their methods for conducting research, by their experiments, social surveys, content analyses, field research or ethnography". As mentioned earlier in chapter 1.5 the objectives of this study are sixfold. They serve for two main outcomes, namely a) for the identification and understanding of processes and roles of process owners, and b) for developing a framework for estates and facilies management.

Firstly, the literature has to be explored to determine elements about stakeholders and processes. Secondly, the theoretical findings have to be identified in given real cases and and specific business environments. To better understand the real cases, experience was made and data collected in a pilot study and in three different countries to compare given situations and learn about the perspectives of responsible management and practitioners. Being equipped with business perspectives research focuses in the next step on the context of interest, which is England. Applying different methods of data collection and further developing a strategy for realizing data collection, processes and stakeholders were identified. It is necessary to apply a range of strategies to verify and highlight the value of the final framework.

The first of the two main outcomes mentioned above can be seen as an essential and important step to provide orientation for a further qualitative exploration of the details and processes in practice. The findings made feed the second outcome of this study, which is a framework for estates and facilities management. It is titled "The process of water safety management, *Legionella* prevention and risk management in hospitals: a framework for estates and facilities management with focus on England."

The methodology required to achieve the aim and objectives of this study is aligned to the research problem in order to answer the research question of this study after data collection and analyses have been run. By iteratively answering four defined subquestions SQ1-SQ4 (see chapter 1.3), decisive elements can be investigated step-wise to finally answer the research question (chapter 9.2). In order to address the aim and objectives it is necessary to align the outcomes of the literature review with the present situation in hospitals and tailor the research methodology towards generating empirical findings. For that, a profound knowledge of different management categories, as mentioned in chapter 3.4, is essential. Special interest lies in risk management, process management, and stakeholder management. Furthermore it is important to understand the background and the management instruments in place, which are described in section 3.3.2.

How the objectives are embedded within the research process is presented in chapter 6.15 in the logic of the sequential research phases. In order to dreate a framework for the business units estates and facilities management in hospitals, the choice of the methodology contributes towards affirming or rejecting elements of the framework, but also to making it pragmatic through the integration of suggestions from senior professionals with experience and background in their specific field.

This section of the thesis will provide an overview of the explorative nature of this study and interpretative research paradigm to serve as the basis for elaborating on triangulation as a key element of the selected research design.

Taking into consideration the above mentioned explanations, this chapter will provide the methodological overview on the explorative orientation of this study. Its orientation, which is built on an interpretative research paradigm, is chosen to serve as the basis for elaborating on triangulation as a key element of the selected research design. Secondly, the entire sampling design will be discussed with reference to the sampling methods, unit of analysis, target population, sampling frame and realised sample during the different phases and levels of this study. Thirdly, the selected data collection methods of this study, namely, semi-structured interviews, a self-administered web-based survey, document and secondary data collection, and focus groups will be discussed. Analysis procedures are selected and presented. Fourthly, reliability, validity, trustworthiness and triangulation as an essential element of the research design will be discussed. Lastly, the ethical considerations that have to be considered for developing the framework for application in practice will be elucidated.

Since it was necessary to obtain data from several hospitals for a qualitative exploration of the processes and to determine whether there are individual or comparable elements of the processes and stakeholders, a multiphase research strategy was chosen. It developed continuously throughout the research to obtain insights that enable the researcher to give answers to the research problem. In order to integrate expert knowledge to the final output, the proposed framework of chapter 8, the entire research project follows a sequential order with a multiphase triangulation approach. For giving an orientation on the methodology applied following a sequential structure of data collection realized in different phases, Figure 6-1 presents a summary. It is organised in the phases Ia, Ib (both interview studies), phase II (survey study) and phase III (validation through focus group). Details of applying triangulation are explained in chapter 6.12.2.

	Phase Ia	Phase Ib	Phase II	Phase III	
Theory	**Exploratory pretest**	**Data collection**	**Data collection**	**Validation**	**Output**
Literature review & methodology	Interview study	Interview study	Survey study	Focus group (framework proposal)	Final Framework

Start ⟷ End

Figure 6-1: Sequential steps of the research study design

For this research project, different data collection methods were applied. They comprise interviews, secondary data and a survey. After analysing procedures a famework is compiled, fed by results of previous research phases. As is explained in chapter 6.3.5 with respect to its sequential exploratory mixed methods design character, and is explained with respect to overall interpretation in chapter 6.12.2, the plan of work for data collection and analysis consists of the above mentioned four consecutive steps. As already mentioned, phases Ia and Ib represent interview studies. One special type of one-to-one interviews is the expert interview, which has been applied for this research. Even the survey addresses specialists, as it seeks to address the different members sitting in water safety groups. Hitzler (1994, p.26) as cited in Pfadenhauer (2009 p.82) states the expert "typically knows the knowledge stock that is 'characteristic' or 'relevant' for a certain field, he has, so to speak, an overview of a specialist knowledge field and can offer fundamental problem solutions or can apply these to individual problems within this area". By considering and integrating experts' knowledge during the interviews in the course of the project, the research is in line with its aim of a specific orientation to a professional field. Specialists' knowledge is, thus, integrated at each phase of data collection (6.9.3, 6.9.4, 6.9.5, 6.9.7.1, 6.9.7.2, 6.9.7.3) and the final validation phase (6.9.6 and 6.9.7.4).

An embedded design applies cases (represented by hospitals as organisations) for analysis. Data of the cases have been empirically collected during an exploratory first phase with cases in the UK, Germany and Switzerland (Figure 6-2). A consecutive country-specific phase narrowed the research more specifically on England. Data from interviews and documents was collected and analysed during the exploratory phase, which had a focus on taxonomy and to explore job descriptions and factors in hospitals that have a thematic connection to *Legionella,* risk management and water systems for the purpose of water safety management. This phase was also necessary to test the fluency of the procedures selected for data collection and verify and confirm the case strategy chosen. Research of the following phase collected and analysed data from interviews, a survey and documents. The specific focus of this phase was to find patterns, define coding structures, build categories, analyse and compare content by applying cycles of content analysis to find levels of abstraction to create a draft version of a framework, which underwent a validation step in a final focus group by experts in the field of risk management and water safety.

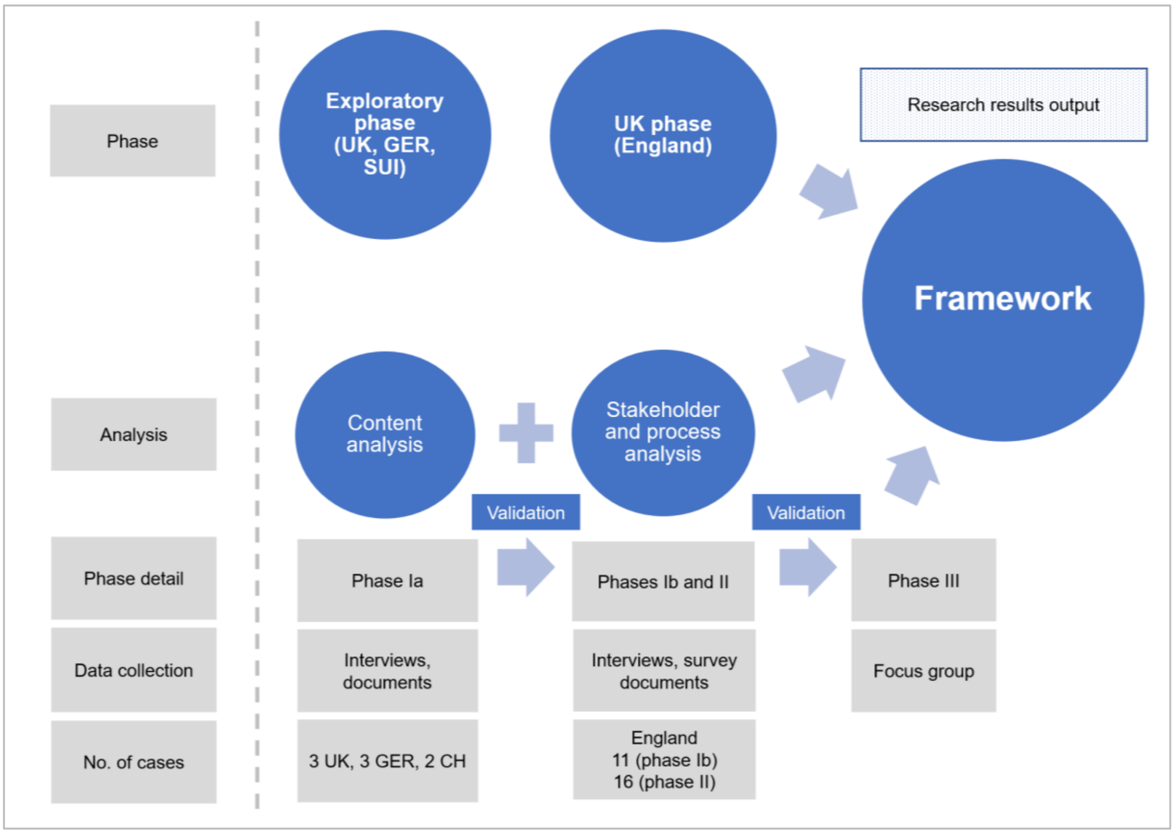


Figure 6-2: Embedded sampling design with hospitals as cases

Methodology is built on a mixed methods research design and a multilevel triangulation approach. The dominant analysis strategies for gaining evidence, and the alignment of the objectives to the respective analysis strategy for answering the subquestions is cross-referenced to the respective chapter and summary table of this thesis (Figure 6-3).

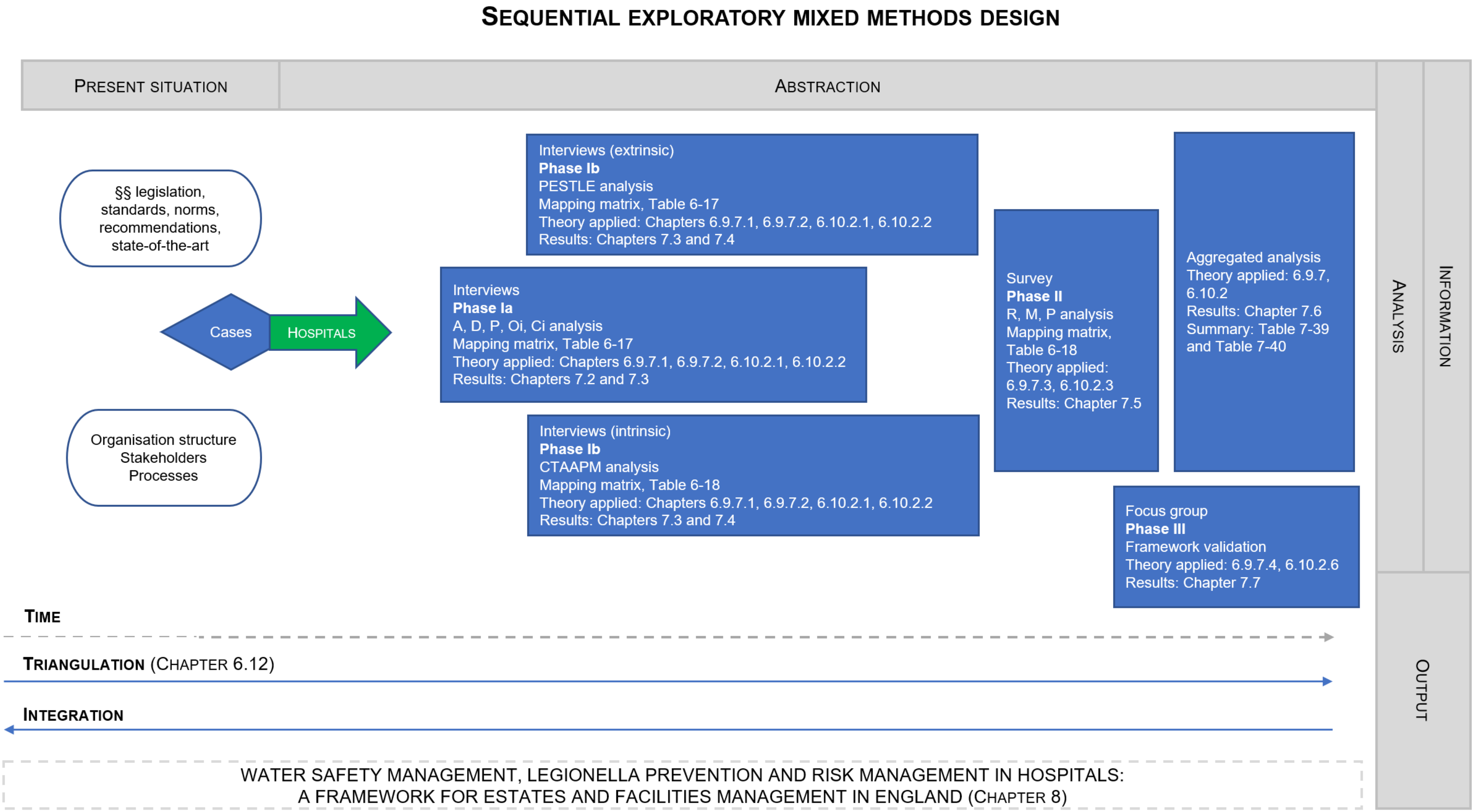


Figure 6-3: Mapping diagram for steps of analysis feeding the creation of the framework

To sum up the characteristics of data collection and analysis procedres, Table Appendix A-12 and Table Appendix A-13 present all procedures applied during research. Details are explained in chapter 6.9.

In order to provide orientation and navigation though chapter 6, a summarised view on the structure of this chapter as well as highlighted theory and characteristics of this study are summarised in Table 6-1.The table is colour coded. Dark elements indicate, that here the elements of the research match in a strong way to the specific characteristics of theory presented in the respective chapter. For elements in bright colour the match is just for specific characteristics of theory. Dark and bright elements for the same feature show that they are complementary represented and considered in the study, where the dark coloured element is the main element this research is characterised by theory. The last column of the table presents standards for reporting qualitative research (SRQR) according to O'Brien et al. (2014), as presented in Table Appendix A-11. They have been considered and applied for organising a structure for the methodology chapter. The specific standards that are referenced are indicated with the codes numbered 'S5' to 'S15' and assigned to each chapter of this thesis, presented in first column of the Table 6-1. The aim was to represent and meet all standards of the SRQR for the methodology chapter, and thus, give a referenced logic to the structure chosen, striving for completeness in the theoretical deliberations for the methodology applied in this research. Where seen necessary, sub-headings of chapter 6 introduce specific theory, followed by the applied methods of this research.

Table 6-1: Mapping methodology: Theoretical perspectives and application in study design

Thesis chapter	**Feature**	**Theory**	**SRQR** no. according to O’Brien et al. (2014)
6.1	Philosophy/Paradigm	Positivism; Critical realism; Interpretivism; Postmodernism; Pragmatism	S5
6.2	Theory development	Deduction; Abduction; Induction	S5
6.3	Research design and methodological choice	Qualitative research; Quantitative research Mono method; Multi method; Mixed method with triangulation	S7
6.4	Purpose	Explorative; Descriptive; Explanatory; Evaluative; Combined studies	S7
6.5	Research strategy	Experiment; Survey; Archival research; Case study Ethnography; Action research; Grounded theory; Narrative inquiry	S12
6.6	Time horizon	Cross-sectional; Longitudinal	S10
6.7	Sampling strategies	Purposive non-probability; Probability	S8
6.8	Literature review	Literature review	
6.9	Data collection	Secondary data; Interview; Questionnaire Semi-structured interviews; Document analysis; Web-based survey; Focus group	S10, S11, S12, S13
0	Data analysis	Interview study, phase Ia Interview study, phase Ib Document analysis, phase Ib Web-based survey, phase II Focus group framework validation, phase III	S14
6.11	Reliability, valitidy, trustworthiness	Reliability; Validity; Trustworthiness	S15
6.12	Triangulation	Data triangulation; Theory triangulation; Method triangulation; Multiphase triangulation approach	S15
6.13	Transferability - to-wards generalisation	Described in chapter	n/a
6.14	Critical review on frameworks	Described in chapter	n/a
6.15	Creating a framework	Described in chapter	n/a
6.16	Ethical considerations	Confidentiality; Cross cultural; Bilingual	S9
6.17	Researcher character-istics and reflection	Described in chapter	S6
6.18	Summary	Described in chapter	S5 to S15

6.1 Philosophy/Paradigm

According to Saunders et al. (2016 p.124) “the term research philosophy refers to a system of beliefs and assumptions about the development of knowledge”. In general, the philosophy - or in other words paradigm - can be distinguished between positivism, critical realism, interpretivism, postmodernism and pragmatism.

An interpretitive paradigm is evident in this study since existing literature was explored and interpreted to establish the basis for subsequent research steps towards a framework. This approach corresponds with the research question and does not solely rely on the research philosophy position (Sekaran and Bougie, 2016 p.29). According to Sekaran and Bougie (2016 p.29) “Pragmatism stresses the relationship between theory and practice”, which matches with business research environments. Into this sector hospital environments with processes, duties and responsible persons in water safety and *Legionella* risk management and preventative action in estates and facilities management fit perfectly. For this research, pragmatism was considered to be applied as the dominant research paradigm. “The focus is on the consequences of research, on the primary importance of the question asked rather than the methods, and on the use of multiple methods of data collection to inform the problem under study” Creswell and Plano Clark (2011 p.41). It was considered to match the purpose of this study as the research design focuses on analysing a situation where there arise questions about potentials of abstraction, standardisation and generalisation of processes. But contrary to the stand-alone theory of positivism, here is no aim at evolving law-like generalisations. As the given problem (chapter 1.2) potentially occurs widely around different hospitals, the chosen paradigm fits perfectly on the demands of the subject of investigation. The work will aid responsible management persons and generate new significant knowledge about processes. For pragmatism is often used in mixed methods research (Saunders et al., 2016, Creswell and Plano Clark, 2011), this research accordingly gets fed by theories and practices of mixed methods research and thus requires an appropriate research design. Since this study is more explorative and built from a pragmatic, yet interpretative paradigm, triangulation will occur within a predominantly qualitative research design. In detail the research design will be described and explained in chapters 6.3, 6.9, 0, and 6.12.

This study is therefore not a ‘clean’ mixed method research strategy that aims to bridge the qualitative-quantitative gap. It also does not strive to be allocated to one paradigm or disqualify others in the competition between qualitative and quantitative research. Instead, it is an approach in which mixing occurs necessarily in a research strategy (Bryman, 2008a p.15). In addition, critical realism as well as pragmatism are both related to mixed methods research as their way of looking at the world is asking for qualitative and quantitative research methods (Saunders et al., 2016 p.169).

6.2 Theory development

In order fo find the right strategy to investigate a given research problem, an appropriate approach to theory development becomes essential (Saunders 2016 p. 170).

According to Saunders et al. (2016 p.167) there are three different ways to develop theory. Their different characteristics are described hereafter.

6.2.1 Applied in the research design

For this research an inductive approach for theory development was applied for phases 1 and 2 in order to explore a phenomenon and to become able to build a theory from the findings (Bryman and Bell, 2015). By iteratively exploring (Figure 6-4), detecting and describing the demand for guidance of people in duty towards a described process of water safety management, *Legionella* prevention and risk management in hospitals, process elements and the stakeholders for a working process (see chapter 7) were discovered. Later in this research, a deductive approach was applied for phase III to validate the research result, which is, in the context of this research, a framework for estates and facilities management.

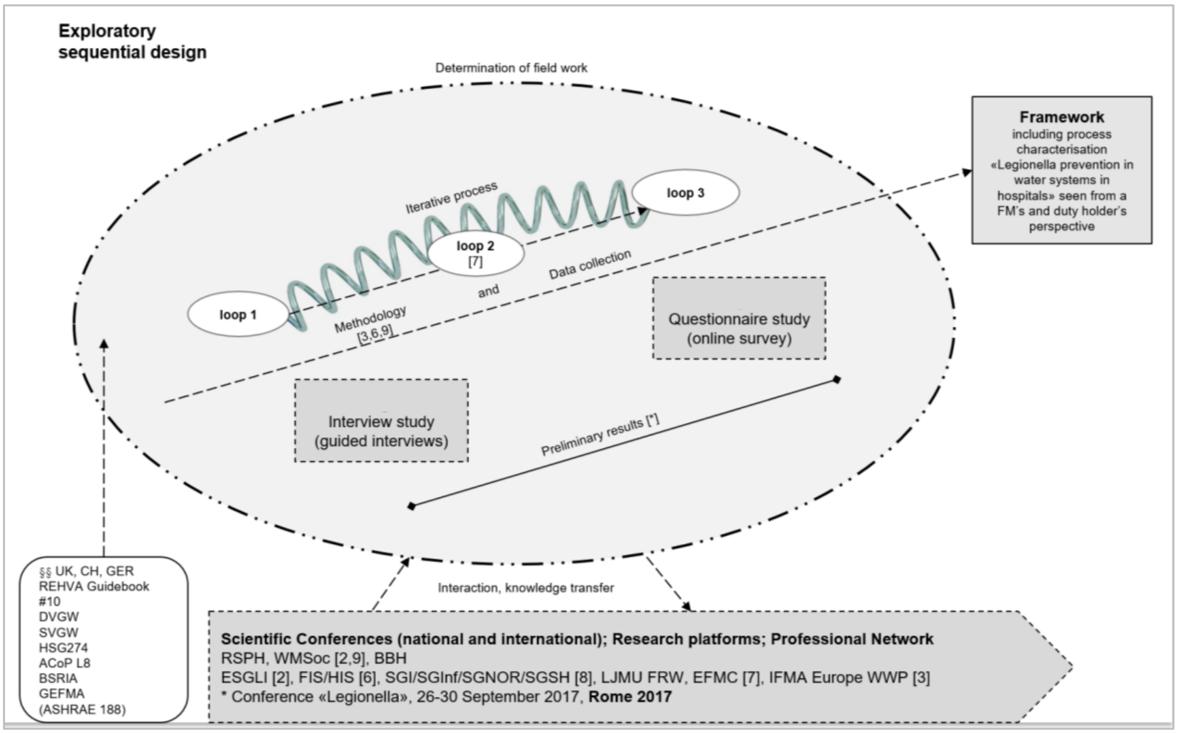


Figure 6-4: Iterative process towards a framework

6.3 Research design and methodological choice

This chapter outlines different types of research as well as their design from a theoretical point of view. At first, a focus is laid on the nature of both qualitative and quantitative research. Two sections follow with an explanation of the key differences between qualitative and quantitative research. This serves as an introduction to the subsequent chapter, which characterises mixed methods research design. The mixed methods research design introduces a combined perspective of qualitative and quantitative research. Finally, chapter 6.3.5 states which type of research design was chosen for this research project.

6.3.1 Qualitative research (QUAL)

Qualitative research is a "… situated activity that locates the observer in the world. It consists of a set of interpretative, material practices that make the world visible" with a view to transforming the world (Denzin and Lincoln, 2000a p.3). It is characterised by multiple ways of knowing; there is no fixed method to study the world because each individual may experience the same event differently (Minichiello and Kottler, 2010 p.16). According to Anderson (1987 p.384), qualitative research "emphasizes inductive, interpretative methods applied to the everyday world which is seen as subjective and socially created". "Qualitative research is often associated with an interpretive philosophy" (Dezin and Lincoln 2011 as cited in Saunders et al., 2016 p.168). The qualities of various phenomena are investigated where data tend to be continuous, with the emphasis on description and explanation as opposed to measurement and prediction (Fitch, 1994 p.32). "It is interpretive because researchers need to make sense of the subjective and socially constructed meanings expressed about the phenomenon being studied" (Saunders et al., 2016 p.168).

To further highlight the individual nature of qualitative and quantitative research designs, the next section will focus on quantitative research.

6.3.2 Quantitative research (QUAN)

Du Plooy (1996 p.32) defines quantitative research as methodologies that "manipulate variables and attempt to control natural phenomena. They construct research questions or hypotheses and test them against the facts of 'reality'." According to Allen et al. (2009 p.3), quantitative researchers are essentially concerned with how an understanding about a specific phenomenon can be generalised to a larger population.

Similarly, Maree (2012 p.145) define quantitative research as "… a process that is systematic and objective in its ways of using numerical data from only a selected subgroup of a universe (or population) to generalise the findings to the universe that is being studied". In describing the quantitative research process, Van Wyk (2010 p.89) states that the aim of such studies is to generalise about a specific phenomenon, based on the findings obtained from a sample that is representative of that population. Here the findings may be statistically manipulated "to produce broadly representative data of the total population and forecasts of future events under different conditions" (Van Wyk, 2010 p.89). Furthermore, quantitative research is specifically concerned with measurement and control (Du Plooy, 2002 p.82, Terre Blanche et al., 2006 p.272), the quantification of constructs (Babbie et al., 2007 p.49) and facts and objectivity (Durrheim and Painter, 2006 p.132).

6.3.3 Differences between qualitative and quantitative research

Qualitative research provides more degrees of freedom. By contrast, qualitative research addresses these shortcomings because it allows the researcher to clarify vague questions and provides the platform for objects under research and participants to supply detailed answers and to elaborate. According to Mouton and Marais (1990 pp.155-156) and Fouché and De Vos (2007 p.102), qualitative research differs from quantitative research in three main points. Firsty, a less formalised structure is used, secondly the scope is more undefined and thirdly a more philosophical approach is followed.

The predominant differences between qualitative and quantitative research are summarised in Table 6-2 (Daymon and Holloway, 2011 p.13, Minichiello and Kottler, 2010 pp.18-20, Swart, 2010 p.113, Allen et al., 2009 p.3, Willis, 2007 p.7, Babbie et al., 2007 p.273, Fouché, 2007 p.269, Fouché and De Vos, 2007 p.102, Walt, 2006 p.79, Denzin and Lincoln, 2000b pp.8-10).

Table 6-2: The differences between qualitative and quantitative research

Qualitative research (QUAL)	**Quantitative research (QUAN)**
Analytical and interpretative	Predominantly empirical and experimental
Concerned with attaching meaning to phenomena	Focuses on measuring phenomena
Explicit and present values	A value-free stance is adopted
Focuses on answering “how questions”	Focuses on answering “what questions”
Improvisation is key in which the research strategy is developed throughout the research process	Structured, precise and consistent methods are used as well as a step-by-step recipe for the research strategy
Research is bounded by context, that is, the participants’ natural environment	Research is context free
A close relationship with research participants is evident	A distant relationship with participants is evident
Exploration of participants’ experiences and life worlds	Search for causal explanations and testing hypotheses
Intersubjectivity is vital to obtain the trust of participants	Maximum control over extraneous factors
Contextualisation is key	Generalisation is key
Authenticity is the criterion to achieve excellence in scientific research	Reliability is the criterion to achieve excellence in scientific research
Thematic analysis is conducted	Statistical analysis is conducted

6.3.4 Mixed methods research

With reference to Saunders et al. (2016) there are three major methodological categories. They are characterised as ‘mono’, ‘multi’ and ‘mixed’ methods. The mono method means that just one data collection procedure is applied in the research, whereas the multi method integrates more than one method for data collection, analyses and interpretation.

A multi method strategy can generate valuable additional insights coming from more than just one source or focus (Saunders et al., 2016). Saunders et al. (2016) brings it to the point by saying "mixed methods research is the branch of multiple methods research that combines the use of quantitative and qualitative data collection techniques and analytical procedures" (Saunders et al., 2016 p.169). As one can imagine by studying the different methods available in research, there are multiple ways and possibilities of combining them.

Directing the view on different ways of combining qualitative and quantitative data collection methods, there are convergent, sequential, embedded, transformative or multiphase research designs possible (Bryman and Bell, 2015 p.647, Creswell and Plano Clark, 2011 pp.69-70). Prior to, and during research it is essential to make decisions on the purpose (chapter 6.4), the time horizon (chapter 6.6). and the sampling strategies (chapter 6.7). As the research process needs continuous orientation and guidance from theory, data collection (chapters 6.9 to 6.11), analysis procedures (chapter 0), verification and validation strategies (chapters 6.11, 6.12, and 6.13) essentially need to be considered and determined. Specific procedures of theory are, for example, described by Creswell and Plano Clark (2011), Hanson et al. (2005), and Plano Clark (2005) as cited in Creswell and Plano Clark (2007 p.80). Their specific choice then tailors an appropriate design to the given research problem.

6.3.5 Applied in research design

This study faces a complex problem, which is identifying the processes and stakeholders on *Legionella* water safety and prevention in hospitals to create a framework for estates and facilities management with focus on England. From the above explanations it becomes evident, that just a mono method or a multiple method would not be enough to answer the research problem sufficiently. The specific and careful consideration and determination of combining different methods and sources of data is seen the best way of achieving that goal (Figure 6-5).

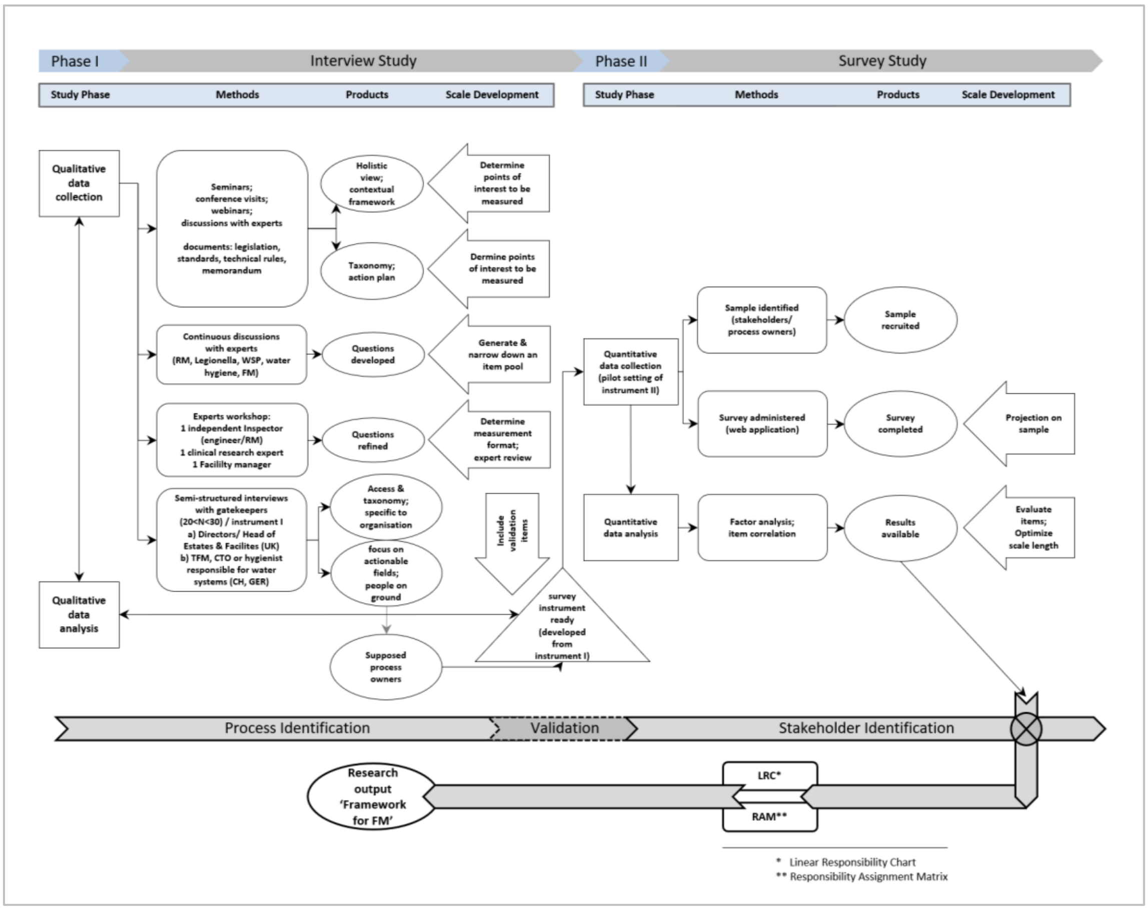


Figure 6-5: Conjunction of interview and survey study findings - basis for a framework (Leiblein et al., 2017c)

Regarding the connection of results of collected and analysed data within and over different phases, a decision was made whether quantitative leads to qualitative phases or qualitative builds to quantitative phases. In this research, mostly qualitative data was collected, where in some phases scales were defined in such a way, that quantitative analyses became possible. They are limited to descriptive and do not allow for statistical analyses.

Selected from the different types of mixed methods designs, an embedded design was applied in the research project where a subordinate quantitative design is embedded into a qualitative research design. One of the strategies for defining the object of analysis was the mixed methods case study, which is described in chapter 6.5, which needed cases and participants. However, when the researcher contacted responsible people of hospitals to request an interview, few of these senior management professionals were willing to grant an interview owing to the time consuming nature of one-on-one or telephone interviews and their responsibilities at executive level. Martins (2010 p.162) confirms this by stating that "... with interviews lasting from 30 to 60+ minutes it is sometimes difficult to obtain the cooperation of respondents". The same problem was evidenced in a rather long web-based survey of about 25 minutes time required for completion. But the extensive character was necessary to collect any possible data in this potentially difficult environment for data collection success. As stated by Miles et al. (2014 p.42) "We have to face the fact that numbers and words are both needed if we are to understand the world".

The application of a mixed method approach was seen as the right element enabling the combination of inductive and deductive elements (Sekaran and Bougie, 2016 p.106). It was therefore chosen for this research. Sekaran and Bougie (2016 p.106) agree with Miles et al. (2014) that some research questions need qualitative and quantitative data in order to get meaningful findings. Specified and in detail, chapter 6.9 describes the data collection, the applied qualitative, quantitative and the conjunct applied mixed methods of the research design.

6.4 Purpose

Each research designed is made for a certain purpose. The purpose in research design represents a combined study as it covers exploratory (Du Plooy, 1996 p.32, Tustin, 2010b p.85, Cargan, 2007 p.188, Robson, 2003 p.59, Mouton, 2002 p.108, Baker, 1999 p.204), descriptive (Saunders et al., 2016 p.175) and explanatory (Saunders et al., 2016 p.176) elements (Saunders et al., 2016 pp.174-176). Babbie et al. (2007 p.88) identifies the following three purposes of exploratory research, a) to address the researcher’s understanding of a specific phenomenon, b) to test desire to acquire better the viability of an extensive research study, and/or c) to develop methods that can be employed in future studies. In line with these purposes, the aim of this study is to obtain a better understanding of the processes and stakeholders on *Legionella* water safety and prevention in hospitals in order to elaborate a framework for estates and facilities management with focus on England. Methods, data and findings, resulting in that specific framework, can be used as a basis for future studies and can also be customised for, and applied by specific stakeholder groups. With respect to the research objectives according to chapter 1.5, research objective 2 can be categorised as descriptive, 4 explanatory and 1, 3, 5 and 6 explorative. This is to be understood in their primary character. Of course, one can argue, that there may also be elements in between these types of gouping. A combination of different purposes in research design can be used in a mixed methods research project, as stated by Saunders et al. (2016 p.176).

6.5 Research strategy

A strategy gives a framing element to any endeavour. Thus, the research strategy chosen will continuously guide and organise the steps of this research. It defines a certain logic of doing the research. The next sections will inform about the research strategy applied in this research. Decision making of applying the right strategy is subjected to the research philosophy (chapter 6.1) and the approach of theory development (chapter 6.2). In that context, both the research question and the aim of the study, are the ultimate elements for deveoloping a research strategy that is tailored to the research context and the proposed research environment (Saunders et al., 2009 p.141).

The research strategy applied in the research project followed an embedded design investigating cases, which consider the situation of hospitals with regard to water safety management and *Legionella* prevention. In the words of Yin (2014 p.16), a case study is “an empirical inquiry that investigates a contemporary phenomenon […] in depth and within its realworld context, especially when the boundaries between phenomenon and context may not be clearly evident”.

Yin also says the ‘contemporary’ phenomenon is another description for ‘the case’. A phenomenon, or ‘defined case’, was focused on in-depth and within its real context, the hospital environment. In addition, a specific problem was diagnosed and studied. These elements are, according to Wilson (2010 p.108), indicators for a case study. But there are also elements of survey (Saunders et al., 2016 p.728) and action research in this research, according to Saunders et al. (2016 p.178). One can even refer certain parts to grounded theory according to Strauss and Corbin (1998 p.12) as cited in Bryman and Bell (2015 p.584). Especially when arguing that the final framework output shall be understood as guiding reference, coming from pactitioners, developed with the instruments of research, and made public for the purpose of being applied in practice. The framework shall be the result of the development of a collaborative solution which is built on a diagnosed problem (Bryman and Bell, 2015 pp.418-419). Details of the strategy for developing the frameword by conducting different research phases is described in chapter 6.12.2. In the research progess the decision for case study research was defined at a very early stage to build up research on collected numbers of cases following certain criteria (Figure 6-6).

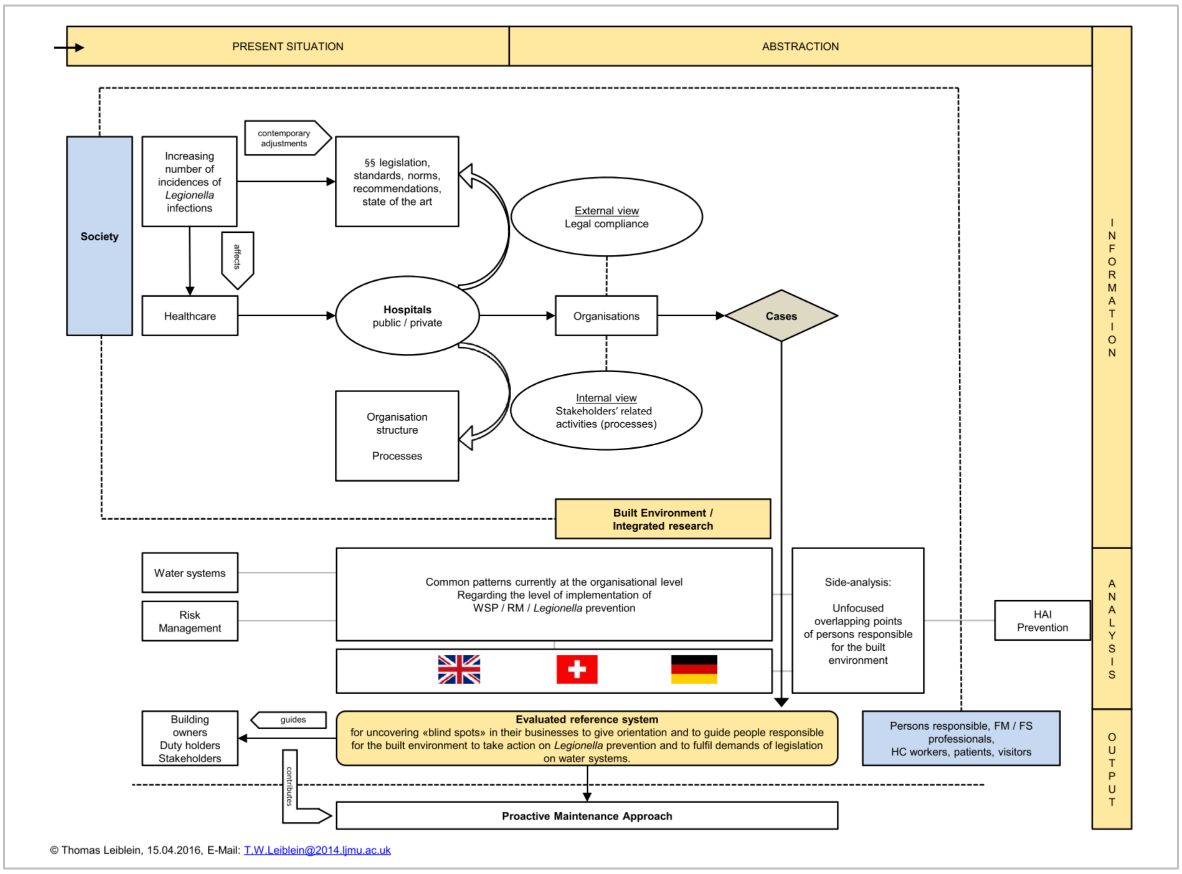


Figure 6-6: Initial case study framework (Leiblein et al., 2016 p.891)

According to Yin (2014) there are two dimensions with respect to case studies. In a first dimension two different types of case studies can be defined: single and multiple case studies. This case study strategy incorporates multiple cases, which is more than one. “The rationale for using multiple cases focuses on whether findings can be replicated across cases. Cases will be carefully chosen on the basis that similar results are predicted to be produced from each one” (Saunders et al., 2016 p.187, Yin, 2014 p.50).

That means a case definition and selection criteria are essential to be made to deep-dive into the study object of interest. Case definition may be viewed as an iterative research process. It had to be finalised before starting the research project with focus in England. As a result of a finding described in chapter 6.9.2.1 the case study environment, in which the object of analysis is embedded, is "healthcare in England (as part of the United Kingdom)". The unit of analysis is the hospital's Estates or FM department. The object of analysis is "water safety and the process of *Legionella* prevention and risk management" (see Figure 6-7 in chapter 6.9.2.1). Accessing organisations will be realised by interviews with responsible persons, which are, for example Heads of Estates and Facilities of NHS Trusts, NHS Foundation Trusts and similar positions (see also Table Appendix A-14 in chapter 6.9.7.1). A decision criterion for participants being considered for the research project is that they must be members of a water safety group or water safety management group, as this group may also be called (Leiblein and Maynard, 2019).

The second dimension for case studies is a holistic view and an embedding regarding the span of focus (Saunders et al., 2016 p.187, Yin, 2014 p.50). This could be, for example, that a whole organisation is being studied, considering all relevant elements of this specific organisation. It could also be the case considering specific, selected departments. Therefore an embedded approach is used (Saunders et al., 2016 p.187). For this research project context, a multiple embedded case study was conducted. It is perfectly in line with the quotation of Miles et al. (2014 p.33) that "multiple-case sampling adds confidence to findings".

According to Plano Clark and Ivankova (2016 p.146) "A mixed methods case study is a research design in which researchers embed quantitative methods within a case study design to enhance the application of the case study for examining the case(s)". This can be helpful for getting a better overview about the characteristics of specific cases. The decision for this approach supports qualitative and quantitatieve methods to work out meaningful results out of a small number of cases (Plano Clark and Ivankova, 2016).

6.6 Time horizon

It is important to define and understand the time horizon of a research as it may have an influence on the quality, quantity and currency of data collected. For this research design a cross-sectional approach has been choosen. A specific phenomenon is in the focus of the research activities and data collection is done selectively on a short period of time.

On the one hand, the assignment to this classification can be justified by the subdivision of the research project into several data collection phases (see chapters 6.3.5 and 6.12.2). On the other hand, characteristics can also be found within the individual data collection phases that can be assigned to a cross-sectional approach. Despite the fact that the project took several years, and within which different strategies had to be developed and applied in order to obtain data, it cannot be regarded as longitudinal. The reason for this is that data collected within the defined case (hospital) is placed in an overarching context by means of analyses.

The phenomenon defined by the research case, which is investigated, is answered step by step by including and studying individual cases (hospitals).

Data is collected and analysed in different phases. The data of the included cases (hospitals) are not collected at the same time and hospitals are not accompanied and studied over a longer period of time. Instead, it is important to capture the picture as comprehensively as possible in order to create a practice-oriented framework based on the results.

6.7 Sampling strategies

Also for the sampling the strategy gives a framing element. The sampling strategy orientates the data collection, that is, to achieve the objectives, and thus, collecting data to answer the subquestions and the research question.

6.7.1 Theory

According to Bryman and Bell (2015 p.14) sampling is the “selection of sample relevant to the research question”. Or, in the words of Flick (2010 p.125), “sampling strategies describe ways of disclosing a field”. There are two main strategies for sampling that can be distinguished. They are non-probability and probability. The difference is the choice of each case being selected from the target population. For non-probability samples “the probability of each case being selected from the target population is not known and it is impossible to answer research questions or to address objectives that require you to make statistical inferences about the characteristics of the population” (Saunders et al., 2016 p.276). In contrast, with probability samples “the chance, or probability of each case being selected from the target population is known and is usually equal for all cases” (Saunders et al., 2016 p.275).

Miles and Huberman (1994 p.28) describe forms of sampling for qualitative research, which are more or less systematic and more or less pragmatic. Purposive sampling is a selection of cases solely on reasons referring to the research question (Saunders et al., 2016 p.301). Purposive non-probability sampling may be one of six different subtypes, based on how the case selection is done. Saunders et al. (2016 p.298) distinguish between extreme case, heterogeneuous, homogeneous, critical case, typical case, an theoretical. Sampling in qualitative research is seriously is a way of managing diversity (Creswell and Plano Clark, 2011). It aims at capturing the variation and variety in the phenomenon under investigation by studying the empirical material, of course, as far as possible, and limited to the methodological choice. The sampling strategy pursues a certain goal. Patton (Patton, 2002) suggests alternatives of purposive sampling. Placed in the theoretical context of the research project, they are relevant for the decision made in chapter 6.7.2. In his list of alternatives, Patton (2002) mentions the criterion of convenience, which refers to the selection of those cases that are the easiest to access under given conditions. However, this is not really a suggestion for how to plan a sampling but rather a second-best choice, if none of the more defined alternatives can be applied. Although this strategy may reduce the effort, it should only be chosen if it is the only way to do a study. This because of limited resources of time and people or due to problems of applying a more directed way of sampling.

Miles and Huberman (1994 p.28) mention the use of a homogeneous sample in particular for interviewing or of a theory-based sample derived from a specific theoretical construct, which is to be elaborated empirically. They also suggest mixed forms like a random purposeful sampling, when a consistently purposeful sampling would produce too large numbers of cases to be handled. Or they suggest stratified purposeful sampling, based on building subgroups in the sample for comparison. They also suggest mixed sampling, which is putting multiple interests and needs into concrete terms in one sample. Finally, they list snowball sampling, which is going from one case to the next, asking interviewees for other people who might be relevant for the study and the like.

6.7.2 Applied in research design

For this research project a purposive non-probability sampling strategy was applied. The category ‘heterogeneuous’ (Saunders et al., 2016 p.298) is presumably the one representing best the cases of this research as elements of Patton’s (2002) described ‘limited resources’, ‘accessibility’, ‘mixed sampling’ and ‘snowball sampling’ can be identified.

6.8 Literature review

One of the first steps is to structure one's own research work on the basis of known, already published information. In order to build research upon a solid foundation guiding and justifying the direction of the research project, the first empirical step begins with systematically reviewing the field of research interest.

6.8.1 Theory

Blumberg et al. (2011) gives a further function to the purpose of a systematic review. It forms a “scientific contribution to the field. The primary objective of a systematic review is the evaluation of a research field through assessing a complete set of the relevant studies covering the field.” (p.114). According to Wilson (2010 p.55) “A literature review can be described as ‘identifying, evaluating and cirtically assessing’ what has been published on your chosen topic”. Easterby-Smith et al. (2012 pp.102-103) complements that a systematic review helps the researcher to find out specific needs of a research field and it guides to later placing and fitting one’s own results into a specific research context.

With the interpretation of Saunders et al. (2016 p.73), Wilson (2010 pp.57-61), a literature review is a process starting with the defined research question and the related objectives. As a consequence, the results of the literature review are used to better know about potential areas of research onto which the focus of the research can be spotted or onto which the focus can be sharpened. It also aids in formulating the research question, the aim and the objectives of this research project.

6.8.2 Applied in research design

The literature review was done by referring to the key areas described in chapters 2, 3 and 4. They all relate to the research question and the aim (Easterby-Smith et al., 2012).

The specific review results are summarised in chapter 5. It was the purpose of the researcher to build research on a solid foundation. For that, the initial literature review was undertaken before data collection began. Nevertheless, accompanying literature was continuously added to the research project. The main task of the literature review is to identify available literature that underpins the legitimacy of the research project. In particular, the search aimed at literature on business focused research in healthcare, water safety management, risk management and *Legionella* prevention. All of that with a focus on processes and stakeholders. However, the extent to which the relevant standards and technical rules in the United Kingdom (e.g. BS8580, the HTM04, ACoP L8, documents of the WMSoc) can actually be found in the management of the individual hospitals, can be empirically investigated with this work. The empirical approach following the literature review uses qualitative research methods that include interviews, document analysis, an online survey and focus groups for validation (see chapters 6.9.3 to 6.9.6).

6.9 Data collection

Among the different types of data collection reported by literature four are highlighted specifically that are selected for this research. They are ‘semi-structured one-to-one interviews’, ‘documents and other secondary data’, ‘web-based survey’ and ‘focus groups’. This chapter introduces each of these specifically after presenting references to theory and the contextualisation of the sampling design.

6.9.1 Theory

According to Aldridge and Levine (2001 p.6), Singh (2007 p.69), Martins (2010 p.144), and Maree (2012 p.155), both one-on-one interviews and web-based surveys, are examples of survey research which can be defined as “the assessment of the current status, opinions, beliefs, and attitudes by questionnaires or interviews from a known population” (McMillan and Schumacher, 2001 p.602). The difference between the two data collection methods is that the interview is qualitative and administered by the interviewer. This means that the researcher guides the interview (Martins, 2010 p.143). The progress of doing the interview is guided by an interview guide (Martins, 2010 p.162). In contrast, the web-based survey focuses on obtaining qualitative and quantitative data. The survey is self-administered, which means that the respondents complete the questionnaire by themselves (Lighthelm, 2007 p.184).

For the purpose of this study it should be noted that the qualitative interview should not be confused with an in-depth field research interview, where the researcher is interested in the actions of the participants in their natural environment (Babbie et al., 2007 p.305). The questions are rather developed too deeply go into the working environment of the interviewee in the sense of understanding their processes and duties. But this procedure does not comply with the definition of an in-depth field research interview. To put it further, in the interview study phase Ib (UK context), the researcher should be able to apply the respondent’s expertise to the understanding of the processes and stakeholders in order to compile a framework.

The advantages of using survey research are that responses can be obtained from a large number of respondents. It also provides strong generalisability because the survey is often conducted in the respondents' naturalistic setting (Allen et al., 2009 p.11). According to Aldridge and Levine (2001 p.12) it does provide the researcher with descriptive material, which can be further explored. Although a survey does not really allow the researcher to make causal inferences, thereby not providing "cause-effect relationships among variables" (Allen et al., 2009 p.11). The data collection approach for this study allows the researcher to follow up and further explore the data obtained from different sources of interviews of two research phases (Ia and Ib) and develop a web-based survey (phase II) that feeds the framework.

6.9.2 Sampling design

The next sections focus on the unit of analysis, population, sampling frame, sample and the sampling methods.

6.9.2.1 Unit of analysis

According to De Vos (2007 p.104), the unit of analysis becomes evident when the research problem is defined, since the researcher has already decided whether individuals, an event or organisations will be explored. According to Mouton (2002 p.47&p.91) the unit of analysis is the "furniture of the social world" – it is the objects or entities to which the findings of the research apply or the elements on which summary descriptions are created (Babbie et al., 2007 p.85). Various categories of unit of analysis are identified by Mouton (2002 p.91), namely individuals, organisations, institutions, collectives, social objects, social actions or events and interventions. Since this study focuses on obtaining the insights of processes and stakeholders for a certain area of responsibility, the unit of analysis for the purpose of this study is specific departments of specific organisations, which are hospitals Figure 6-7.

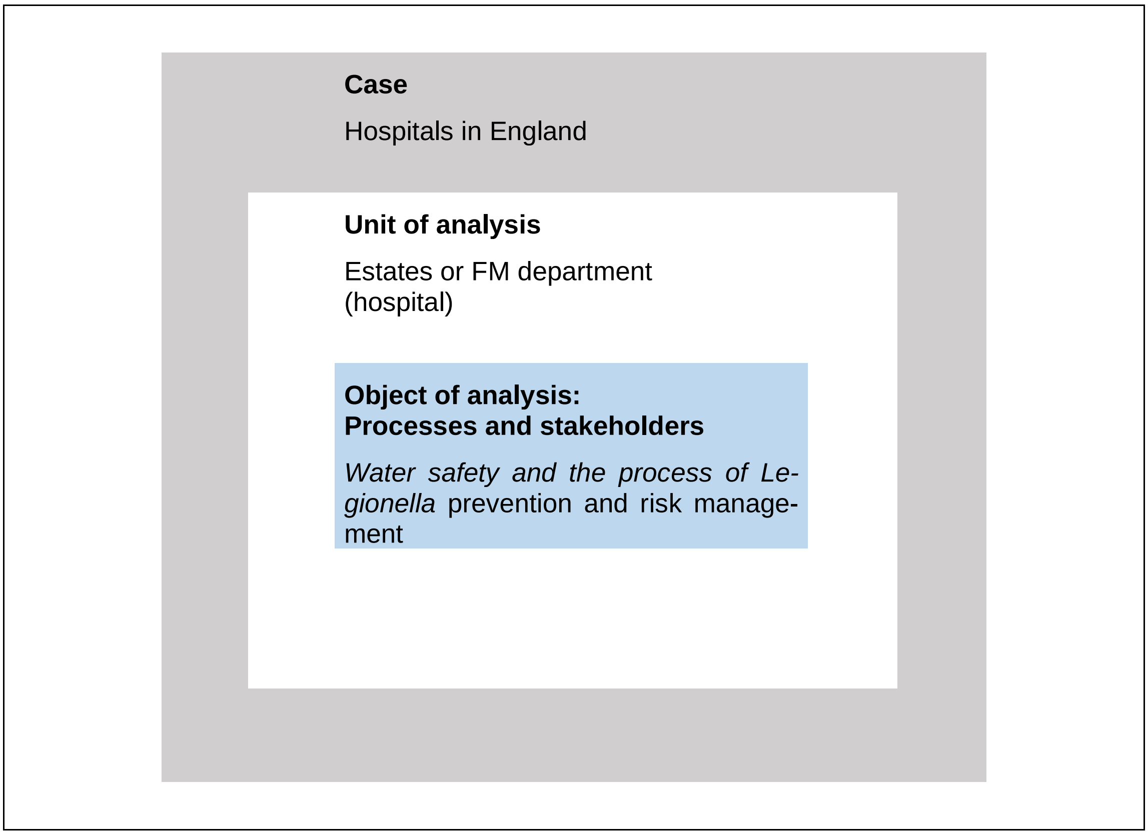


Figure 6-7: Case environment

6.9.2.2 Population

The population is the "universe of units" (Bryman, 2001 p.85) or "totality of units" (Daymon and Holloway, 2011 p.209) from which the sample is drawn, and is defined as "… the totality of persons, events, organisation units, case records or other sampling units with which the research problem is concerned" (Strydom, 2007 p.194). The population is therefore the overall figure or phenomenon the researcher is interested in investigating (Thomas, 2011 p.61) and is the entirety of sampling units relevant to the research problem (Maree, 2012 p.147).

For the purpose of this study existing hospitals in Germany, Switzerland and England (phase Ia), respectively England (phases Ib and II) list the potential population. They include the processes and stakeholders under investigation. It was expected that only a small number of these organisations would be accessible. To judge the sampling frame (Table 6-3), it is essential to understand the thoughts presented in chapter 6.9.2.4.

6.9.2.3 Sampling frame

Maree (2012 p.147) define the sampling frame as a "list of all the units in the population in which each unit is uniquely numbered or can be uniquely identified". Mouton (2002 p.135) refers to the sampling frame as the collection of cases from which the actual sample will be drawn, which serves as the basis for sampling. According to Babbie et al. (2007 p.199), to ensure that the sample is representative of the population, the sampling frame should include a large number of members of the population.

Table 6-3: Population and sampling frame

	Germany	Switzerland	England	**Represented in research**
Number of hospitals in research	3 phase Ia →	2 phase Ia →	3 phase Ia → 11 phase Ib → 16 phase II →	**35 in total** ↑ 8 phase I a 11 phase I b 16 phase II
Total number of hos-pitals in country	2017 (Klauber et al., 2015 p.360, Table 20-1)	288 (BAG, 2017 p.3, Table 1)	1920 (Statista, 2017)	

Tustin (2010d p.337) and Fouché and Delport (2007 p.82) state that a sample is a "subset of a population" or a "small representation of a whole". Since this study identifies processes and stakeholders of a very specific and selected topic in a very sensitive business environment (hospitals / healthcare setting) it became evident, that different strategies of approaching hospitals had to be tried to increase the likelihood that these specific addressees would answer the interviews and the survey (see chapter 6.9.7). Yet, a total of 35 organisation individuals of the theoretical sampling frame indicated their willingness to participate in the study, which comprises the sample of this study. As the type of study of phase Ia contains elements attributed to an international, multisite study, challenges in international studies (e.g. language barriers) have been considered (Tate et al., 2017 p.474).

The next section investigates the sampling methods used in the study.

6.9.2.4 Sampling methods

Sampling methods can either be categorised as probability samples, which are utilised in quantitative research, or as non-probability samples, which are generally used in explorative, qualitative research (Strydom, 2007 p.327), (Cargan, 2007 p.242). Since a specific sampling procedure is applied in line with the exploratory nature and predominantly qualitative research approach, non-probability sampling methods were used in this study. However, it should be noted, that the results of the survey would only be applicable to the realised sample and it would not be possible to generalise the results to the population of this study, because each organisation in the population did not have an equal chance of being selected (Tustin, 2010d p.344). Furthermore, the rationale behind the sampling procedure was to purposively obtain a sample of hospitals that were willing to participate in the interview and survey study to obtain insights for identifying the processes and stakeholders on *Legionella* water safety and prevention in hospitals in order to elaborate a framework for estates and facilities management with focus on England. In line with the sampling process explained above, the following two sampling methods were applied: purposive and convenient sampling. Purposive sampling is based on relevance (Gibson and Brown, 2009 p.56) and can be defined as "a type of non-probability sampling in which the units to be observed are selected on the basis of the researcher's judgment about which ones will be the most useful or representative" (Babbie et al., 2007 p.184).

Purposive sampling requires the researcher to have knowledge of the participants involved and any bias that may occur in the selection of participants cannot be controlled (Cargan, 2007 p.243). For the purpose of this study, purposive sampling was applied in two ways: Firstly, since this study was specifically concerned with identifying processes and stakeholders on water safety management in hospitals across Germany, Switzerland and England (phase Ia) respectively England (phases Ib and II), these were purposely selected. Secondly, since this study was based on estates and facilities management with a water safety management perspective, only the senior professionals in these organisations were purposely approached to participate in the study.

A convenience sample, also referred to as an accidental, available or opportunity sample, is drawn from the “units of analysis that are conveniently available” (Du Plooy, 2002 p.114) or “readily accessible” (Cargan, 2007 p.242). According to Mabry (2008 p.223), convenience sampling will always be a key consideration in any sampling strategy, since the willingness of participants could be limited or access to a site or documents could be restricted, which forces the researcher to conduct the study with the elements or participants that are available. In line with these arguments, convenience sampling was applied in this study because only those organisations that expressed their willingness to participate were included in the sample. Furthermore, one-on-one interviews were also only conducted on site with senior professionals who were conveniently available and actually willing to participate. If they were not physically available, a more convenient way in doing telephone interviews (one-to-one / telephone or internet-mediated interview) was chosen.

6.9.3 Semi-structured one-to-one interviews

Berg and Lune (2012 p.105) give a simple definition for interviewing. They see it “as a converstation with a purpose”. A more detailed view is given when categorising interviews by a structural level. There are three commonly known different types. They are unstructured, semi-structured and structured interviews (Saunders et al., 2016 p.390, Berg and Lune, 2012, Easterby-Smith et al., 2008). A semi-structured interview can be defined as an interview in which the researcher utilises an interview schedule with predetermined questions to guide the interview, but not to dictate the interview (Greeff, 2007 p.296). It also allows the researcher to deviate and ask follow-up or probing questions based on the participants’ responses (Du Plooy, 2002 p.177).

Interview types can further be distinguished by the setting in which the interview is held. There are one-to-one or one-to-many situations (Saunders et al., 2016 p.392). With reference to Saunders et al. (2016 p.392), there are three sub-types of one-to-one interviews. They are one-on-one, telephone and internet-mediated interviews and depend on the type of communication and where the interview is conducted. One-on-one interviews are “… conducted on a one-on-one basis to collect qualitative data from respondents” (Martins, 2010 p.162). Greeff (2007 p.296), Gibson and Brown (2009 p.86), Alvesson (2011 p.9), and Thomas (2011 p.162) distinguish between three types of one-on-one interviews, namely unstructured, semi-tructured and structured interviews.

For the interview situation one-to-many, there are numbers of different terminologies (Saunders et al., 2016 p.416). Two main categories are group interview and focus group (Saunders et al., 2016 p.416). As ‘focus group’ is one specific element of a separate phase of this research project (phase III), it is explained in more detail in chapters 6.9.6 and 6.9.7.4.

Group interviews are, according to Saunders et al. (2016 p.419), interviews where a moderator (e.g. researcher) needs to ensure each participant has an equal chance to share his or her opinion. There are similarities in the structure of group interviews and focus groups. Of these, the element of the focus group was seen appropriate for the research progress. The advantage of the semi-structured interviews is that "you can get the best of both worlds" (Thomas, 2011 p.163), which implies that it gives structure to the discussion and affords participants the opportunity to introduce new topics at the same time (Greeff, 2007 p.296). Further advantages and disadvantages associated with one-on-one interviews in general are presented in Table 6-4 (Greeff, 2007 p.299, Babbie et al., 2007 p.267).

Table 6-4: Advantages and disadvantages of one-on-one interviews

Advantages	**Disadvantages**
• Relatively quick access to large amounts of valuable data. • Depth of data and access to experts' and practitioners' knowledge. • Opportunities for probing to encourage the participants to further elaborate. • Requests for secondary data, which support in understanding processes, organisational structures, stakeholders, rules of collaboration, policies, process environment.	• Requires (personal) interaction which requires cooperation. Achieving this goal when doing the interviews on-site in different countries is difficult, because it may be time- and cost consuming. For that, an explicit and clear communication is the key to access. • Participants may be unwilling to share information. • The researcher may ask questions that do not evoke the desired response. • Participants may not tell the truth or provide accurate answers (motivations e.g. fear, pressure, lack of time, frustration, pragmatism).

The selection of the type of an interview also determines the type of relationship between the researcher and the participant. The following issue pertaining to the relationship, as highlighted by Daymon and Holloway (2011 pp.235-236), was also taken into consideration as people at management were interviewed:

- "Difficulties may arise when the researcher has to interview participants in status positions, since these participants usually drive their own agenda. This was the case in this study. It requires patience of the researcher and a diplomatic and tactful way of communication and phrasing of questions."

6.9.3.1 The design of the interview guide

According to Greeff (2007 p.296), the terms "interview schedule" and "interview guide" are often used interchangeably to refer to a question sheet to guide the interview, which provides the researcher with a set of predetermined questions to engage the participant(s).

Similarly, Thomas (2011 p.163) defines an interview schedule or guide as a list of issues that need to be addressed during the discussion. However, Aldridge and Levine (2001 p.6) state that an interview schedule is used in structured interviews and an interview guide in semi-structured interviews.

An interview guide during phase Ia (Figure Appendix A-3) and phase Ib (Figure Appendix A-6) instead of an interview schedule was the preferred term for this study. The advantage of compiling an interview guide prior to the interviews is that it assists the researcher to think openly about what he or she aspired to achieve in the interview and compels the researcher to review any difficulties that may occur during the interview (Greeff, 2007 p.296). Furthermore, an interview guide gives the discussion a logical order and allows the researcher to easily navigate between different parts of the discussion (Liamputtong, 2011 p.76).

The following sections will focus on question types and interview guide structures, as well as the measures that were employed to ensure that the questions in the interview guide were understandable and correctly interpreted.

6.9.3.2 Question types associated with a semi-structured interview

All interview types are based on questions, which can either be open-ended or closed. Open-ended questions allow the participant to formulate the answer with their own words, own explanations and own logic (Bernard et al., 2017 p.81). In contrast, closed questions are answered with one word or a few words, which can also be predefined by the researcher to be chosen for selection by the participant (ibid p.81).

Besides the focused questions in the interview guide that will be asked on the basis of the categories identified in the literature to address the research problem, a semi-structured interview also allows the researcher to ask other questions during the discussion to supplement the focused questions and to ensure the success of the interview (Liamputtong, 2011 pp.77-78, Du Plooy, 2002 p.176).

6.9.3.3 Interview guide categories

The purpose of the one-to-one interviews was not only getting access to a topic that is usually not easy accessible. It was necessary to work out topics of interest in hospitals in order to address theoretical issues identified in literature and getting the perspective of people responsible in order to build a fundament for the web-based survey to complete data collection.

More specifically, the interviews were used to explore and identify the needs in terms of processes and stakeholders in water safety risk management and *Legionella* prevention in hospitals to build the basis for a framework for estates and facilities management. For achieving this, it was necessary to address the finer details of each phase of the research project.

Although the one-to-one interviews were semi-structured, these predetermined questions enabled the researcher to guide the discussion during the interview and keep or bring it back on track. Furthermore, the interview guide categories facilitated the data analysis process. The semi-structured nature allowed the researcher to prompt, probe and develop new questions as the discussion progressed.

6.9.3.4 Pilot testing for improving quality of interview guide and questions

To determine the quality of the interview guide - as also later for the survey questionnaire of phase II - pilot testing was conducted for the one-to-one interviews. It is, according to Foddy (1993 p.185), guidelines for evaluating the proposed questions of the interview guide. Evaluation questions included the following specific scrutiny:

- Did the questions make the participants uncomfortable?
- Did the questions have to be repeated?
- Were the questions misinterpreted?
- Which questions were the most difficult to read?
- Did any sections of the interview seem to be too long?
- Were there any sections in the interview that required further elaboration?

Two pilot one-to-one interviews were conducted for phases Ia and Ib with independent participants, who were not included as participants or respondents during data collection phase. They were professionals with more than 25 years of international experience in the field of water safety management. Since the one-to-one pilot test interview participants had background knowledge of the study because of the researcher’s requests and explanations (teaser) for getting motivated for pilot testing, it was of great advantage to also integrate both for pilot testing in the later stage of the research, the web-based survey. Here, two additional experts, specifically in the UK context, gave feedback on the survey content and structure to accurately determine the quality of the questions. Their written feedback is exemplified in Figure Appendix C-4.

6.9.4 Documents and other secondary data

A general definition on secondary data is “data that were originally collected for some other purpose. They can be further analysed to provide additional or different knowledge, interpretations or conclusions” (Saunders et al., 2016 p.727). Thus, secondary data is raw data and published data which has been collected for a purpose other than that which it is used for in the present context or stage of the study (Saunders et al., 2016 p.316). Such data includes both quantitative and qualitative data and can be distinguished by three major categories. They are document based, survey based and received from multiple sources. It may be referred to a specific source and how the data has been collected (Saunders et al., 2016 p.318). Bryman and Bell (2015 pp.555-563) distinguish different types of secondary data with reference to the origin of the data. These are a) personal documents, b) public documents, c) organisational documents, and d) mass media outputs. In addtition they categorise secondary data by the way of how information is provided and accessed. This could likewise be visual data, virtual documents and text-based documents (Bryman and Bell, 2015 pp.564-567).

6.9.5 Web-based survey

Jansen et al. (2007 p.2) identified the three categories of collecting survey data online, which are ‘point of contact’, ‘e-mail based’ and ‘web-based’. The point of contact type is characterised by where the respondent completes the survey on a computer provided by the researcher.

In the e-mail-based category a survey is delivered via e-mail to respondents and the data are manually coded by the researcher. In a web-based survey the survey resides on a network server that is accessed via a web browser. That case does not require the researcher to manually code the data. A survey usually consists of a set of questions, which can also be termed a type of questionnaire. Saunders et al. (2016) categorise ‘delivery and collection questionnaire’, ‘interviewer-administered questionnaire’, ‘online questionnaire’, ‘postal questionnaire’, ‘self-administered questionnaire’. Generally speaking they define questionnaire is a “general term including all data collection techniques in which each person is asked to respond to the same set of questions in a predetermined order” (Saunders et al., 2016 p.725).

6.9.6 Focus group

Focus groups became widely used in marketing research during the 1980s. The original source is found in sociology. Today focus groups are used for diverse research applications and in different science disciplines, for example business research. There are numerous books on doing focus groups. Helpful guidance on conducting virtual focus groups is also provided and considered for this research project (Stewart and Shamdasani, 2014).

Many corporations are using focus-group results for exploratory applications. As a group interview tool, focus groups have applied research potential for functional areas of business. Especially where the generation and evaluation of ideas or the assessment of needs is indispensable. In exploratory research the qualitative data that focus groups produce may be used for enriching all levels of research questions and hypotheses (Blumberg et al., 2011 p.157).

Focus groups can even be applied for the purpose of validation. According to Blumberg et al. (2011 p.269) a focus group is a panel of people. They are “(…) led by a moderator, who meet for one to two hours. The facilitator or moderator uses group dynamics principles to focus or guide the group in an exchange of ideas, feelings and experiences on a specific topic” (Blumberg et al., 2011 p.269). Usually a focus group is held with eight to ten participants and a moderator (Sekaran and Bougie, 2016 p.121). The researcher, who operates as moderator, intends to produce a group setting that “stimulates discussions that would not occur in simple two-person interactions and encourages people to explore similiarities and differences of opinion”, according to Patton 1987 as cited in Bernard et al. (2017 p.87).

The past chapters described the theory of different types of data collection. The next chapter applies this theory to the research project and exemplifies the procedures used during the course of research.

6.9.7 Applied in research design

The following chapters present in detail the specific nature of methodology applied in this research.

6.9.7.1 Semi-structured interviews

In this study, semi-structured one-to-one interviews were conducted with eight and eleven participants in the realised sample of phases Ia and Ib respectively.

For that, a catalogue of questions for both interview studies was compiled. The semi-structured interviews required semi-structured data collection instruments (Blumberg et al., 2011 p.246).

The researcher considered the following requirements of semi-structured interviews, which required the interviewer to focus on guiding the conversation around the research topic. In each situation he managed the course of the interview without distracting the natural flow of the discussion.

He also had to sense when a certain topic had been exhausted and when it was time to move to the next element of the interview. The researcher supported the participants to connect the various topics under discussion in order to see the collective whole of the interview. Finally, he had to manage the time of the interview and evaluate the significance of information while it was being produced (Gibson and Brown, 2009 p.88). In addition to these requirements, the researcher also probed for responses to make sure that the participants elaborated further on those answers that were either incomplete or unclear (Babbie et al., 2007 p.269).

One of the objectives of the semi-structured one-to-one interviews in this study was to explore the gaps of knowledge and reporting in topics of water safety and *Legionella* risk management from the perspective of estates and facilities management that were found in literature. Another intention was identifying the areas of interest to further elaborate the questions for the web-based survey. The participants of the interviews all held senior management or executive positions in estates and facilities management. The interviews were recorded by means of a dictaphone with prior permission from the participants. Although recording of interviews can make participants uneasy, it ensures that the researcher is not distracted by taking notes. Furthermore it provides a complete record of the interview and the participants can follow the researcher's interest in the answers supplied (Kelly, 2006 p.298). According to Babbie et al. (2007 p.266), recording an interview is essential to ensure accurate interpretations and analysis. However, the dictaphone should be placed out of sight so as not to unnerve the participants (Greeff, 2007 p.298). A complete record of the interviews therefore enabled the researcher to compile a full transcription of each interview to facilitate data analysis. In parts the researcher did the transcription himself, which allowed him to immerse himself in the data and focus on certain key issues (Daymon and Holloway, 2011 p.234). Where the researcher used the support of a transcription service, as described in chapter 6.10.2, he did not fail to check and revise the output results for achieving the highest levels of desired accuracy and completeness.

6.9.7.1.1 Iterative development towards interview questions

For phase Ia and Ib the interview questions were developed by the researcher and then discussed and piloted with each of the two experts in their professional field. The interview guide was then revised to clarify language and improve content capture prior to the initiation of the study. The focus of these discussions was laid on the overall structure and understandability. There was also seen a chance of discussing and complementing the questions with aspects of contemporary issues with the experts are confronted in their experience in consulting, research, public work or governmental limitations.

Each discussion with the experts was carefully considered for taking influence on the proposed focus of the questions, that were based on preliminary results of the literature review (Tate et al., 2017).

They were held as one-to-one one-on-one discussions. During the discussions field notes were placed on the draft version of the interview questions for later consideration.

There were two consecutive phases of interview studies designed in this research project with each based on a different interview guideline. The interviews held in the England, Germany and Switerland (phase Ia) were eight semi-structured, one-to-one telephone or internet-mediated (3) and one-to-one one-on-one (5) interviews. Phase Ib comprised eleven interviews with experts in England and were semi-structured one-to-one / telephone or internet-mediated.

The initial interview guide was further refined through iterative review of small batches of interview transcripts as the study enrolled subjects. Based on these reviews, the interview guide was adapted partway through interview recruitment to clarify the wording of an interview prompt. The researcher was thereby guided on giving more space in terms of time to questions where there is a higher potential of receiving comprehensive answers in the sense of answering the research question.

6.9.7.1.2 Two interview studies initiate data collection

During the interview study phase Ia, a minimum of two interviews was held likewise in England, Germany and Switzerland with people responsible for water systems in hospitals. In places where a visit on site was not possible, telephone or internet-mediated interviews were held (Skype, Adobe connect). The intended interviewee target group were gatekeepers to the organisation in a «typical» estates, FM or role of equivalent job positions. There was a threefold set of aims in conjunction with this first step of research. Phase Ia itself is an important pilot stage (6.9.3.4) and thus, a very exploratory phase. It shall confirm the procedures chosen and test whether or not the strategy for data collection can be handled. Furthermore, it gives the chance to modify the data collection process in an early phase of the research project if seen necessary. The three aims are to

- Explore job descriptions and functions in hospitals that have a connection to *Legionella* risk management of water systems and water safety management
- Test the fluency of the procedures selected for data collection, which especially means accessibility to interview partners of a certain management level, their willingness to participate, the quality of answers, the amount and variety of purposeful data
- Verify and confirm the case strategy chosen. In this context, ‘case’ is to be understood according to the interpretation of Yin (2014) and Saunders et al. (2016), as reported in chapter 6.9.2.

6.9.7.1.3 Selecting and accessing interview partners

Mainly the interview study phase Ib is to figure out job titles, a set of descriptions, functions of people responsible for water safety in hospitals and reflect a better picture on their affiliation within the organisation. The target group was set as Head of Estates and Facilities of NHS Trusts, NHS Foundation Trusts, NHS hospital Trusts or similar positions. All eleven interviewees hold positions of higher management and meet the criterion of their affiliation.

The aim at this stage of data collection is to get deeper and more specifically into the topic of stakeholders and process owners.

It shall access estates and FM representatives of hospitals, gain deeper knowledge on the organisational structure and the process of *Legionella* prevention and water safety and get an impression of the understanding of processes in a hospital as an organisation.

For that, there were applied open and closed ended types of questions. Before the questions were finally set up, there were two deliberations considered for compiling the interview guideline:

- Closed-ended questions were included, although a sample of 11 interviews was too small for any statistically significant analysis. Although closed-ended questions are more typical for analysis and quantification with a statistical purpose, those questions were included. It can be reasoned by the fact that the questions were seen relevant to gain basic evidence on certain elements on the specific topic.
- At first, the questions were grouped following a certain structure to be in line with the proposed procedures for analysing. Three main categories, that will also be applied as the basic structuring element of the survey in research phase II, were 'roles and responsibilities', 'management and processes', and 'processes and collaboration' (see also CTAAPM and PESTLE categories in chapter 6.10.2). But with respect to the coding process during template, thematic and content analysis with matrix instruments, the questions were better grouped into categories of lower level themes. These were set with ‘managerial / operational’ and ‘process owners / process elements’. Going deeper in the hierarchy of the grouping for detailed developing of the coding process was seen as the right approach for preparing analysis. Because of the exploratory character of the research, this measure was seen logical and helpful for initiating a purposeful coding process.

Random sampling of professionals in England, meeting the above-mentioned criteria and having responsibility in estates and facilities management, according to their job description (=filter criterion), was undertaken. Recruiting of interview partners and access was given by chance via asking first and second rank contacts of the researcher, available through the professional job network LinkedIn. Even professional groups were searched for potential contacts if interested. By evaluating the job descriptions made public in the platform, contacts were selected by identifying those meeting the criteria of being in the position of the required target group. In all cases, the search was made for a designated ‘Head / Director of Estates and Facilities’ by applying Boolean search. Table Appendix A-14 shows exemplified job titles and functions of potential interview partners of different organisations. With some of these an interview was conducted. Intensive and persistent search and request loops had to be conducted in order to get a number of eleven interview partners. Figure Appendix A-1 shows an invitation request for interwiew via LinkedIn contacting professionals who were qualified by job title. Another hurdle was the limitation of the text message with only a number of 300 characters available to attract interest to qualify for contact consideration. Figure Appendix A-2 shows a subsequent invitation via email for an interwiew, contacting professionals who qualified by job title and agreed on a contact request via LinkedIn.

Of all the search and request attempts finally eleven interviewees participated. In most cases (8) an interview appointment could be arranged directly with persons requested in the respective hierarchy level of management, otherwise an interview was delegated by first contacts to employees at a different organisational level (3).

Table 6-5 shows the profile of the response activities attempted during requesting for interviewees meeting inclusion criteria.

Table 6-5: Responses on phase Ib interviewee invitation

Recruiting interval	Number of target persons found in LinkedIn meeting inclusion criteria	First grade contact in LinkedIn	Second grade contact in LinkedIn	Third grade contacts	Number of target persons where at maximum two remiders were set after no reaction replied the initial message	Number of confirmed LinkedIn new contact requests	Number of rejections	Number of confirmed interview partners
Feb-May 2018	83	5	39	39	30	65	6	11

Table Appendix A-15 lists all interview partners, by job description, who agreed on participating in the study during phase Ib by giving their written consent. There is an announced duration of about 45 min for each interview. Because the interview may develop a high level of interest in the interviewee of this exploratory research approach, the interview time may exceed the planned time. To meet and confirm the research criteria of confidentiality, as described in chapter 6.16, the interviewees were handed an information and consent form prior to the interview. Table Appendix A-15 table shows the identifier of each interview participant, job descriptions, the date on which each interview was held as well as the duration of the interviews in minutes. For data processing in terms of preparing data, coding and for analysis purpose, each interview partner was abbreviated with an identifyer 'IP' (IP1 to IP11). Altogether the duration of the interviews of phase Ib was about 737 minutes or around 12.3 hours. The audiotaped interviews were transcribed into a standardised template structure, defined by the researcher (see Figure Appendix F-1 for phase Ia and Figure Appendix F-2 for phase Ib), which resulted in 171 pages or 91'254 words of transcribed interview data material. Interruptions in audio recording occurred three times where the audiorecording device did not work properly. Technical problems were each solved within one minute or faster. Consequently, recording generated two files. Each is shown separately in column 'Duration' (Table Appendix A-15), but was aggregated for data processing and analysis.

6.9.7.2 Documents and other secondary data

The interviews provide the opportunity of requesting additional data from the interview partners. For that, the researcher asked specifically for them to provide certain documents of interest, which are seen in organigrams, diagrams, reports or policies. Such documents were requested during the one-to-one interviews of phase Ia and Ib. Where there was no constraint against it, they delivered those documents by sending an email to the researcher with the documents attached. In cases, and for the purpose of this study, documents were handed out or sent to the researcher via e-mail after completing the interview. The selection of documents attached to the e-mail was made by the interview partners. The researcher particularly requested for specific documents such as 'policy', 'water safety plan' and 'process diagrams'.

Document analysis intends to apply content analysis as a data analysis method applied on policies or plans by visual methods and image-based research, according to Saunders et al. (2016 p.608) and Quinlan (2011 p.226). For the purpose of the document analysis an overview about the received documents was made in the form of tables to better gather the sources. This was done, according to criteria 'ID of organisation', 'type of document', 'title of document', 'content', 'type of document'. The group 'type of document' presents the researcher's classification of the document according to its content. Classification criteria were applied successively in the following order of consecutive runs:

Run 1: The document title indicates a certain document class.
Run 2: The content of the document indicates certain criteria for a specific document class.
Run 3: The structure implies a certain type of document.

Results are presented in chapter 7.3

6.9.7.3 Web-based survey

Preliminary results of the one-to-one interviews were studied prior to generating the web-based survey, which allowed the researcher to further explore issues and further develop questions evidenced in the interview data.

6.9.7.3.1 Characteristics of web-based survey

The target population were identified in management responsibilities by roles for the process of water safety management. As a result of the interview studies phases Ia and Ib, the target group has been defined as water safety group members. It would be interesting to look at the makeup and influence of the different disciplines in the WSG. From a clinical perspective it's not just infection control who are involved but also the specialist user groups such as dialysis, aquatic therapy, decontamination etc. But in this research the focus is set on the non-clinical perspective, specifically on estates and facilities management.

The survey takes 25 minutes for completion. Admittedly, this time interval is quite long for a web-based survey. While designing and programming the survey the questions had been reduced to the minimum number that seemed to be necessary to collect sufficient information for answering the research questions.

Initially the survey underwent a pilot test with two professionals and then was revised to improve applicability (See chapter 6.9.3.4). Before launching the survey, it was clear that there would be no 'recipients list' to which the survey could have been sent easily and comfortably. A consequence of the sensitive topic is, that only a rough estimation about the potential impact was possible, i.e. number of people who could be addressed.

A web-based survey was used in this study for the following reasons, as described by Ma and McCord (2007 p.9):

- It significantly reduces data collection costs and complexity;
- the manual data entry process is avoided;
- it eliminates interviewer bias;
- it increases the response to sensitive questions;

- it allows the incorporation of audio and visual material;
- and it offers higher quality data because it often incorporates system functionality that prohibits response errors.

Furthermore, since the respondents will not have much time to complete the survey because of their management positions in business, a survey method that provides a fast and effortless answering process was required. The purpose of the web-based survey was to obtain various inputs from a wide range of water safety management group members from different professional fields of clinical and non-clinical background, which was not possible by conducting one-to-one interviews only.

The online survey link was distributed by the researcher via invitation e-mail requesting different institutions, organisations and societies (Table Appendix A-16) and also posts on the researcher's LinkedIn profile and into different LinkedIn professional groups. Also, the help of former interview partners supported distributing the online survey link.

A general invitation e-mail was provided to former interviewees. Specific examples are given in Figure Appendix C-2 and Figure Appendix C-3.

Since a web-based survey is an example of a server-side system, in which the respondent completes the survey while he or she is connected to the internet through a browser, and the "answers are ... transmitted to the server on a flow basis as each submit or next button is pressed" (Couper, 2008 p.3), a convenient and purposeful online survey tool to assist researcher to design and distribute the survey and to collect and analyse data was used to host the web-based survey.

The LJMU web application 'Online surveys' (formerly 'BOS') was applied to compile an online survey, tailored to the research progress. The online platform is available at https://www.onlinesurveys.ac.uk/, a product from Online surveys, Jisc, One Castlepark, Tower Hill, Bristol, BS2 0JA, UK. Free registration for the researcher was gained through the LJMU student account. Via the dashboard the researcher programmed the survey termed "Water Safety Management", built up of 31 dominant questions with partial subquestions. The questions were distributed over 28 online pages. Three different categories had been defined for clustering the questions into logical sections. These are 'Roles and responsibilities', 'Management and processes' and 'Processes and collaboration'. Furthermore, the survey contained questions with logic, resulting in a different pathway in the case of non-applicable answers. 'Online Surveys' allowed the researcher to create the above-mentioned categories by integrating different pages for each category. According to Maree (2012 p.160) Maree and Pietersen, it is essential to provide a brief overview of each questionnaire category to avoid confusion and ensure a logical flow.

The respondents were prompted to access and complete the survey via a survey link that transferred them to the starting page of the survey. An exemplified invitation letter that was sent to respondents is presented in Figure Appendix D-1. The survey tool allowed the researcher to create a link to the respective questionnaire, which was included in the e-mail to the respondents. The respondents were given some weeks to complete the survey. As there was no e-mail address list for water safety group members available containing more than the already recruited interview participants, great efforts have been made to attract survey participants through institutions, organisations and societies (Table Appendix A-16).

None of the institutions, organisations or societies was able to refer their members to any connection to a water safety group (Table Appendix A-17). This is notable as it makes access to interview participants more difficult.

The following sections will focus on explaining the actual question types, response system, questionnaire categories and the measures employed to improve the quality of the questionnaire. The web-based survey, as per the survey tool design, is presented in Figure Appendix A-7.

6.9.7.3.2 Question types utilised in web-based survey questionnaire

The questions in the web-based survey were of different types. One type was statement, closed-ended questions. Statements were utilised because the researcher aspired to determine the extent to which respondents had a particular attitude towards or perspective on a certain phenomenon (Babbie et al., 2007 p.246). The closed ended question type allows the respondent to select an option from a range of options (Delport, 2007 p.174).

The advantages of closed-ended questions are, according to Maree (2012 p.161) that:

- it provides a simple and quick answering process
- it ensures uncomplicated coding and statistical analysis;
- respondents are more likely to answer sensitive questions.

By contrast, the disadvantages associated with closed-ended questions are, according to Delport (2007 p.175),Maree (2012 p.161) that:

- the response options provided sometimes guide respondents towards a certain answer
- the desired answer may not be available
- the questions could be misunderstood
- the questions may lack detail
- simplistic answers are sometimes provided to complex issues
- a respondent may answer the questionnaire even if he or she is not knowledgeable on the topic.

However, in the current study, the respondents were of such a specific topic and membership to ensure that they had knowledge of and experience in the topic under investigation. The questionnaire was evaluated by a team of experts to ensure that the questions were understandable.

6.9.7.3.3 Response system

A multiple-choice response system, or more specifically, a multiple-choice, single response system (Cooper and Schindler, 2003 p.251) was used in this study. This type of questions offers at least three fixed-alternative responses of which respondents should select the option that most accurately represents their opinion (Lighthelm, 2007 p.398). ‘Yes/no’ questions were regarded as dichotomous responses that only gave the respondents two response options (Delport, 2007 p.175),(Lighthelm, 2007 p.397). However, the response option ‘I prefer not to answer’ and ‘not available’ were also integrated and could therefore be regarded as a multiple-choice question because it offered further response options.

For a series of questions of the questionnaire a Likert scale response system was used, which is a type of multiple-choice question (Delport, 2007 p.177). A Likert scale, according to Babbie et al. (2007 p.246), is the ideal choice if statement questions are presented. This measurement method, developed by Rensis Likert in 1932 (Singh, 2007 p.75), comprises a series of statements that highlight a respondent's favourable or unfavourable attitude towards the phenomenon under investigation (Lighthelm, 2007 p.408). Besides the advantage that the design process of a Likert scale is relatively simple, the reliability can be measured together with the data collection process (Du Plooy, 1996 p.82). The response options of the Likert scale provided in the questionnaire were dependent on the question. The survey tool allowed the researcher to compile these questions by selecting the "multiple-choice (only 1 answer)" option.

6.9.7.3.4 Quality of web-based survey questionnaire

Various measures were implemented to ensure the quality of the questionnaire for the web-based survey. Firstly, the researcher made use of a panel of experts to evaluate the academic soundness of the questionnaire. This panel comprised two professionals in the fiels of water safety management in the United Kingdom. They suggested changes, which were eliminating jargon, excluding unnecessary questions, and reviewing the overall wording of the questions (Singh, 2007 p.71). The researcher took orientation from the recommendation that the questionnaire should not exceed 120 items (Maree, 2012). Further revisions to the questionnaire were made, and the final programmed questionnaire was shared with the supervisor for a final review. A pilot test (chapter 6.9.3.4) was then conducted, which served as an additional quality measure of this questionnaire. Gibson and Brown (2009 p.55) and Strydom (2007 p.331) define a pilot test as a preliminary evaluation to enable the researcher to make adjustments to questions to ensure the optimal quality of the actual investigation. According to Babbie et al. (2007 p.257) and Babbie (2007 p.257), it is essential to pretest a questionnaire to identify any problematic areas such as ambiguous questions and also to determine whether the intended data collection methods are effective (Du Plooy, 2002 p.93). The pilot test was specifically conducted to determine the completion time of the questionnaire, to establish whether the link to the questionnaire and navigation between the various pages on the web-based survey worked properly, and to determine whether the questions were understandable and correctly interpreted.

6.9.7.3.5 Measurement levels

Variable categories are often also labelled "measurement levels", since the process of assigning numerals to variables is known as measurement (Du Plooy, 2002 p.117). Measurement levels will now be discussed in the context of this study.

Both nominal and ordinal measurement levels are used. According to Allen et al. (2009 p.10) they are often described as categorical. In nominal measurement, values are distinguished from one another by different names. Normally they consist of two or more categories (Maree, 2012 p.148). Similarly, according to Levin et al. (2010 p.11), nominal measurement involves naming or labelling. This is classifying or categorising cases and counting the frequency of occurrence.

Ordinal measurement was used, which is a level of measurement in which rank order is used to highlight the differences between variables (Du Plooy, 2002 p.119). It specifically involves scales that include level of agreement, such as the Likert scale (Maree, 2012 p.148).

Figure Appendix A-7 illustrates the structure, Table Appendix A-18 and Table Appendix A-19 characterise the methodological and technical structure of the survey. A screenshot of the survey's opening page is attached on Figure Appendix C-1. For explanation purpose several survey questions included diagrams and detailed text information, an organogram or a map explaining a certain hierarchy or a schematic drawing.

6.9.7.4 Focus group for framework validation

A final step for the thesis's output will be a framework, which contains a type of process map with corresponding duties and activities, organised in a logical manner, based on the research data. It further outlines important process owners, seen from the facilities management's perspective. The output is the result of the findings of fieldwork phase Ia, Ib and II.

The «framework» should be understood as the final output document guiding practice, based on practice. It represents an evaluated current-state guidance document containing information and knowledge necessary for management responsibilities. It is tailored specifically to the context of hospitals (healthcare organisations) and the perspective of estates and facilites management. The framework could, for example, be published by a specific professional body such as IHEEM, HEFMA, government (NHS) or other societies with educational missions (RSPH, WMSoc).

The focus group has been designed with two elements - an initial presentation followed by a set of prepared questions to which the experts of the focus group are asked to answer. The focus group will be structured and moderated by the researcher in a one-to-many, internet-mediated setting. As described in chapter 6.9.6 the focus group is applied for the purpose of validation in this research. Specifically for the framework validation. But as the framework is an output based on all previous research phases, the validation step indirectly validates the overall research, seen from the point of view of the panel of experts in the focus group. Thus it can be said that stakeholder feedback was taken into consideration for assessing validity (Tate et al., 2017 p.477). Whether or not and to what extent this framework is accepted from the point of view of practitioners in estates and facilities management should be verified by means of the validation. In a focus group with 5 to 6 participants, the framework will be presented in a concise and adequate way. The focus group does not consist of 8 to 10 participants as read earlier (6.9.6), but of 6 experts as this number seems to be sufficient in the opinion of the researcher. Independent experts in that specific field of research in the UK, with proven experience and decades of expertise are rare.

A graphical representation of the proposed framework, as outlined in chapter 8, is presented to the participants accompanied by the questions, to enhance their understanding and to specifically establish its applicability.The applicability and impact of the framework for estates and facilities management in hospitals (healthcare organisations) in England will be reflected from two main perspectives:

- From the perspective of the *process* of *Legionella* prevention and risk management for water safety in healthcare organisations

- From the perspective of the *process owners* (people responsible) of *Legionella* prevention and risk management for water safety in healthcare organisations

In total, 8 questions are asked about possibilities and benefits for application in practice (Table 6-6). Potential improvements are asked for, which will be considered before thesis submission to revise the framework output, bringing it into its final shape.

Table 6-6: Questions for the focus group validation phase

Question no	**Question**
1	What is good / helpful? (General statement)
2	Where is the greatest added value for Estates and Facilities Management? (Why?)
3	Are all relevant processes mapped? (Which are missing?)
4	Are all process owners sufficiently identified and represented?
5	Is there a need for adjustments / additions? (If so, please give a reason)
6	Will the framework be considered by you or colleagues as soon as it has been published? (e.g. awareness improvement in process thinking, training, risk management)
7	Do you know about similar works that have been published scientifically?
8	Side question: Would it be worth considering setting up an organized, independent networking platform in the UK for the exchange of knowledge for Water Safety Group Members? (The different members of the target group could be reached more quickly and directly by this)

Participants are selected according to specific criteria and invited prior to the focus group session. In total there are the researcher, who is also the moderator, and 5 experts. The criteria are that the expert panel should consist of professionals from UK Hospital Trusts in the position of Head/Director of Estates and Facilities, who haven’t been involved during research data collection at an earlier stage and who are experts in the field of water safety management, e.g. independent consultants. Participating experts are listed in (Table Appendix A-20). The correspondence for invitation and the presentation slides are presented in Figure Appendix D-1 and Figure Appendix D-2.

During the focus group each participant is requested to answer eight questions, being given the chance for general and specific comments on the framework (Figure Appendix D-3). The answers are recorded with an audio recording device, transcribed and then analysed qualitatively. Audio taping will be done after receiving informed consent. A critical reflection will be presented in chapter 9.1.

The characteristics of the focus group interview board of experts, meeting at a virtual online session on Friday, 11 October 2019, is summarised in Table Appendix A-20. Each person gave actively his/her consent for audio taping and analysing the focus group session.

6.10 Data analysis

Data collection ist just one side of the coin. Data analysis and how data is visualised are techniques that require deep understanding of the data and the continuous alignment to the research objectives. Analyses must not drift or direct into misinterpretation.

6.10.1 Theory

In general, data analysis always comprises the three steps ‘data condensation’, ‘data display’ and ‘conclusion drawing/verification’, according to Miles et al. (2014 p.12). “Data condensation refers to the process of selecting, focusing, simplifying, abstracting, and/or transforming the data that appear in the full corpus (body) of written-up field notes, interview transcripts, documents and other empirical materials” (Miles et al., 2014 p.12). The step of data display puts data in the right format for analysis. Conclusion drawing is the interpretation of data, weighted in its output, which will be verified in a final step. Throughout the entire research project analysis is an ongoing process. The above-mentioned steps of data analysis are done concurrent to the data collection during planning, conduct and follow-up, which is in line with Miles et al. (2014 pp.12-13).

In order to give data a logic structure for analysis they first need to be structured. According to Tustin (2010a p.522), data description is usually the first step in the data analysis process to allow the researcher to conduct an initial examination of the data. The step of structuring data begins with the type of data whether it is quantitative or qualitative in its nature. In this research qualitative as well as quantitative data is seen to deliver information for the research output and to answer the research question. The theory behind it will be presented more in detail in the next paragraph.

6.10.1.1 Quantitative data

Saunders et al. (2016 p.496) says “Quantitative data in a raw form, that is, before these data have been processed and analysed, convey very little meaning to most people. These data, therefore, need to be processed to make them useful, that is, to turn them into information. Quantitative analysis techniques such as tables, graphs and statistics allow us to do this, helping us to explore, present, describe and examine relationships and trends within our data”. Babbie et al. (2007 p.405) defines quantitative data analysis as the “… numerical representation and manipulation of observations for the purpose of describing and explaining the phenomena that those observations reflect”. According to Kruger et al. (2007 p.218), quantitative data analysis per se does not provide answers to the research and questions - analysed data only become significant when interpreted. However, prior to interpretation and constructing meaning, raw data must first be analysed. The initial analysis of the data entailed a descriptive analysis to obtain the frequencies and percentages of individual items, which is an example of univariate analysis since only one variable is measured (Tustin, 2010c p.646).

6.10.1.2 Qualitative data

Based on Christensen et al. (2014 p.394) qualtitative data analysis can be distinguished between descriptive statistics and inferential statistics. According to Christensen et al. (2014 p.394) “In descriptive statistics, the goal is to describe or summarize your research data”. “Qualitative data analysis is the interpretation and classification of linguistic (or visual) material with the following aims: to make statements about implicit and explicit dimensions and structures of meaning” (Flick, 2014 p.370). For that, qualitative data analysis involves “… reducing the volume of raw information, shifting from trivia, identifying significant patterns and constructing a framework for communicating the essence of what the data reveal” (De Vos, 2007 p.333). Qualitative data analysis is also concerned with integrating order, structure and meaning to the collected data. The researcher has to search for statements in the data that relate to predetermined categories to contribute towards generating theory (De Vos, 2007 p.333). Similarly, according to Daymon and Holloway (2011 p.323), qualitative analysis is the process of searching for categories and patterns in the data collected by means of coding, which enables the researcher to relate the findings to concepts and themes identified in the literature. Explicitly they say “… to generate theory, new models or theory-based generalizations”.

Myers (2013 pp.166-174) explains that qualitative data analysis can be differentiated into coding, memos, analytic induction, series of events, critical incidents, hermeneutics, semiotics, content analysis, conversation analysis, discourse analysis, narrative analysis and metaphorical analysis. However, this list is not intended to be exhaustive (Myers, 2013). From the researcher’s perspective, the moment that decides on a successful or unsuccessful data interpretation is seen in a suitable coding strategy, suitable coding matrices and the ability of the researcher to bring together the different data sources and content analyses of the individual research phases. For that, the analysis instrument ‘matrix’ is of specific interest.

6.10.1.3 Matrix (see also (Cassell and Syman, 2004)

Hussy et al. (2010 p.267) mention that methods to analyse visual material, are not well developed. One way to meet this challenge is to analyse qualitative data with matrices. This method is used to analyse qualitative data from different data collection methods, such as documents, interviews, focus groups (Nadin and Cassell, 2011). Based on Miles et al. (2014 p.109) “A matrix is essentially the “intersection” of two lists, set up as rows and columns.” At first sight this appears quite simple, but finding a matrix type fitting the data analysis appropriate to the research question, is not easy. There are different types of matrices described by Miles and Huberman (1985), Miles et al. (2014). But according to Miles and Huberman (1985 p.211) “There are no fixed canons for constructing a matrix. Matrix construction is rather a creative yet systematic task that furthers your understanding of the substance and meaning of your data-base, even before you begin entering information. Thus, the issue is not whether one is building a correct matrix, but whether it is a functional one that will give you reasonable answers to the questions you are asking - or suggest promising new ways to lay out the data to get answers.” In the following paragraphs, the matrix types that have been considered for this research are described briefly.

- **Matrix type: Data accounting log**

This type is helpful for getting an overview about the different types of material collected (Miles et al., 2014 p.122). It informs about which data has been collected, what size it is and what can be found and identified for data analysis. The data accounting log is of the highest value to keep the data manageable when working with multiple cases over a long period of time with lots of different types of data. The data accounting log was used in a very detailed way for document analysis, which is described in 6.10.2.2.

- **Matrix type: variable-by-variable Matrix**

According to Miles et al. (2014 p.233) “A variable-by-variable matrix has two main variables in its rows and columns.” This type of matrix is useful to see relationships between variables. This type of matrix was applied for the stakeholder analysis, in a modified way of pairwise-comparison.

- **Matrix type: checklist Matrix**

Based on Miles et al. (2014 p.142) “A checklist matrix is a format for analysing field data on a major variable or general domain of interest. The basic principle is that the matrix includes several components of a single, coherent variable, though it does not necessarily order the components.” This type of matrix was used for several analyses. According to Miles et al. (2014) it can be used for the purpose of comparison when working with multiple cases. This type of matrix was applied, for example in the survey analysis of processes in hospitals being absent or present. All identified processes from research phase Ia and Ib were checked for the presence or absence in each hospital/Trust. Another example ist the analysis of survey data referring to survey question 22. Each participant was asked to indicate the presence or absence of a certain stakeholder for being present in the hospital/Trust and about their individual collaboration.

- **Matrix type: case ordered descriptive meta-matrix**

According to Miles et al. (2014 p.214) “A case-ordered descriptive meta-matrix hierarchically organizes cases according to selected criteria to compare common variables or outcomes of interest.” In this research this type of matrix is applied and seen as a further developed variable-by-variable matrix indicating ranks and thus giving a hierarchic order to process items.

6.10.1.4 Document analysis

«Documents are an important source of data on key event chronologies» and «Documents emphasize the ‘official’ truth, and tend to gloss over conflict and complexity. Interviews are artificial interactions that can be influenced by lapses of memory, impression management, the moods of the participants, and the quality of the rapport between interviewer and interviewee. However, they can be multiplied easily, providing different perspectives on temporally embedded phenomena. In practice, most process research involves combinations of sources to access different dimensions and to ensure the limitations of one source are compensated by the strengths of others» (Buchanan, 2009 p.411).

6.10.2 Applied in research design

In the research project, qualitative data was analysed with descriptive statistics and tables, as described in more detail in the following sections. The data analysis method used in this study was a method identified by De Vos (2007 p.334) which is an integration of analytical spiral (Creswell, 1998 pp.142-165), which implies that the researcher moves in analytic circles instead of applying a preset linear approach when analysing qualitative data, and data analysis process (Marshall and Rossman, 1999 pp.152-159). Although this analysis process will be presented linearly, these steps can also move in circles, which emphasises the rationale for the integration of a circular and linear process (De Vos, 2007 p.334).

Since the realised sample for the web-based survey was too small, it was deemed more appropriate to use a nonparametric procedure for statistical analysis. A modified inferential analysis, which is an example of bivariate analysis that focuses on the analysis of two variables (Tustin, 2010c p.646), was further applied to determine whether differences of importance existed between items.

The analysis process utilises different types of analysis instruments of qualitative and quantitative data analysis for:

- process identification and analysis
- stakeholder identification and analysis
- process owner identification and analysis

To mention some of the analysis instruments, the following are highlighted:

- tables
- matrices, e.g. paired comparison of identified processes giving the rank of a process seen from the stakeholder groups' perspective
- frequency analyses

6.10.2.1 Semi-structured interviews

The following steps, which should only be considered as guidelines, represent the data analysis steps for this study (De Vos, 2007 pp.334-339): planning for recording the data; data collection and preliminary analyses; managing or organising the data; reading and writing memos; generating categories, themes and patterns; coding the data; testing emergent understandings; searching for alternative explanations; and presenting the data. Each of these steps is discussed in Table Appendix A-21 with specific reference to how it was applied to the one-to-one interview data in this study (De Vos, 2007 pp.336-338, Marshall and Rossman, 1999 pp.153-155, Creswell, 1998 pp.143-144).

6.10.2.1.1 Specific analysis of phases Ia and Ib

Analysis for the interview studies of phases Ia and Ib was aided by the analytical software NVivo. For the purpose of analyses made during this study, NVivo 11 for Windows, Version 11.4.1.1064 in the edition: Pro, QSR International was used. The program was applied to help to manage, explore and find patterns in the data. The process of exploring included the following steps: Import collected data (Interviews, documents for desk research); explore; code; query; reflect; visualise the insights.

There are different ways of how to organise, analyse and vidualise data with NVivo. Considered were a) making mind maps to brainstorm initial ideas, searching starting points and develop assumptions; b) making concept maps to show the relationships or patterns that are expected to be found in the data based on prior experience or preliminary reading, c) survey results and other datasets. A dataset contains structured data arranged in records (rows) and fields (columns). In this research the datasets contain either the responses to interviews or to the survey. The dataset source in NVivo was created by importing data from a spreadsheet or text file. Audio files from the audio taped interviews were transcribed in MS Word, then imported, considering necessary editorial requirements. Audio files were transcribed without timestamps. The process of creating the time consuming and labour intensive transcripts was aided by applying the professional 'TranscribeMe' service. The steps were 1) selecting audio sources to be transcribed, 2) get pricing/place an order, 3) audio files are uploaded to TranscribeMe, 4) downloading completed transcripts for further processing by the researcher.

In NVivo there are certain software-specific key terms defined. They are

- Sources: Sources are research materials including documents, PDFs, datasets, audio, video, pictures, memos and framework matrices.
- Source classifications: Source classifications provide information about the sources.
- Coding: Coding is the process of gathering material by topic, theme or case.
- Nodes: Nodes are containers for coding that represent themes, topics or other concepts. It enables gathering related material in one place so that emerging patterns and ideas can be looked for.
- Cases: Cases are containers for coding. Each case represents a 'unit of observation'.
- Case classifications: Case classifications allow recording information about cases.

Analysed data was summarised in framework matrices. There were framework matrices applied for the interviews to summarise the data in a grid format. The grid has rows for case nodes (the interview partners of the different organisations) and columns for the theme nodes (summaries in the cells where the case and the theme intersect). The reason to decide to work with condensed source materials in the framework matrix is that it makes it easier to see everything about a theme by looking down a column. Furthermore, the reader gets to see how different themes relate to each other for a particular individual (organisation) across a row. Even comparing becomes possible in terms of excerpts of the experiences of different individuals by comparing one row to another.

Prior to starting to work with framework matrices it was necessary to import source materials, code source content to case nodes and set up thematic code hierarchies Figure Appendix A-8.

Text analysis was made in different ways. It started with a text search query. A word or a certain phrase was searched for in the source material, then displayed in a word tree to visualise words in context. This was followed by word frequency queries**,** listing the most frequently occurring words in the sources. The visualisation of the results of the latter was done by either word cloud, chart, tree map diagram or cluster analysis diagrams.

Results of phases Ia and Ib were recognised and integrated for determining questions of the online survey.

6.10.2.1.2 Content analysis procedures for the interview study phase Ia

Content analysis procedures comprise three consecutive steps:

- Step 1: Definition of categories (Table 6-7)
- Step 2: Searching items/words by question words per category (Table 6-7)
- Step 3: Word frequency query

Table 6-7 lists the question categories and those words included for queries during analysis that were found delivering answers. According to a self-developed scheme, ordering and analysing data of phase Ia with NVivo was realised (Figure Appendix A-8).

Table 6-7: Questing categories for identifying elements of *Legionella* prevention in healthcare facilities (phase Ia)

Category	**Included words ask for**	**Words included for queries (also stemmed words)**
Actors	WHO?	Responsibility, Role, Stakeholder, Water Safety Group
Drivers	THROUGH?	Authority (Legislation, Legal), Guidance (Recommendation), Standard
Professional field	WHAT?	Estates, Facilities/Facility Management, Health care (Health authorities, NHS, Trust, Health & Safety), *Legionella* (*Legionella* management, *Legionella* prevention, *Legionella* risk management), Water Management (Water Safety, Water Safety Team, Water Safety Group, Water Systems)
Organisation's **i**nstruments	HOW?	Prevention (Monitoring, Sampling, Audit, Control), Process (Documentation, Matrix, Accountability), Strategy (Risk, Structure, Duty)
Clinical **i**nstruments	HOW?	Hygiene commission, hospital hygiene, infection prevention
Layer 1 (see Figure Appendix A-8)		Layer 2 (see Figure Appendix A-8)

6.10.2.1.3 Analysis procedures interviews phase Ib

The transcription of semi-structured interviews (Blumberg et al., 2011 p.246) is followed by thematic analysis of the interviews (Saunders et al., 2016 pp.597-599) applying thematic coding. From the transcribed interviews first categories for analysis are being developed. Transcription was also followed by template analysis of the interviews (Saunders et al., 2016 pp.597-599) applying thematic coding. The concept for analysis, according to the suggested steps by Saldaña (2016) are:

- Find patterns in the interviews
- Define coding structures according to find answers to the research questions
- Build categories
- Analyse interviews → collect important statements
- Cycles of content analysis and abstraction. Reduction to the core elements
- Summarise in a table

This was followed by content analysis and quantifying qualitative data (Saunders et al., 2016 p.608). There were two outputs:

- Output (a): An entity of process steps and process owners, based on the results of the cases being involved. The process owners comprise responsibilities by roles cooperating with or affiliated to estates and facilities management, their job within the organisation is assigned to either non-clinical or clinical content of work.
- Output (b): Suggestions for a process-logic/process-chain (=ordering/structuring the process steps in a logic manner). Reflection of what the hospital cases have in common in their organisational structure (patterns). Summary outputs e.g. by Linear responsibility chart/Responsibility Assignment matrix/Accountability chart/Governance arrangements.

In one major run the interviews from phase Ib are analysed, independently of each other, with regard to two different perspectives. One is based on an intrinsic point of view, the other on an extrinsic point of view.

- **Extrinsic perspective**

The extrinsic point of view is based on an analysis method from the management sciences. The analysis is carried out according to the categories 'Political', 'Economic', 'Social', 'Technological', 'Legal', 'Environmental' (Table 6-8). It is called PESTLE analysis according to its initial letters. This analysis is intended to shed light on the extrinsic view of the process and the stakeholders.

The PESTLE analysis (also known as STEP) is a model of external environmental analysis. It comes from macroeconomics. The analysis lists the factors of the individual categories that can have an influence on the investigated unit. The analysis method is used by companies when it comes to a market and to investigate the market opportunities (Fahey and Narayanan, 1986, Keller and Kotler, 2006 p.85ff., Lynch, 2006 p.84ff., Sander, 2004 p.303ff.). The analysis is performed by companies that want to expand into a new market, such as a new country. PESTLE can be a good aid in assessing the risks and opportunities involved. The results can therefore be used for the external analysis of a SWOT analysis.

In this research context, the categories of the PESTLE analysis are applied to the process of water safety management and *Legionella* prevention.

A unit to be investigated is always a case, i.e. a hospital or a trust. Here, too, the chance of a potentially implemented "process of *Legionella* prevention" can be critically questioned in order to examine necessities and opportunities and to systematically present an overall picture of the process from the present state of the art with the involvement of various organisations. The focus in the PESTLE analysis lies in process, water safety management and *Legionella* prevention from an extrinsic point of view.

Table 6-8: Categories structuring the analysis of interviews phase Ib (PESTLE-analysis)

Category	**Quests for**	**Code**
Political	circumstances for organisational state	PP
Economic	any types of financial aspects to be considered	PEc
Social	organogram, responsibility, stakeholders and relationships of stakeholders	PS
Technological	Technological requirements and demands for preventative or reactive actions	PT
Legal	Legislation, technical guidance, recommendations, policies, compliance	PL
Environmental	structures in the built environment having an influence on processes	PEn

- **Intrinsic perspective**

From the intrinsic perspective, relevant categories are formed for the analysis, which concern the personal responsibilities of the stakeholders in the management of their processes within the individual cases (hospitals). They include the categories 'Control', 'Transparency', 'Accountability', 'Awareness', 'Prevention', 'Management' (Table 6-9). This analysis procedure is hence termed CTAAPM, according to the initial letters of the six categories.

The focus in the CTAAPM analysis lies in stakeholders, and managing processes in water safety management and *Legionella* prevention from an intrinsic point of view.

Table 6-9: Categories structuring the analysis of interviews phase Ib (CTAAPM-analysis)

Category	**Quests for**	**Code**
Control	measurement of compliance	CC
Transparency	processes, policies and procedures visible to all people involved	CT
Accountability	individuals taking responsibility for their actions	CAc
Awareness	status and quality knowledge, continous training, and education	CAw
Prevention	orientation of main task with focus on prevention, detection, risk management	CP
Management	management practices in place	CM

In both analysis methods, individual, similar elements can occur (items). However, it is important to question and interpret them in the context of the analysis purpose.

Where possible, references to current legislation, technical rules and existing documentation received during research are made to underpin topicality and strengthen the practice-oriented approach.

6.10.2.1.4 Procedures of PESTLE and CATTPM analyses

- **First run of analysis**: Scanning for items in the transcribed interviews that can be referred to PESTLE and CTAAPM categories respectively.
- **Second run: Selected excerpts after second run of analysis:** The information content is narrowed down to a core content level.
- **Condensed excerpts according to third run of analysis:** Abstraction and assigning core content level to a meta-level building themes.

6.10.2.2 Document analysis of phase Ib

Document analysis enables the recognition of the process thinking of the cases being involved. It lays the foundation of collecting, identifying, distinguishing and reflection of the process elements. Document analysis has been applied for the case that secondary data in types of documents was provided after requesting for additional documents during the interviews. Documents that have been requested and been considered for research are, for example, organograms to get informed about hierarchy structures, positions and functions and departments. Content analysis of documents took a closer focus on word count, significant headings, paragraphs or structuring elements such as captions in documents. Based on the following strategy, differentiating detailed analyses were applied.

- Step 1: Word count on key words Water Safety, Strategy, Process, Role, Responsibility, Duty, Accountability, Risk, Guidance.
- Step 2: Identification of topics linked with the key words: documents were reviewed and the proximity of text phrases in the documents.
- Step 3: Collection of all headings / paragraphs containing the key words.
- Step 4: Analyses following two main strategies:
  - Analysis strategy 1 = representing higher organisational level = Management perspective ‘strategic’,
  - Analysis strategy 2 = representing lower organisational level = Management perspective ‘operational’

Analysis results:

- Aggregation of content analysis, e.g. Strategies mentioned in Policy / WSP
  →Output: Matrix of/for process owners
  →Output: Collection of process steps (Focus: Water Safety Group, Estates and Facilities Management)
- Preparations for aggregated analyses, e.g. combined consideration of role, responsibility, duty, accountability

6.10.2.3 Web-based survey analysis of phase II

The resulting survey is a web-based survey. For the time of the open interval (Table 6-10) was accessible online by the URL at https://ljmu.onlinesurveys.ac.uk/water-safety-management-survey.

Table 6-10: Interval of duration of open survey

	open date	**closing date**
Interval of survey	21 Nov 2018	12 Feb 2019

The survey was open from 21st November 2018 to 12th February 2019. Admittedly several months is a long period. The fact that the survey took about 25 minutes for completion, combined with the circumstance that the people invited, with their specialist knowledge and their demanding managerial postitions made it necessary to provide a long time interval. It also became necessary to actively promote the survey to increase the response rate. A total of 169 people of the targeted group (member of a water safety group) have entered the opening page of the web based survey. 17 respondents completed the survey, causing a response rate of 10%.

This survey is not a quantitative study. It is a type of focused survey, which is different to a snapshot-survey (which normally looks for a high N). No trends, statistics, correlations. It is intended for a rather a very specific target population. The questions are constructed for verifying interview-findings and go beyond, on a more specific detailed level. Analyses are to prioritise processes, verify or decline their importance. The only purpose of this survey study (phase II) is to get further insights and qualified responses specifically from members of water safety groups. Thus the survey is rather a complementary phase to a) strenghten the results from the previous research phases results, and to b) structure, include or omit data for generating the framework output and to answer the subquestions and the research question.

6.10.2.4 Process analysis

Qualitative and quantitative data analyses are applied for the identification of the process steps and the process owners. Data and method triangulation will help selecting and condensing relevant information. Where appropriate, the following analysis methods are included: Descriptive Analysis (e.g. 2009 Mouchtouri (Cooling Towers)); Thematic Analysis, Template Analysis (Saunders, 2016), Matrix analysis, Stakeholder analysis (including matrix opposite), PESLTE and CTAAPM analysis.
For the definition of the importance of the processes and process steps, which were identified through the survey study, the analysis in preparation for the final framework output will be different to that of the survey analysis procedure. In this final step of analysis before the framework can be compiled, the data is much more in focus for prioritising and identifying a process hierarchy, according to the evaluation of all data collected and findings/resumes taken yet.
One principal analysis will be a pairwise comparison with corresponding scoring methodology. It will be the core element for achieving a process hierarchy. Pairwise comparison looks at each identified process step and compares it individually to each of the others by allocating a comparative score. The analysis procedure is inspired by Eiras et al. (2014 p.116), who applied inter-correlations in a test-statistic context, and by Etrust (2010). In this research context, pairwise comparison is allied to calculate a hierarchic order by ranks of certain process elements.

The exemplified scoring scheme of Table 6-11 will be applied for the pairwise comparison, as a clear set of criteria for determining rank importance:

- If two compared process steps are equally important they both score '1'
- If one is slightly more important than another it scores 2 and the other scores 0.50
- If one is clearly more important than another it scores 3 and the other scores 0.33
- If one is significantly more important it scores 4 and the other scores 0.25

Table 6-11 Scheme for paired comparison of identified processes

Process ID	ID 1	ID 2	ID 3	ID 4	ID 5	Total	Rank hierarchy
ID 1		1	2	3	4		
ID 2	1						
ID 3	0.5						
ID 4	0.33						
ID 5	0.25						

6.10.2.5 Stakeholder analysis

A stakeholder analysis can be used in many circumstances such as a procurement exercise, development of a specific project, or, as in this case, process and process owner (stakeholder) identification and characterisation. The involvement of the right people not only ensures that they are engaged with the process, it also maximises the potential for the widest range of issues and options to be considered as part of an interdisciplinary endeavour in any collaborative approach, as is the case with water safety management. Stakeholders can be grouped into areas of importance by considering 'power' to influence the process and 'interest' in the outcome.

A stakeholder matrix for estates and facilities management summarises the outcome, indicating each group member's level of involvement, their 'power' to define or influence the process and how 'interested' they are likely to be in getting involved. In this research, stakeholder analysis is applied for analysing a) stakeholder's interest in the outcome and b) their power to influence the process. Figure 6-8 shows the grouping categories that have been defined.

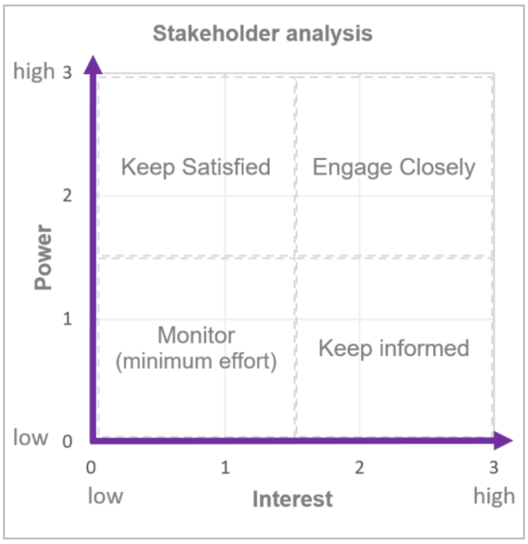


Figure 6-8: Scheme of a stakeholder matrix indicating 'power' and 'interest'

Additional to the analysis there are elements identified and coordinates given in brackets to identify certain elements in the stakeholder matrix. They are used to identify and to assign elements to three different groups ‘low', 'high', and 'check role'. The following is an explanation of the groups ‘low’, high and ‘check role’ with reference to Figure 6-8: The grouping intends to show where there are types of relations of different quality levels such as "engaged closely" (group 'high') and rather "monitored" (group 'low'). The 'check role' group represents a category where, based on the interviewees’ assessment, there is either strong interest and low power (3;1) or low interest and strong power (1;3). This group is classified with 'check role' and can be interpreted as critical. It is worth further analysis.

6.10.2.6 Focus group analysis

The focus group was analysed in a similar way as already described for the interviews. Transcripts of the feedbacks have been condensed and excerpts of the core messages listed in tables for each question. The steps are described in Table Appendix A-22. The aim of the analysis is the validation of the first compilation of the framework output. This is in line with Tate et al. (2017 p.477) “Assessing validity through stakeholder feedback”.

6.11 Reliability, valitidy, trustworthiness

Although various theorists (Lincoln and Guba, 1985),(Janesick, 2002),(Morse et al., 2002),(De Vos, 2007) address the inappropriate usage of validity and reliability in qualitative research, the principles of qualitative research were found an appropriate approach to the research question in this research. This paragraph explains which elements lead to reliability, validity and trustworthiness in the research project.

6.11.1 Reliability

Reliability refers to replicability (Janesick, 2002 p.394), which is “a matter of whether a particular technique, applied repeatedly to the same object, yields the same result each time” (Babbie et al., 2007 p.143). According to Delport (2007 p.163), reliability is not concerned with what is being measured, but how well a phenomenon is being measured. According to Bryman and Bell (2015 p.49) “Reliability is concerned with the question of whether the results of a study are repeatable”. But Wilson (2010 p.116) argues that although reliability is an important element of any study, it is “not sufficient unless combined with validity. In other words, for a test to be reliable, it also needs to be valid.” Wilson (2010 p.116).

6.11.2 Validity

“Validity is concerned with the integrity of the conclusions that are generated from a piece of research (Bryman and Bell, 2015 p.50)”. Or in other words, as stated by Frankfurth and Nachmias (1992 p.158) as cited in Wilson (2010 p.119), “Is one measuring what one intends to measure?”.

Validity needs to be assured internal and external. Internal validity Wilson (2010) distinguishes between content and construct. The content part of the internal validity relates to the measurement tools measuring the right things as well as the right sampling with respect to the aim of the study (Wilson, 2010). The construct part is about using the right tools (Wilson, 2010). A possible way to do so is data triangulation. The different types of triangulation are described in chapter 6.12.1. External validity is focusing on the degree that results of a study can be generalised, and therefore be observed within other cases (Wilson, 2010).

Validity refers to the extent to which an empirical construct correctly reflects the element it is supposed to measure (Delport, 2007 p.160). Various methods of validity can be identified (Babbie et al., 2007 pp.146-147, Delport, 2007 pp.160-161, Daymon and Holloway, 2011 p.92), namely face validity, content validity, criterion validity and construct validity. Face validity focuses on the face value of a measurement procedure, that is, whether the measurement technique looks as if it measures the intended variable. The questionnaire for this study was evaluated by a panel of experts to ensure a high degree of face validity.

Content validity refers to the representativeness or sampling adequacy of an instrument, that is, the extent to which a measure includes the various meanings embedded in a particular concept. Input from the members of the panel, who are experts in the field of water safety management, risk assessment and *Legionella* prevention ensured the content validity of the questionnaire.

Criterion validity implies that there should be independent criteria to which the scores of an instrument can be compared. Construct validity involves determining the extent to which an instrument effectively measures a theoretically defined construct, and it focuses on the relationships between variables. This was achieved in this study through item analysis, which is a measure to identify unsuitable items in a construct (Maree, 2012 p.218). Such analyses are vital to identify problematic questions in the questionnaire that should be rectified to ensure accurate replication of the study in future.

As mentioned above, a distinction should also be made between external and internal validity. According to Kohn (1997 p.9) and Mabry (2008 p.222), external validity in quantitative research refers to the ability to generalise findings to a larger population, while internal validity focuses on whether the methods that are used to generate findings can be trusted (Delport and Fouché, 2007 p.353). Although the findings of this study could not be generalised since non-probability sampling methods were employed, it still provided insight into the present processes, designs and perfoming of water safety management, *Legionella* prevention and risk management processes in hospitals. As mentioned earlier, pilot tests, which increase the reliability of a study (Delport, 2007 p.163), were conducted with professionals in their business and research field in the hospital setting. This for example to ensure that each question in the survey was correctly interpreted.

6.11.3 Trustworthiness

Reliability and validity are two essential criteria to achieve trustworthiness. To gain trustworthiness is a kind of verification strategy. Morse et al. (2002) developed verification strategies to establish reliability and validity in qualitative research. Verification is defined as the "process of checking, confirming, making sure, and being certain" (Morse et al., 2002 p.9). These verification strategies aimed at achieving trustworthiness, as proposed by Morse et al. (2002 pp.11-12), are summarised in Table 6-12.

Table 6-12: Verification strategies to achieve trustworthiness

Strategy	Description
Methodological coherence	This strategy focuses on ensuring similarity between the research question and elements of the method. The interdependent nature of qualitative research requires that the selected research method should correspond with the data and the data analysis method.
Appropriate sample	The participants in the research must have knowledge of the research topic or should be those individuals who best represent the topic under investigation.
Collecting and analysing data concurrently	There should be mutual interaction between existing knowledge and what the researcher aspires to know.
Thinking theoretically	Ideas that emerge from the data are reconfirmed by new data, which stimulates new ideas which should also be verified by existing data.
Theory development	This represents the movement between data and theoretical understanding. Theory should be developed as an outcome of the research process and as a template for comparison that should stimulate further theory development.

To further emphasise the usage of trustworthiness as an alternative measure for conventional reliability and validity, Janesick (2002 p.393) specifically states that validity, reliability and generalising to a population should be replaced with qualitative references, which can be achieved by focusing on trustworthiness (known as rigour in quantitative research) and is established through the elements of credibility, transferability, dependability and confirmability (Lincoln and Guba, 1985, Morse et al., 2002 p.5, Riege, 2003 p.83). According to De Vos (2007 p.346), Lincoln and Guba (1985) matched these elements of trustworthiness to the conventional quantitative constructs of internal validity, external validity, reliability and objectivity and emphasised how inappropriate these constructs are for qualitative enquiry. Therefore, for the purpose of this study, credibility, transferability, dependability and confirmability would be utilised as alternative measures for these quantitative constructs to determine the trustworthiness of the data obtained from the qualitative data. These elements are defined below with an explanation on how each element would be achieved for the purpose of this study.

- **Credibility**

Credibility is equivalent to internal validity in quantitative research (Delport and Fouché, 2007 p.353), and focuses on whether the method of inquiry ensured an accurate identification and description of the subject. A detailed description showcasing the involvement of the variables and interaction will be entrenched in the data derived from the research setting (De Vos, 2007 p.346). In the current study, the principles of Water safety and *Legionella* risk management were based on an extensive literature review, data collection, data analysis and triangulation as a combined research approach. The sequential design ensured that the one-to-one interviews guided categories and questions of the web-based survey. It should be noted that this study was credible within the boundaries of the research setting, population and theoretical framework, as proposed by De Vos (2007 p.346).

- **Transferability**

This represents the alternative for external validity or generalisability (Lincoln and Guba, 1985 p.290). As mentioned earlier, the findings in qualitative research cannot be generalised to the population. An alternative, as proposed by Yin (1994 p.1) and De Vos (2007 p.346), is to generalise to theory which should also result in the development of a theory (Daymon and Holloway, 2011 p.323), or here, a framework, which was accepted for the purpose of this study. Furthermore, transferability is achieved when the whole data collection and analysis process is guided by the categories and subcategories obtained from the literature - this clearly illustrates the theoretical parameters of the study (De Vos, 2007 p.346). Additionally, triangulation helps achieving transferability in this study, because it increased the study's value in other settings (De Vos, 2007 p.346), not only in hospitals.

- **Dependability**

This is the alternative for reliability, whereby the researcher "attempts to account for changing conditions in the phenomenon chosen for the study as well as changes in the design created by increasingly refined understanding of the setting" (De Vos, 2007 p.346). According to Riege (2003 pp.83-84), the following two aspects can be implemented to ensure dependability.

Firstly, a dependability audit during the research design phase can be conducted which entails examining and documenting the inquiry process. It is necessary to determine whether the inquiry processes are applicable, understandable and well documented, and to implement measures to avoid research bias. Secondly, measures should be applied to safeguard against the researcher's theoretical position and biases during the research design. For that, the following measures were applied in this study:

- the results of the interview study Ia guided the categories for the interview study Ib and questions in the interview guide;
- two pilot interviews were conducted to evaluate whether the questions were understandable and correctly interpreted;
- the researcher also avoided the inclusion of any biased questions based on his theoretical position during data collection.

- **Confirmability**

This is the alternative to objectivity. Confirmability focuses on whether the data help to confirm the general findings and indicate the implications (De Vos, 2007 p.346). According to Riege (2003 p.84), it is necessary to conduct a confirmability audit during data collection and analysis - that is, the researcher needs to retain the raw data (such as recordings) and the auditor should determine whether the inferences based on the data are logical during data analysis and the quality of the findings needs to be reviewed. In the current study, the one-to-one interviews were recorded and retained, and a logical data analysis flow was ensured because it comprised circles of theory development, examination and identification. The data were analysed according to the sequential phases of developing the framework. This enabled the researcher to more accurately determine whether the findings corresponded to the theoretical propositions of the study.

6.12 Triangulation

Data that has its origin in different phases and types of data can be considered in a combined way to condense the data quality and thus the verified abstraction. For that, there are certain techniques described in literature, which have been applied in this research. They are introduced in the following sections.

6.12.1 Theory

Cooper and Schindler (2003 p.151), supported by Walt (2006 p.81), argue that exploratory studies can combine qualitative and quantitative research. Although an exploratory study is usually qualitative in the sense that it requires an in-depth investigation of certain phenomena (Van Wyk, 2010 p.84, Singh, 2007 p.64) (Cooper and Schindler, 2003 p.151). According to De Vos (2007 p.361), the concept of triangulation, a term originally developed by Denzin (1978), "… is based on the assumption that any bias inherent in a particular data source, investigator and method would be neutralized when used in conjunction with other data sources, investigators and methods".

Triangulation offers the following advantages (De Vos, 2007 p.362): The researcher is more confident about the results; opposing results may be uncovered through the utilisation of different research designs, which may help to enrich the explanation of the research problem; it may result in the integration of diverse theories to address a common problem; and triangulation can also fulfil the function of testing competing theories. In mixed methods research approaches triangulation is often applied (Sekaran and Bougie, 2016 p.106). According to Rothbauer 2008 as cited in Walle (2015 p.145). "Triangulation, simply put, refers to the process of examining a phenomenon in more than one way in order to provide a more robust analysis.". Denzin (1970 p.301) distinguishes between four different types of triangulation. De Vos (2007 p.362), (Mabry, 2008 p.222) and Daymon and Holloway (2011 p.92) identify various methods of triangulation which include the following:

- Data triangulation, which refers to the utilisation of various data sources, such as interviews and observational data. A significant element of data triangulation is "a wide array of data is gathered in order to demonstrate that the findings do not merely reflect specific circumstances" (Walle, 2015 p.147);
- investigator triangulation, which refers to the involvement of more than one expert or observer in the research to establish inter-subjective conformity. Investigator triangulation builds on the approach that "different researchers can counter the challenge that the investigator influences the observed data" (Walle, 2015 p.147);
- theory triangulation, which refers to the employment of multiple theories to interpret a data set; For theory triangulation it is characteristic to "interpret the data using a variety of theories" (Walle, 2015 p.147);
- and methodological triangulation, which refers to the use of more than one method to study a specific phenomenon by combining qualitative and quantitative research and triangulation by time, focusing on repeat visits to the site to track patterns of events. Methodological triangulation is characterised by "different data gathering schemes are used" (Walle, 2015 p.147), such as interviews or survey. These four types are just basic characteristics of types of triangulation.

Of these, predominantly theory and method triangulation were considered in this research project. The research project follows a sequential order with a multiphase triangulation approach (Youngs and Piggot-Irvine, 2012). According to Denzin (1970 p.310) "Multiple triangulation exists when researchers combine in one investigation multiple observers, theoretical perspectives, sources of data, and methodologies". Triangulation is often referred to when data, that are compared and contrasted, are generated through different methods. Though it is a concept that cannot be limited to a "one-size-fits-all" definition. Triangulation needs rather to be "tailor-made" to fit the research (Wolf, 2010). The research design and contrasting data collecting methods of this study provided the researcher with the possibility to analyse data through three types of triangulation: time triangulation, combined levels of triangulation, and methodological triangulation (Cohen et al., 2007). For the purpose of this study, methodological triangulation was constantly applied during the whole data collection to specifically "maximise the strengths and to overcome the weaknesses of [more than one] approaches" (Van Wyk, 2010 p.91).

The quantitative parts of the interviews and the survey would allow us to measure the present situation of water safety management in various UK hospitals, while the qualitative parts would enable us to address the findings and explore in detail the process of *Legionella* risk management, mapping process characteristic and stakeholders.

6.12.2 Applied in research design

As this research follows a pragmatic approach, it opens up the opportunity for a choice of techniques (Onwuegbuzie and Leech, 2005). Such choice, as Bryman (2008b) suggests, involves critical decisions to be made about:

- The weighting to be given to quantitative and qualitative data (prioritising)
- The sequence of data collection and analysis (implementation)
- The stages at which the quantitative and qualitative data are integrated (integration)

One aim was to integrate and place priority on both qualitative and quantitative data. A large-scale questionnaire was used to triangulate all the former data and evidence that was gained by that time. Data collection and analysis was attempted to be realised under the category of a combined “convergence” and “multilevel” model (Creswell and Plano Clark, 2007), where both qualitative and quantitative data were collected concurrently and compared, contrasted and integrated at almost all stages. The aspect of simultaneous data collection was tried but was not possible for al levels, as accessibility for data collection has been one of the strongest challenges. The struggling moments during data collection of ‘semi-structured one-on-one interviews’, ‘documents and other secondary data’, ‘web-based survey’ and ‘focus groups’ are described in chapters 6.9.3, 6.9.4, 6.9.5 and 6.9.6 respectively. Instead of a simultaneuous data collection, a rather more “sequential” design approach resulted with quantitative (QUAL) preceding qualitative (QUAN) data collection and vice versa (see later this chapter Figure 6-10 and Figure 6-11).

The overall intent of this research was to gain a “fuller understanding” (Creswell and Tashakkori, 2008 p.115) of the process of water safety management, *Legionella* prevention and risk management in hospitals, seen from a facilities management perspective in England.

As Figure 6-9 shows, this approach meant that the overall design, as well as being mixed methods framed within a multilevel model (Creswell and Plano Clark, 2007), was also a larger study that encompassed a multiple case study (Yin, 2009). ‘Level 1’ comprises qualitative and quantitative data collection, analysis and results (QUAN & QUAL), ‘Level 2’ and ‘Level 3’ comprise qualitative data collection, analysis and results (QUAL). Equal priority was placed on quantitative and qualitative data though a distinction was made between qualitative data at Level 2 and Level 3. Levels 1 and 2 correspond to the national sampling frame that incorporated all stakeholders. Level 2 at phases I and III correspond to a national sampling frame. Level 3 corresponds to the in-depth case studies of the accessed hospitals and one separate case study in the national context of England. This multilevel design enabled the researcher to compare and contrast the data from the national sampling frames with data from regional case studies throughout the phases of the research period.

The multilevel model (Figure 6-9) is limited in terms of sufficiently displaying the multiple phases that are integral to mixed methods research.

But it provides a way of viewing each level inherent in the design. It does not reveal the dimension of time through the research project. The research of the process of water safety management, *Legionella* prevention and risk management in hospitals was established around four key phases:

- Phase I a: Interview study I
- Phase I b: Interview study II
- Phase II: Survey study
- Phase III: Focus group: Framework validation

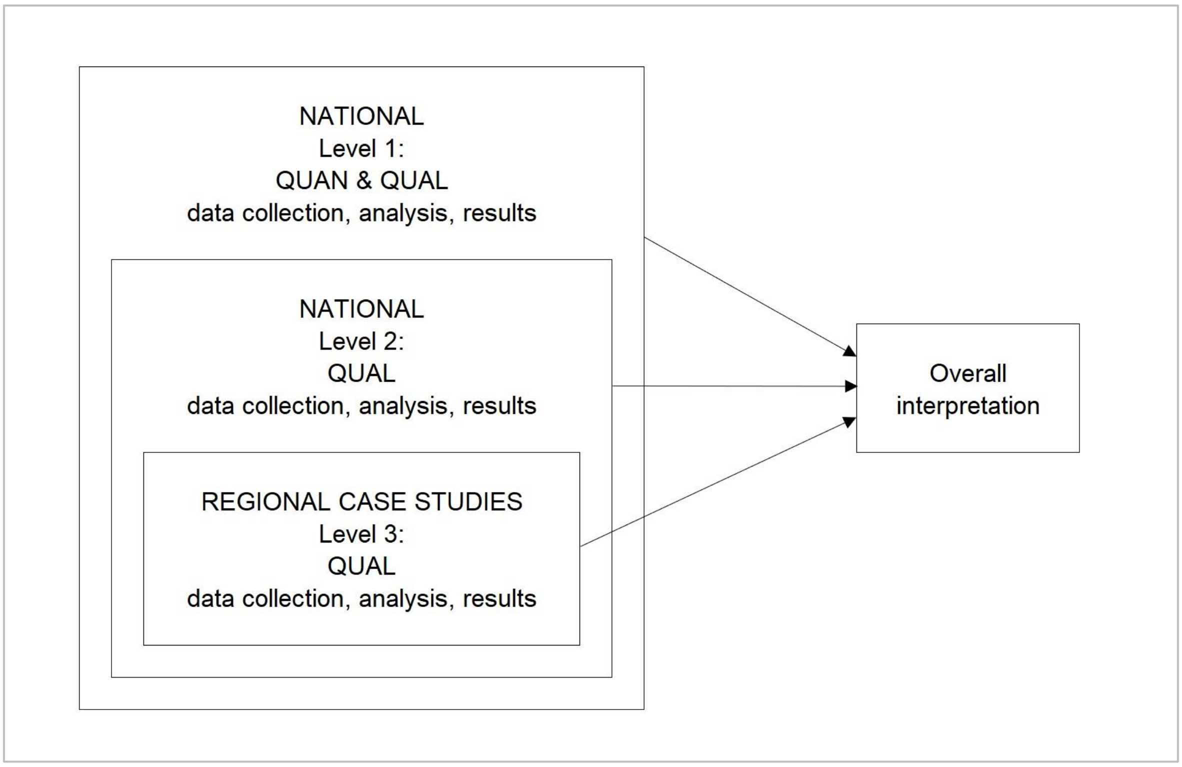


Figure 6-9: Triangulation design: Multilevel model Source: Adapted from Creswell and Plano Clark (2007 p.64), modified

The multiple phase approach is expected to contribute best for answering the research question and sub questions listed in chapter 1.3. It is the researcher's intention to provide both formative and summative findings to professionals in the respective fields and to the research community. The commitment to formative feedback meant ongoing comparison and contrasting of the data across phases I and III of the mixed methods design, leading to the enabling of possible multiphase convergence (see Figure 6-10). The convergence model is used when researchers "want to compare results or to validate, confirm, or corroborate quantitative results with qualitative findings" (Creswell and Plano Clark, 2007 p.65). For this research the convergence model was applied slightly differently at each phase during the research. Each phase having a distinctive yet overlapping and integrated purpose in the overall multilevel research design (see Figure 6-11).

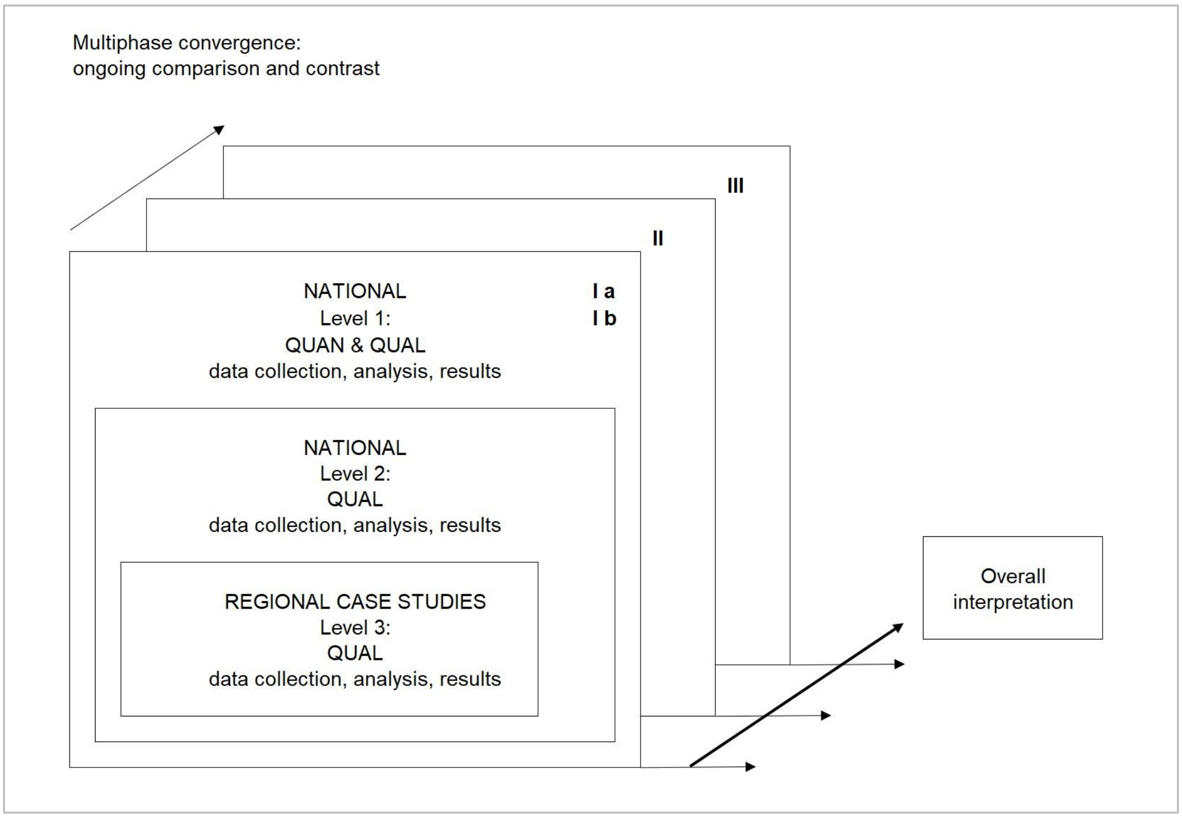


Figure 6-10: Multiphase triangulation design approach: Combining Creswell and Plano Clark's (2007) convergence and multilevel models

The underlying multiphase triangulation design reveals how the multilevel and convergence models of Creswell and Plano Clark (2007) can be combined to show almost simultaneous and concurrent usage of quantitative and qualitative data analysis. This is more complex both in terms of multiple sampling frames and necessary design flexibility. Design flexibility can be required when the research occurs over a prolonged period of time. A range of data collection tools and sampling frames were used across Levels 1, 2, and 3 in the multilevel design (see Table Appendix A-23). The multiple data collection tools were aimed primarily at providing cross-checked or triangulated data from which more rigorous and valid conclusions could be drawn (Denzin, 1997).

Cross-checking for plausibility and the search for common patterns was carried out within a phase and also between phases to generate preliminary findings. While progressing through each phase, the mix of the quantitative and qualitative data collecting tools, particularly through phases I b to III, enabled the researcher to constantly compare and contrast the phase data for the context of England. Furthermore, it enabled to develop an ongoing and cumulative interpretation of the overall findings. Figure Figure 6-11 presents the levels according to the research phases Ia, Ib, II and III, which have been achieved in a secuential way over time, as presented in the introduction of chapter 6.

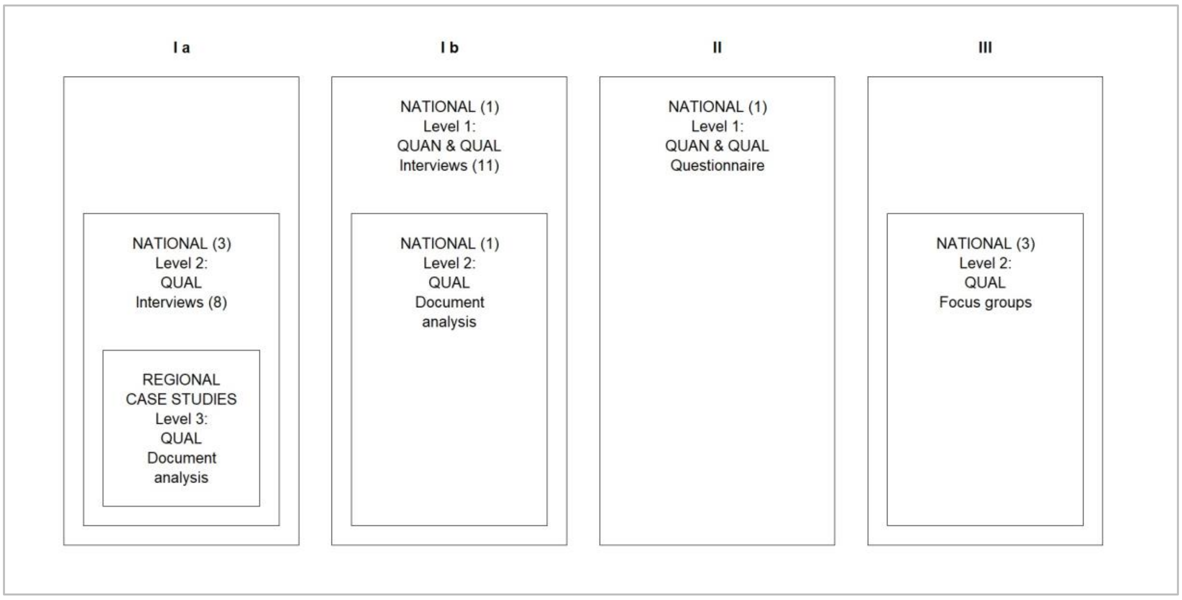


Figure 6-11: Phases used in research design approach applying multiphase triangulation

6.13 Transferability - towards generalisation

Based on Walle (2015 p.148) qualitative research projects are mostly not exactly repeatable, contrary to experiments. A qualitative research project has its specific focuses, challenges and settings. The specific character of a qualitative research project has also been highlighted by Miles et al. (2014 p.34). According to Easterby-Smith et al. (2012 p.341) "generalizability is the extent to which observations or theories derived in one context can be applicable to other contexts."

In accordance with these determinations, this research project aims at finding a level of transferability for the professional field of estates and facilities management, but it doesn't want to be used in any way as a generalising tool to be copy-pasted. Rather, it should be understood as an evidence-based summary of a general topic in a specific context.

6.14 Critical review on frameworks

In order to evaluate what the best type of framework should look like for the present study, a specific literature review was done. It seeks to find relevant and structuring elements to shape the framework.

6.14.1 Background

The aim of the research is to develop a framework for those responsible for water systems based on the insights gained during data collection and analysis. This framework aims at guiding on the prevention of *Legionella* in hospital water systems. The target group is the management level in Estates and Facilities Management. The framework aims to provide orientation by integrating an overall view of the sub-process steps to be considered into an overall process. Detailed diagrams and current references are displayed for individual elements of the framework, which can be interpreted as instructions for action. By comparing the degree of fulfilment of their own organisation (hospital) with the existing elements of the framework, it is possible to determine the current situation. This shows what is currently being done and whether more attention should be paid to certain aspects.

Used as a management instrument, this fit-gap comparison allows resources to be earmarked for specific tasks, which are then used step-by-step and in a systematic manner.

At the beginning of Chapter 4, reference was made to the work of Bereskie et al. (2017) in which they presented an "Innovative Plan-Do-Check-Act (PDCA) Framework for a Safe Drinking Water Supply". Their work focuses on the entire water supply chain. The presented PDCA-WSP framework for drinking water management in Canada describes individual fields of action with federal, provincial/territorial and municipal responsibilities. In other words, different stakeholders with different tasks and responsibilities. If one considers the hospital as a socio-technical system in which various tasks arise that require (drinking) water supply and in which services are performed by different responsibilities (Sax and Colombo, 2016) certain of the ten steps of the PDCA-WSP presented can be transferred to a smaller system - hospital as a complex building system. As a synthesis product from this thesis' research progress, and inspired by elements of the PDCA-WSP, which gives this research an orienting framing, which is transferred to another setting into another national context, the created framework of the present research is to be understood as a target group specific instrument, which makes a contribution to *Legionella* prevention, and thus to public health.

Just as important as the development of a modern, practice-oriented framework for a specific target group is its recognition by experts and professionals (see chapter 6.9.7.4) and its availability. In the course of the research work, contact was made with various organisations (see chapter 6.9.7.3, Table Appendix A-16 and Table Appendix A-17) to recruit interviewees (chapter 6.9.7.1) and survey participants (chapter 6.9.7.3). The organisations became aware of the research work. One of these organisations expressed interest in publishing the final product "Framework" as an official "guiding document" as part of its public relations work. Thus, the framework can be made available for industry-specific training purposes in the future.

6.14.2 Critical literature review

A contextual literature review serves to delimit the scope of a framework in terms of content and subject matter. The review aims to question various publications on frameworks, how to place them in the national context of the UK, to identify and analyse the relationship to the research topic in order to derive elements, the structure, scope and special features for its creation. At the same time, the review serves to identify national frameworks on the research topic that might potentially already exist. In order to reconise the purpose of a framework in this research context, some explanations need to be done.

A framework is generally understood to be the frame around which you fit the detail. This could be in the form of a template. There are different approaches according to which a framework is developed or derived. But also the perspective, what the framework is meant for, has to be taken into consideration before it is developed. In the relationship to the research context there were found for example the following types of frameworks, characterising their purpose or structure:

- Theoretical framework (Crippa et al., 2018)
- Conceptual framework (Amaratunga and Baldry, 2003, Looy et al., 2014)
- Process-based framework (Contandriopoulos et al., 2015)

For the literature review any type of context-specific publication highlighting the term "framework" found in scientific data-bases was evaluated by qualifying its content and appearance. It considers thematic classification, structural elements, content elements and editors or publishing body. The underlying method is rooted in Ullrich's background on implementation theory (Ullrich et al., 2014), where a definition of a precise contextual reference catalogue or definition of reference criteria is needed. It helps implementing theory. For that, each framework was classified by exactly the same set of criteria (Table Appendix A-24).

As a result of this specific literature review on frameworks, a decision was made to create a process-based framework presenting an initial framework overview, a map with processes and process elements in a hierarchic stucture, involved people responsible, a communication scheme, explaining process flowcharts for specific workflows, further structuring elements for risk management procedures, corresponding template documents, control requirements and references to existing guidance documents and finally compliance management tools.

6.14.3 Structuring elements and steps

Bereskie et al. (2017, p.248) describes a Canadian Ministers of the Environment Multi-barrier approach (MBA), where they identified integrated elements rated as critical components of the MBA. There were found further steps described by Bereskie et al. 2017, which seem very important for consideration for developing and structuring a framework "Water safety management, *Legionella* prevention and risk management in hospitals: a framework for Estates and Facilities Management in England". All identified elements are listed in Table 6-13 and Table 6-14. They represent focus elements for structuring the final framework according to the combined logics and principles 'from external to internal view', 'from source to tap', 'from stratecig to operational level' while complying with quality management standard for continuous improvement by plan-do-ckeck-act.

Table 6-13: From Source to Tap: The multi-barrier approach to safe drinking water (CCME, 2002)

Element no.	Element	Descriptions
1	Legislation and policy frameworks	Legislative and policy frameworks highlight responsibilities for each aspect of the drinking water system and should be reviewed and revised as necessary
2	Public involvement and awareness	Public involvement and awareness includes appropriate levels of partnership and communication among stakeholders to increase transparency and availability of public health information
3	Guidelines, standards, and objectives	Regulations provide utility managers and system owners with water quality targets to meet and can be used as part of the decision-making process

4	Research, science, and technology	Research, disease surveillance, and other scientific and technological advancement/development allows for more integrated water quality monitoring and potential for improving operations
5	Management	Drinking water supply management requires cooperation of stakeholders in different fields (e.g., health, environment, and industry) and requires qualified personnel to ensure treatment facility and distribution system are operating at optimum levels
6	Monitoring	Water quality monitoring includes the sampling of water quality at the source, after treatment, and within the distribution network. This allows operators to modify treatment if water quality fluctuates to ensure regulatory compliance and safe drinking water
7	Source water protection and management	Protection of source water based on watershed management involving a coordinated approach among stakeholders to develop short and long-term plans to prevent, minimize, or control potential sources of pollution or enhance water quality
8	Drinking water treatment	Drinking water treatment is key to eliminating pathogens and chemical substances found in source waters. They should be regularly reviewed and upgraded as necessary
9	Drinking water distribution systems	Distribution systems are the final physical barrier in the multi-barrier approach. After water is treated, its quality must be maintained throughout the distribution system

Furthermore, they describe ten consecutive steps of the Plan-Do-Check-Act Water Safety Plan (PDCA-WSP) framework for a safe drinking water supply (Table 6-14).

Table 6-14: The ten steps of the PDCA-WSP, described by Bereskie et al. (2017)

Step	**Description**	**PDCA element**
Step 1	Assemble the team to prepare the PDCA-WSP	Plan
Step 2	Document and describe the system	

Step 3	Document and describe compliance and performance monitoring	
Step 4	Develop supporting programs	
Step 5	Performance maintenance and monitoring	Do
Step 6	Enforce	Check
Step 7	Audit and develop performance benchmarking	
Step 8	Corrective actions	Act
Step 9	Perform management review	
Step 10	Continuous performance improvement	

To sum it up, general thematic, structural and content characteristics were found (Table Appendix A-24), which can be considered in a final framework output.

In the focused mini literature review of chapter 6.14.2 no existing framework of the typ this research wants to present an output was found for the national context of the UK. This gap of a missing framework of that type and content is intended to be closed by the dissemination of this work. This finding is in line with the findings of Chapter 4. In order to further substantiate this finding, a corresponding question (queston 7) is put to the experts of the focus group (chapter 6.9.7.4).

This shows the innovative character of such a framework. A potential need should be covered by this research. Since the framework is aimed at management levels, its page count is limited to a few pages. In addition, the framework will be extended by a tool for visualisation, with the help of which the users will be able to see which compliance level they will achieve in relation to the elements of the framework. Two monitors serve as a meaningful management instrument for the overall overview. A "framework" (chapter 8, Figure 8-22) and a "process" (chapter 8, Figure 8-27) monitor. Explanatory elements in the form of diagrams and references supplement the framework (chapter 8), which should not exceed 20 pages.

6.15 Creating a framework in line wih the objectives

The output of the present research is to cover an assumed demand for guidance: A framework for *Legionella* prevention in in hospitals. It should meet the following criteria:

- ➔ This framework is tailored for estates and facilites management. It is a specified output for people responsible for water safety and *Legionella* risk management in England.
- ➔ It may be utilised as a brief guiding document for how the process of water safety management could be organised and what is essentially being considered.

➔ The title of the framework is aligned to the content, which is: “The process of water safety management, *Legionella* prevention and risk management in hospitals: a framework for estates and facilities management with focus on England”.

There are different approaches and perspectives that have to be considered for framework development, as was described in chapter 6.14. The research design for identifying the content of the framework utilised mixed methods, in which quantitative methods were used in a secondary role. It was chosen to emphasize the qualitative data as it was expected this would help identify the scope and field of stakeholders and processes under research. However, based on prior research experience, it was anticipated the qualitative interviews would provide insights into the circumstances, roles and processes of people responsible for water safety management from an estates and facilities management perspective. Outcome measures include descriptive statistics. The qualitative data from the interviews of phases I a and I b and the qualitative data from the free-text responses in the survey of phase II were were considered all at the point of data analysis to identify themes.

As a prior step to framework development, the reseacher developed an analytic framework for thematic coding through iterative review of batches of transcripts and the free-text survey items. A priori anticipated themes from the literature review were integrated with emerging themes to revise the analytic framework as data collection progressed.

The final version of the coding template, which led to the framework output elements, is available on Table 6-16 indicating the relationship of the categories of the different research phases and the research questions. Mapping matrices present how the research objectives feed answers to the research subquestions, applying different analysis procedures (Table 6-15, Table 6-17, Table 6-18).

Table 6-15: Mapping matrix of the objectives (1 to 6) feeding answers on the subquestions (SQ1 to SQ4)

	SQ1	SQ2	SQ3	SQ4
Objectives		(1)		
	(2)	(2)		
	(3)			
	(4)	(4)		
			(5)	
				(6)

The dominant analysis strategies for gaining evidence, and the alignment of the objectives to the respective analysis strategy for answering the subquestions is cross-referenced to the respective chapter and summary table of this thesis, as presented earlier at the beginning of chapter 6 (Figure 6-3). Ongoing data analysis continued until the researcher concluded thematic exhaustion had been reached. For the most part qualitative data were coded and analysed with NVIVO software (see chapters 6.10.2.1 and 6.10.2.2), but also applying conventional methods and more time-consuming analytical procedures with classically assembled tables and using excerpts. Following preliminary analysis of qualitative and quantitative data, integrated analysis of the quantitative and qualitative data was performed with these methods. Outcomes measures included measures of association for themes by quantitative descriptor.

The framework output is described in chapter 8. The framework output concluded and compiled from the research results and analyses of phases Ia, Ib and II underwent a subsequent validation step by during a focus group for identifying final revisions to qualify the framework for applicability in practice. The whole validation step and the recommendations for revisions are described in chapter 7.7.

Table 6-16: The relationship of the categories of the different research phases Ia, Ib and II and the research subquestions

INTERVIEWS	Details				**INTERVIEWS**	Details				**INTERVIEWS**	Details				**SURVEY**	Details				**Output**
Phase Ia *See chapters 7.2 and 7.3*	Analysis intends to deliver answers to following research subquestions				Phase Ib extrinsic PESTLE analysis *See chapters 7.3 and 7.4*	Analysis intends to deliver answers to following research subquestions				Phase Ib intrinsic CTAAPM analysis See chapters *7.3 and 7.4*	Analysis intends to deliver answers to following research subquestions				Phase II RMP analysis See chapter 7.5	Analysis intends to deliver answers to following research subquestions				
	SQ1	**SQ2**	**SQ3**	**SQ4**		**SQ1**	**SQ2**	**SQ3**	**SQ4**		**SQ1**	**SQ2**	**SQ3**	**SQ4**		**SQ1**	**SQ2**	**SQ3**	**SQ4**	
Actors **A**		x			Political **PP**	x	x	x	x	Control **CC**	x	x		x	Roles and responsibilities **R**		x		x	**F R A M E W O R K (chapter 8)**
Drivers **D**	x			x	Economic **PEc**				x	Transparency **CT**	x	x	x		Management and processes **M**	x		x	x	
Professional field **P**	x	x	x	x	Social **PS**		x	x		Accountability **CAc**		x		x	Processes and collaboration **P**	x	x	x	x	

<table>
<tr><td>INTERVIEWS</td><td colspan="4">Details</td><td>INTERVIEWS</td><td colspan="4">Details</td><td>INTERVIEWS</td><td colspan="4">Details</td><td>SURVEY</td><td colspan="4">Details</td><td rowspan="5">FRAMEWORK (chapter 8)</td></tr>
<tr><td>Phase Ia

See chapters 7.2 and 7.3</td><td colspan="4">Analysis intends to deliver answers to following research subquestions</td><td>Phase Ib extrinsic
PESTLE analysis

See chapters 7.3 and 7.4</td><td colspan="4">Analysis intends to deliver answers to following research subquestions</td><td>Phase Ib intrinsic
CTAAPM analysis

See chapters 7.3 and 7.4</td><td colspan="4">Analysis intends to deliver answers to following research subquestions</td><td>Phase II
RMP analysis

See chapter 7.5</td><td colspan="4">Analysis intends to deliver answers to following research subquestions</td></tr>
<tr><td>Organisation’s instruments
Oi</td><td>x</td><td></td><td></td><td></td><td>Technological
PT</td><td>x</td><td></td><td></td><td>x</td><td>Awareness
CAw</td><td></td><td>x</td><td></td><td>x</td><td></td><td></td><td></td><td></td><td></td></tr>
<tr><td>Clinical instruments
Ci</td><td></td><td>x</td><td></td><td></td><td>Legal
PL</td><td>x</td><td>x</td><td>x</td><td>x</td><td>Prevention
CP</td><td>x</td><td>x</td><td></td><td></td><td></td><td></td><td></td><td></td><td></td></tr>
<tr><td></td><td></td><td></td><td></td><td></td><td>Environmental
PEn</td><td>x</td><td></td><td></td><td>x</td><td>Management
CM</td><td>x</td><td>x</td><td>x</td><td>x</td><td></td><td></td><td></td><td></td><td></td></tr>
</table>

Table 6-17: Mapping matrix for phase Ia and phase Ib (extrinsic) analysis procedures to achieve objectives and to answer the subquestions

Phase Ia											**Phase Ib (extrinsic)**										
	Subquestions				**Objectives**							**Subquestions**				**Objectives**					
	SQ1	SQ2	SQ3	SQ4								SQ1	SQ2	SQ3	SQ4						
A – WHO		x			(1)	(2)		(4)			PP – Political	x					(2)	(3)	(4)		
D – THROUGH	x					(2)	(3)	(4)					x			(1)	(2)		(4)		
				x						(6)				x						(5)	
P – WHAT	x					(2)	(3)	(4)							x						(6)
		x			(1)	(2)		(4)			PEc – Economic				x						(6)
			x						(5)		PS – Social		x			(1)	(2)		(4)		
				x						(6)				x						(5)	
Oi – HOW	x					(2)	(3)	(4)			PT – Technological	x					(2)	(3)	(4)		
Ci – HOW		x			(1)	(2)		(4)							x						(6)
											PL – Legal	x					(2)	(3)	(4)		
													x			(1)	(2)		(4)		
														x						(5)	
															x						(6)
											PEn - Environmental	x					(2)	(3)	(4)		
															x						(6)

Table 6-18: Mapping matrix for phase Ib (intrinsic) and phase II analysis procedures to achieve objectives and to answer the subquestions

Phase I b (intrinsic)											**Phase II**										
	Subquestions				**Objectives**							**Subquestions**				**Objectives**					
	SQ1	SQ2	SQ3	SQ4								SQ1	SQ2	SQ3	SQ4						
CC – Control	x					(2)	(3)	(4)			R – Roles and responsibilities		x			(1)	(2)		(4)		
		x			(1)	(2)		(4)							x						(6)
				x						(6)	P – Processes and collaboration	x					(2)	(3)	(4)		
CT – Transparency	x					(2)	(3)	(4)					x			(1)	(2)		(4)		
		x			(1)	(2)		(4)						x						(5)	
			x						(5)						x						(6)
CAc – Accountability		x			(1)	(2)		(4)			M – Manage-ment and pro-cesses	x					(2)	(3)	(4)		
				x						(6)				x						(5)	
CAw – Awareness		x			(1)	(2)		(4)							x						(6)
				x						(6)											
CP – Prevention	x					(2)	(3)	(4)													
		x			(1)	(2)		(4)													
CM – Management	x					(2)	(3)	(4)													
		x			(1)	(2)		(4)													
			x						(5)												
				x						(6)											

The following Table 6-19 and Table 6-20 indicate how the analysis of survey questions intends to deliver answers to the four research subquestions.

Table 6-19 applies to research phase Ib. Subquestion one is abbreviated with ‘SQ1’ and quests for process elements with elements of answers on questions (Q) 12, 13, 16, 18, and 25_26. Subquestion two is abbreviated with ‘SQ2’ and quests for process owners with elements of answers on questions (Q) 4, 8, 10, 12, 13, 16, and 25_26. Subquestion three is abbreviated ‘SQ3’ and quests for overlapping duties with elements of answers on questions (Q) 10, 12, 13, and 25_26. Subquestion four is abbreviated ‘SQ4’ and quests for facts comparable between organisations with elements of answers on questions (Q) 4, 8, 10, 11, 12, 13, 16, 19, 21_23, 25_26, 28, 32, 33, 34, 36, and 37.

Table 6-19: Strategy of how analysis of questions of phase Ib deliver answers to research subquestions

Interview phase I b question	**Analysis to deliver answers to research subquestions**			
	SQ1	SQ2	SQ3	SQ4
Q4		x		x
Q8		x		x
Q10		x	x	x
Q11				x
Q12	x	x	x	x
Q13	x	x	x	x
Q16	x	x		x
Q18	x			
Q19				x
Q21_23				x
Q25_26	x	x	x	x
Q28				x
Q32				x
Q33				x
Q34				x
Q36				x
Q37				x

Table 6-20 applies to research phase II. Subquestion one is abbreviated with ‘SQ1’ and quests for process elements with elements of answers on questions (Q) 17, 18, 19, 20, 21, 23, 24, 25, 26, 27, 28, 29 and 30. Subquestion two is abbreviated with ‘SQ2’ and quests for process owners with elements of answers on questions (Q) 1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12, 13, 14, 15, 16, 22, 23, 24, 25, 26, 27, 28, 29, and 30. Subquestion three is abbreviated ‘SQ3’ and quests for overlapping duties with elements of answers on questions (Q) 17, 18, 19, 20, 21, 23, 24, 25, 26, 27, 28, 29, and 30. Subquestion four is abbreviated ‘SQ4’ and quests for facts comparable between organisations with elements of answers on questions (Q) 1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12, 13, 14, 15, 16, 17, 18, 19, 20, 21, 22, 23, 24, 25, 26, 27, 28, 29, and 30.

Table 6-20: Strategy of how analysis of questions of phase II deliver answers to research subquestions

Survey phase II questions	**Research focus category**	**Analysis to deliver answers to research subquestions**			
		SQ1	SQ2	SQ3	SQ4
Q1-Q16, Q22	Roles and responsibilities		x	x	x
Q17-Q21	Management and processes	x	x	x	x
Q23-Q30	Processes and collaboration	x		x	x

The analysis strategies presented in Table 6-16, Table 6-19 and Table 6-20, in combination with Table 6-21, provide data and analysis to deliver answers to the research. The research progress towards the framework output, which is the result of this research, delivers answers to subquestions SQ1 to SQ4 and, finally, answers the research question. The research question is then answered in chapter 9.2. Table 6-21 lists the structure of how the research subquestions SQ1-SQ4 are intended to be answered by using results and analyses of the different research phases Ia, Ib and II by applying the multiphase triangulation design described in chapter 6.12.2.

Table 6-21: Strategy for answering the subquestions of the research project applying selected categories of analysis procedures of different phases

	S U B Q U E S T I O N S			
	SQ1	**SQ2**	**SQ3**	**SQ4**
	THROUGH, WHAT, HOW (Oi)	WHO, WHAT, HOW (Ci)	WHAT	THROUGH, WHAT
	PP, PT, PL, PEn	PP, PS, PL	PP, PS, PL	PP, PEc, PT, PL, PEn
	CC, CT, CP, CM	CC, CT, CAc, CAw, CP, CM	CT, CM	CC, CAc, CAw, CM
	M, P	R, P	M, P	R, M, P
	Content as available	Content as available	Content as available	Content as available

The next section highlights the ethical considerations applicable to this study.

6.16 Ethical considerations

According to Easterby-Smith et al. (2012 p.95) there are a couple of important thoughts that have to be considered before doing the research:

- Ensure that no harm comes to participants
- Respect the dignity of research participants
- Ensure full information to gain (informed) consent of research participants
- Protect the privacy of the subjects under research
- Ensure confidentiality of research data
- Protect anonymity of individuals or organisations
- Avoid deception about the nature or aims of the research
- Declaration of affiliations, funding sources and conflicts of interest when communicating research results
- Avoid any misguiding or wrong interpretation of research findings

Since this study obtained insights into the processes of water safety management, *Legionella* prevention and risk management in hospitals, certain ethical issues had to be considered. Firstly, the researcher had to determine whether the interview participants and the survey respondents preferred to participate anonymously.

There is always a possibility of a loss of standing or employment when confidential information is divulged (Stake, 2000 p.447). Even though giving information about business processes, documents, risks in the context of infectious diseases might be an argument for cautiousness or reticence. Anonymity implies that the researcher does not reveal the identity of the respondents and participants or even the name of the organisation. This can be done, inter alia, by using pseudonyms, changing the names of the participants, protecting data by applying labels with letters and numbers and securely storing the research notes and transcriptions (Daymon and Holloway, 2011 pp.66-67). Although a list of participating organisations would be available, the anonymity of each organisation, interview participant and survey respondent was kept confidential throughout the research process. To address confidentiality issues, Stake (2000 p.447) argues that it is advisable to enter into a contract between the researcher and organisations, where the research boundaries are stipulated and the researcher assures the participants that the research is to be conducted purely for academic purposes. Furthermore, it is essential for the researcher to share draft documents with the participants to ensure that their views are accurately represented (Stake, 2000 p.448). The researcher should obtain permission from the participants well in advance to record the interview discussions, disclose facts and identities, and, in the compilation of a research contract, informed consent needs to be obtained. This basically implies that the participants must understand and accept the terms of the agreement (Thomas, 2011 p.69). To obtain informed consent, the researcher needs to disclose the nature and purpose of this study, the expected benefits, information on anonymity, confidentiality and the storage and presentation of data as well as the credentials of the researcher (Thomas, 2011 pp.69-70). All was done in the course of the research.

6.16.1 Confidentiality and protection of participants and research data

Formal research contracts were drawn up for the parts of the interview study in terms of consent forms to disclose information and insights and to record the discussions. By realising this formal step the interview participants respected the academic nature of the study. Informed consent was obtained for the survey part and the focus groups. The respondents and participants' identities were protected. To ensure that the facts were accurately presented, a draft document of the findings of the research was shared with the respondents and participants on request.

6.16.2 Cross cultural bilingual research and translation

An early, initial idea was to do a comparative study with focus on the situations of water safety risk management, *Legionella* prevention in the professional field of estates and facilities management in three countries of two different languages and cultural backgrounds. This is described in chapter 6.5 and 6.9.2. For data collection and data analysis of data gathered during phase I a, which included German and Swiss-German speaking countries Germany and Switzerland, a lot of effort was necessary to establish country- and language- specific data collection instruments. Those interviews held in the German language were audiotaped, transcribed and then translated into adequate English. As Germany and Switzerland have different-to-the-UK organisation structures of water safety risk management and *Legionella* prevention (see Leiblein et al. (2017b)), further considerations led research on having a focus on analysing the cases in England. This decision also helped avoiding language or cultural barriers (Tate et al., 2017), or misunderstanding and misinterpretation of terminology.

6.17 Researcher characteristics and reflection

Since 2011, the researcher has been working on the topic of *Legionella* prevention in drinking water systems. Since then, the researcher’s network and experience has grown continuousely.

In the first few years his focus was almost exclusively set on two German-speaking countries. With the beginning of the doctorate at Liverpool John Moores University, and with the emergence of the research question, the interest has widened up to the English speaking context, and thus, to a more holistic view with the increasing amount of international literature studied. During this time, similarities and differences in the approach of organisations (hospitals) to water hygiene, prevention, risk management and facilities management were studied.

In order to capture and investigate these differences scientifically methodically valid, the presented research design was chosen in the context of this work. On the one hand, the work systematically collects data on a given research question. On the other hand, findings were collected and critically reflected during the course of the research. Furthermore it was possible to stimulate discussions and to discuss practices in prevention activities.

This was made possible by the researcher's career to date. For many years, he has worked as a research associate at the Institute of Facility Management at Zurich University of Applied Sciences. There he became familiar with facilites management in all its facets and areas of responsibility. Furthermore, his scientific-technical background as a graduate engineer for nutrition and hygiene technology, with numerous further training courses, and a Master’s degree in Life sciences, enables him to better understand and communicate with different stakeholders, addressing the target audience within this sensitive subject area. Since 2019 he is working at middle-management level in the professional field of infection prevention for a Swiss private hospital, which is one hospital of more than 85 of an international clinic network.

With the research results and experiences, based on analyses and literature studies, and with the continuous examination of updates in legislation and recommendations and guidelines, the desired, practice-oriented approach of research may be carried forward.

Findings will be used to the best of knowledge for didactic purposes and for sharing with the research community. The scientific nature of communication and reporting was then and is now a fundamental requirement of the work.

6.18 Summary

The purpose of chapter 6 was to discuss the methodology used to detect and measure the processes of water safety management, *Legionella* prevention and risk management in hospitals in practice to develop a framework for facilities management.

It was indicated that this study was a combined study with explorative, descriptive, explanatory and evaluative purpose inherent in its nature and built from an interpretative research paradigm. It combines qualitative one-on-one face-to-face, telephone interviews and a web-based survey, embedded in a mixed methods research design.

Although triangulation by means of a combination of qualitative and quantitative methods was outlined as the research methodology, it was indicated that a predominantly qualitative research design would be followed. The purpose of doing two interview studies, which constitutes the first phase of data collection, would be to obtain and confirm inputs of organisations regarding processes and stakeholders. The data obtained from the first phase would inform the second phase of data collection, the survey. This would be conducted to address the trends identified in the interviews; explore the finer details of processes, stakeholders and management. Phases one and two feed the final output, the framework, which will be validated in a focus group, the last phase of data collection.

Since this study was primarily concerned with obtaining insights from water safety group members from the perspective of estates and facilities managagement on the present processes, designs and perfoming of water safety management, *Legionella* prevention and risk management processes in hospitals, it was essential to purposively select respondents who were willing to participate in the study. The sample of the two interview studies phase Ia and phase Ib comprised eight and 11 interviewees respectively, as described in detail in chapter 6.9.7.1. A total of 169 people of the targeted group of people, which is members of a water safety group, have entered the opening page of the web-based survey. Only 17 respondents completed the survey, giving a response rate of 10%. Purposive non-probability and convenient sampling strategies were applied, as described in 6.7.

In chapter 6.9.7.3 it was indicated that the web-based survey would be designed by means of the BOS design program and would comprise 31 questions with a total of 54 differents items quested, and with variations in the type of response options. Various methods would be employed to ensure the quality of the questionnaire, which included the evaluation of the questionnaire by an expert panel covering academics' and professionals' perspective background. The measurement levels would include both ordinal and nominal. The data analysis methods employed for the web-based survey would initially entail descriptive analysis including non-statistical quantitative analyses by means of thematic coding, frequency analyses and matrix analyses.

It was argued that the questions and categories for the semi-structured one-on-one interviews of phase Ia and Ib would lead to setting up the survey questions of phase II. The overall data analysis method proposed for this study was a combination of Creswell's (1998) analytic spiral, which was integrated with the analysis process from Marshall and Rossman (1999).

Trustworthiness was presented as an alternative for establishing reliability and validity in qualitative research, to ensure the credibility, transferability, dependability and confirmability of the study. Credibility, which was described as the alternative for internal validity, was achieved through an extensive literature review and the application of triangulation (chapter 6.12) as a leading research design element within the boundaries of the research setting, population and theoretical framework of the study. Thus the scene was set for focusing on stakeholders, processes, risk management, knowledge management, water safety and *Legionella.*

The chapter concluded with a discussion of the ethical aspects that were considered for this study, which specifically focused on maintaining the anonymity of the survey respondents and interview participants. The next chapter presents the results and analyses of the data that has been collected, giving the elements for the framework.

7 Results and analyses

The following chapter is of great importance for this research and the generation of the output. It introduces and explains the results and analyses in a structured way of the sequential order of the research progress.

7.1 Literature review

The literature review (chapters 2 to 5), upon which this research is built, brought up three main areas of interest to focus on during analyses. Analysis procedures are aligned to the research aim (section 1.4), objectives (section 1.5), the research problem uncovered and the subquestions arising. The three main areas are:

- Analyses focus I: Processes
- Analyses focus II: Stakeholders (functions, roles, resonsibilities)
- Analyses focus III: Training and training needs

With reference to the methodology described in the first paragraph of chapter 6, the analysis procedures of phases I a, I b, II and III, which all apply content analysis methods such as thematic, template and descriptive analysis, are referred to these three main areas of analysis.

7.2 Phase I a – interview study (QUAL)

With data originating from phase Ia an initial concept map was compiled, defining categories, which allow analysing the interviews in a structured manner and with respect to identifying the process of *Legionella* prevention in healthcare facilities. The categories are 'actors', 'drivers', 'professional field', 'organisation's instruments', 'clinical instruments'. Afterwards, words which occurred during the interview were grouped into the respective category. The selected words are based on the common business language of the interviewee. This was done to keep the originality of the words from the interview partners. Selected were those words that were found purposefully matching the category. The selected words are expected to be important starting points for deeper analysis of the data. They build on the experience during the interviews, transcription process and first familiarising works with the texts. Subsequent identification and analysing cycles aimed at working out case classifications, differences, relationships and patterns. Several cycles of data analysis led to deeper understanding of the data in this exploratory research (triangulation).

The exemplified dataset of the case characteristics (Table Appendix A-25) contain structured data arranged in rows (numbered hospitals 01-08) and columns (case characteristics). They also contain quotations of the responses of the interviewees. The recruited interview partners of the hospitals were affiliated to different positions / functions. They were seen as the 'data source' answering the interview questions and providing additional data material in the form of documents (chapter 7.3).

Evaluating the quality of the answers included three qualifying aspects 'completeness', 'appropriateness' and 'source' (Table 7-1). Quality here is defined as the number of occurrences of a certain interview response, rated by the content quality of the answers.

For that, the transcripts underwent a thematic analysis step. Translation issues were considered carefully, as data sources were obtained from German and English sources.

Table 7-1: Quality of answers – assessment according to completeness, appropriateness and source

Country	Job description of gatekeeper	Quality of the answers according to completeness / appropriateness / source
UK	Deputy Director of Estates	++ / ++ / ++
UK	Associate Director of Estates	++ / ++ / ++
GER	Hygienist	++ / + / 0
GER	Head of Construction Management	+ / + / +
CH	Head of Technical Services	0 / + / ++
UK	Water Safety Manager	+ / ++ / +
CH	Head of Technical Services	+ / + / ++
CH	Sanitary worker	0 / + / 0
GER	Head of Building Services	+ / ++ / ++

Text analysis was carried out and then visualised. It started with a text search query. For that, a key word or a certain phrase was searched for in the source material, according to the pre-defined categories. The resulting word frequency query lists the most frequently occurring words in the interviews. The search included stemmed words. The total counts were referred to the respective country and visualised in a case-ordered meta matrix (Table 7-2). According to the arithmetic mean of the counts per country, three ranks were assigned, where rank 1 represents the country with the most frequent counts.

As a method of confirming findings and testing the validity of the data obtained, method triangulation and source triangulation was applied (chapter 6.12.2). To increase the credibility of the results, phase I a considered a variety of different types of data analysis and visualisation methods. The spectre contains:

- Case characteristics (Table Appendix A-25)
- Quality of answers – Assessment (Table 7-1)
- Word frequency query (Table 7-2)

Summarised in the case characteristics presented in Table Appendix A-25 some general areas of mor specific interest ave been derived fromt the interview participants.

For Germany it was ‘the hygiene commission’ and ‘shared responsibilities’ (hospital 03),

For Switzerland it was ‘costs per jear spent on water safety’ (hospital 05) , ‘professional expertise’ and ‘challenge in the common understanding between clinical and non-clinical (e.g. technical) representatives’ (hospital 07).

For The UK (England) it was ‘good nderstanding of roles and responsibilities’ (hospital 02) and the ‘interdisciplinary and complex task of achieving water safety management’ (hospital 06).

Table 7-2 and Table 7-3 list the total counts of words (with stemmed words) that were defined for each main category and found during a word frequency query. Table 7-3 shows the case-ordered meta matrix, with ranks for each country, according to the arithmetic mean of the results of the word frequency counts.

Table 7-2: Total word counts per category phase Ia

Category	Words	Hospital 01	Hospital 02	Hospital 03	Hospital 04	Hospital 05	Hospital 06	Hospital 07	Hospital 08	
Actors	Responsibility	17	36	34	21	16	29	36	16	205
	Role	2	10	0	0	1	1	0	0	14
	Stakeholder	0	0	0	0	0	2	3	0	5
	Water Safety Group	5	34	0	0	1	25	2	0	67
Total Counts Category Actors		**24**	**80**	**34**	**21**	**18**	**57**	**41**	**16**	291
Drivers	Authority	3	3	3	7	2	4	1	5	28
	Legislation	1	1	0	0	2	4	1	1	10
	Legal	3	0	3	4	1	8	9	2	30
	Guidance	9	0	0	0	0	6	0	0	15
	Recommendation	0	2	8	4	1	0	4	1	20
	Standard	1	3	3	0	9	4	3	1	24
Total Counts Category Drivers		**17**	**9**	**17**	**15**	**15**	**26**	**18**	**10**	127
Professional field	Estates	16	55	1	1	4	8	2	0	87
	Facilities	4	12	15	5	3	15	8	9	71
	Facility Management	2	2	5	3	2	5	2	5	26
	Healthcare	4	7	0	1	0	6	0	1	19
	Health authority	0	0	1	4	0	0	0	0	5
	NHS	4	8	0	0	0	1	0	0	13
	Trust	10	39	0	0	0	8	0	0	57
	Health & Safety	1	5	2	1	3	2	1	1	16
	Legionella	22	22	25	29	28	45	31	12	214
	Legionella managem	2	1	1	0	0	0	0	0	4
	Legionella preventio	3	3	0	1	12	12	4	3	38
	Legionella risk manag	3	1	2	1	1	7	1	3	19
	Water Management	4	8	8	8	8	1	0	0	37
	Water Safety	15	61	8	3	3	44	5	7	146
	Water Safety Team	1	3	1	0	1	2	2	0	10
	Water Safety Group	5	34	0	0	1	25	1	0	66
	Water Systems	12	7	3	1	5	30	4	11	73
Total Counts Category Professional field		**108**	**268**	**72**	**58**	**71**	**211**	**61**	**52**	901
Organisation's Instruments	Prevention	9	18	10	2	17	24	18	6	104
	Monitoring	4	5	9	4	7	12	1	8	50
	Sampling	2	6	33	24	12	8	15	4	104
	Audit	0	3	2	0	0	2	0	0	7
	Control	9	20	7	9	14	13	7	2	81
	Process	5	14	10	5	67	19	23	3	146
	Documentation	6	16	21	11	10	18	19	10	111
	Matrix	0	0	3	0	4	0	8	1	16
	Accountability	1	1	2	0	1	2	9	2	18
	Strategy	2	4	2	1	1	7	1	2	20
	Risk	21	37	11	11	9	36	19	16	160
	Structure	6	5	3	7	15	6	9	3	54
	Duty	3	4	1	0	1	4	2	2	17
Total Counts Category Organisation's Instruments		**68**	**133**	**114**	**74**	**158**	**151**	**131**	**59**	888
Clinical Instruments	Hygiene commission	1	3	21	14	10	2	11	1	63
	hospital hygiene	0	0	6	0	0	0	18	8	32
	infection prevention	3	15	0	0	0	2	0	0	20
Total Counts Category Clinical Instruments		**4**	**18**	**27**	**14**	**10**	**4**	**29**	**9**	115

Table 7-3: Section A) Results word frequency query (wfq); Section B) countries ranked by the results of wfq

A

Category	Hospital 01	Hospital 02	Hospital 03	Hospital 04	Hospital 05	Hospital 06	Hospital 07	Hospital 08	Total counts
Actors	24	80	34	21	18	57	41	16	291
Drivers	17	9	17	15	15	26	18	10	127
Professional Field	108	268	72	58	71	211	61	52	901
Organisation's Instruments	63	119	104	69	91	132	108	56	742
Clinical Instruments	4	18	27	14	10	4	29	9	115
Total counts	**221**	**508**	**264**	**182**	**272**	**449**	**280**	**146**	

B

Arithmetic mean value	Hospitals	Country	Rank
393	01, 02, 06	United Kingdom	**1**
276	05, 07	Switzerland	**2**
197	03, 04, 08	Germany	**3**

It was found that in England (United Kingdom) water safety follows the principles of the water safety plan. Preliminary results have been presented with a poster at aconference in Rome (see Figure Appendix A-9). There is institutionalised a water safety group with certain roles and responsibilities within the organisation. Processes are described and organised in fundamental documents, such as policies and plans. All these are indicators for defined and documented organisational structures. In contrast, in Germany and Switzerland, there is the institutionalised hygiene commission playing a central role in the organisation with respect to water safety, risk management and *Legionella*.

The attitude of interviewees of these two countries, in terms of sharing documents for research purposes is less supportive and qualitatively inferior to that experienced in England.

Of course, it may be argued that *Legionella* and risk management in hospitals is a sensitive topic, which prevents sharing information. But, according to different national backgrounds and logics - either following the lead of the water safety group or the hygiene commission respectively - it means different roles, organisational structures and process logics. In order to study the field of interest, a decision for further research practices was made.

Decision-making was made by following the criteria listed below:

- Appropriateness of the management level of the interview partners
- Quality of organisational structures (identifiable organisational structures, accountability, job titles)
- Completeness of data collection procedure intended to feed the research. This also included the openness of answers during the interview, the quality of answers during the interview, the availability of interview partners, the number of additional documents provided by the interview partners
- Traceability of the described tasks and activities. Plausibility and evidence of existing structures with reference to standards and laws

The procedures described for data collection and the results obtained from phase Ia show that information could be collected within the underlying research design. However, the interviews showed that the number of questions asked was very large and the interview took too long in time. On average, a full interview lasted about 79 minutes. Addressing precise questions should be chosen. Nevertheless, they must meet the requirement to contribute to answering the questions (objectives) of the actual research project. The initial phase I a, which could be rated as a ‘pilot study’ provided important insights for data collection and data evaluation. Necessary adjustments were taken into account as lessons learned for the subsequent interview study phase I b. In this pilot study, the instruments and procedures for data collection and analysis were tested under field conditions for three countries. It became clear that in the context of England there seem to be implemented clearer, more systematic structures in the organisations. The interview partners in England are, experienced during research progress, more open-minded in sharing experience and insights than those in Switzerland and Germany. The roles of the responsible persons in the sense of water safety also appear to be defined more clearly, and anchored in the guidelines and recommendations for those being responsible.

England seems to have the greatest potential for finding interview partners who provide insight into current documentation on the structure of the organisation (job descriptions, water safety plan, water safety policy, reports, structures, roles and responsibilities). It becomes clear that with regard to a general awareness of the "process of *Legionella* prevention", divided into the logics process scheme and process managers, there are hardly any starting points for comparing the organisations of the three countries.

It was also found that roles are clearly defined in England, which contributes collaboratively to water safety and *Legionella* prevention. In addition to typical organisational ‘management responsibilities by roles’, members (functions) of the ‘water safety group’ were also identified (see chapter 7.3). The hospitals in the two German-speaking countries differ from the English system in two aspects. On the one hand, there is a lack of clearly assignable function descriptions of the responsible persons, or their differentiation and roles are not described as unequivocally as in England. On the other hand, those responsible from more technical areas of estates/FM of the organisations in Germany and Switzerland are more subordinated to hygiene (commission) within the organisational structure.

Based on these findings, and in combination with the findings presented in the document analysis (chapter 7.3), the next steps in the research project were undertaken with a revised focus following a refined strategy, contextualised to England (UK) and encompassed by a closer aligned methodology.

7.3 Phase I a and I b – document analysis (QUAL + QUAN)

This chapter brings together content from the document analysis and illustrates, in particular, information on the overarching research topics water safety management process and roles and responsibilities. Charts or schemes that are presented here are anonymised to meet criteria mentioned in chapter 6.16. Some are considered for delivering content elements of the framework and are indicated with source specific content.

For phase Ia there were different document classes possible, such as organograms, terms of reference, organisational structure, WSG progress reports, WSG minutes, water safety plan, water safety - specific procedural documents, policy. Those documents have been provided by the organisations in England. The types of additional documents received during the interviews are:

- Hospital 01, England, 6 additional documents, i.e. Deputy Director Estates role and responsibilities; Existing Estates Structure; New estates staff structure; Organisation structure clinical directorates; Organisational Structure/Corporate Directorate; Water Safety Group TOR (Terms of Reference).
- Hospital 02, England, 14 additional documents, i.e. DOH - Health Building Note 00-02: Sanitary spaces; Organisational structures (1 x Estates Facilities Senior Team; 1 x Estates Tree); 3 x Infection Prevention & Control Committee (IPCC) - Water Safety Group – Progress Report; 6 x Water Safety Group Terms of Reference; 2 x CAD drawings of Hot and Cold Water services.
- Hospital 03, Germany, no additional documents provided.

- Hospital 04, Germany, no additional documents provided.
- Hospital 05, Switzerland, one additional document, i.e. organisational structure.
- Hospital 06, England, 4 additional documents provided, i.e. Water Safety Plan (WSP); WSP Point of use Filtration; WSP Thermostatic Mixer Valves; Water Safety Risk Management Policy and Procedures
- Hospital 07, Switzerland, 2 additional documents provided, i.e. Structure Technical Services; Organigram.
- Hospital 08, Germany, no additional documents provided.

The roles and water safety group members presented hereafter are taken from the document "*Water Safety Risk Management Policy and Procedures*" (pp. 9-14) of hospital 06, listed hereafter:

Management responsibilities by roles:

Duty holder, Director of Infection Prevention and Control (DIPC), Lead Infection Control Doctor (Medical), Infection Control Officer, Responsible Person Water (RPW), Deputy Responsible Person Water (DRPW), External Auditor/Authorising Engineer, Infection Prevention and Control Team (IPCT), Ward/Department Managers, Estate Maintenance Workers /Contractors, Water Safety Group, Authorised Person(s) (Water), Competent Persons (Water Hygiene Technicians, Plumbers, Manager (Trust/Contractor), *Legionella* Risk Assessor, Estates/Engineering Professionals and Managers, Other Relevant Staff/Contractors, Water Hygiene Contractor.

Water safety group members:

Lead Infection Control Doctor (LICD) (Chair), Director of Estates and Capital Development (Vice Chair), Head of Operational Maintenance (RPW), Mechanical Maintenance Manager (DRPW), Head of Infection Prevention Team, Infection Control Officer (Consultant Microbiologist), Managerial Representative (Cleaning Services), Head of Estates Maintenance & Chief Engineer, Water Hygiene Contractor, External Auditor/Authorising Engineer, Clinical Representatives.

A case-ordered matrix as a summary table for structuring and overseeing the content of the documents obtained during phas Ia is provided in Table Appendix A-26, which lists the types, titles and categories of documents for each interview participant of phase Ia. The elements per row in column 'ID organisation' index the interview participant of the respective hospital. With the exception of organisation number 05 there were additional documents obtained from all the interview participants from the organisations in England. The category types of the documents comprise 'Organograms', 'Terms of Reference', 'Job profile Deputy Director Estates', 'IPCC Assurance reports', 'Water safety group minutes', 'Water safety plan and attached elements', 'Water Satefy Risk Management Policy and procedures'.

A case-ordered matrix as a summary table for structuring and overseeing the content of the documents obtained during phas Ib is provided in Table Appendix A-27, which lists the types, titles and categories of documents for each interview participant of phase I b. The elements per row in column 'ID organisation' index the interview participant of the respective hospital. With the exception of organisations number 09 and 10 there were additional documents obtained from all the interview participants from the organisations.

For phase I b there were recorded different document classes, such as ‘policy’, ‘water safety plan’, ‘process flow chart’, ‘instruction’, ‘guidance document’, and ‘risk assessment form’. According to their content the documents are classified into seven different major categories, which are ‘WSP – Water Safety Plan’, ‘Policy – Water Safety Policy’, ‘Process – Process Flow chart’, ‘Role, Responsibility, Duty Matrix / Structure / Chart’, ‘Accountability Chart’, ‘Audit Plan / Report’, ‘ToR Terms of Reference’. The list has been developed during data collection and finalised after receiving the last documents. It was the basis for document analysis.

Table Appendix A-26 and Table Appendix A-27 present the total amount and type of documents received, listed for phase Ia and Ib independently. As the list for the documents received during research phase Ib with including every table of content would effect 49 additional pages in this thesis, a summary table was favourably compiled. Figure Appendix A-10 picturises the amount of content in a list.

All the documents had been collected for desk research during the interviews on phase Ia and Ib. Decision making of qualifying the document by its type of information was made in a sequential process order, as described in chapter 6.10.2.2 and at the beginning of chapter 7.3. Seven categories were seen to be the most frequently occurring and most important terms in the documents with respect to their relevance to management. Table 7-4 details the types and size of documents of phase Ib that have been considered during analysis and the triangulation process. Table 7-4 must be read in the following manner: The availability of the documents to the researcher after the interviews phase Ib are shown in the respective colour, where green indicates that type of document was obtained from the interviewee and thus, being available for analysis. A self-standing document lists dark green. When evidence of content for certain document type characteristics were found in a reference document, e.g. in WSP or Policy or ToR, the cell is listed bright green, while giving information about any other presence of specific terms as cross reference in other documents. For cells containing ‘n/a’ there was no such corresponding type of document obtained. Listed is also the number of cumulated pages of the original documents. Identified as leading documents, a total of seven water safety plans and nine water safety policies had been received.

Table 7-4: Additional documents from interview partners received during phase Ib

		ID interview partner										
		01	**02**	**03**	**04**	**05**	**06**	**07**	**08**	**09**	**10**	**11**
Document / information type	WSP Water Safety Plan			n/a		n/a				n/a	n/a	
	Policy Water Safety Policy									n/a	n/a	
	Process Process Flowchart		In WSP	In Policy	n/a	n/a	In WSP	In WSP	In WSP	n/a	n/a	n/a
	Role, Responsibility, Duty Matrix / Structure / Chart	In WSP	In Policy	In Policy		In Policy	In Policy	In Policy	In Policy	n/a	n/a	n/a
	Accountability Chart	In WSP	n/a	n/a	n/a	n/a	n/a	n/a	In ToR	n/a	n/a	n/a
	Audit Plan / Report		In Policy	In Policy	In WSP	n/a			In Policy	n/a	n/a	n/a
	ToR Terms of Reference	n/a		n/a		n/a	n/a	In Policy		n/a	n/a	n/a
		97	191	39	159	38	391	148	168	0	0	24
		Cumulated number of pages of the documents provided for document analysis										

7.4 Phase I b – interview study (QUAL + QUAN)

Extracted and condensed answers on the questions selected for analysis are presented in Table Appendix B-1 to Table Appendix B-15. The tables present in the left column the hospital ID, which represents each interview participant, the middle column presents the extract of the specific answer given, and the right column presents the PESTLE and CTAAPM analysis category that was identified for the content of the text part. The tables are the parent texts for the further condensed results tables presented in this chapter, with exception of 7.4.14 'dominant topics for WSG members from Estates / FM', for which was found the extracted table presents the results concisely from the beginning.

During three cycles of analysis, questions 4, 8, 11, 12, 13, 14, 16, 18, 19, 21, 23, 25, 26, 28, 32, 33, 34, and 36 of the interview study phase Ib were seen those with the most relevant content and quality of answers for contribution in answering the research questions and to build on the framework output. Each question and the corresponding output of answers from the interviewees are presented in this chapter, each with a separate heading for a better navigation of the reader. The structure is organised in a way starting with a header of the original question, followed by a statement of the researcher's purpose of analysis, and completes with a summary, followed by a table presenting the extracted information of the answers assigned the corresponding PESTLE and CTAAPM thematic coding categories (chapter 6.10.2.1). For questions 13, 14, 25, 26, and 28 the extract of the answers follows after figures which present specific summaries. For questions 19, 21, 23, 32, and 37 it was possible to reduce the extract of the answers to a basic minimum and compile a table for each. Table 7-5 presents the selected focus questions. Question 13 and 14, 21 and 23, as well as 25 and 26 are presented in a combined way in chapters 7.4.6, 7.4.10 and 7.4.11 respectively.

Table 7-5: Selected focus questions characterising eleven hospital cases

Question number	**Question content**
Q4	Could you please mention the "top 3" of your key functions within your organisation?
Q8	How many people are members of the water safety group?
Q10	Could you please mention potential conflicts or conflict potential about who is responsible for what? Potential conflicts for carrying out minor tasks: There are PFIs, Trust, FM companies and Trust estates departments.
Q11	In which way is *Legionella* a topic of interest in your organisation?
Q12	Could you describe the way you are actively managing the hospital's water systems?
Q13_14	How robust do you assess your *Legionella* risk management and prevention process are at present (FM's non-clinical perspective)? [Scale 1-5] Reasons?
Q16	In short words, what is your understanding/definition of a) a process? b) a process step? c) a process owner?

Q18	Does a common process of *Legionella* prevention and water safety exist in your organisation? Why / why not?
Q19	Taken from your experience: Which three things do you think hit strongest a common process of *Legionella* prevention and water safety in your organisation?
Q21_23	Are there management instruments or tools / software that you apply?
Q25_26	In general: how would you rate the following six areas that are assessed as “critical” for water safety management? [1 = not very critical; 3 = moderate critical; 5 = very critical]; Scale 1-5 for each]. Please give also a reason/explanation for each decision. A) Allocation of responsibilities B) Training and competence of personnel C) Control measures D) Communication and Management E) Record keeping F) Reviews
Q28	Are there any comparable elements to the given scheme of governance arrangements? (Remark: The interview partner was handed a scheme of governance arrangements, see Figure 7-9, p. 172.
Q32	Which are the dominant topics that the water safety group is confronted with? Please mention the ‘top 5’.
Q33	Which topics in water safety risk management and prevention of *Legionella* present the biggest challenges?
Q34	What has been your greatest success / goal you achieved in your organisation within the past 12 months with respect to *Legionella* prevention and water safety?
Q36	A rough estimation: How much money do you annually spend for water safety?
Q37	Is the budget enough to meet the requirements?

7.4.1 Top 3 key functions

4	Which are the “top 3” of your key functions within your organisation?

Purpose of analysis: Interesting for the analysis is to see the scope of responsibilities being a WSG member. The focus is on water safety issues being part or not of their work.

Summary: With the exception of categories ‘PS’ and ‘CAc’ analysis has found main elements for consideration for the framework. Category nodes and main elements are listed in Table 7-6 (n/a - not available), an extended table is put in Appendix B (Table Appendix B-1).

Table 7-6: Category nodes and main elements in answers on question 4, phase I b

Analysis	Category	Occur-rence	Identified main elements and consideration for framework
PESTLE	PP	3	Managing PFI arrangements
	PEc	4	Asset management
	PS	0	n/a
	PT	6	Estates maintenance; Temperature checks; removal of blind ends
	PL	9	Compliance; ACoP L8, HSG 274/HTM04; statutory and mandatory compliance; Health and Safety Works Act
	PEn	4	Test, maintain and audit of the hospital's water systems
CTAAPM	CC	7	Environmental hazards; higher risk areas
	CT	3	Risk assessment; Control; categorisation; adhere to regu-lations and HTMs
	CAc	0	n/a
	CAw	2	Raising awareness
	CP	7	Patient safety; control and manage all engineered services on the trust; risk; compliance; documentation
	CM	9	Risk register, safety; governance; compliance; pipework; distribution systems; influence and control any alterations

7.4.2 Members of the WSG

8	How many people are members of the water safety group?

Purpose of analysis: Interesting for the analysis is to see how many people, in fact, join the WSG. According to the HTM 04-01 there are specific roles/responsibilities mentioned. It could be of interest to see, whether or not certain roles/responsibilities are not represented, either judged by the total number of members, or the composition of the group.

Summary: Analysis found main elements for consideration for the framework for categories 'PP', 'PS', 'PL' and 'CAc'. Category nodes and main elements are listed in Table 7-7 (n/a - not available), an extended table is put in Appendix B (Table Appendix B-2).

Table 7-7: Category nodes and main elements in answers on question 8, phase I b

Analysis	Category	Occur-rence	Identified main elements and consideration for framework
PESTLE	PP	4	Reporting structures from departments to water safety group; exception reports; risk mitigation
	PEc	0	n/a
	PS	11	Members in WSG; external auditing independent role; ex-emplarily group according to HTM
	PT	0	n/a
	PL	1	HTM; appropriate training
	PEn	0	n/a
CTAAPM	CC	0	n/a
	CT	0	n/a
	CAc	7	PFI; reporting
	CAw	0	n/a
	CP	0	n/a
	CM	0	n/a

7.4.3 Potential conflicts: PFIs, Trust, FM companies, estates departments

10	Could you please mention potential conflicts or conflict potential about who is responsible for what? Potential conflicts for carrying out minor tasks: There are PFIs, Trust, FM companies and Trust estates departments.

Purpose of analysis: This analysis focuses on a specific point where it gets complicated. All the possible lines of responsibility and accountability need to be thought of. This can get very complicated where there are PFIs, Trust, FM companies and Trust estates departments. Quite often there are conflicts about who is responsible for what and ridiculous costs for carrying out minor tasks (because the PFIs and external FM companies work on life cycle costs and manage to justify themselves this way). This might be a whole can of worms with need to be understood. Consultants have often been the public health pig in the middle when there have been cases and actions need to be taken.

Summary: The following “PFI golden triangle” (Figure 7-1) was extracted from the statements given. It describes dependencies and obligations between different parties. The PFI golden triangle is seen an important guidance element for being put into the framework to sentisize on the specific situation with Private Finance Initiatives.

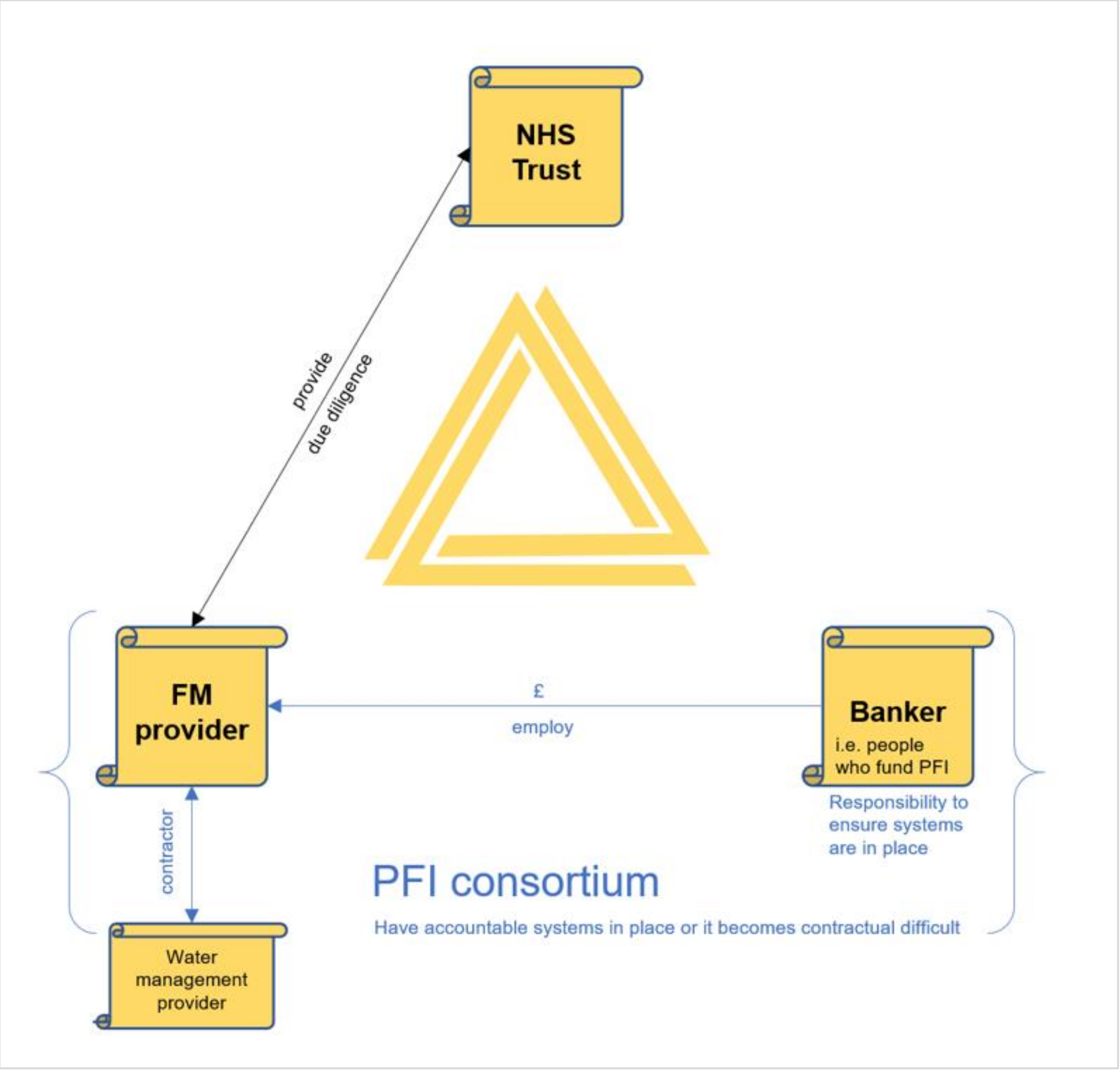


Figure 7-1: The "PFI golden triangle"

Analysis has found the main elements for consideration for the framework. Category nodes and main elements are listed in Table 7-8, an extended table is put in Appendix B (Table Appendix B-3).

Table 7-8: Category nodes and main elements in answers on question 10, phase I b

Analysis	Category	Occur-rence	Identified main elements and consideration for framework
PESTLE	PP	9	Risk management; PFI provider
	PEc	21	Trust finances for water systems is the only real conflict; FM companies; Trust's responsibility to do certain elements; escalated further up the management chain; contractual; PFI golden triangle
	PS	14	FM company; roles and responsibilities; misalign with the Estates strategy; Trust Estates Department
	PT	3	Maintenance contract; approved provider; stakeholders; systems are adequately financed; maintenance; life cycle
	PL	17	Meet the necessities in place; liability; flushing the outlets; current standards; water safety; strategies; policies; make the most money while staying compliant; third-party-managed sites; landlord sites; PFI; good trust checking
	PEn	12	Pseudomonas aeruginosa; FM; 30 years time; robust process; won't consider all of the outlets; other wards; system surrounding them; isolated project; considering the whole system
CTAAPM	CC	22	Minimum requirements; fulfil requirements; contract contemporary; current legislation and guidance; risk; decision's made; due process of spending money; getting information; service failure points; monitor; lease agreements; control; correct flow rates; FM provider on the sites, Estates team

	CT	21	WSG; governance is right; issuing penalties; warning notes; temperatures; feasible, practicable, and reasonable; maintenance contract; approved provider; equipment manufacturers who use water in their system
	CAc	21	Interest to find problems and issues; Health Technical Memorandum (HTM); operation Estates team; microbiology; director of infection prevention control; testing for *Legionella*; evidence; risk assessed appropriately by authorising engineer; major refurbishments; management company
	CAw	20	Proceed without adequate process; PFI companies are very much, ask for evidence; parties just aren't cooperative; Patient care and patient centred service is well done; priority list; skill and experience; proactive; water cooler; principles of engineering; meet requirement
	CP	8	Current standard; responsibility
	CM	30	Conflicts; PFI agreement, communication; contractual loops around ability between the client and the service provider; good governance arrangement with FM provider; a due process; day-to-day management and work; temperatures or pressures; outsources their entire management and maintenance of their estate to a profit oriented company and external consultancy company; third-party-managed estate; wholly-owned premises

7.4.4 *Legionella* – a topic of interest

11	In which way is *Legionella* a topic of interest in your organisation?

Purpose of analysis: Interesting about this analysis is the extent to which the topic of *Legionella* is taken up in the organisations. The researcher hopes that the nature of the question will provide clues about the subject areas, the awareness of those people responsible, the organisation of people and processes involved and identify elements of the process.

Summary: With the exception of categories 'PEc', 'PT' and 'CT' analysis has found main elements for consideration for the framework. Category nodes and main elements are listed in Table 7-9 (n/a - not available), an extended table is put in Appendix B (Table Appendix B-4).

Table 7-9: Category nodes and main elements in answers on question 11, phase I b

Analysis	Category	Occur-rence	Identified main elements and consideration for framework
PESTLE	PP	3	WSG; microbiologist; monthly reports; permissions in communication to external; topic of interest in understanding at board level; PHE
	PEc	0	n/a
	PS	10	Water management committee; *Legionella* and *Pseudomonas;* staff at risk
	PT	0	n/a
	PL	3	Law; compliance; NHS; lack of control
	PEn	4	Water contaminants; set of requirements; single pipe systems with no returns; maintain by temperature; critical care areas
CTAAPM	CC	2	Compliance; scheme of control
	CT	0	n/a
	CAc	1	Microbiologist
	CAw	1	Management team negating their duties and responsibilities
	CP	2	E-mail alert; risk management assurance committee
	CM	10	Outlets of the system; report; compliance; different hierarchies; Health and Safety committee.

7.4.5 Managing water systems

12	Can you describe the way you are actively managing the hospital's water systems?

Purpose of analysis: Interesting about this analysis is to find evidence about the management procedures of the people responsible.

Summary: Analysis has found main elements for consideration for the framework. Category nodes and main elements are listed in Table 7-10, an extended table is put in Appendix B (Table Appendix B-5).

Table 7-10: Category nodes and main elements in answers on question 12, phase I b

Analysis	Category	Occurrence	Identified main elements and consideration for framework
PESTLE	PP	1	External scrutiny from the environment agency
	PEc	3	Make people aware; hot water generation
	PS	11	Reassurance; monthly basis; meeting; board level; Chief Executive's level; water safety group should meet on a quarterly basis; should attend that meeting
	PT	2	Thermal disinfection; temperature checks; entire domestic hot water system in most problematic wing
	PL	10	A schedule and an escalation level; process of *Legionella* prevention; ACoP; HTM 04-01; good-practice documents; flush taps; store water at above 60°C; guidance note
	PEn	4	Action plans; very high-risk areas, hot water generation; flushing regimes; testing
CTAAPM	CC	4	Temperature checks; sentinel outlets, constraints of L8; HTM 04-01 gives a lot more detail around healthcare premises than the ACoP L8; HSG274. water safety within healthcare premises
	CT	2	Look at the entire system from the point where it enters the site through to the point where the end user's using it
	CAc	9	Water flushing; holistic perspective; roles and responsibilities within the HTMs; authorising engineer is the independent advisor

	CAw	3	Planned preventative maintenance; collaborative process; responsibility; sending people on training courses
	CP	10	Regular sampling; microbiological testing; risk; cost; pro-active with *Legionella* sampling; risk assessments; plan schedules; testing regimes; planned preventative maintenance; dead legs; remedial work scheduled
	CM	15	Overseeing a water safety contractor; sufficient schemes of control; auditing wards for scale and flushing; contractor performance; temperature monitoring; action plan; log book; changed management structures; old management; mismanagement; risk assessments; trained, accredited, and authorised

7.4.6 Robustness of *Legionella* risk management and prevention process

13, 14	From a scale 1 to 5, where 5 is highest, how robust do you assess your *Legionella* risk management and prevention process are at present? Reasons?

Purpose of analysis: Interesting for the analysis is the rating on the one hand, and the exact reasons for the robustness of the prevention process on the other hand.

Summary: With respect to the robustness of *Legionella* risk management and prevention process, one hospital scales a ‘two’ and three rank a ‘three’. Six hospitals rank a ‘four’ and one a ‘five’, indicating the highes value for robustness for hospital 11 (Figure 7-2).

Figure 7-2: Robustness of *Legionella* risk management and prevention process, scale levels from 1 to 5

The focus of further analysis is put on the extrinsic perspective on the process of water safety management and *Legionella* prevention, which applies PESTLE analysis. No CTAAPM analysis was done as it is designed for the intrinsic perspective with focus on stakeholder managing processes. Analysis has found main elements for consideration for the framework. Category nodes and main elements are listed in Table 7-11, an extended table is put in appendix B (Table Appendix B-6).

Table 7-11: Category nodes and main elements in answers on combined questions 13 and 14, phase I b

Analysis	Category	Occur-rence	Identified main elements and consideration for framework
PESTLE	PP	10	Reviewed; conducting audits; external assurance; robust process; risk assessments
	PEc	2	Gaps; sufficient budgets; resource availability
	PS	6	Appointing an external, independent authorising engineer on water; water hygiene services; training documentation; method statements, risk assessments; annual water systems audit; external auditor
	PT	8	Testing for *Legionella*;, temperature; flushing regime; tank cleaning; return water temperatures; finances do play a major part; taps that were incorrect; daily checks; building management system
	PL	12	Primary legislative guidance; design and operational management part; *Legionella* levels above what is acceptable; quality standards
	PEn	13	Flushing challenges; risk assessment, identifying little-used outlets, critical care areas; immunosuppressed people; isolate areas; install filters to the taps

7.4.7 Common understanding of a process

16	In short words, what is your understanding/definition of a) a process, b) a process step, and c) a process owner?

Purpose of analysis: Interesting for the analysis is the understanding of the three terms from responsible persons (here, the interview partners). It may give an answer on whether or not there is a common understanding in the definition of a process. It further may specify subtle distinctions in the understanding or interpretation of the meaning, which potentially has an effect on the overall process thinking and the awareness of the different roles.

Summary: The focus of further analysis is put on the extrinsic perspective on the process of water safety management and *Legionella* prevention, which applies PESTLE analysis. No CTAAPM analysis was done as it is designed for the intrinsic perspective with focus on stakeholder managing processes. To narrow down a common understanding of the meaning of process, process step and process owner, participants of hospital ID01 and ID08 conclude precise and brief definitions in the understanding of process management.

Every reply and interpretation from the interview participants bears interesting and comprehensible thoughts. Analysis has found main elements for consideration for the framework for categories 'PS' and 'PEn'. Category nodes and main elements are listed in Table 7-12 (n/a - not available), an extended table is put in Appendix B (Table Appendix B-7).

Table 7-12: Category nodes and main elements in answers on question 16, phase I b

Analysis	Category	Occurrence	Identified main elements and consideration for framework
PESTLE	PP	0	n/a
	PEc	0	n/a
	PS	11	Process step; hierarchy. responsibility for that process; processes are designed around the HTM04; hard FM provider then will have to inter-provide to our model to allocate whose responsibility is that; processes through policy and procedure; a standard operating procedure; terminology; a document that outlines who the process owners are not only in terms of the individuals or the roles, but in terms of the functions and the departments; water safety team will own the processes; it's not schematic, it's written; guiding document; described in the water safety plan
	PT	0	n/a
	PL	0	n/a
	PEn	11	Same nodes and main elements as above for 'PS'

7.4.8 A common process *Legionella* prevention and water safety

18	Can you explain why / why not a common process of *Legionella* prevention and water safety does exist in your organisation?

Purpose of analysis:

Interesting for the analysis is whether or not there is recognised a major process of water safety and *Legionella* prevention in the understanding of the managers.

Summary: Analysis has found main elements for consideration for the framework. Category nodes and main elements are listed in Table 7-13, an extended table is put in Appendix B (Table Appendix B-8).

Table 7-13: Category nodes and main elements in answers on question 18, phase I b

Analysis	Category	Occur-rence	Identified main elements and consideration for framework
PESTLE	PP	2	People available; a lot to balance
	PEc	2	Budgets available
	PS	6	Water safety plan; defined different process steps; common processes across the board in the trust
	PT	1	Outsource the technical services part
	PL	5	HTM; guiding document; processes and responsibilities; ACoP. those documents (HTM, HSG, ACoP) give a kind of starting point how to find access to generalise a process; it's essentially HTM that we're following
	PEn	2	Temperature monitoring; *Legionella* monitoring process
CTAAPM	CC	1	Generalisation is not a good option for each site or ward
	CT	1	Good engineering
	CAc	2	Shared processes between various hospitals within the trust
	CAw	5	Building adaptation; new construction, new building, or new wing; would expect that the designers, being engineers, would understand the healthcare technical memorandum concerning design of domestic water systems and would sufficiently understand to be able to design and construct a safe system; test your process; water safety policy; water safety plans; process owner; same access to knowledge
	CP	5	You shouldn't try and force a process into a system; water safety policy dictates what we do and how we do it
	CM	11	Process; ‘management’; terminology thing; controlled document; water safety plan; water safety policy

7.4.9 Top three arguments hitting strongest a common process

19	Taken from your experience: Which three things do you think hit strongest a common process of *Legionella* prevention and water safety in your organisation?

Purpose of analysis: Interesting for the analysis is to find evidence on currently experienced process inhibitors and if there are potential elements indicated likewise by the majority of the participants.

Summary: The top three arguments hitting strongest a common process water safety are presented in Table 7-14. No arguments were given by interview participant of hospital ID04, one argument was given by interview participant of hospital ID03 (‘n/a’ means not available).

Table 7-14: Top three arguments hitting strongest a common process water safety

ID hospital	No.1 to hit process	No.2 to hit process	No.3 to hit process
ID 01	Communication	Knowledge of present state and being informed about outcomes	Information is freely available to the water safety group
ID 02	Patient safety	Flushing little used outlets	Defect reporting
ID 03	Have references from estates, the authorising engineer	n/a	n/a
ID 04	n/a	n/a	n/a
ID 05	Proving that you’ve got return water temperatures at every part of the system	Identification of little used outlets	Biannual inspection
ID 06	Having a temperature regime that meets the approved code of practice and the HSG.	Water circulation / movement	monitoring
ID 07	Setting up of the water safety group	Testing regime and documentation	Positive feedback from the Chief Executive
ID 08	Flushing	Temperature monitoring	Positive count reporting (microbiological monitoring)
ID 09	Acknowledgement at a senior level	Temperature testing	*Legionella* testing

ID 10	Risk assessments	Scheme of control	Temperature testing
ID 11	Testing	Monitoring	Recording

Further analysis has found additional main elements for consideration for the framework. Category nodes and main elements are listed in Table 7-15, an extended table is put in Appendix B (Table Appendix B-9).

Table 7-15: Occurrence of category nodes in answers on question 19, phase I b

Analysis	Category	Occurrence	Analysis	Category	Occurrence
PESTLE	PP	2	CTAAPM	CC	6
	PEc	2		CT	1
	PS	2		CAc	2
	PT	4		CAw	3
	PL	1		CP	8
	PEn	4		CM	12

7.4.10 Application of management instruments, tools, software

21, 23	Are there management instruments or tools / software that you apply?

Purpose of analysis: It is interesting to get evidence on currently applied management instruments and tools / software in organisations.

Summary: Table 7-16 presents management instruments, tools and software being in use, that have been mentioned by the eleven interview participants. The original table for analysis is put in Appendix B (Table Appendix B-10).

Table 7-16: Management instruments or tools / software in use

Hospital ID	Management instrument, tool, software
ID 01	ZetaSafe®
ID 02	• Asset management system with planned maintenance tasks and reactive maintenance tasks • L8 guard (flushing software system)
ID 03	ZetaSafe®
ID 04	Process-led Datix & wide risk register
ID 05	Estates Management Computer System (maintenance tasks PPM)
ID 06	Helpdesk, CFM, CMMS
ID 07	ZetaSafe®
ID 08	Assignment matrix (Clearwater)
ID 09	Software management systems since two years looking at sentinel points, temperature monitoring, laboratory results (*Legionella* testing)
ID 10	CAFM, i.e. Micad Property Management Software
ID 11	Maintenance portal system dor delivery and maintenance work inPPM

Analysis has found main elements for consideration for the framework for categories ‘PEc’, ‘PEn’ and ‘CP’. Category nodes and main elements are listed in Table 7-17 (n/a - not available), an extended table is put in Appendix B (Table Appendix B-11).

Table 7-17: Category nodes and main elements in answers on combined questions 21 and 23, phase I b

Analysis	Category	Occurrence	Identified main elements and consideration for framework
PESTLE	PP	0	n/a
	PEc	1	Cost can be quite considerable. The question then is what's the benefit to spending £100,000 on a system

	PS	0	n/a
	PT	0	n/a
	PL	0	n/a
	PEn	1	Desktop exercise to assign a war; high, medium, or low patient risk; clinical risk rating; extract out of the risk assessments; determine an engineering risk; between the two then compare that to how many defects have been reported on that risk assessment
CTAAPM	CC	0	n/a
	CT	0	n/a
	CAc	0	n/a
	CAw	0	n/a
	CP	1	Clinical risk rating; risk assessments; determine an engineering risk; Escalation level; proactive management; Helpdesk is ineffective for corrective maintenance or breakdown activities; moving into an assignment matrix
	CM	0	n/a

7.4.11 Six critical areas for water safety management

25, 26	On a scale from 1 to 5 - where 1 is not critical 3 moderate and 5 very critical - how would you rate the following six areas that are assessed as “critical” for water safety management? Reasons? Areas: A) ‘Allocation of responsibilities’, B) ‘Training and competence of personnel’, C) ‘Control measures’, D) ‘Communication and Management’, E) ‘Record keeping’, F) ‘Reviews’

Purpose of analysis: Interesting for the analysis would be collecting specific examples from organisations to give a better understanding on the interpretation of the different 'areas' as well as evidence by responsible persons in organisations speaking from their experience/perspective (here: the interview partner). It presents some aspects that are assessed as “critical” for water safety management.

Summary: Allocation of responsibilities is rated ‘very critical’ by nine of eleven participants, ‘moderate’ by one and between ‘very critical’ and ‘moderate’ by one (Figure 7-3).

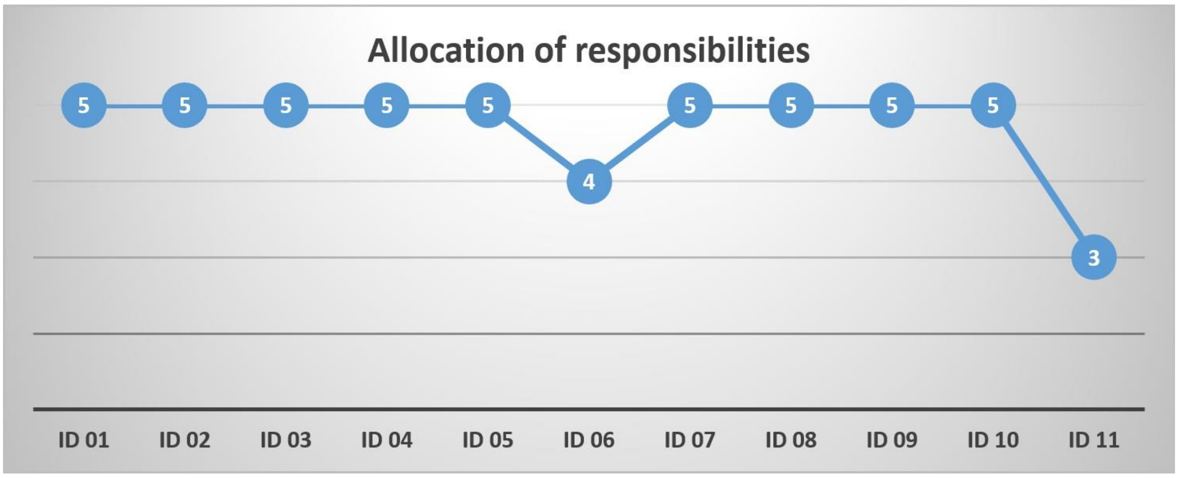


Figure 7-3: Rating of ‘allocation of responsibilities’ (5 is very critical, 3 is moderate, 1 is not critical)

Training and competence of personnel is rated ‘very critical’ by eight of eleven participants and between ‘very critical’ and ‘moderate’ by three (Figure 7-4).

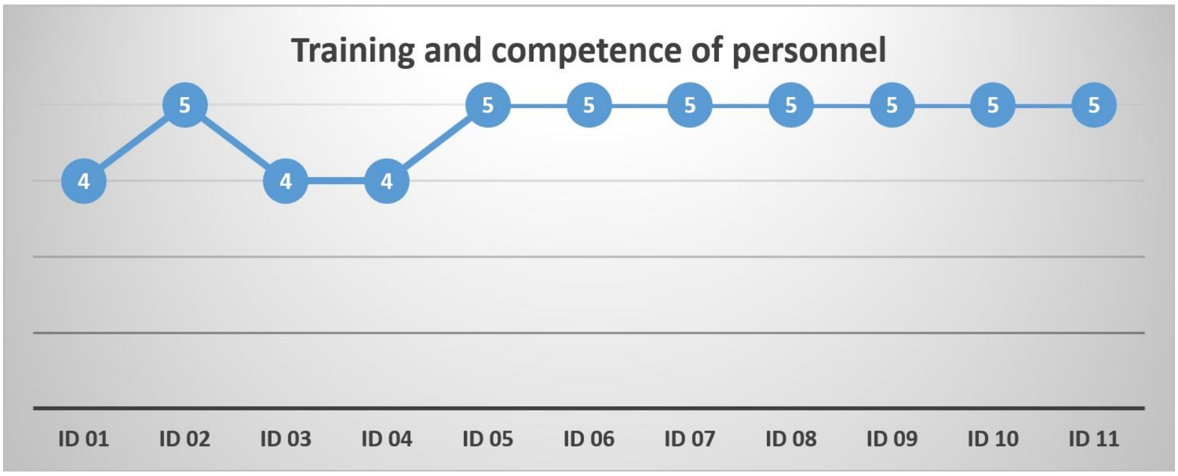


Figure 7-4: Rating of ‘training and competence of personnel’ (5 is very critical, 3 is moderate, 1 is not critical)

Control measures is rated ‘very critical’ by seven of eleven participants, between ‘very critical’ and ‘moderate’ by three and ‘moderate’ by one (Figure 7-5).

Figure 7-5: Rating of ‘control measures’ (5 is very critical, 3 is moderate, 1 is not critical)

Communication and management is rated ‘very critical’ by seven of eleven participants, between ‘very critical’ and ‘moderate’ by one and ‘moderate’ by three (Figure 7-6).

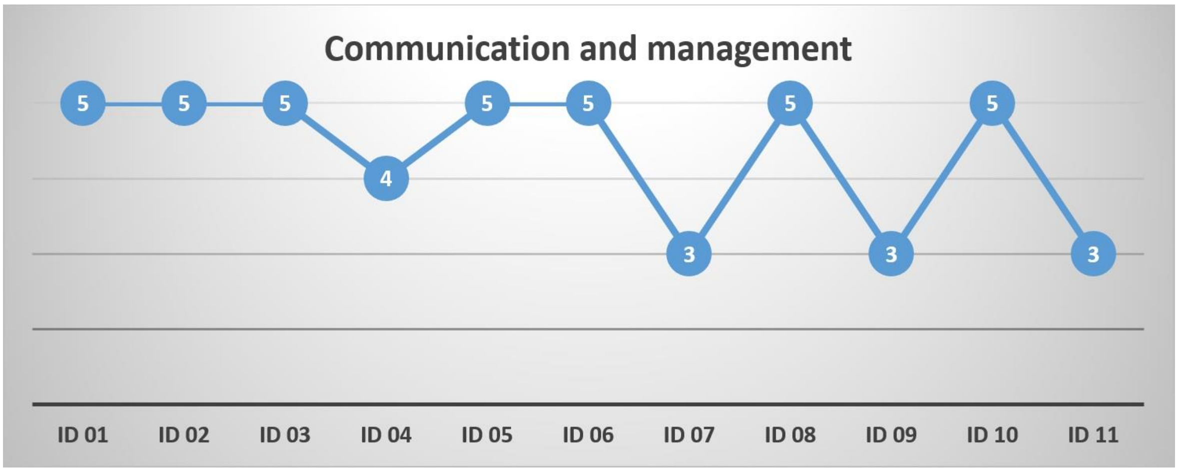


Figure 7-6: Rating of ‘communication and management’ (5 is very critical, 3 is moderate, 1 is not critical)

Records keeping is rated 'very critical' by six of eleven participants, between 'very critical' and 'moderate' by four and 'moderate' by one (Figure 7-7).

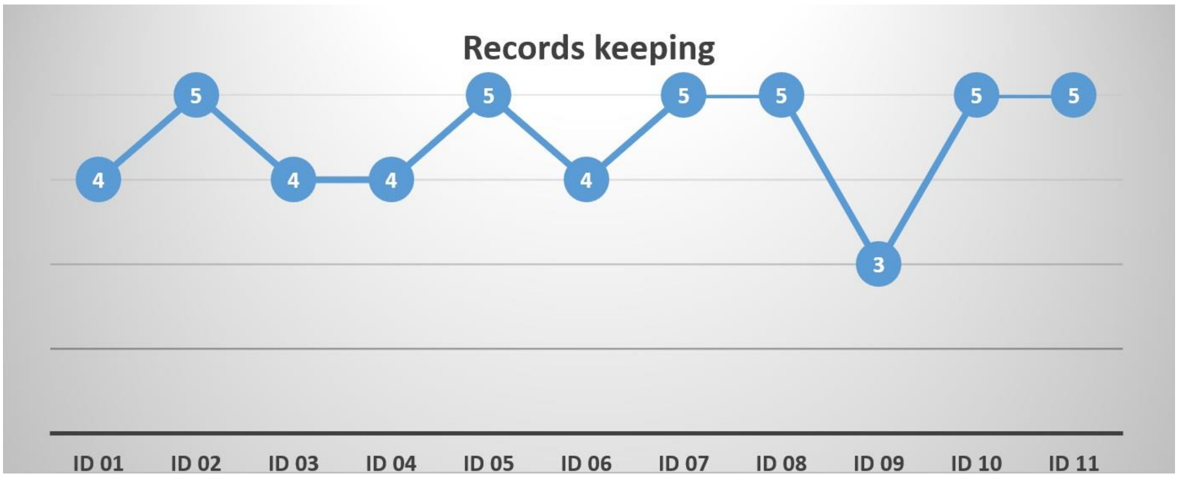


Figure 7-7: Rating of 'records keeping' (5 is very critical, 3 is moderate, 1 is not critical)

Reviews is rated 'very critical' by four of eleven participants, between 'very critical' and 'moderate' by three, 'moderate' by three and 'not critical' by one (Figure 7-8).

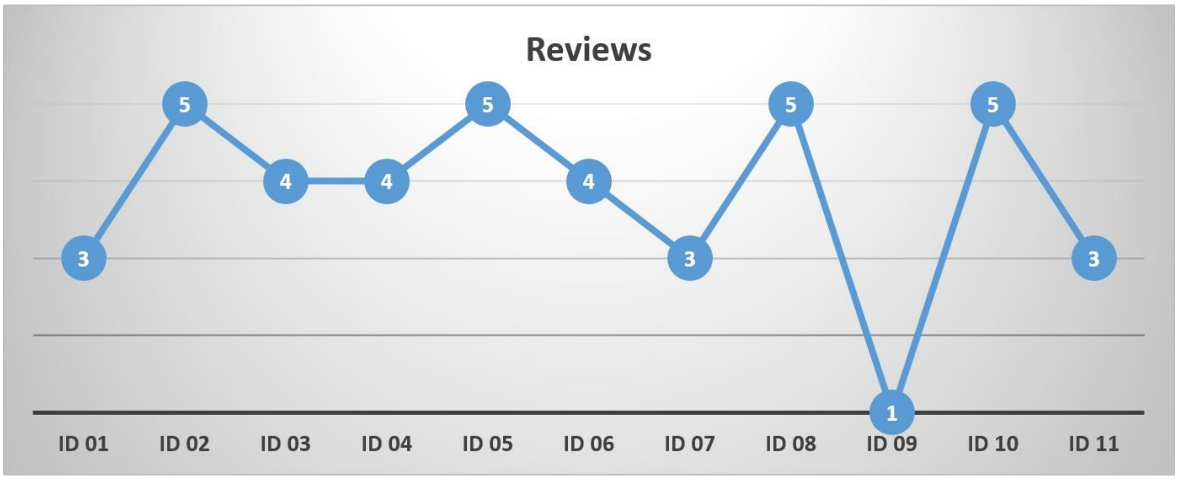


Figure 7-8: Rating of 'reviews' (5 is very critical, 3 is moderate, 1 is not critical)

Analysis has evidenced how professionals at management level rate the aforementioned six main elements. They will be considered for the framework as critical elements need guidance.

The occurrence of category nodes for the answers in a combined analysis for question 25 and 26 identified are listed and hichlighted in Table 7-18 indicating the category nodes and Table 7-19 indicating the orrurence. An extended table is put in Appendix B (Table Appendix B-12).

Table 7-18: Category nodes in answers on combined question 25 and 26, phase I b

Area	**Category nodes**
Allocation of responsibilities	PS, CAc
Training and competence of personnel	CAw

Control measures	CC
Communication and Management	CC, CM
Record keeping	CC, CAw
Reviews	CAw, CP

Table 7-19: Category nodes and main elements in answers on combined question 25 and 26, phase I b

Analysis	Category	Occurrence	Analysis	Category	Occurrence
PESTLE	PP	0	CTAAPM	CC	21
	PEc	0		CT	0
	PS	9		CAc	9
	PT	0		CAw	20
	PL	0		CP	8
	PEn	0		CM	6

7.4.12 Governance arrangements scheme

Previous to the compilation of the following governance arrangements schemes, there was a step-wise collection and preparation of data necessary. The whole entity for data analysis here is represented by the data provided by the 11 interview participants of phase Ib. For the interviews there was provided a structured scheme based on preliminary results. It was presented to the interviewee to quest the structure of governance arrangements against the scheme provided by the researcher. Differences and changes compared to the original scheme are indicated in a different colour. Where elements of the provided scheme are met, the blue colour peristed. Where differences were detected, a bright grey colour is given as a placeholder to compare the respective governance arrangements scheme of the interviewed person. Evidence found in this chapter address organisational aspects (organogram structure) and directions of communication. Findings presented here have been considered for compiling the framework elements #5 management hierarchies, and #7 communication pathways.

28	Are there comparable elements to the provided scheme of governance arrangements?

Purpose of analysis: The scheme in Figure 7-9, originated in WSPolicy/WSPlan of hospital ID11 and found during document analysis of phase I b, was provided to the interviewees in order to analyse and feedback the structure of their specific governance arrangement, reflected from their professional context. The scheme provided is to be understood as reference on which the interviewees comment and describe “their” organisation’s scheme as well as possible.

It focuses on the positioning and the function of the WSG. Either the interviewees offered or were requested to send any supporting material or document containing a scheme, which could be referenced during document and further analysis of this research. These were shown in chapter 6.9.4. On the basis of the oral information received during the interview, a simplified scheme was drawn for each interviewee. The job descriptions of the interview participants, which characterise the individual perspective from an estates and facilities management context, are characterised in Table Appendix A-15.

Summary: The following explanations give advice on how to read and interpret the results presented in the following sections:

- Firstly an individual scheme is presented that was compiled according to the given answers and/or supplementary information gained through document analysis. Where possible, similar structures compared to the presented scheme of the interview were presented in the same arrangement of the referenced scheme, whereby differences, e.g. omissions, from the reference scheme are indicated in bright grey in the same scheme. Additional elements, different labelling or different communication pathways are highlighted in blue. Each scheme is the result of an intense analysis bringing together structural, ordering and logical elements. Bidirectional arrows show information flow, one-directional arrows show reporting structures. Dotted lines indicate a more informal way of communication whereas full lines indicate systematic and structured ways of communication, regulated and described in a policy. Defined frames mean clusters of responsibilities and collabpration and white boxes provide additional specific information on roles.
- Secondly an additional explanation contain the essence of the interviewee's comments with the main differences compared to the provided scheme. In chapter 8.1 a summarising scheme for framework output is compiled while acknowledging the results and considering the schemes of document analysis (chapter 6.10.2.2). The resulting scheme in the framework represents an amalgamed version with the potentially highest level of completeness.

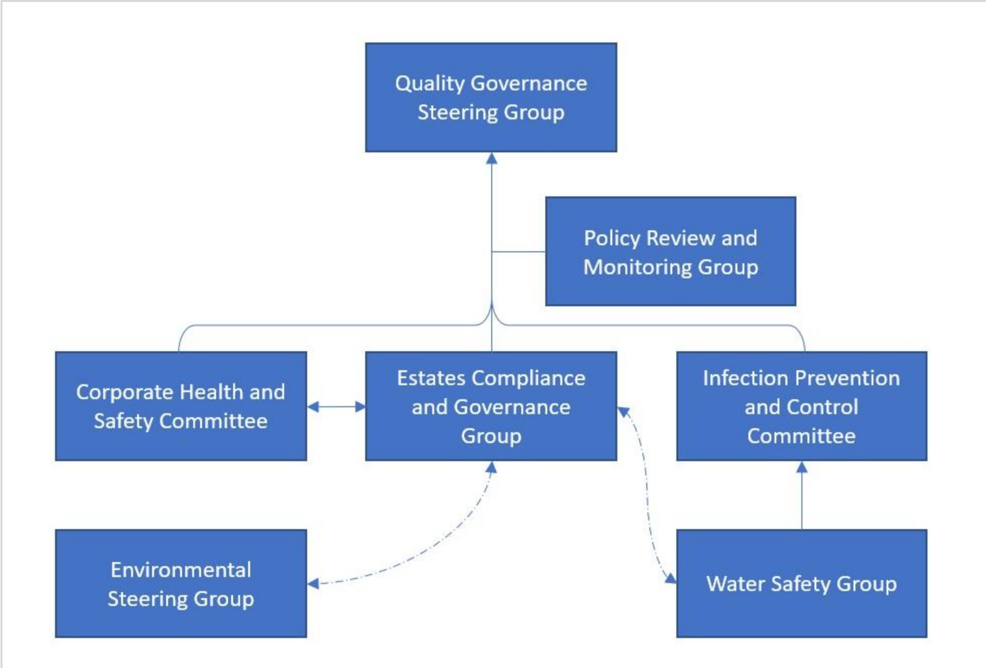


Figure 7-9: Governance arrangements scheme provided for comparison

Additional **explanation** on the scheme in Figure 7-9 is: The water safety group is a sub-group of the Infection Prevention and Control Committee (IPCC). The Estates Compliance and Governance Group (ECGG) informs the Corporate Health and Safety Committee (CHSC) and reports on compliance to the Quality Governnce Steering Group (QGSG). There is estates and infection prevention representation on the Environmental Steering Group (ESG) and the Corporate Health and Safety Committee.

Figure 7-10: Governance arrangements scheme interview participant hospital ID01

Additional **explanation** on the scheme in Figure 7-10 is: It matches roughly. The water safety manager is connected closely to all of these groups mentioned in the scheme. The water safety group, the one place that all meet, meets on a monthly or two-monthly basis. There are around nine meetings a year. For the management hierarchy of the WSG, see excerpts of documents 'water safety policy' and 'water sfety plan', mentioned in chapter 7.3, interview phase Ib (Table Appendix A-27), hospital ID 01.

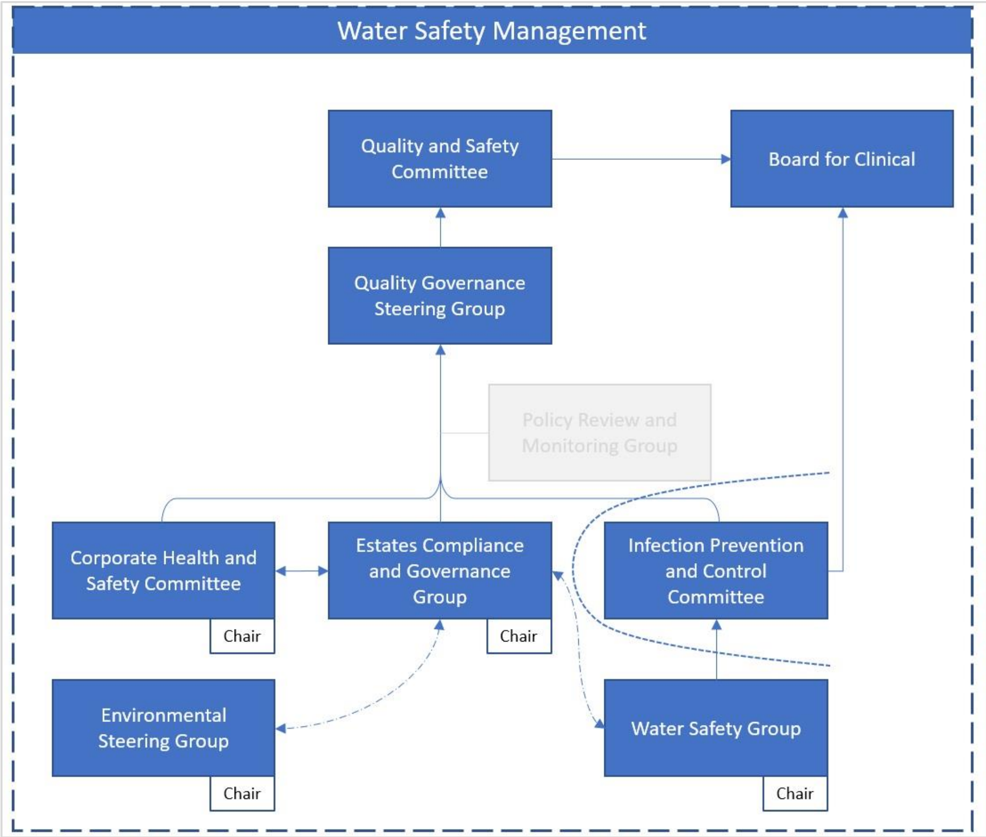


Figure 7-11: Governance arrangements scheme interview participant hospital ID02

Additional **explanation** on the scheme in Figure 7-11 is: Quality and Safety group is the direct line to the board for clinical. Governance has been restructured recently. Quality and Safety Committee is a new concept, recently in the last six months, just to give that high-level view of Quality and Safety to the board. The whole point for the water safety management is to protect the patients, which is clinical, so that's the ultimate reporting structure. Infection Prevention Control is a separate entity that has to be reported to the Department of Health.

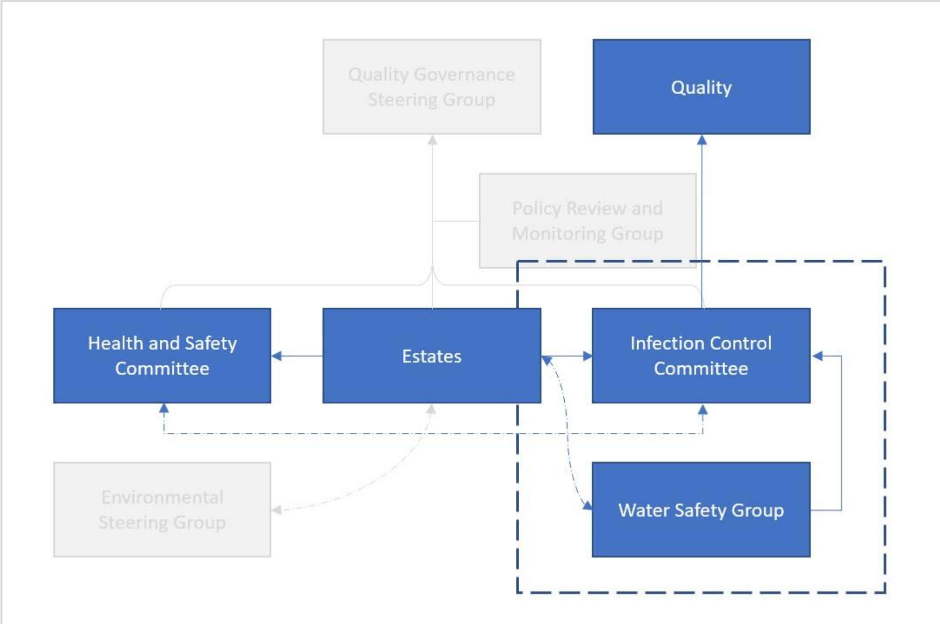


Figure 7-12: Governance arrangements scheme interview participant hospital ID03

Additional **explanation** on the scheme in Figure 7-12 is: The Water Safety Group (WSG) falls into Infection Control Committee (ICC). The top committee is the Quality Governance Steering Committee (QGSC) one, followed by Infection Control and then Estates and Water Safety Group feed into that. More details are available from excerpts from the water safety policy, mentioned in chapter 7.3, interview phase Ib (Table Appendix A-27), hospital ID 03.

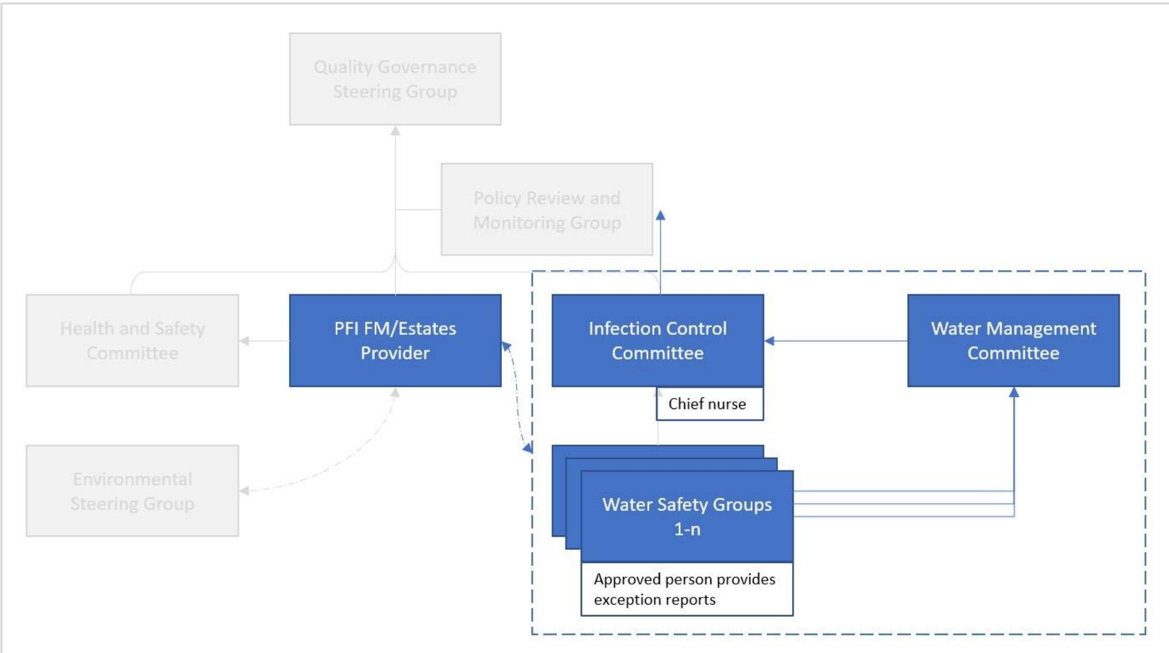


Figure 7-13: Governance arrangements scheme interview participant hospital ID04

Additional **explanation** on the scheme in Figure 7-13 is: There are issues with water safety, which the Infection Control Committee (ICC) would be interested in. Within the existing policy the roles and responsibilities are quite clear, that's because there are lots of hospitals having local water safety groups. Specifically to the different groups there are highlighted:

- Water Management Committee (WMC). It could be implemented trust wide as an organisational group. The formal meeting is with full change of reference The water management committee is quite structured. It tends to look more intrinsically at the trend analysis. It's not designed for getting new data. It's designed so that it governs, makes sure governance is in place or any long-term things, trends are observed and responded to, or any when new innovations are looked at. And so it's the best angle of effective governance and escalation.
- Water Safety Groups (WSGs). They are acting locally on the hospital sites (=site-based). They are interested in the business of their own hospital and organised less formal than WMC. They tend to be more reactive. They are set up sometimes to deal if there was an irregular water sample, it would be appropriate for the water safety group to set an impromptu meeting to discuss the problem, to analyse the risk, and to agree to a strategy for dealing with that problem.
- Infection Control Committee (ICC). If there are risks that are not - or the water committee feels that they're not - fully mitigated, or there are trends causing concern, then those issues would be escalated to the Infection Control Committee (ICC), which is a broader body of people. In it there sits the chief nurse, who also sits in a local WSG. The ICC deals with the pertinence of infection control.
- Private Finance Initiative (PFI). PFI creates an ambiguity in those responsibilities because according to the contract, the PFI agreement, there's an estates provider who sits alone, almost, outside of the trust. That can be problematic in terms of the communication. It can create contractual loops around the hospital’s or trust’s ability between the client and the service provider. Relationships must be better than that. An organisation should be managed to put those issues to one side. Good governance arrangement on this particular matter with the FM provider are to be achieved.
- Contractors (Estates provider). It requires modification of old contracts as historical artefacts to take account of the current situation. Communication and management combined between the different stakeholder groups. From an organisational governance perspective it's very important. People responsible would seek assurance, they would want to see evidence of processing and evidence of good management.

More details are available from the ‘Water Hygiene Management Responsibility Structure’ from interview partner hospital ID 04, mentioned in chapter 7.3, interview phase Ib (Table Appendix A-27).

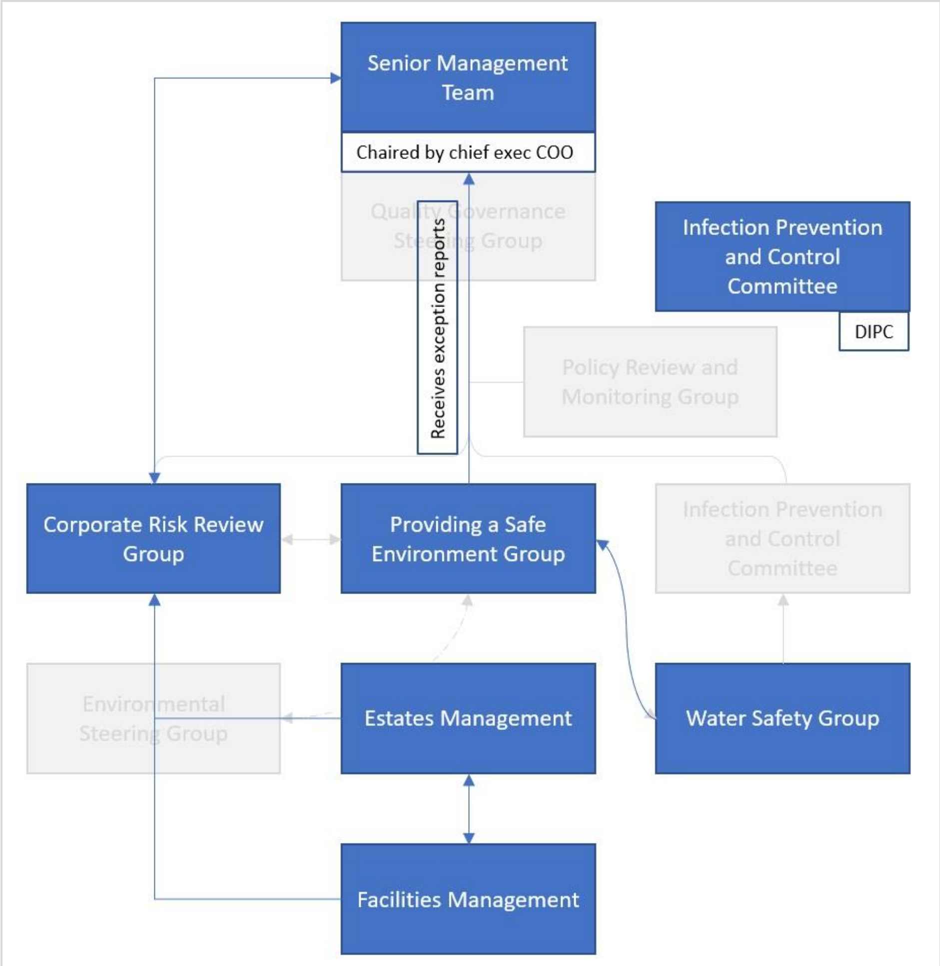


Figure 7-14: Governance arrangements scheme interview participant hospital ID05

Additional **explanation** on the scheme in Figure 7-14 is: There is a Corporate Risk Review Group (CRR) that looks at the risk factors from every department across the organisation.

Water safety policy is reviewed by the Water Safety Group (WSG). They are responsible for ensuring that the policy is up to date, that it is reviewed every two years, that it reflects external guides and some best practice, and they own that policy. A reviewed version then will be fed into Providing a Safe Environment Group (PSE), which ratifies the new version. So the WSG will own the policy, but can't just work in isolation. They have to escalate the policy for approval. And the PSE group will just send an exception report to Senior Management Team (SMT) to inform SMT that the policy is in-date and properly managed.

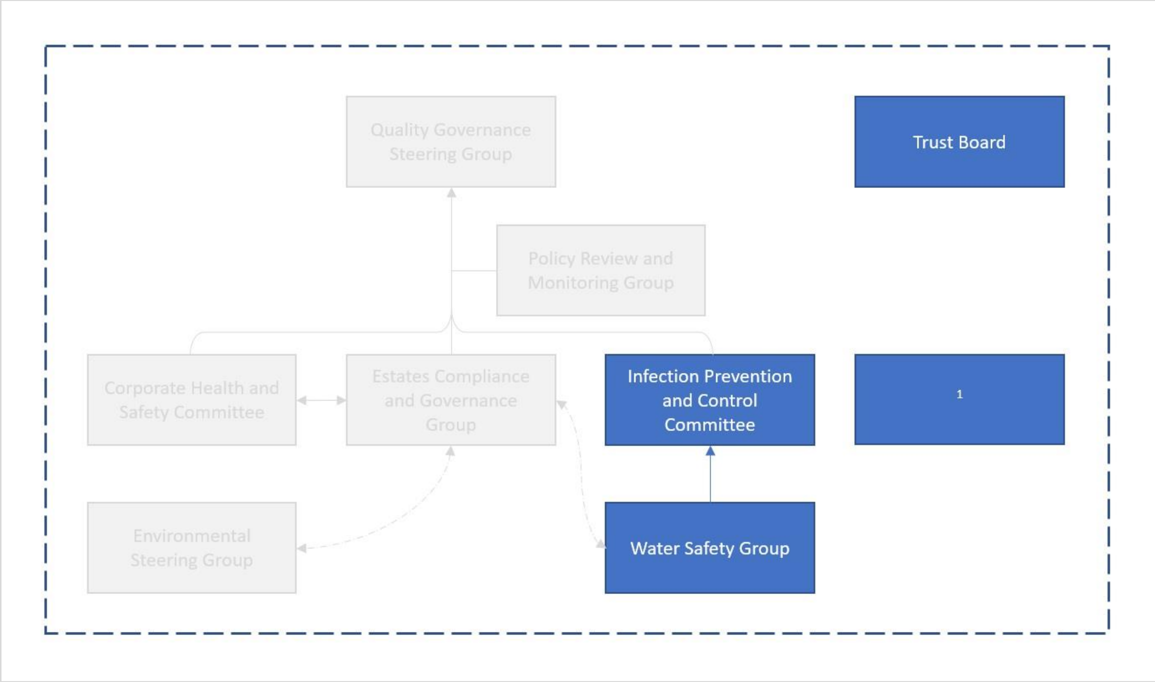


Figure 7-15: Governance arrangements scheme interview participant hospital ID06

Additional **explanation** on the scheme in Figure 7-15 is: [1]All the groups that are mentioned in the provided scheme are also relevant in our organisation. It would be organised in a different way. For that, see trust organogram (water safety), mentioned in chapter 7.3, interview phase Ib (Table Appendix A-27), hospital ID 06.

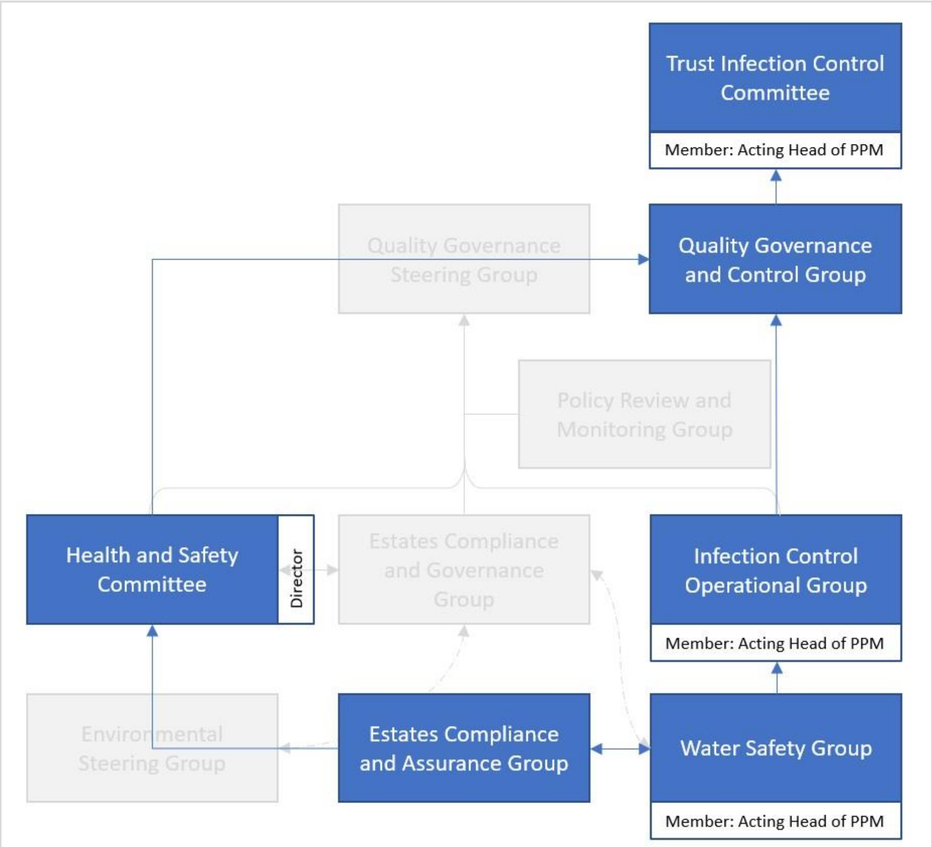


Figure 7-16: Governance arrangements scheme interview participant hospital ID07

Additional **explanation** on the scheme in Figure 7-16 is: For detailing organisation specific procedures, there will be diagrams and matrices which show the processes. There will be a water safety plan (management plan), the constitution of the water safety group, the process of monitoring compliance and effectiveness, and the communication pathways of the management approach for water hygiene. For that, more details are available from the documents considered for analysis mentioned in chapter 7.3, interview phase Ib (Table Appendix A-27), hospital ID 07.

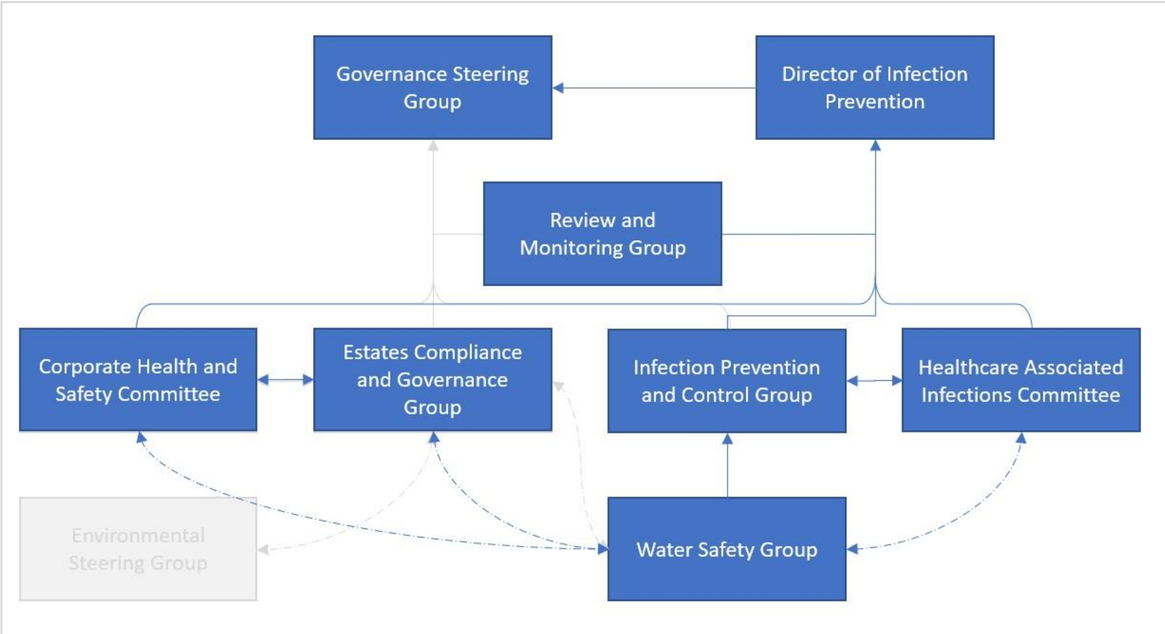


Figure 7-17: Governance arrangements scheme interview participant hospital ID08

Additional **explanation** on the scheme in Figure 7-17 is: Basically, the structures or the names of the groups are comparable. Health and Safety is represented corporately in the other groups. There are shared responsibilities, they do go across the organisation.

More details are available from excerpts from the policy “The safe management of water systems”, mentioned in chapter 7.3, interview phase Ib (Table Appendix A-27), hospital ID 08.

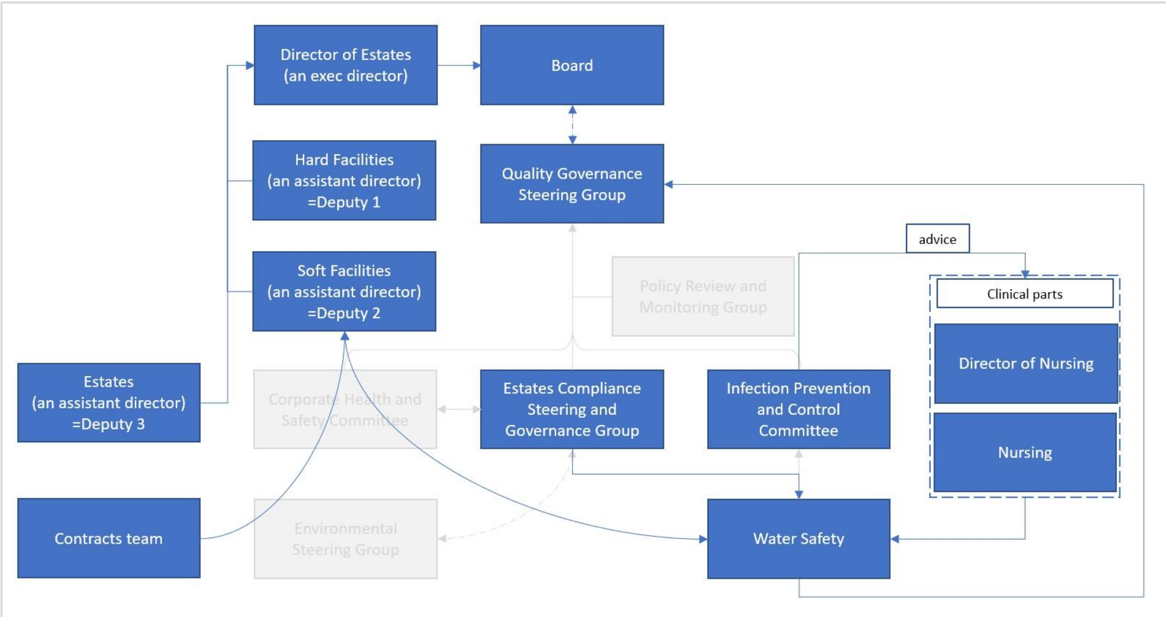


Figure 7-18: Governance arrangements scheme interview participant hospital ID09

Additional **explanation** on the scheme in Figure 7-18 is: In terms of water safety, the Water Safety Group (WSG) would be central. So it's in the WSG that the strategy for how we're going to deal with our water issues is decided upon. This group assurance is given to the board of directors. As to whether or not we are moving in the right direction, whether we are doing everything we can do, and it's in the same group that any failings come to light through the board's interaction with the external authorised engineer and any other external bodies that we work with. The WSG is very much central to how water safety is run. The other groups have input into that WSG for example, the Estates Compliance Steering and Governance Group (ECSG). The scheme provided is different to the clinical parts. The director of nursing, our clinical groups, would interact but they sit in WSG. They sit in on the WSG but they rely on the advice from the Infection Prevention and Control Committee (IPCC). So IPCC will tell them whether or not it's scientifically safe, whether or not there are any problems from a scientific point of view but, yeah, they don't speak completely for the clinical team. So if the clinical team want to, then they can ignore the IPCC if they think that what's being said is unreasonable.

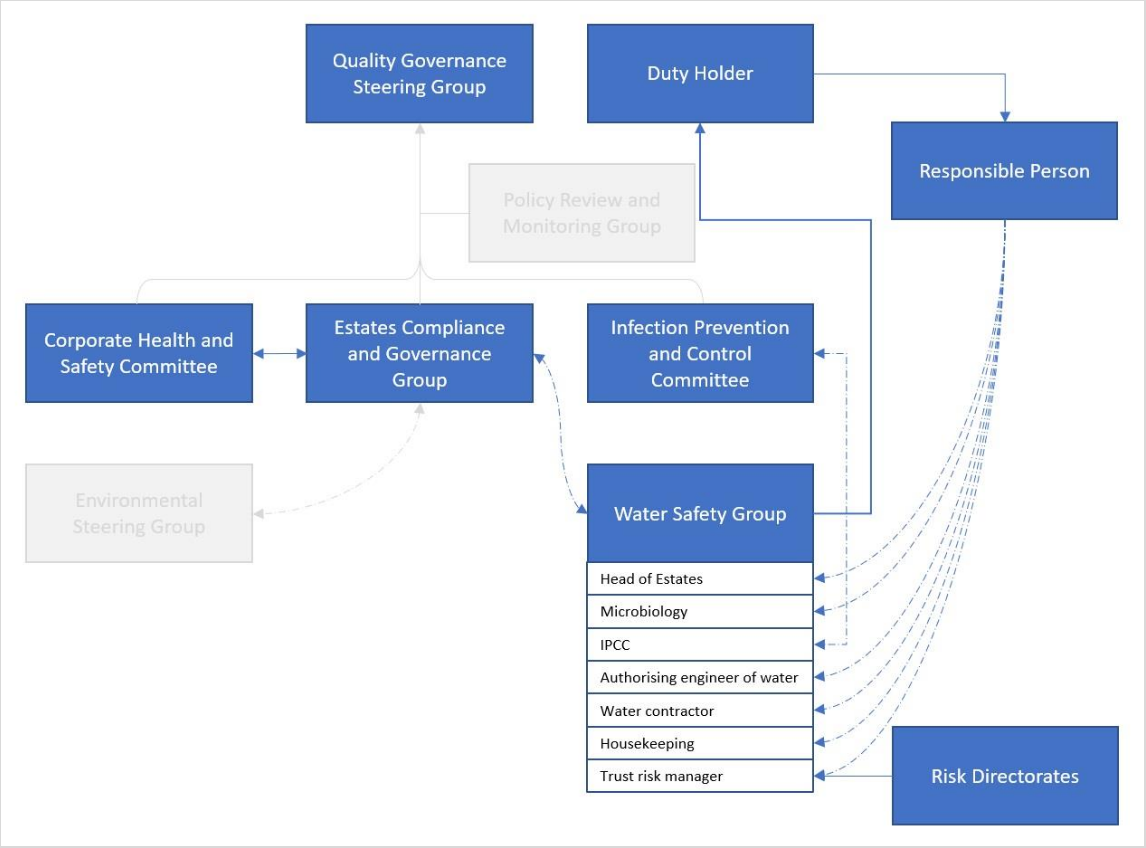


Figure 7-19: Governance arrangements scheme interview participant hospital ID10

Additional **explanation** on the scheme in Figure 7-19 is: The water safety group does not report into infection prevention and control committee because the water safety group would be made up of more people from infection prevention and control. It is that it's only infection prevention and control who should be part of the water safety group. They're the only group that can confirm whether or not a space is available for clinical practice or clinical service delivery. If there's any issue about a ward area or a space, it's infection prevention and control that would make that decision, to say, "Yes, we can't use this space, or this bay, or this ward, or this room at the moment." It would not be estates that made that decision. Now, me as a senior estates manager, it wouldn't be me that said, "Right now, we can't let-- the patients are going to have to be moved. We can't use this area or ward at the moment. We'll have to move all the patients out." That's not where the responsibility lies, that lies with the infection prevention and control. And the funny thing is that, my partner, my fiancee, she is infection prevention and control, and she's got a master's in infection prevention and control. She's very passionate about the patients and about the control measures around infection prevention and control. And that's actually been published five or six times already on cannulation, which sticking needles in people. They're quite a tough bunch, actually. So the water safety here would not report into infection prevention and control because they would be part of that group. Also, I think that the water safety group would report directly to the holder. And the water safety group would, we'd invite the duty holders to be there, but they might not turn up. But I'm just trying to drill all of this structure while we're talking. The head of estates would be at the meeting. Microbiology would be at the meeting. Infection control would be at the meeting. And the authorising engineer of water would be at the meeting. And then probably, a representative from the water contractor.

And so there'd be a number of professionals at that meeting, that the results would report to the duty holder. But as I've said before, the duty holder's responsibilities are divulged to the responsible person. I'm the deputy to the responsible person. But one of the key areas-- and maybe part of the housekeeping team would be there because they'd be doing the cleaning method statement that's agreed to, or maybe part of the self-services would be at the meeting as well because they manage cleaning. And I think that the estate's compliance and governance group-- the water safety group would be part of compliance because water safety is part of compliance.

I don't want to, personally or even as a professional in post, taking onboard all of that risk myself. I want to share the news and share where we're up to, and make sure that the right resources are allocated to the issues. For instance, the issues identified within the building, water risk assessments. It's no good to identify something and have a risk assessment when you're actually not doing anything about it. You've got to get on with those things.

Somebody from the risk directorates, the trust risk manager, would be at the water safety group as well. So we've got no quality governance steering group at the moment, but to be honest, I'm just building the blocks to build up compliance within this trust. They're so non-compliant, it was surprising. It's the worst trust I've ever been to, the levels of non-compliance. So I'm really getting those solid building blocks in place at the moment. So just at the moment, we haven't really got that structure. The water safety group would really be the completely centred group because they've different responsibilities, and responsibility will be shared. But everyone has to take his or her part with their respective background. And those responsibilities are clearly defined within the water safety policy. And the water safety plan that I'm just building at the moment. A combination. The policy and the water safety plan in combination could be relevant, which is called the scheme of control.

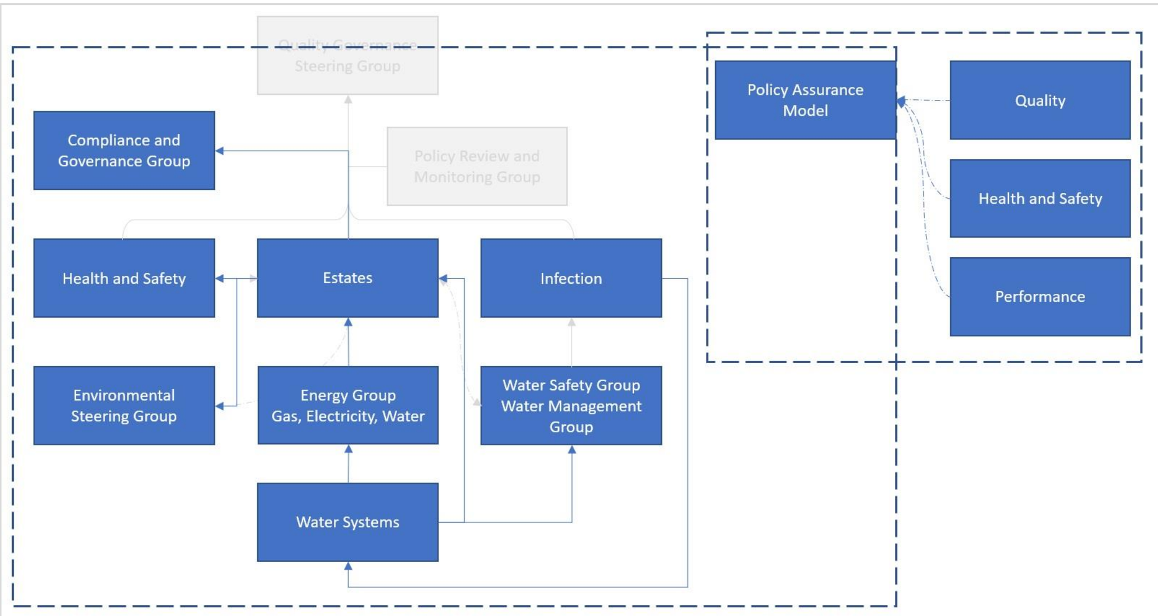


Figure 7-20: Governance arrangements scheme interview participant hospital ID11

Additional **explanation** on the scheme in Figure 7-20 is: *Legionella* usually comes under either the water management group, obviously, and it's also an agenda item under the hospital's health and safety committee. So it figures under both. Policy review, that's certainly done by me on water systems. For Environmental Steering Group (ESG), minutes are maintaned. Not a delegate is sent, but Estates puts input outside their meetings to assist that committee. The policy assurance model (PAM) is a bit like a mix of some of those in the provided scheme, with quality, health and safety, performance. So it's a bit of a mix of all three. And then we have standard management meetings that can cover anything, and that can include water. The scheme you've got there is similar to what we have here. I'm not going to say it's exactly the same, but it's very much similar in terms of the flow process that you've got there.

More details are available from excerpts from the water safety plan, mentioned in chapter 7.3, interview phase Ib (Table Appendix A-27), hospital ID 11.

7.4.13 Dominant topics for WSG members from Estates / FM

32	Which are the five dominant topics the water safety team / group is confronted with?

Purpose of analysis: Interesting for the analysis is to find evidence on currently experienced dominant topics and if there are potential elements indicated likewise by the majority of the participants.

Summary: Table 7-20 lists the five dominant topics from each hospital. Instead of five dominant topics interview participants of hospital ID07, ID04 and ID02 responded four, three and two dominant topics, respectively. Corresponding 'PESTLE' and 'CTAAPM' analysis category codes are indicated for each hospital ID in the lines following the hospital ID number.

Table 7-20: Dominant topics a water safety team / group is confronted with

ID hospital	**#1 dominant topic**	**#2 dominant topic**	**#3 dominant topic**	**#4 dominant topic**	**#5 dominant topic**
ID 01 *Categories*	Design of new water systems *PT, PEn*	Reviewing installations *PL, CC, CT, CAc, CAw, CM*	Water sample results *CC*	Cleanliness issues of water taps *PEn, CAw, CP*	External audits and approvements of compliance *PL, CP*
ID 02 *Categories*	monitoring *PL, CC, CAw, CP*	Flushing compliance *PEn, CP*	Risk assessments *PL, CAw, CP, CM*	Action planning *PL, CP, CM*	Board awareness *PP, PS, CM*
ID 03 *Categories*	Patient safety *PP, PEn, CAw*	Flushing *PEn, CP*	n/a *n/a*	n/a *n/a*	n/a *n/a*
ID 04 *Categories*	budget *PEc*	compliance *CC, CAw*	Protectiveness for the group *PL, CC, CAc, CP, CM*	n/a *n/a*	n/a *n/a*

ID 05 *Categories*	Identifying little-used outlets *PEn, CAw, CP*	flushing *PEn, CAw, CP*	Temperature regimes compliance *CC, CAw, CP*	General testing *CC, CAw*	Plans/design of the water systems *PT, PEn*
ID 06 *Categories*	flushing *PEn, CAw, CP*	Microbiological sampling results *PL, CC, CP, CM*	*Legionella* risk assessments / dead legs detection *CP, CM*	Temperature regimes compliance *CC, CP, CAw*	Independent audit reports *PL, CP*
ID 07 *Categories*	Shower hoses and heads *PEn, CAw, CP*	Drink dispenser *PT, PEn, CAw*	Colour therapy bubble tubes *PT, PEn*	Little used outlets *PEn, CAw, CP*	n/a *n/a*
ID 08 *Categories*	Understanding liability *PS, CAw*	Making robust risk management *CAw, CP, CM*	How to receive assurance *PL, CC, CAc, CM*	Understanding of government processes *PP, PL, CAw*	Selling the dream *PS, CM*
ID 09 *Categories*	*Legionella* contamination *PL, PEn, CAc, CAw*	compliance *CC, CAw*	Dead legs *PEn, CAw, CP*	Dealing with generation systems *PT, PEn, CAw, CM*	Cold water systems *PL, CC, CM*
ID 10 *Categories*	Water hygiene governance *PP, CM*	Water hygiene risk *PL, CAw, CP, CM*	Water hygiene compliance *CC, CAw*	Compliance scheme of control *PL, CC, CM*	Non-compliance → water safety plan *PL, CC, CM*
ID 11 *Categories*	Water safety plan *CM*	Control of *Legionella* *PL, CAw, CC*	Control of *Pseudomonas* *PL, CAw, CC*	Business continuity or contingency plans *CP, CM*	Training and keep stuff up to date *CAw, CP*

Analysis has evidenced elements for consideration for the framework. The occurrence of category nodes identified are listed in Table 7-21.

Table 7-21: Occurrence of category nodes in answers on question 32, phase I b

Analysis	Category	Occurrence	Analysis	Category	Occurrence
PESTLE	PP	4	CTAAPM	CC	16
	PEc	1		CT	1
	PS	3		CAc	4
	PT	5		CAw	27
	PL	16		CP	23
	PEn	16		CM	17

7.4.14 Biggest challenges in water safety risk management

33	Which topics in water safety risk management and prevention of *Legionella* present the biggest challenges?

Purpose of analysis: In the further development of the previous question 32 it is interesting for the analysis to find evidence on topics that present the biggest challenges from the participants' perspective, and if there are potential elements indicated likewise by the majority of the participants.

Summary: With the exception of category 'PP' analysis has found main elements for consideration for the framework. Category nodes and main elements are listed in Table 7-22 (n/a - not available). An extended table is put in Appendix B (Table Appendix B-13).

Table 7-22: Category nodes and main elements in answers on question 33, phase I b

Analysis	Category	Occurrence	Identified main elements and consideration for framework
PESTLE	PP	0	n/a
	PEc	5	Budget restrictions; remedial work; lack of sufficient backlog investment; major reconstruction
	PS	2	Water Safety Group
	PT	4	Hospitals are 40 to 60 years old; flushing; temperature regime; decentralisation

	PL	1	*Legionella* control, *Pseudomonas* control
	PEn	4	Old systems; end of life cycle; replacing
CTAAPM	CC	1	Compliance with PAM (premises assurance model), which is the NHS control methods for water systems
	CT	2	Planned preventative maintenance regime
	CAc	2	Water Safety Group; allocating the correct resource to resolve risk issues
	CAw	8	Communication around contamination; Compliance requirement; ensure training and auditing is being carried out
	CP	5	Improve compliance; temperature controls; imported risks from manufacturers and suppliers
	CM	3	Microbiological sampling results. *Legionella* risk assessments; audit reports

7.4.15 Success stories

34	What has been your greatest success / goal you achieved in your organisation within the past 12 months with respect to *Legionella* prevention and water safety?

Purpose of analysis: Interesting for the analysis is to evidence which topics have been challenged and mastered recently by responsible management people.

Summary: With the exception of category 'PP' analysis has found main elements for consideration for the framework. Category nodes and main elements are listed in Table 7-23 (n/a - not available). An extended table is put in Appendix B (Table Appendix B-14).

Table 7-23: Category nodes and main elements in answers on question 34, phase I b

Analysis	Category	Occurrence	Identified main elements and consideration for framework
PESTLE	PP	0	n/a
	PEc	1	a new hot water and cold water riser to split the system
	PS	5	Influencing our water hygiene contractor
	PT	3	Underused outlets

	PL	1	Reducing the number of areas where *Legionella* can grow
	PEn	3	Experts; enough capacity in the pipework
CTAAPM	CC	4	Test; water samples and test for *Legionella;* heritage from the previous director of infection and prevention control; started the journey of the worst wing of the hospital, of the distribution systems, regeneration system; identification of considerable quantities of dead legs all around the site
	CT	1	Right government structures
	CAc	4	Working groups with their terms of reference; appointing and authorising engineer of water
	CAw	9	Risk assessments; components of taps were actually propagating the growth of the bacteria; *Pseudomonas;* a particular ward using that particular process; cutting all of that old pipework out
	CP	4	Temperature control; utilising the building management system, it monitors the tank temperature
	CM	9	Monitor strategy; risk assessment; clinical risk influenced the engineering risk assessment program, high patient risk areas first and then down to the car park right at the end; governance structure; collaboration; water safety action plan; quarterly testing

7.4.16 Money annually spent for water safety

36	A rough estimation: How much money do you annually spend for water safety?

Purpose of analysis: Analysis intends to give a picture on costs spent on water safety.

Summary: Further analysis quested only category ‘PEc’ (PESTLE). Annually costs spent on water safety range from £30,000 to 400,000. As there are different situations present in the hospitals, futher information needs to be considered for precise interpretation. Details are presented in Appendix B (Table Appendix B-15).

7.4.17 Budget sufficiency

37	Is the budget enough to meet the requirements?

Purpose of analysis: Interesting for the analysis is to find evidence on the sufficiency of currently available budgets to meet the requirements.

Summary: Further analysis quested only category ‘PEc’ (PESTLE). Five interview participants mentioned the budget being not sufficient, four mentioned that it is sufficient, of which two commented that it would only be sufficient for basic solutions without exceptional events. Two participants were unclear, with tendency towards ‘not sufficient’. Four of the eleven interview participants gave comments for further explanation. More details are presented in Appendix B (Table Appendix B-16 and Table Appendix B-17)

7.4.18 Summary tables for phase I b interview study

The total occurrence of category nodes and main elements identified during analys of phase Ib is listed in Table 7-24.

Table 7-24: Total occurence of category nodes and main elements derived from analysis (described in chapter 7.4) for consideration for framewort output

Analysis	Category	Occurrence	Analysis	Category	Occurrence
PESTLE	PP	38	CTAAPM	CC	84
	PEc	42		CT	32
	PS	90		CAc	60
	PT	36		CAw	98
	PL	76		CP	81
	PEn	100		CM	121

Of the totality of items presented in Table 7-24, selected key terms and excerpts (Table 7-25) have been grouped according to PESTLE and CTAPPM coding principles. They were taken as guiding reference for compiling and designing the components of the framework output to be validated in a focus group (see chapter 7.7). Overall, during analysis there was taken a specific focus on questions 4, 10, 11, 12, 13, 14, 18, 19, 21, 25, 26, 28, 33, 34, as they were found to contain most of the focus topics of interest. In combination with the findings of the analysis of elements of frameworks (chapter 6.14), the output “The process of water safety management, *Legionella* prevention and risk management in hospitals: a framework for Estates and Facilities Management with focus on England” was finalliy compiled. All possible coding categories, as introduced in chapter 6.10.2.1, are represented throughout the data analysis procedures of phase Ib.

They have been applied for the two analysis perspecitves a) external perspective: PESTLE (PT, PL, PS, PP, PEc, PEn), and b) internal perspective: CTAAPM (CT, CAw, CC, CM, CAc, CP) respectively.

Table 7-25: Aggregated key excerpts from phase I b - guidance for framework complilation

Question	Hospital ID	Underlined passages / key terms	PESTLE / CTAAPM
4	04	Backlog repair, which is the investment into the estate.	PT
4	07	ALARP. So that's as low as reasonably practical	CAw
4	07	Risk assessment	CT
4	07	Risk register	PT
10	11	PFI golden triangle	PP, CM
11	10	Scheme of control	CC
12	07	Action plan	CM
12	08	Everyone in both organisations believed that water safety is an estate function or an FM function, not a function of the WSG	CM
12	08	Get to know it's a collaborative process and everyone has a responsibility.	CAw, CM
12	08	Log book	CM
12	10	An NHS organisation should meet all the requirements of L8 and HSG274. So in reality, HTM 04-01 is not really required, although it is much more detailed around water hygiene issues, or water safety within healthcare premises.	PL, CC
12	10	Roles and responsibilities are duty holder which, on paper, is the chief executive.	PS, CAc
12	10	Roles and responsibilities within the HTMs, and within water hygiene are well defined and do not, or should not, differ from each individual NHS organisation.	PS, CAc

12	10	It's a very rigid structure. And that's because they don't want to have too many people involved on who makes the decisions.	PS, CAc
12	10	The authorising engineer is the independent advisor.	PS, CAc
13, 14	07	The factor was that we failed. The elements were why did we fail. The activities were to correct, which is our remedial action. And the achievements were we are now clear of *Legionella*	PP
13, 14	08	Due diligence	PL
13, 14	10	Nobody is doing anything without a permit now under my direction.	PP
13, 14	10	Training documentation of the team	PL
13, 14	10	Water hygiene contractor. They've also been producing the risk assessments. I don't think that the risk assessments are of a great quality.	PP
18	05	That's what the HTM documents say. They say they're guidance. They're not mandatory. They're not law. They say in the front piece they're guidance documents, and that's the way we use them. We use them as guidance. The way I see it - well, the way both myself and my compliance manager look at these documents.	PP, CAw CP
18	05	Doing something differently still covering the risk?	CP
18	05	Test your process	CAw
18	08	Water safety plan	CM
18	10	There will be a water safety plan, water safety policy.	CM
19	01	Electronic record keeping system or web system where information is freely available to the water safety group.	CM
19	02	Defect reporting	PT
19	05	Little-used outlets	CP, CM
19	05	Stagnant water	CP, CM

19	06	Planned preventative maintenance	CP, CM
19	07	The process of water safety	CM
19	07	Water action tech plan	CM
19	07	Water Safety Group. We've got the testing regime and the documentation	CM
19	08	Robust plan that says we need to do 10 samples a week, then we do	CC, CP, CM, PEc
19	09	It's not proactive, it's reactive	CM
19	09	The information to respond reactively	CM
21	02	Escalation level	CP, CM
21	02	Proactive management	CM
21	04	In-house estates teams have their own software, and it prescribes tasks. From a different sort of risk management perspective, we've got a trust-wide risk register, and we also use a reporting software system for health and safety risks known as 'Datix'. it describes the risk, what the mitigation is. There should be a risk assessment in that document	CP, CM
21	05	The ability of going from electronic to paper and then paper back to electronic isn't great. Pieces of paper get lost. People don't fill them in properly. It's not a great system, but that's not in itself a wholly water safety problem.	CM
21	08	Assignment matrix	CM
21	11	Maintenance portal system, which is for delivery and maintenance work in PPM.	
21	11	Software for workflow	
25, 26	04	We've got a person at each site, and they know what they're responsible for; All organisations and all processes rely on communication. You must have good communication; The risk profile can change.	PS, CAc

25, 26	09	If your responsibility is clearly defined and there's no scope for confusion, your staff and personnel are adequately trained and on a good level competent and your control measures are secure, then whilst your communication it's necessary to have communication and it's necessary to have management, but if your first three elements are correct then your management becomes less critical because it becomes more of a case of just ensuring that documentation and information is being passed around correctly, which is important but not critical. It's not going to save somebody's life or kill somebody.	CC, CM
25, 26	11	A fresh pair of eyes	CAw, CP
28	04	Evidence of processing and evidence of good management	PS, CM CAw
28	04	We've also got PFI. PFI creates an ambiguity in those responsibilities because according to the contract, the PFI agreement, there's an estates provider who sits alone, almost, outside of the trust.	CM
28	07	Action plan, policy, water safety plan, matrix which shows the processes that we take	CAc, CAw, CM
28	10	Central testing point, which is the far end of each system. And then central testing, test one, test two, test three. So in short, you test the whole of the system and you don't miss something by just doing one under the system. So that's why the schematics are important, because they identify the central testing points.	CAc, CAw, CM
28	10	Scheme of control	CAc, CAw, CM
28	10	So we've got no quality governance steering group at the moment, but to be honest, I'm just building the blocks to build up compliance within this trust. They're so non-compliant, it was surprising. It's the worst trust I've ever been to, the levels of non-compliance. So I'm really getting those solid building blocks in place at the moment. So just at the moment, we haven't really got that structure.	CAc, CAw, CM

28	11	Flow process	CAc, CAw, CM
28	11	PAM, the policy assurance model	CAc, CAw, CM
33	09	Decentralisation	PEn, CM
33	11	PAM (premises assurance model), which is the NHS control methods for water systems	CC, CP CAw
34	01	So I've broken it down into manageable chunks where I could say 'work over £ 5,000 pounds' I've worked out this budget. And then £ 5,000 pound the next month.	CAw, CM
34	01	The clinical risk, basically, influenced the engineering risk assessment program, so I've in with the high patient risk areas first and then down to the car park right at the end.	CAw, CM
34	06	Governance structure; Managerial deficiencies; Collaboration	CM
34	07	n-line thermal disinfection unit	CM
34	07	We've achieved all the things that we're after in the water safety group. We followed the procedure that's in the water safety action plan.	CAw, CP, CM

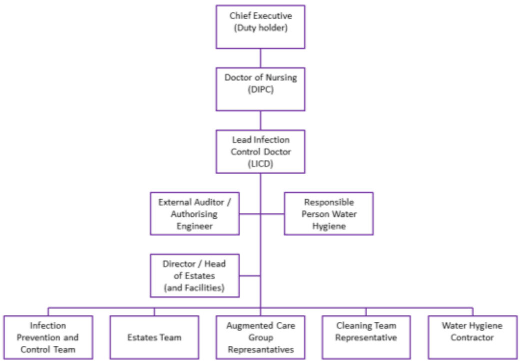
7.5 Phase II – web-based survey (QUAL + QUAN)

The following sections present results and analyses from the web-based survey. They contain both elements of qualitative and quantitative research.

7.5.1 Proposed logic of accountability chart

For the purpose of developing an accountability chart and governance arrangements that could be referenced to for a question section during the survey in phase II, Table 7-26, Figure 7-21 and Figure 7-22 present sequential evolutionary steps.

Table 7-26: Proposing and developing an accountability chart

<table>
<tr>
<td>Version 1 after analysing the interview studies phases Ia and Ib (interviews and documents), before feedback of professionals (pre-test survey).</td>
<td>Version 2 after feedback of professionals (pre-test survey). This chart later was essential part of questions 13 and 14 of the web-based survey.</td>
</tr>
<tr>
<td>
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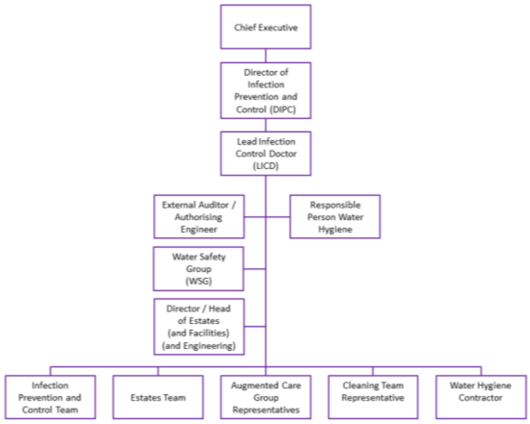
<td>
</td>
</tr>
<tr>
<td colspan="2">The Water Safety Group (WSG) represantation in the organisation’s hierarchy, according to preliminary results of phases Ia, Ib.</td>
</tr>
</table>

Based on preliminary findings of interview study phase Ia and Ib (interviews and documents), a scheme of governance was compiled, with the WSG centered (Figure 7-21). It furthermore details of how the WSG constitutes (basic mambers) and with which other roles and responsibilities the WSG is interacting.

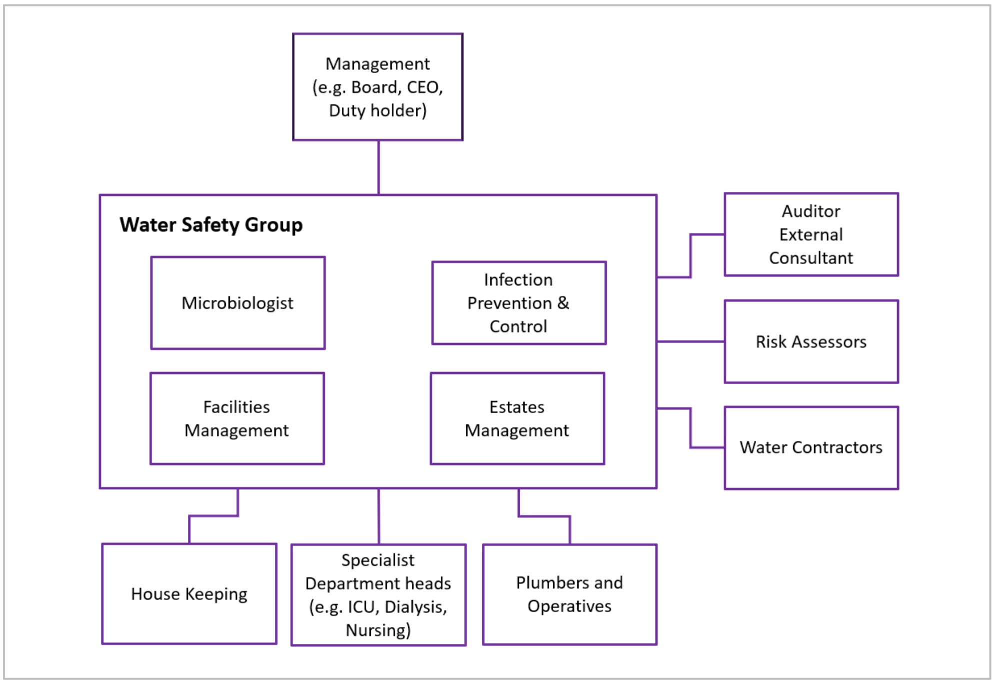


Figure 7-21: Scheme of governance of the WSG

To better understand the positioning of the WSG in an organogram showing the logic of an organisational structure, the following complementary analyses with data from phase II (survey) has been performed. In the survey a proposed scheme was presented to the participants. Figure 7-22 presents how a trust or hospital is organised with respect to the positioning and the function of the water safety group. The Water Safety Group is a sub-group of the Infection Prevention and Control Committee. The Estates Compliance and Governance Group informs the Corporate Health and Safety Committee and reports to the Quality Governance Steering Group. There is Estates and Infection Prevention representation on the Environmental Steering Group and the Corporate Health and Safety Committee.

Figure 7-22: Governance arrangements scheme provided for comparison during study phase II

Survey participants had to compare their own organisational structure with the presented scheme and comment differences in free text entry boxes. The scheme intended do illustrate organisational practices of the water safety group showing conjunctions of different stakeholders. A majority of the respective participants in trusts or hospitals follow a basic structure of a type like the proposed on in Figure 7-22 or in a similar way (Figure 7-23).

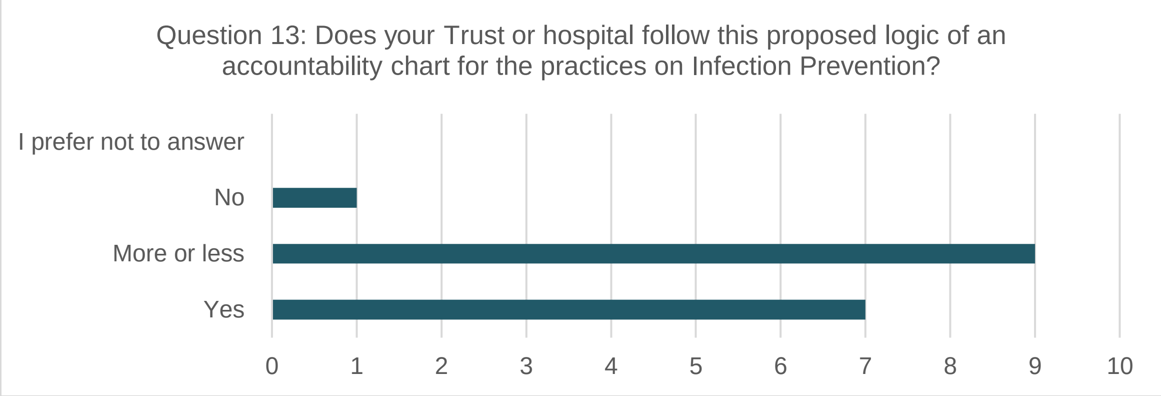


Figure 7-23: Accountability chart - Poropsed logic for practices on Infection Prevention

In a follow-up question those participants who answered the question (question 13) on whether or not they were following the proposed logic of an accountability chart with “no” or “more or less”, were asked about which rate does their trust or hospital approximately follow the proposed logic of the accountability chart. Three of ten replied 90% and 80% resepectively, one of ten replied 70%, 60%, 50% and 40% respectively (Figure 7-24).

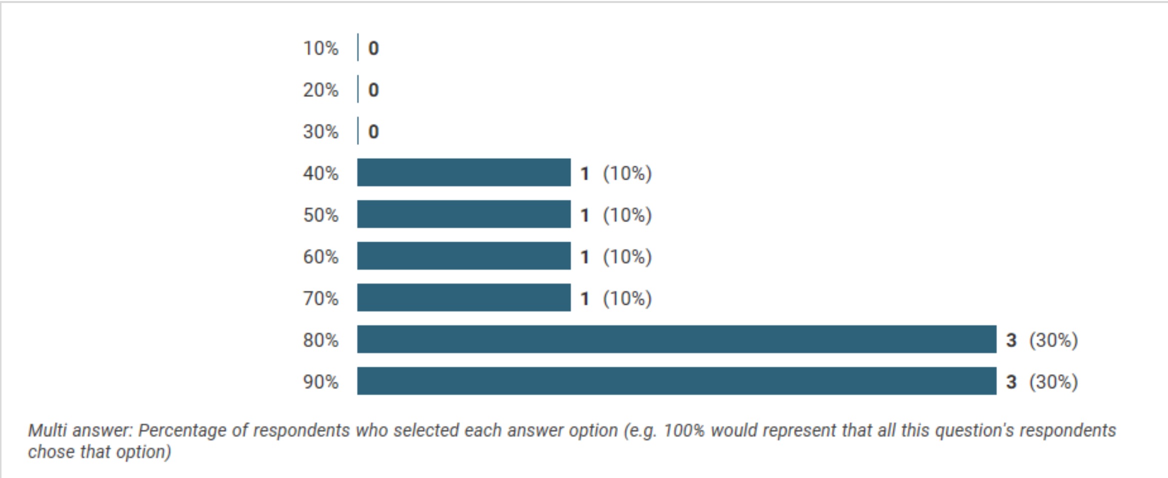


Figure 7-24: Degree of equality to the poropsed logic for practices on Infection Prevention (question 14)

Some reasons for what would be seen different to the proposed logic of the accountability chart are listed in Table 7-27, which represent some hospital or trust specific organisational regulations.

Table 7-27: Reasons why own logic does not follow 100% the proposed logic of an accountability chart

The Trust works across three geographical areas and does not have its own DIPC- this role is available from a local acute Trust through an SLA.
Water safety committee is Under Estates,& Reports to the infection control and prevention commitee
as a mental health Trust we don't have any augmented care units
Soft FM and Clinical Nursing involvement is lacking. Operational Estates, Estates Capital & Project Management IP&C, Microbiology and H&S team involvement is very good.
We are doing some work to embed this but much of this is new and untested. We are doing some work around approved contractor re: water hygiene I think engagement with cleaning service needs to be strengthened (and I would also add medical physics)
infection control doctor is not separate

Survey participants have also been asked whether or not the scheme of governance is comparable to their own trust or hospital. A majority of the respective participants in trusts or hospitals follow a structure of a type like this (Figure 7-25).

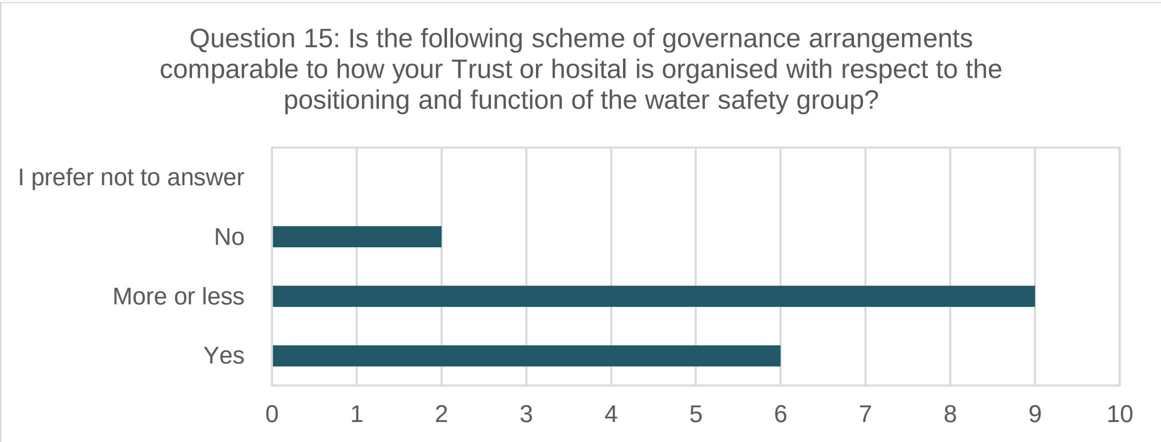


Figure 7-25: Proposed governance arrangements

Those who replied to the question (question 15) whether or not the scheme of governance is comparable to their own Trust or hospital with “no” or “more or less” were asked in a follow-up question (question 16) about which rate does their Trust or hospital approximately follow the proposed logic of the previous governance arrangements chart. Two of eleven replied 90%, three of eleven replied 80%, two of eleven replied 70%, one of eleven replied 60%, 50%, 40%, and 10% respectively (Figure 7-26).

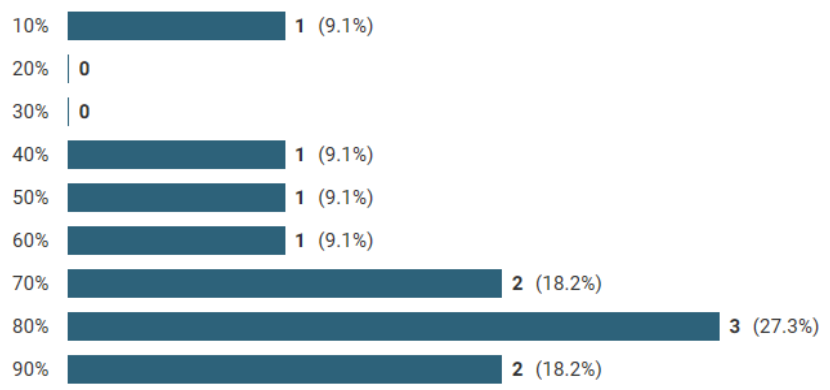


Figure 7-26: Degree of equality of proposed logic of the previous governance arrangements chart according to participants' reply on question 16

Some reasons for what would be seen different to the proposed logic of the governance arrangements scheme are listed in Table 7-28.

Table 7-28: Reasons why their own trust does not follow 100% the proposed logic of governance arrangements

The WSG is part of the IPC Committee which reports to the Trusts Quality Committee
we report up through Estates into the WSG (Chaired by DIPC) and then into the Infection Prevention and Control Committee - not the H&S Committee
Chart layout /Reporting
Governance arrangements differ due to the construct of the Organisation
The water safety group is higher position than the chart it reports directly to the quality steering group and feeds into IPCC meeting it is not classed as a sub group
I'm uncertain of the specific routes after WSG reports through Infection Prevention and Control Committee (IPCC) but I think there are slight differences because IPCC reports through clinical governance and EFM / H&S report through Organisational Risk. Once again much of this is in a constant state of flux because there seems to be no perfect answer and everyone seems to want to try something new. Whatever the answer is I think problems go and they go back down and then up again but often very little improvement takes place in between. Hopefully we will one day fix this but we are not there yet - and lack of funding means this is less likely than before
Slight changes to suit the Trust

Taking into consideration the results from the interview of phase Ib, especially the analyses presented in chapter 7.4.12, the document analysis of phase Ib (7.3) and further results from the web-based-survey phase II presented in the previous sections of this chapter, the logic and elements for a governance arrangements scheme gained sufficient evidence to compile a version for integration into the framework output (chapter 8) after consideration of aggregated analyses (chapter 7.6). A communication pathway is drafted for the framework validation (chapter 7.7) representing one of the elements of the framework, see Figure Appendix D-2. Figure Appendix E-1 contains the final framework elements #5 'management hierarchy' and #7 'communication pathways'.

Amalgamend from the present available situations, the highlighted differences an potentials in the organisationals structures, an potentially all-imbracing version is compiled.

7.5.2 Water safety management training needs

With reference to preliminary results oresented in a research poster at the LJMU Facutly Research Week 2019 (Leiblein and Maynard, 2019) water safety management training needs for management and practitioners in hospitals have been assumed, but according to replies from paticipants are not clearly concluded. The poster is attached to the Appendix C (Figure Appendix C-5). The objective of the poster was to present preliminary results on questions of the web-based survey of phase Ib with specific focus on training and training needs. The poster intended to inform about and characterise different stakeholders in water safety management and *Legionella* prevention in hospitals across the UK. The survey participants held functions shown in Figure 7-27 and are members of different organisations (Figure 7-28) with management's (FM) and engineering affiliations.

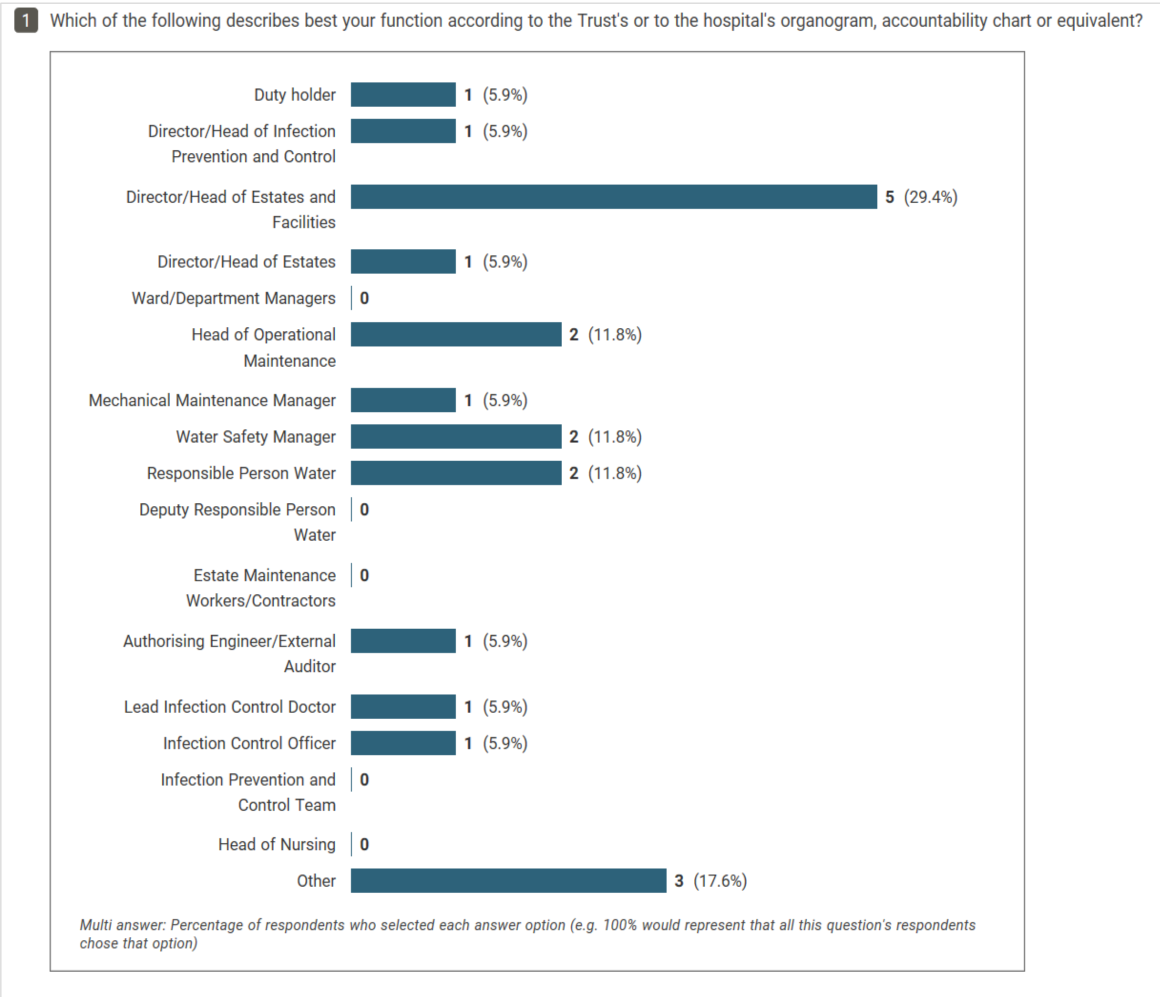


Figure 7-27: Functions of the survey participants

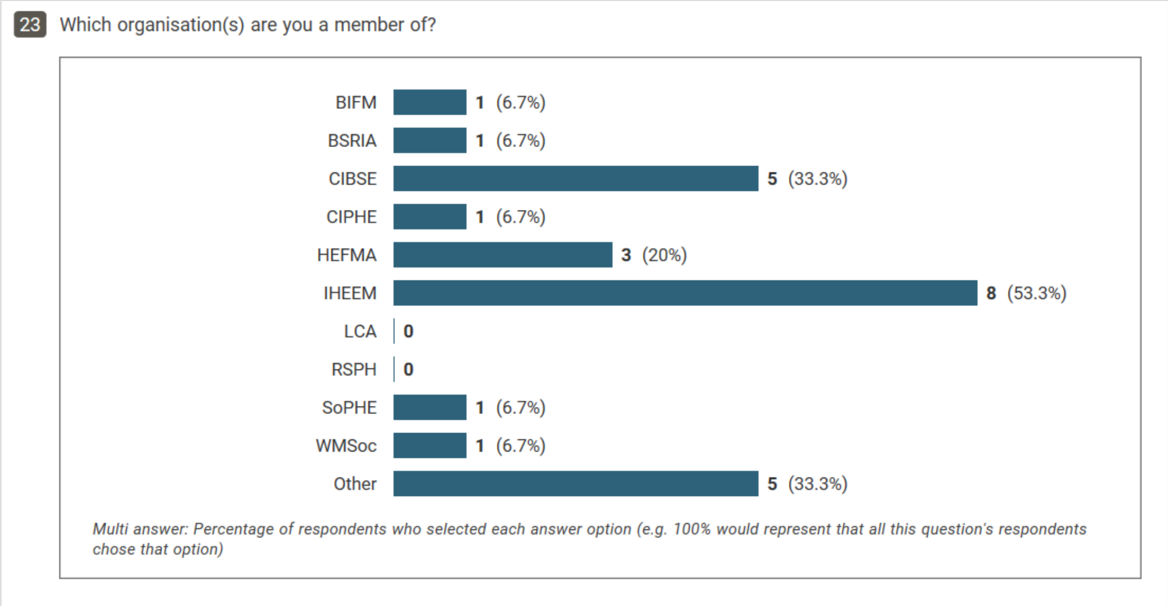


Figure 7-28: Membership of survey participants

All respondents feel they a) adequately understand and appreciate their role/remit in the water safety group, b) are adequately trained and c) have adequate instruction and guidance to allow them to fulfil their role effectively (self-assessment).

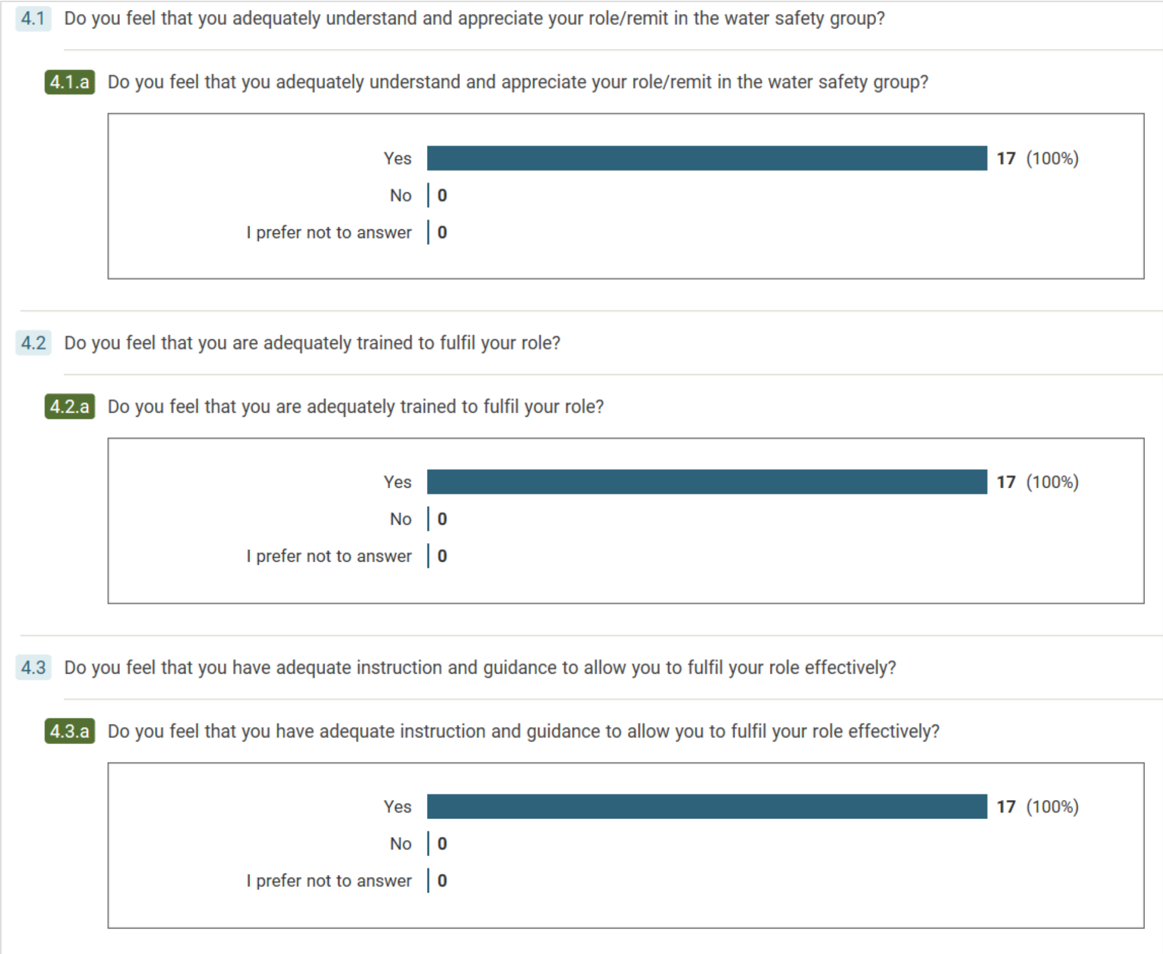


Figure 7-29: Self-assessed adequate understanding, appreciation, training, instruction and guidance

On the question what training needs they would require (self-assessment) with regards to both Legionella and water hygiene, the majority replied “none”. One participant justifies “I think I get by and there is no requirement for me to do more. I think I could progress to the next level and offer more to the Trust and to colleagues but there is no clear route laid down for me to follow". He continues that he "will press for funding if I identify something which might be fit for purpose - I'm just not sure if this even exists" (Table 7-29).

Table 7-29: Training needs required with regards to Legionella and water hygiene

28 What training needs do you require with regards to both Legionella and water hygiene?

Showing all 14 responses Show less
None
none , up to date currently
None currently - however I periodically complete refresher training in my role as Responsible Person
none
Up to date at present Author of the Trust's Water Management Policy & SOPs (including Plan)
As AP and RP I require 3year competence update,
None
I have the awareness I need for my level of input and to direct and discuss with the group the advise given by various specialists in attendance, to make sound collaborative judgments.
Update on awareness training
I think I get by and there is no requirement for me to do more I think I could progress the next level and offer more to the Trust and to colleagues but there is no clear route laid down for me to follow. I will press for funding if I identify something which might be fit for purpose - I'm just not sure if this even exists
Fully compliant to HTM/L8 standards
Training is on-going, I will attend the IHEEM AE conference next month
Training has been received.
none

In addition to their own training needs, participants assessed poor understanding of best practice in their organisations, being ‘noticeable’ (23.5%), ‘present but negligible’ (5.9%), ‘present’ (35.3%), ‘present and strong’ (5.9%), and tremendous (11.8%). ‘Absence’ was replied by 11.8% (Figure 7-30).

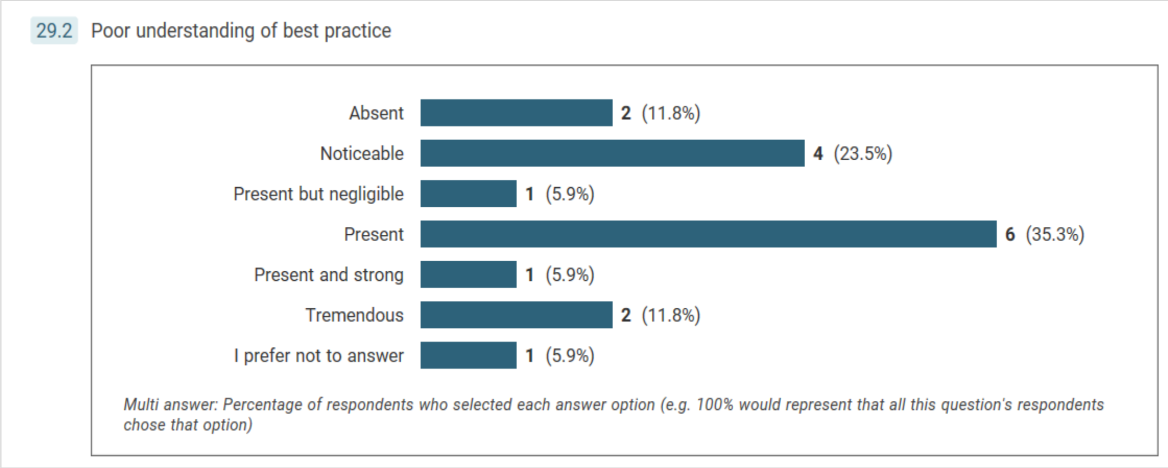


Figure 7-30: Poor understanding of best practice

With respect to training needs most participants seem to be up to date, yet over 41.2% wish further involvement in the design stage of water systems. However, findings underpin certain gaps of sufficient training as well as the demands and the need for CPD. It becomes evident, that the role of FM is very present and collaboration of water safety management group members with FM is rated between intense (29.4%), advanced (52.9%) and moderate (17.6%).

With respect to the percentage of time approximately spent on water hygiene, there is a great range from between <5% up to 100%. Two of 16 responses indicate less than 5%, nine of 17 participants indicate between 5 to 10%, one of 17 participants replied 15-20%, one 40%, one 60% and one 100% of active working time. One participant's comment is "constant involvement but obviously as part of the wider remit of Head of Operational Estates".

A water safety policy and an associated water safety plan defining processes on water safety risk management usually covers 'minimum standards of training and competency of persons'. Participants have been asked to assess whether or not they are involved in the process. As an optional question they have been asked to indicate the progress of completion. If they more likely to oversee the process strategically and their active role in the process is not operational, they were asked to answer with "I prefer not to answer". Almost 65% are involved in the process on minimum standards of training and competency of persons, 35% are not. The progress of completion is about 56% - for a total of 9 of 17 possible responses (Figure 7-31).

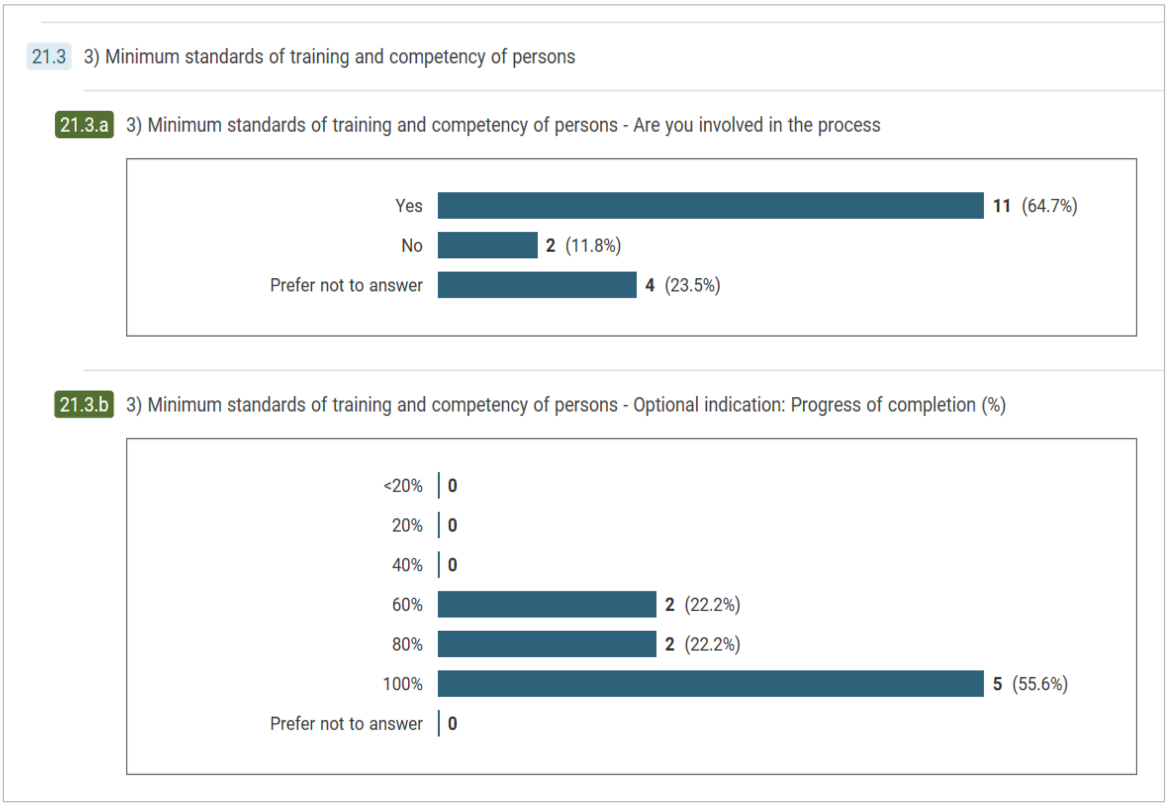


Figure 7-31: Minimum standards of training and competency of persons

In order to meet the specific needs management personnel and other practitioners in hospitals and Trusts may require, according to the results of this analysis, which was specifically addressed to people with duties in water safety managment and *Legionella* prevention in hospitals across England:

- specific training, and
- more sense of awareness about processes, regulations and risks, and responsibilities.

Training and education is taken into consideration to be elements in the framework output.

7.5.3 Management procedures

The management procedures listed in Table 7-30 refer to source 'HTM 04-01: Safe water in healthcare premises, Part B: Operational management Para 6.16 Fig. 3 Documentation of management procedures', available at https://www.gov.uk/government/publications/hot-and-cold-water-supply-storage-and-distribution-systems-for-healthcare-premises.

Table 7-30: Management procedures according to HTM 04-01

Element	**Description**
A)	Identification and description of water systems
B)	System risk assessments
B1)	Identification of potential hazards

B2)	Determine existing control measures
B3)	Assess and prioritise risk
B4)	Identify additional or improved control measures
C)	Controlling risks
C1)	Implement and maintain monitoring and control measures
C2)	Define corrective actions
D)	Verification and auditing
E)	Periodic review
F)	Supportive traning and review programmes

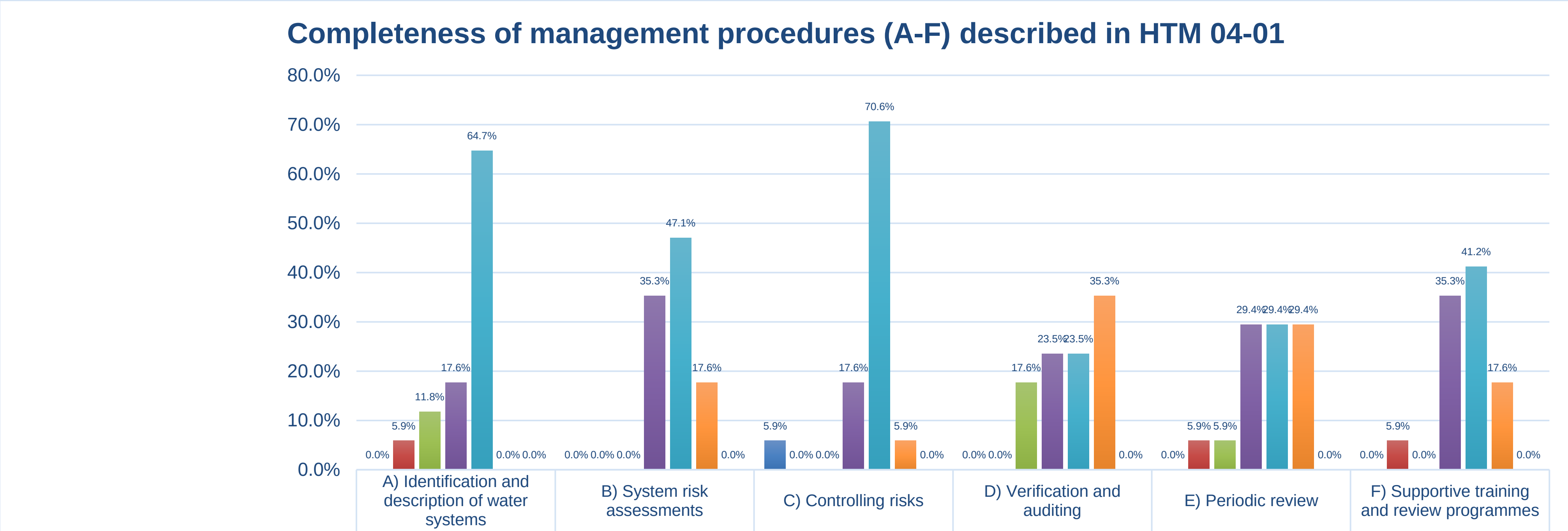
Participants have been asked to answer how they assess the completeness of works of management procedures in their own organisation. Question 19 introduced management procedures and questioned the participants on the completeness of works in the current state of the trust or hospital they are employed with. The elements have been rated in the following order ‘Not taken action at all’, ‘Work has just begun - first steps’, ‘Work has begun - clearer structures’, ‘Improvable but in a fair progress’, ‘Continuous improvement in a good state’, ‘Everything's done that can be done’. For the following results management procedures (from A to F) the ratings are listed in brackets in the previously given order after each procedure. For the elements B ‘System risk assessments’ there are four more specific sub-elements and for C ‘controlling risks’ there are two more specific sub-elements (see Table 7-30).

They completeness of management procedures (A to F), described in HTM 04-01 are, according to Figure 7-32, Figure 7-33 and Figure 7-34, A) Identification and description of water systems (0% 5.9% 11.8% 17.6% 64.7% 0%), B) System risk assessments (0% 0% 0% 35.3% 47.1% 17.6%), B1) Identification of potential hazards (0% 0% 0% 29.4% 58.8% 11.8%), B2) Determine existing control measures (0%, 0%, 0%, 17.6%, 64.7%, 17.6%), B3) Assess and prioritise risk (0% 5.9% 0% 11.8% 70.6% 11.8%), B4) Identify additional or improved control measures (0% 5.9% 0% 17.6% 64.7% 11.8%), C) Controlling risks (5.9% 0% 0% 17.6% 70.6% 5.9%), C1) Implement and maintain monitoring and control measures (5.9% 0% 5.9% 23.5% 58.8% 5.9%), C2) Define corrective actions (0% 5.9% 11.8% 17.6% 47.1% 17.6%), D) Verification and auditing (0% 0% 17.6% 23.5% 23.5% 35.3%), E) Periodic review (0% 5.9% 5.9% 29.4% 29.4% 29.4%), F) Supportive traning and review programmes (0% 5.9% 0% 35.3% 41.2% 17.6%).

Results show there is continous improvement in a good state in place, nevertheless there is a potential range for improving certain management procedures.

There are even elements C) controlling risks and C1) implement and maintain monitoring and control measures that have been indicated as 'not taken action at all', and six additional (A, B3, B4, C2, E and F) where 'work has just begun'.

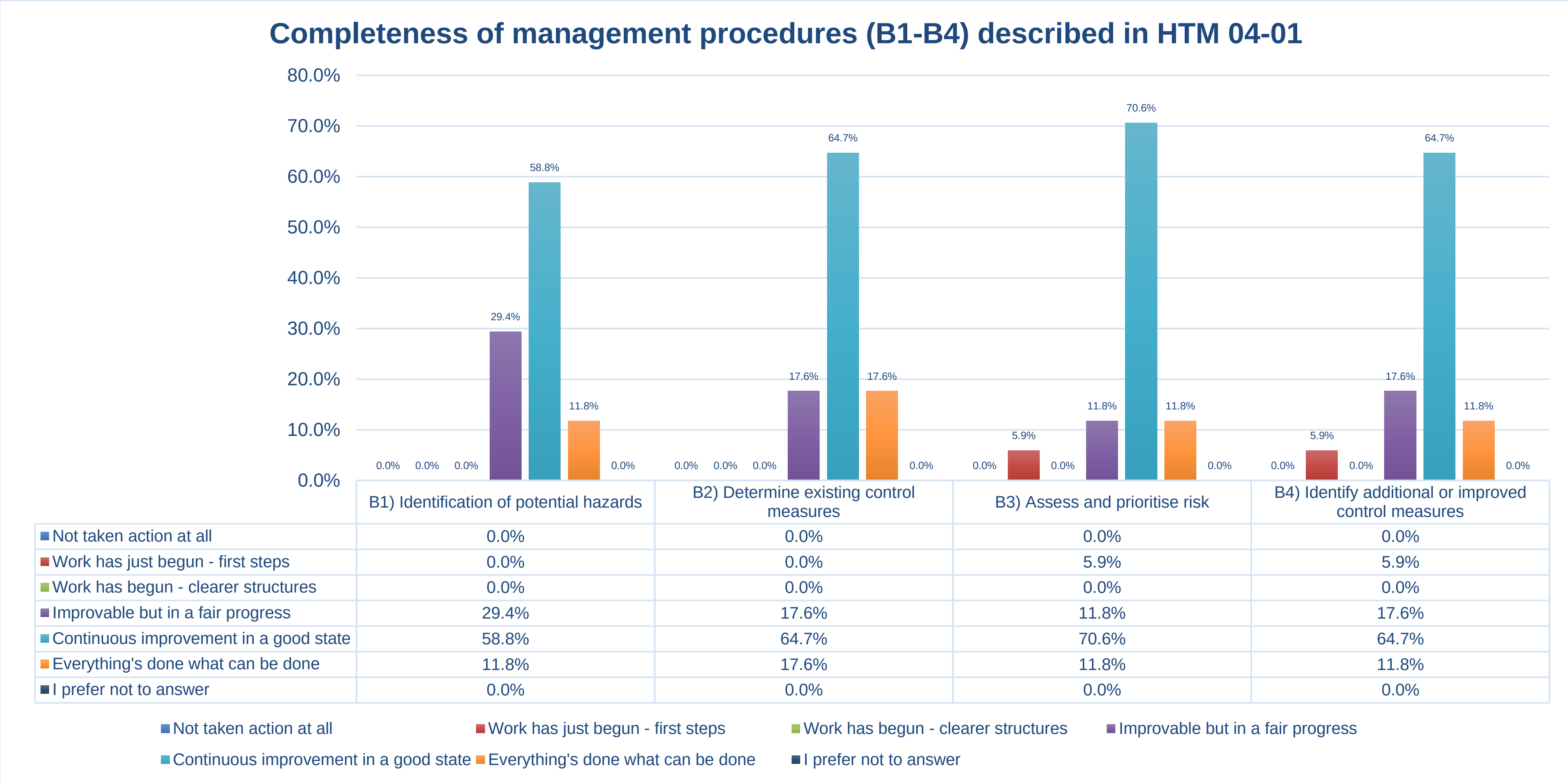
There are significant management procedures according to technical guidance. The framework will be tailored to meet demands and potentials detected by the findings presented above, especially with respect to ‘System risk assessments’, ‘Verification and auditing’, ‘Periodic review’, ‘Supportive training and review programmes’ and ‘Identification of potential hazards’.



	A) Identification and description of water systems	B) System risk assessments	C) Controlling risks	D) Verification and auditing	E) Periodic review	F) Supportive training and review programmes
Not taken action at all	0.0%	0.0%	5.9%	0.0%	0.0%	0.0%
Work has just begun - first steps	5.9%	0.0%	0.0%	0.0%	5.9%	5.9%
Work has begun - clearer structures	11.8%	0.0%	0.0%	17.6%	5.9%	0.0%
Improvable but in a fair progress	17.6%	35.3%	17.6%	23.5%	29.4%	35.3%
Continuous improvement in a good state	64.7%	47.1%	70.6%	23.5%	29.4%	41.2%
Everything's done what can be done	0.0%	17.6%	5.9%	35.3%	29.4%	17.6%
I prefer not to answer	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%

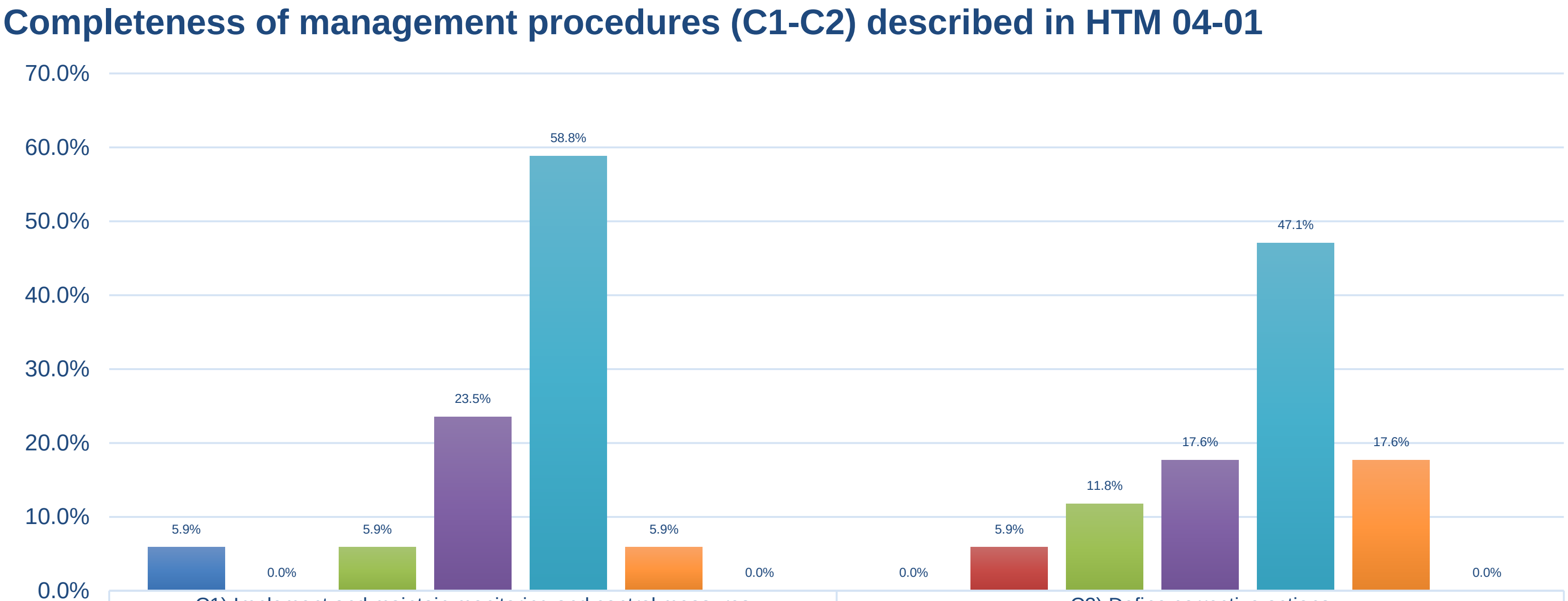
Not taken action at all; Work has just begun - first steps; Work has begun - clearer structures; Improvable but in a fair progress; Continuous improvement in a good state; Everything's done what can be done; I prefer not to answer

Figure 7-32: Completeness of management procedures (A-F) described in HTM 04-01



	B1) Identification of potential hazards	B2) Determine existing control measures	B3) Assess and prioritise risk	B4) Identify additional or improved control measures
Not taken action at all	0.0%	0.0%	0.0%	0.0%
Work has just begun - first steps	0.0%	0.0%	5.9%	5.9%
Work has begun - clearer structures	0.0%	0.0%	0.0%	0.0%
Improvable but in a fair progress	29.4%	17.6%	11.8%	17.6%
Continuous improvement in a good state	58.8%	64.7%	70.6%	64.7%
Everything's done what can be done	11.8%	17.6%	11.8%	11.8%
I prefer not to answer	0.0%	0.0%	0.0%	0.0%

Figure 7-33: Completeness of management procedures (B1-B4) described in HTM 04-01



	C1) Implement and maintain monitoring and control measures	C2) Define corrective actions
Not taken action at all	5.9%	0.0%
Work has just begun - first steps	0.0%	5.9%
Work has begun - clearer structures	5.9%	11.8%
Improvable but in a fair progress	23.5%	17.6%
Continuous improvement in a good state	58.8%	47.1%
Everything's done what can be done	5.9%	17.6%
I prefer not to answer	0.0%	0.0%

Not taken action at all · Work has just begun - first steps · Work has begun - clearer structures · Improvable but in a fair progress · Continuous improvement in a good state · Everything's done what can be done · I prefer not to answer

Figure 7-34: Completeness of management procedures (C1-C2) described in HTM 04-01

Question 20 introduced management procedures taken from Table 7-30 and asked the participants which management procedures are 'most complex in terms of quantity of tasks', 'most complex in terms of quantity of people involved in collaboration', 'most cost-driving', 'most time-consuming', and the 'most efficient'.

For the following management procedures, the ratings for the procedures are listed in brackets in the previously given order. A) Identification and description of water systems, B1) Identification of potential hazards, B2) Determine existing control measures, B3) Assess and prioritise risk, B4) Identify additional or improved control measures, C1) Implement and maintain monitoring and control measures, C2) Define corrective actions, D) Verification and auditing, E) Periodic review, F) Supportive traning and review programmes.

They are, according to Figure 7-35, most complex in terms of quantity of tasks (31.6%, 15.8%, 0%, 15.8%, 15.8%, 15.8%, 0%, 0%, 0%, 0%), according to Figure 7-36 most complex in terms of quantity of people involved in collaboration (4.8%, 14.3%, 14.3%, 0%, 4.8%, 38.1%, 9.5%, 4.8%, 0%, 4.8%), according to Figure 7-37 most cost-driving (0%, 5.3%, 5.3%, 5.3%, 10.5%, 36.8%, 21.1%, 5.3%, 0%, 5.3%), according to Figure 7-38 most time-consuming (17.6%, 5.9%, 0%, 0%, 5.9%, 52.9%, 11.8%, 0%, 0%, 0%), and according to Figure 7-39 most efficient (7.7%, 15.4%, 11.5%, 11.5%, 7.7%, 15.4%, 11.5%, 3.8%, 7.7%, 3.8%).

Based on the results the most complex management procedure in terms of quantity of tasks is the ‘Identification and description of water systems’ (31.6%), the most complex in terms of quantity of people involved in collaboration is ‘Implement and maintain monitoring and control measures’ (38.1%), the most cost driving is also ‘Implement and maintain monitoring and control measures’ (36.8%), the most time-consuming is also seen in ‘Implement and maintain monitoring and control measures’ (52.9%), and the most efficient are ‘Identification of potential hazards’ and ‘Implement and maintain monitoring and control measures’ (each 15.4%). Thus, for ‘Identification and description of water systems’, ‘Implement and maintain monitoring and control measures’ and ‘Identification of potential hazards’ there should be made a careful and purposeful considerations how to invest resources available. This need good and forseeing management and management instruments for decision making. For that, elements in the framework will consider certain elements to address the aforementioned management procedures with guidance.

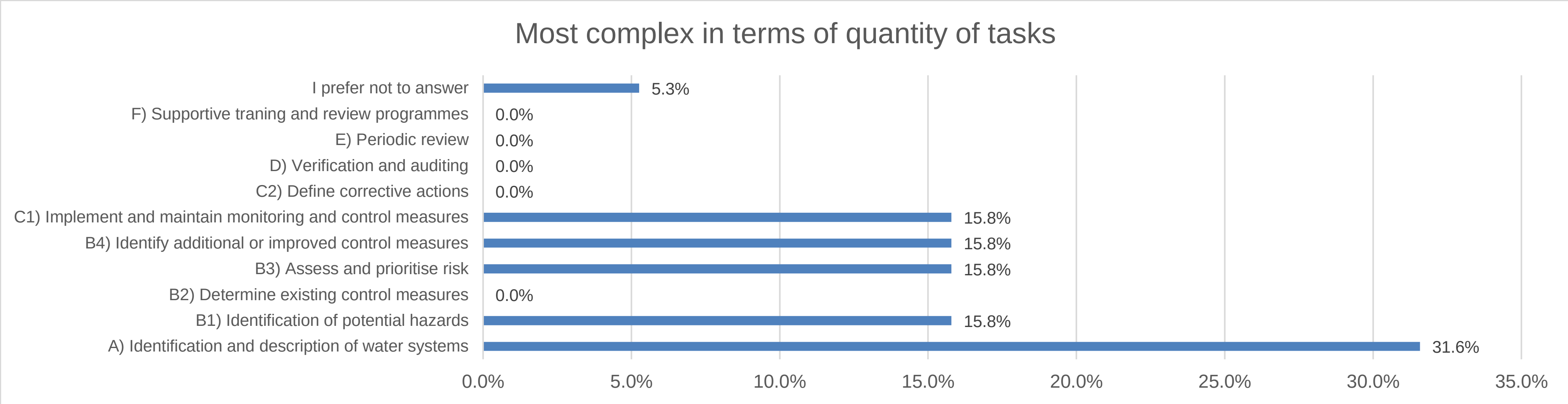


Figure 7-35: Most complex management procedures in terms of quantity of tasks

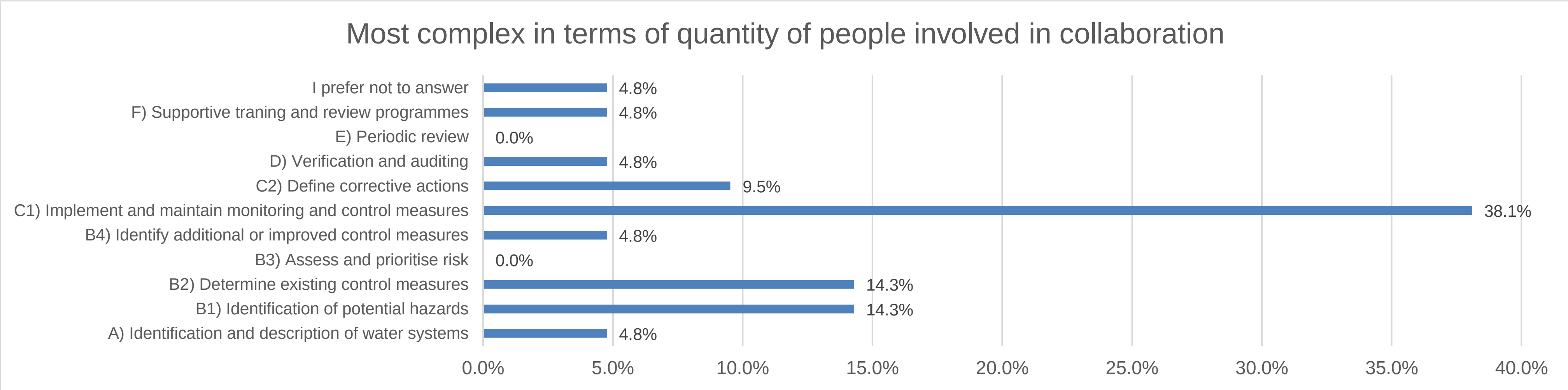


Figure 7-36: Most complex management procedures in terms of quantity of people involved in collaboration

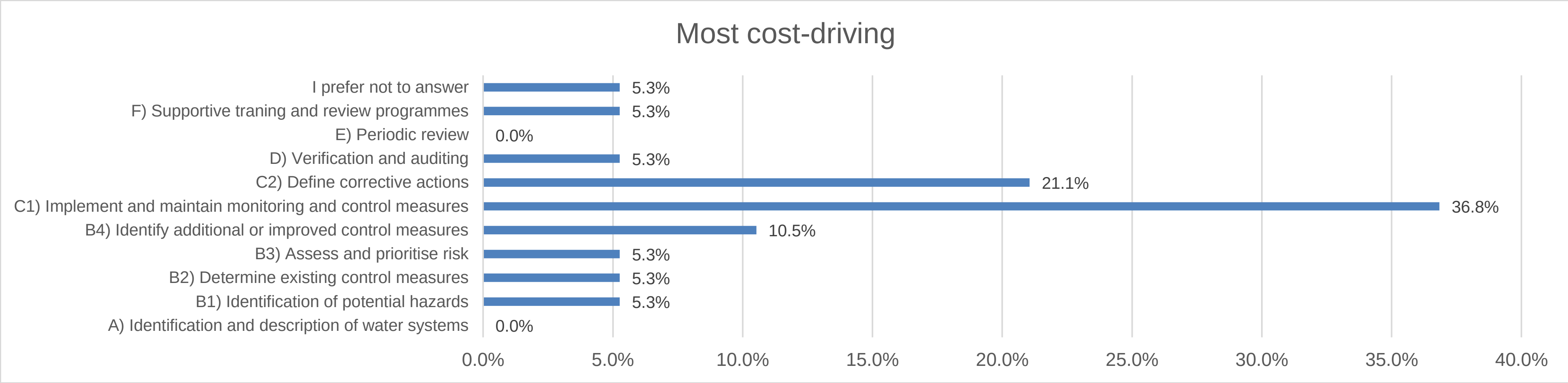


Figure 7-37: Most cost-driving management procedures

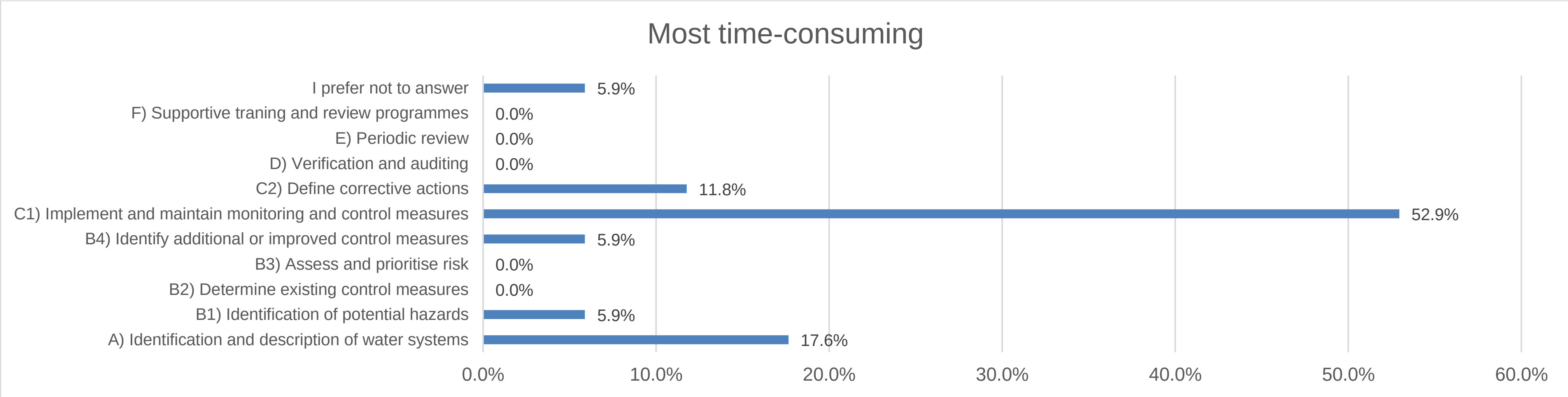


Figure 7-38: Most time-consuming management procedures

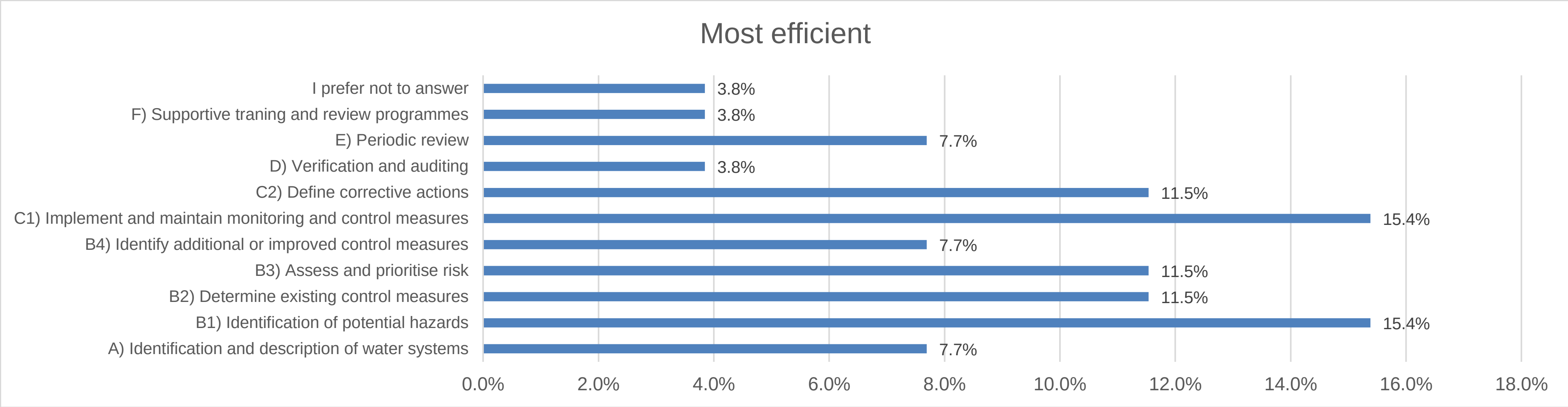


Figure 7-39: Most efficient management procedures

Question 21 introduced that a water safety policy and an associated water safety plan defining processes on water safety risk management usually covers certain elements according to HTM 04-01. These elements are 1) Frequency of *Legionella* and Pseudomonas risk assessments, 2) Frequency and locations for sampling, 3) Minimum standards of training and competency of persons, 4) Escalation procedure when *Legionella*/Pseudomonas found in water samples, 5) Actions to take following a single case or reported outbreak of Legionnaires' Disease (outbreak policy), 6) Operational procedures for ensuring safe water systems (occupation/closure of parts of building), 7) Operational maintenance procedures to prevent bacteria forming (storage/supply of water systems), 8) Preventative and control measures, 8a) Key personnel, 8b) Elevated *Legionella* pneumophila (Lp) counts, 8c) Positive P. aeruginosa, 8d) Nosocomial case, 8e) Taking areas out of service, 8f) Use of POU filters, 8g) Flushing of little used outlets, 8h) High risk/augmented care areas. For the element ‘8) Preventative and control measures’ there are eight more specific sub-elements.

The participants of the survey - 88.2% of which are members of water safety groups - have been asked to assess each element whether or not it is in their responsibility (Figure 7-40) and the estimated level of completion in their trust / hospital. There is a variation for those who are responsible for certain processes with 30% to 71% of the participants. There is also a high amount of people who prefer not to answer, with a variation between 18% and 35%. Responses of those being not responsible for certain processes range between 6% and 35%.

In detail, Figure 7-41 lists the estimated progress of completion in 20 percent increments for each of the process elements 1 to 8 of HTM 04-01, and Figure 7-42 for the elements 8a to 8h. The aggregated potential of improvement for certain elements with a completion progress of 0-60% is up to 40%. It is 27.3% for 1) Frequency of *Legionella* and Pseudomonas risk assessments, 18.2% for 2) Frequency and locations for sampling, 22.2% for 3) Minimum standards of training and competency of persons, 20.0% for 6) Operational procedures for ensuring safe water systems (occupation/closure of parts of building), 22.2% for 7) Operational maintenance procedures to prevent bacteria forming (storage/supply of water systems), 30.0% for 8) Preventative and control measures, 11.1% for 8c) Positive P. aeruginosa, 11.1% for 8d) Nosocomial case, 11.1% for 8e) Taking areas out of service, 11.1% for 8f) Use of POU filters, 40.0% for 8g) Flushing of little used outlets, and 22.2% for 8h) High risk/augmented care areas. As a consequence of these results, some elements that show a potential of improvement of at least 20% will be considered for integration into the framework. They are namely ‘Frequency of *Legionella* and Pseudomonas risk assessments’, ‘Minimum standards of training and competency of persons’, ‘Operational procedures for ensuring safe water systems ‘, ‘Operational maintenance procedures to prevent bacteria forming’, ‘Preventative and control measures’, ‘Flushing of little used outlets’ and ‘High risk/augmented care areas’.

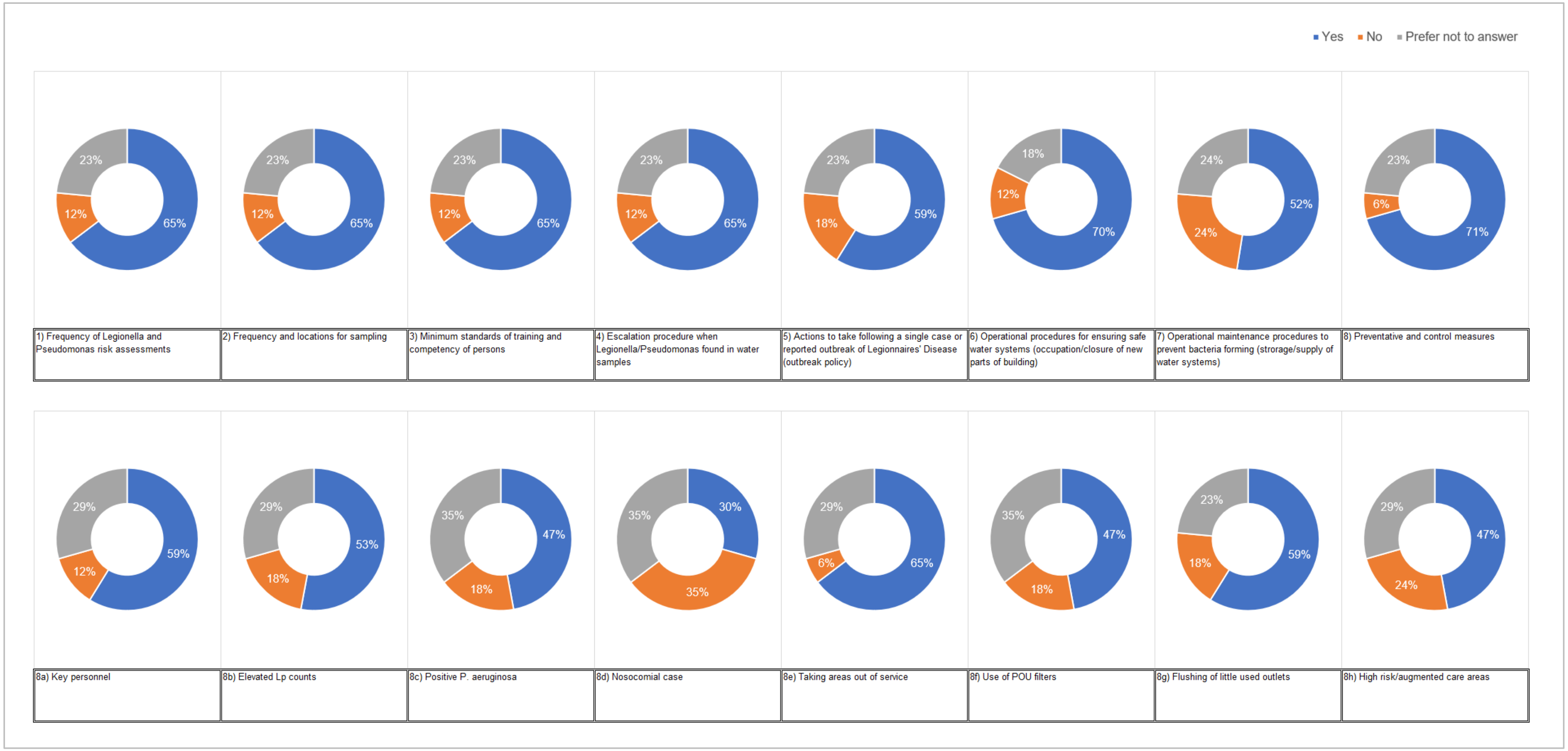


Figure 7-40: Responsibility of survey participants on certain elements of processes on water safety risk management

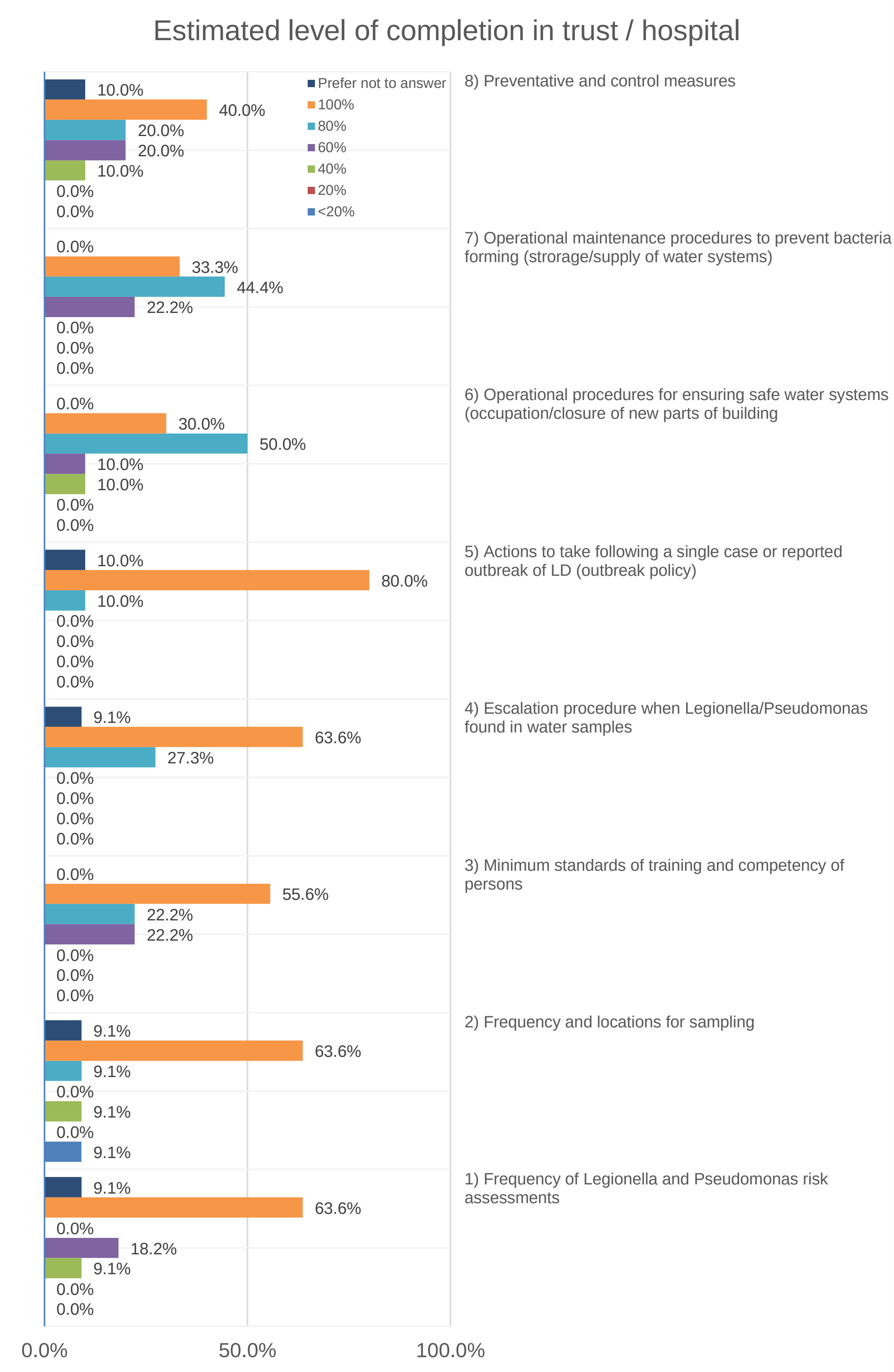


Figure 7-41: Progress of completion. Estimated level of completion in trust / hospital

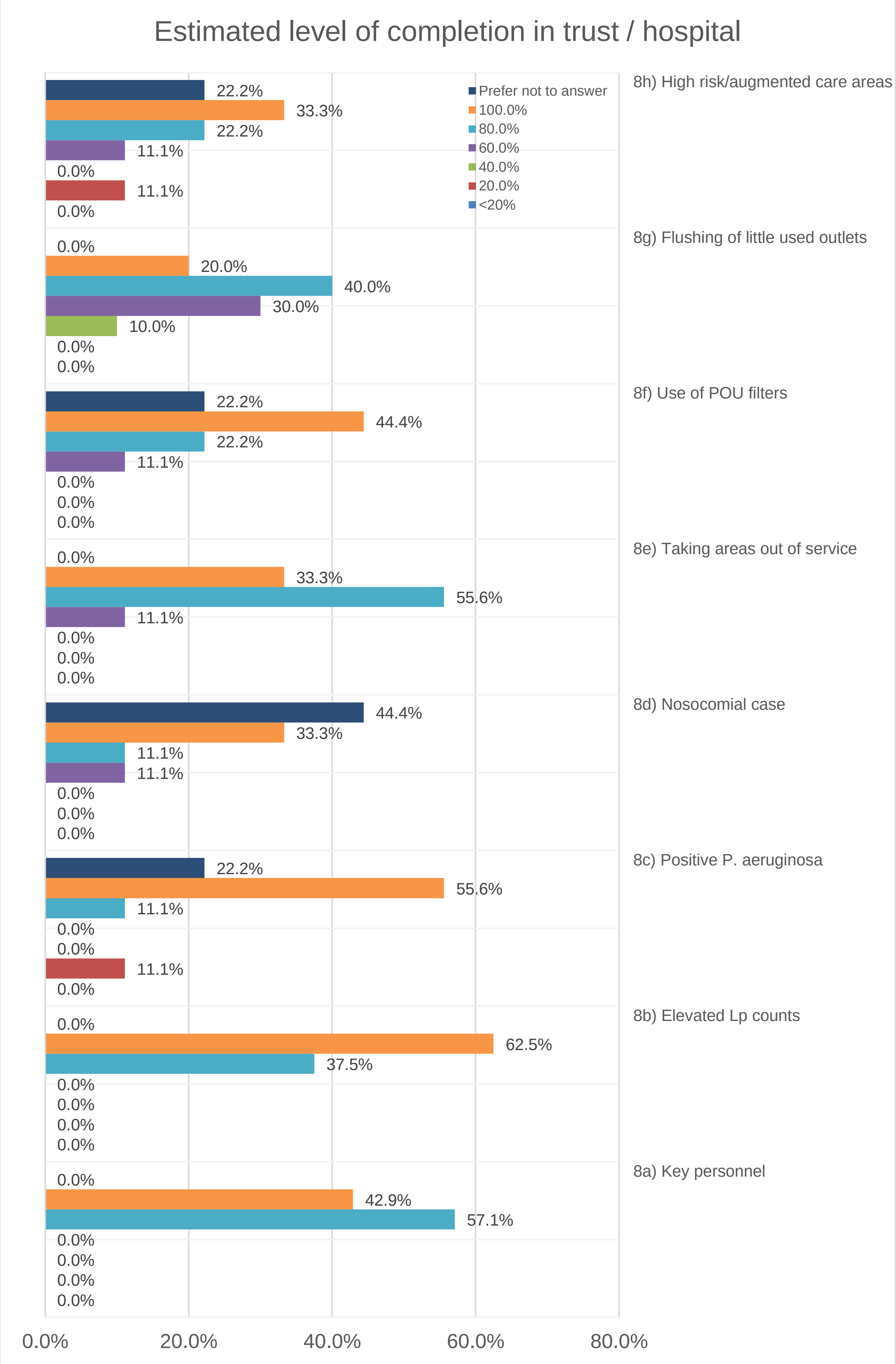


Figure 7-42: Progress of completion. Estimated level of completion in trust / hospital

Different roles presented in this section originated from document analysis of phase Ia and Ib. The roles comprise ‘Duty Holder’, ‘Director of Infection Prevention and Control (DIPC)’, ‘Lead Infection Control Doctor (Medical)’, ‘Infection Control Officer’, ‘Responsible Person Water (RPW)’, ‘Deputy Responsible Person Water (DRPW)’, ‘External Auditor/Authorising Engineer’, ‘Infection Prevention and Control Team (IPCT)’, ‘Ward/Department Managers’, ‘Estate Maintenance Workers/Contractors’, ‘Water Safety Group (WSG)’, ‘Authorised Person(s) (Water)’, ‘Competent Persons’, ‘Estates/Engineering Professionals and Managers’, ‘Other Relevant Staff/Contractors’, ‘Water Hygiene Contractor’. During phase II, the survey study, participants have been asked with survey question no. 22 to answer whether or not the respective role is present in their trust/hospital (Figure 7-43). They have also been asked to evaluate the quality of collaboration being ‘direct’, ‘indirect’ or even ‘not available’ (Figure 7-44). Furthermore, the participants have been asked whether or not they recognise overlapping duties with their role (Figure 7-45).

Further qualitative results, of how collaboration is characterised in practice, are presented in chapter 7.6.2.

Figure 7-43: Presence of different roles in Trust/hospital

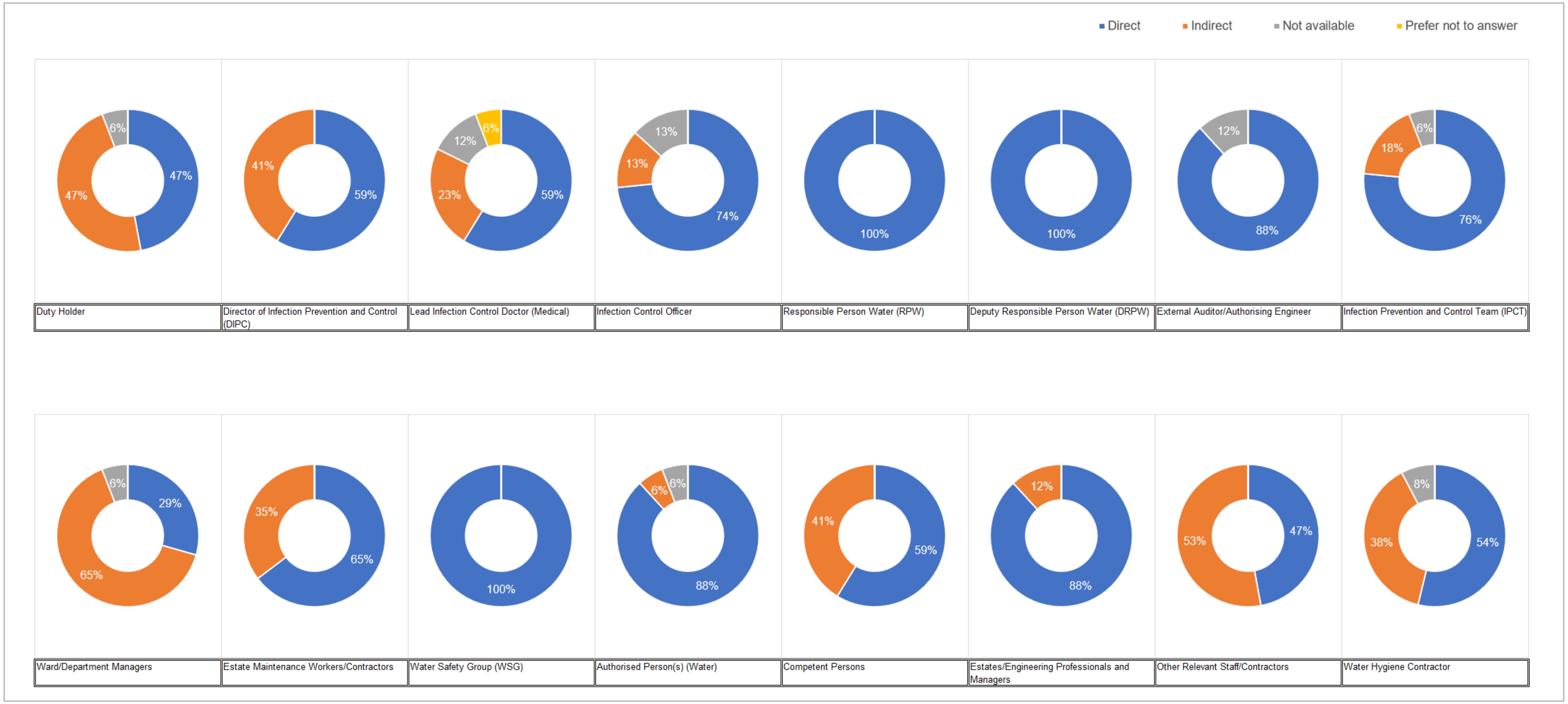


Figure 7-44: Collaboration with different stakeholders

Figure 7-45: Perceived overlapping duties of own role with different other roles

A total of 11 potential inhibitors for an accurate process definition were asked for being rated on their presence or absence. Aggregated analysis found potential inhibitors present in 76.47% (see Figure 7-46, calculated arithmetic mean of 'aggregated 2' with categories 'noticeable' 'present but negligible', 'present', and 'present and strong'), absent in 17.65%, and 5.88% prefered not to answer. To highlight the dominant inhibitors, those that were mentioned at least 5 times are highlighted with a blue cell in Table 7-31. They are, in a descending order of nomination, 'lack of budget' (47.1%), 'poor understanding of best practice' (35.3%), 'uncertainty about process owners' (29.4%), 'lack of time' (29.4%), 'lack of knowledge' (29.4%), 'lack of interest' (29.4%), 'lack of power' (29.4%), 'old habits in the organisational structure' (29.4%).

Table 7-31: Summary of stated potentials of inhibiting an accurate process definition (survey question 29)

Inhibitor	**Occurrence/Total number of responses (Frequency %)**							**aggregated**
	Absent	Noticeable	Present but negligible	Present	Present and strong	Tremendous	I prefer not to answer	'present', 'present and strong', 'tremendous'
Regulatory uncertainty	4/17 (23.5)	2/17 (11.8)	4/17 (23.5)	2/17 (11.8)	3/17 (17.6)	1/17 (5.9)	1/17 (5.9)	6/17 (35.3)
Poor understanding of best practice	2/17 (11.8)	4/17 (23.5)	1/17 (5.9)	6/17 (35.3)	1/17 (5.9)	2/17 (11.8)	1/17 (5.9)	9/17 (52.9)
Uncertainty about clearly defined process steps	3/17 (17.6)	4/17 (23.5)	2/17 (11.8)	4/17 (23.5)	1/17 (5.9)	2/17 (11.8)	1/17 (5.9)	7/17 (41.2)
Uncertainty about process owners	3/17 (17.6)	4/17 (23.5)	1/17 (5.9)	5/17 (29.4)	1/17 (5.9)	2/17 (11.8)	1/17 (5.9)	8/17 (47.0)
Lack of time	1/17 (5.9)	4/17 (23.5)	2/17 (11.8)	5/17 (29.4)	3/17 (17.6)	1/17 (5.9)	1/17 (5.9)	9/17 (52.9)
Lack of budget	2/17 (11.8)	1/17 (5.9)	0/17 (0.0)	8/17 (47.1)	2/17 (11.8)	3/17 (17.6)	1/17 (5.9)	13/17 (76.5)
Lack of knowledge	2/17 (11.8)	4/17 (23.5)	3/17 (17.6)	5/17 (29.4)	1/17 (5.9)	1/17 (5.9)	1/17 (5.9)	7/17 (41.2)
Lack of interest	4/17 (23.5)	2/17 (11.8)	3/17 (17.6)	5/17 (29.4)	2/17 (11.8)	0/17 (0.0)	1/17 (5.9)	7/17 (41.2)
Lack of power	5/17 (29.4)	2/17 (11.8)	2/17 (11.8)	4/17 (23.5)	2/17 (11.8)	1/17 (5.9)	1/17 (5.9)	7/17 (41.2)
Lack of support from decision makers	4/17 (23.5)	3/17 (17.6)	2/17 (11.8)	3/17 (17.6)	3/17 (17.6)	1/17 (5.9)	1/17 (5.9)	7/17 (41.2)
Old habits in the organisational structure	3/17 (17.6)	5/17 (29.4)	4/17 (23.5)	1/17 (5.9)	2/17 (11.8)	1/17 (5.9)	1/17 (5.9)	4/17 (23.5)

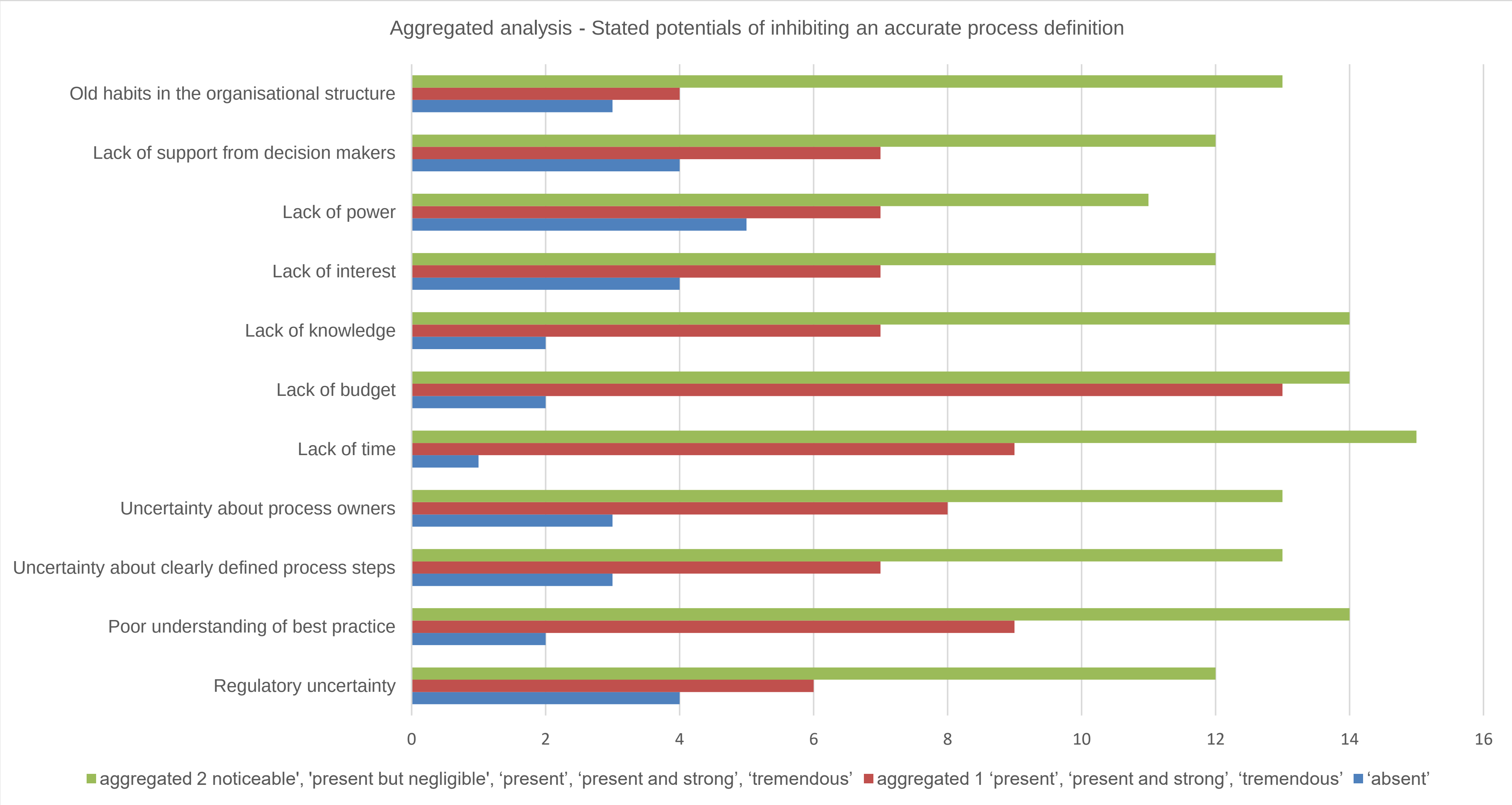


Figure 7-46: Aggregated analysis - Stated potentials of inhibiting an accurate process definition

The involvement of and the identification at management level not only ensures that people are engaged with the process and procedures, it also maximises the potential for awareness and support to be considered as part of an interdisciplinary endeavour and collaborative approach, as is the case with water safety and *Legionella* prevention in hospitals. With respect to management procedures there is, at management level of trusts or hospitals, potential to increase power and interest as well as the level of completeness of certain procedures.

Aggregated analyses in the following chapter will elaborate further details on the processes, the stakeholders, the process owners.

7.6 Aggregated analyses

This chapter applies aggregated analyses in order to take into account the results of the different phases of research and to harmonise results for compiling the elements of the framework. It aims at process and stakeholder identification and analysis to determine the entity of process elements to be included into a process map and stakeholders for consideration in the framework. For that it comprises data results and previous analyses made for phases I b to II and includes qualitative and quantitative elements.

7.6.1 Process identification and analysis

Participants have been asked (question 18) which of a given catalogue of assumed processes, sub-processes and working steps they see as being a 'main process', a 'sub-process' or a 'work step' in water safety management? The catalogue comprised 27 elements, which are 'Description of systems', 'operational considerations and requirements', 'Risk assessments', 'Governance and management responsibility', 'Operational management', 'Emergency action', 'Monitoring Systems', 'Performance monitoring', 'Microbiological monitoring', 'Testing for *Legionella*/*Pseudomonas'*, 'Management of water safety risks and issues', 'Energy management', 'Safe hot water temperature', 'Utilisation', 'Temporary closure of wards/departments', 'Leak detection/water conservation', 'Water treatment undertaken by the local water supplier', 'Maintenance responsibility', 'Maintenance practice', 'Constitute and organise the Water Safety Group', 'Compile and maintain Water Safety Plans', 'Documentation', 'Data management and record keeping', 'Compliance of the healthcare estate', 'Contract maintenance', 'Maintenance brief', 'Staff training and competence', 'Water hygiene training'. Detailed information on some terms, were given by explanations for:

- Data management and record keeping (e.g. As-fitted drawings; Schematic drawings; Asset Register)
- Description of systems, operational considerations and requirements (e.g. Source of supply: a) Temperature control regime, b) biocide regimes; Metal contamination; Water softening; Filtration; Metering; Water storage; Pressurisation/supply pumps; Cold water distribution systems; Drinking water; Hot water storage and distribution; Instantaneous water heaters for single or multi-point outlets; Pressure and expansion vessels; Safe hot water delivery devices; Showers; Point-of-use filtration; Remove of redundant pipework and services; Cleaning and disinfection).

- Other operational considerations(e.g. Vending, chilled water and ice-making machines; Portable/room humidifiers; Non-wholesome water storage; Deluge showers; Trolley wash procedures; Lawn spinklers and garden (or similar) hoses; Vehicle washing plant; Decorative internal and external water Features; External water features; Wet fire and automatic sprinkler Systems; Patient contact equipment (e.g. respiratory nebulisers, humidifiers); Heater cooler units used in cardiac surgery; Flowers and plants; Buried pipelines; Other risk systems).

Analysis started by calculating the relative frequency for each group and to assign a rank according to the result of relative frequency. For elements that showed less than 10% difference in the comparison of the percentage of their relative frequency, an option for decision-making was defined that it could either be assigned to 'main process', 'sub-process' or 'work step' (Figure 7-47).

		Group 1			Group 2			Group 3			
		Main process [%]	Rank according to percentage		Sub-process [%]	Rank according to percentage		Not to be described as a process, but as a work step [%]	Rank according to percentage		I prefer not to answer [%]
	Description of systems, operational considerations and requirements	64.7	**6**		29.4	**20**		5.9	**22**		0.0
	Risk assessments	70.6	**5**		23.5	**23**		5.9	**22**		0.0
	Governance and management responsibility	76.5	**3**		17.6	**25**		5.9	**22**		0.0
	Operational management	60.0	**7**		33.3	**19**		6.7	**18**		0.0
	Emergency action	37.5	**12**		50.0	**11**		12.5	**15**		0.0
	Monitoring systems	33.3	**13**		66.7	**3**		0.0	**25**		0.0
	Performance monitoring	33.3	**13**		60.0	**6**		6.7	**18**		0.0
	Microbiological monitoring	26.7	**17**		73.3	**1**		0.0	**25**		0.0
less than 10% difference. Could either be assigned to 'process' or 'sub-process'	Testing for Legionella/Pseudomonas	43.8	**10**		50.0	**11**		6.3	**20**		0.0
	Management of water safety risks and issues	81.3	**2**		18.8	**24**		0.0	**25**		0.0
less than 10% difference. Could either be assigned to 'sub-process' or 'work step'	Energy management	25.0	**18**		37.5	**16**		37.5	**4**		0.0
	Safe hot water temperature	29.4	**15**		52.9	**7**		17.6	**9**		0.0
	Utilisation	5.9	**26**		64.7	**4**		17.6	**9**		11.8
	Temporary closure of wards/departments	11.8	**24**		35.3	**17**		52.9	**2**		0.0
	Leak detection/water conservation	0.0	**27**		35.3	**17**		58.8	**1**		5.9
	Water treatment undertaken by the local water undertaker	23.5	**19**		29.4	**20**		41.2	**3**		5.9
	Maintenance responsibility	56.3	**8**		25.0	**22**		18.8	**8**		0.0
	Maintenance practice	29.4	**15**		52.9	**7**		17.6	**9**		0.0
	Constitute and organise the Water Safety Group	87.5	**1**		6.3	**26**		6.3	**20**		0.0
less than 10% difference. Could either be assigned to 'process' or 'sub-process'	Compile and maintain Water Safety Plans	47.1	**9**		41.2	**13**		11.8	**16**		0.0
	Documentation	17.6	**22**		64.7	**4**		17.6	**9**		0.0
	Data management and record keeping	17.6	**22**		70.6	**2**		11.8	**16**		0.0
	Compliance of the healthcare estate	76.5	**3**		5.9	**27**		17.6	**9**		0.0
	Contract maintenance	23.5	**19**		52.9	**7**		23.5	**7**		0.0
	Maintenance brief	11.8	**24**		52.9	**7**		35.3	**5**		0.0
less than 10% difference. Could either be assigned to 'process' or 'sub-process'	Staff training and competence	41.2	**11**		41.2	**13**		17.6	**9**		0.0
	Water hygiene training	23.5	**19**		41.2	**13**		29.4	**6**		5.9

Figure 7-47: Process analysis based considering 27 process elements

In order to determine a process hierarchy within each of the three groups 'main process', 'sub-process' and 'work step' (later termed 'task'), subsequent analyses became necessary. For that each of the 27 elements was assigned an 'ID' prior to pairwise comparison (Figure 7-48, Figure 7-49, Figure 7-50).

A decision on structuring hierarchically within each group was then achieved by pairwise comparison (Figure 7-51, Figure 7-52, Figure 7-53). For each group a new rank hierarchy was calculated. A clear set of criteria was set for determining the importance of each element categorised as 'main process', 'sub-process' or 'work step'. The scoring methodology used for the pairwise comparison is dscribed in Table 7-32.

Table 7-32: Scoring methodology for pairwise comparison

Scoring	Condition
If two compared process steps are equally important they both score '1'	for the case when the difference between the two items is ≤5%
If one is slightly more important than another it scores 2 and the other scores 0.50	for the case when the difference between the two items is >5% but ≤10%
If one is clearly more important than another it scores 3 and the other scores 0.33	for the case when the difference between the two items is >10% but ≤25%
If one is significantly more important it scores 4 and the other scores 0.25	for the case when the difference between the two items is >25%

Elements rated as main process

		Group 1			
		Main process [%]	Rank according to percentage		ID assigned for pairwise comparison
	Description of systems, operational considerations and requirements	64.7	6		ID 1
	Risk assessments	70.6	5		ID 2
	Governance and management responsibility	76.5	3		ID 3
	Operational management	60.0	7		ID 4
less than 10% difference. Could either be assigned to 'process' or 'sub-process'	Testing for Legionella/Pseudomonas	43.8	10		ID 5
	Management of water safety risks and issues	81.3	2		ID 6
	Maintenance responsibility	56.3	8		ID 7
	Constitute and organise the Water Safety Group	87.5	1		ID 8
less than 10% difference. Could either be assigned to 'process' or 'sub-process'	Compile and maintain Water Safety Plans	47.1	9		ID 9
	Compliance of the healthcare estate	76.5	3		ID 10
less than 10% difference. Could either be assigned to 'process' or 'sub-process'	Staff training and competence	41.2	11		ID 11

Figure 7-48: Process identification 'main process' elements

	Element rated as sub-process	Group 2			
		Sub-process [%]	Rank according to percentage		ID assigned for pairwise comparison
	Emergency action	50.0	11		ID 1
	Monitoring systems	66.7	3		ID 2
	Performance monitoring	60.0	6		ID 3
	Microbiological monitoring	73.3	1		ID 4
less than 10% difference. Could either be assigned to 'process' or 'sub-process'	Testing for Legionella/Pseudomonas	50.0	11		ID 5
less than 10% difference. Could either be assigned to 'sub-process' or 'work step'	Energy management	37.5	16		ID 6
	Safe hot water temperature	52.9	7		ID 7
	Utilisation	64.7	4		ID 8
	Maintenance practice	52.9	7		ID 9
less than 10% difference. Could either be assigned to 'process' or 'sub-process'	Compile and maintain Water Safety Plans	41.2	13		ID 10
	Documentation	64.7	4		ID 11
	Data management and record keeping	70.6	2		ID 12
	Contract maintenance	52.9	7		ID 13
	Maintenance brief	52.9	7		ID 14
less than 10% difference. Could either be assigned to 'process' or 'sub-process'	Staff training and competence	41.2	13		ID 15
	Water hygiene training	41.2	13		ID 16

Figure 7-49: Process identification 'sub-process' elements

	Elements rated as work step	Group 3			
		Not to be described as a process, but as a work step [%]	Rank according to percentage		ID assigned for pairwise comparison
less than 10% difference. Could either be assigned to 'sub-process' or 'work step'	Energy management	37.5	4		ID 1
	Temporary closure of wards/departments	52.9	2		ID 2
	Leak detection/water conservation	58.8	1		ID 3
	Water treatment undertaken by the local water undertaker	41.2	3		ID 4

Figure 7-50: Process identification 'work steps' elements

Main process

Process ID	ID 1	ID 2	ID 3	ID 4	ID 5	ID 6	ID 7	ID 8	ID 9	ID 10	ID 11	Total	Rank hierarchy
ID 1		0.5	0.33	1	3	0.33	2	0.33	3	0.5	3	14	**6**
ID 2	2		0.5	3	4	0.33	3	0.33	3	0.5	4	20.7	**5**
ID 3	3	2		3	4	1	3	0.33	4	1	4	25.3	**3**
ID 4	1	0.33	0.33		3	0.33	1	0.33	3	0.33	3	12.7	**7**
ID 5	0.33	0.25	0.25	0.33		0.25	0.33	0.25	1	0.25	1	4.24	**10**
ID 6	3	3	1	3	4		4	0.5	4	1	4	27.5	**2**
ID 7	0.5	0.33	0.33	1	3	0.25		0.25	2	0.33	3	11	**8**
ID 8	3	3	3	3	4	2	4		4	3	4	33	**1**
ID 9	0.33	0.33	0.25	0.33	1	0.25	0.5	0.25		0.25	1	4.49	**9**
ID 10	2	2	1	3	4	1	3	0.33	4		4	24.3	**4**
ID 11	0.33	0.25	0.25	0.33	1	0.25	0.33	0.25	1	0.25		4.24	**10**

Figure 7-51: Pairwise comparison 'main process' elements

Sub-process

Process ID	ID 1	ID 2	ID 3	ID 4	ID 5	ID 6	ID 7	ID 8	ID 9	ID 10	ID 11	ID 12	ID 13	ID 14	ID 15	ID 16	Total	Rank hierarchy
ID 1		0.33	0.5	0.33	1	3	1	0.33	1	2	0.33	0.33	1	1	2	2	16.2	**10**
ID 2	3		2	0.5	3	4	3	1	3	4	1	1	3	3	4	4	39.5	**3**
ID 3	2	0.5		0.33	2	3	2	1	2	3	1	0.33	2	2	3	3	27.2	**6**
ID 4	3	2	3		3	4	3	2	3	4	2	1	3	3	4	4	44	**1**
ID 5	1	0.33	0.5	0.33		3	1	0.33	1	2	0.33	0.33	1	1	2	2	16.2	**10**
ID 6	0.33	0.25	0.33	0.25	0.33		0.33	0.25	0.33	1	0.25	0.25	0.33	0.33	1	1	6.56	**16**
ID 7	1	0.33	0.5	0.33	1	3		0.33	1	2	0.33	0.33	1	1	2	2	16.2	**10**
ID 8	3	1	1	0.5	3	4	3		3	3	1	0.5	3	3	3	3	35	**4**
ID 9	1	0.33	0.5	0.33	1	3	1	0.33		3	0.33	0.33	1	1	3	3	19.2	**7**
ID 10	0.5	0.25	0.33	0.25	0.5	1	0.5	0.33	0.33		0.33	0.25	0.33	0.33	1	1	7.23	**13**
ID 11	3	1	1	0.5	3	4	3	1	3	3		0.5	3	3	3	3	35	**4**
ID 12	3	1	3	1	3	4	3	2	3	4	2		3	3	4	4	43	**2**
ID 13	1	0.33	0.5	0.33	1	3	1	0.33	1	3	0.33	0.33		1	3	3	19.2	**7**
ID 14	1	0.33	0.5	0.33	1	3	1	0.33	1	3	0.33	0.33	1		3	3	19.2	**7**
ID 15	0.5	0.25	0.33	0.25	0.5	1	0.5	0.33	0.33	1	0.33	0.25	0.33	0.33		1	7.23	**13**
ID 16	0.5	0.25	0.33	0.25	0.5	1	0.5	0.33	0.33	1	0.33	0.25	0.33	0.33	1		7.23	**13**

Figure 7-52: Pairwise comparison 'sub-process' elements

Work step

Process ID	ID 1	ID 2	ID 3	ID 4	Total	Rank hierarchy
ID 1		0.33	0.33	1	1.66	**3**
ID 2	3		0.5	3	6.5	**2**
ID 3	2	2		3	7	**1**
ID 4	1	0.33	0.33		1.66	**3**

Figure 7-53: Pairwise comparison 'work step' elements

Finally, a pareto chart for each group ‘main process’, ‘sub-process’ , and ’work step’ visualises the resulting hierarchy in a descending order of frequency (Figure 7-54, Figure 7-55, Figure 7-56). A pareto chart represents the distribution of data in descending order of frequency, with a cumulative line on a secondary axis as a percentage of the total.

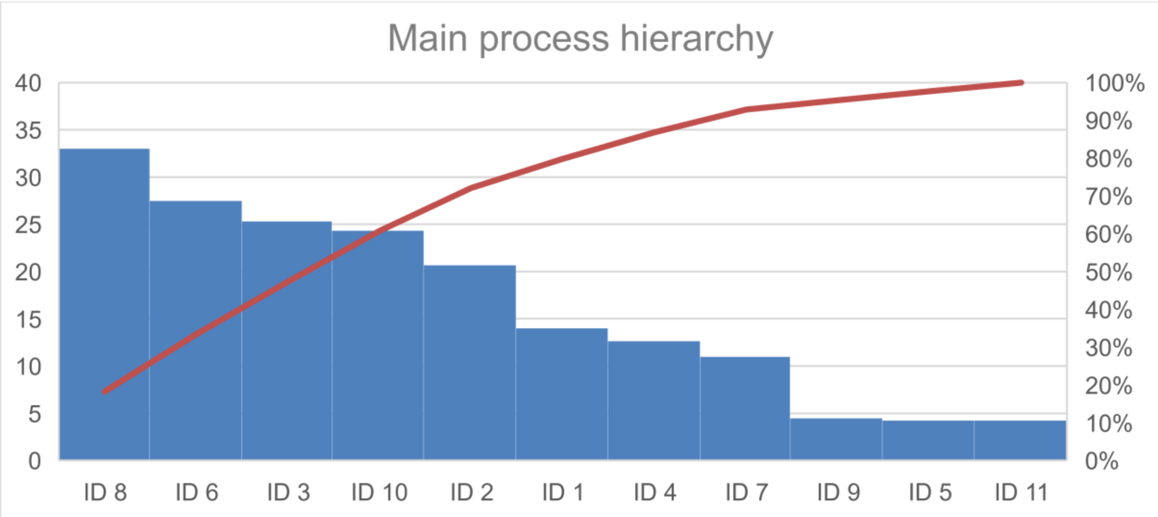


Figure 7-54: Pareto chart for ‘main process’ elements

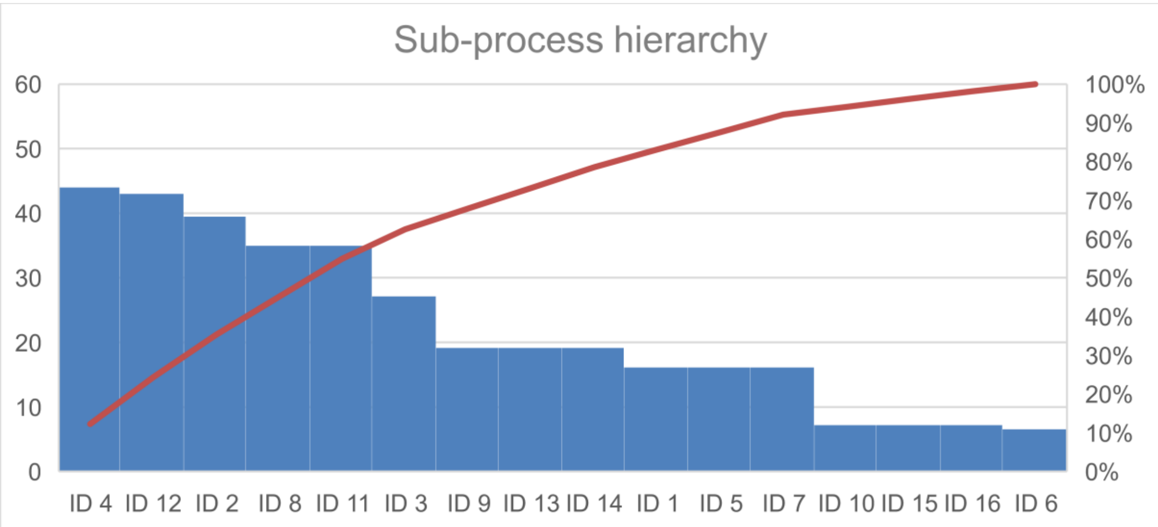


Figure 7-55: Pareto chart for ‘sub-process’ elements

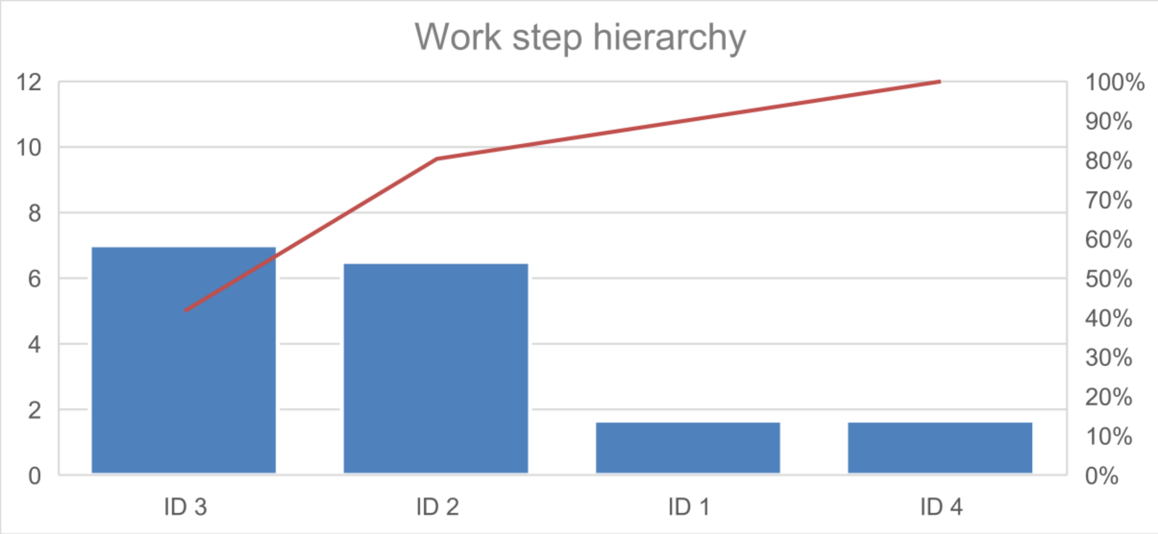


Figure 7-56: Pareto chart for 'work step' elements

Determining a process hierarchy

Taking into consideration the previously identified main processes, sub processes and work steps (they have been given a new term ‘tasks’), and underlying the process hierarchy presented in chapter 3.4.2, the following water safety management process map was compiled to be one essential element of the framework (Figure 7-57). For some elements were assigned to likewise MP and SP (i.e. ‘Compile and maintain Water Safety Plans’, ‘Testing for *Legionella*/Pseudomonas’, ans ‘Staff training and competence’) and to SP and Tasks (i.e. ‘Energy management’) after analysis of phase II, the preliminary process map was considered to undergo a further step for development. Final MP, SP and Tasks for the framework were set after the validation step of phase III (chapter 7.7), resulting in the final process map for framework output (chapter 8).

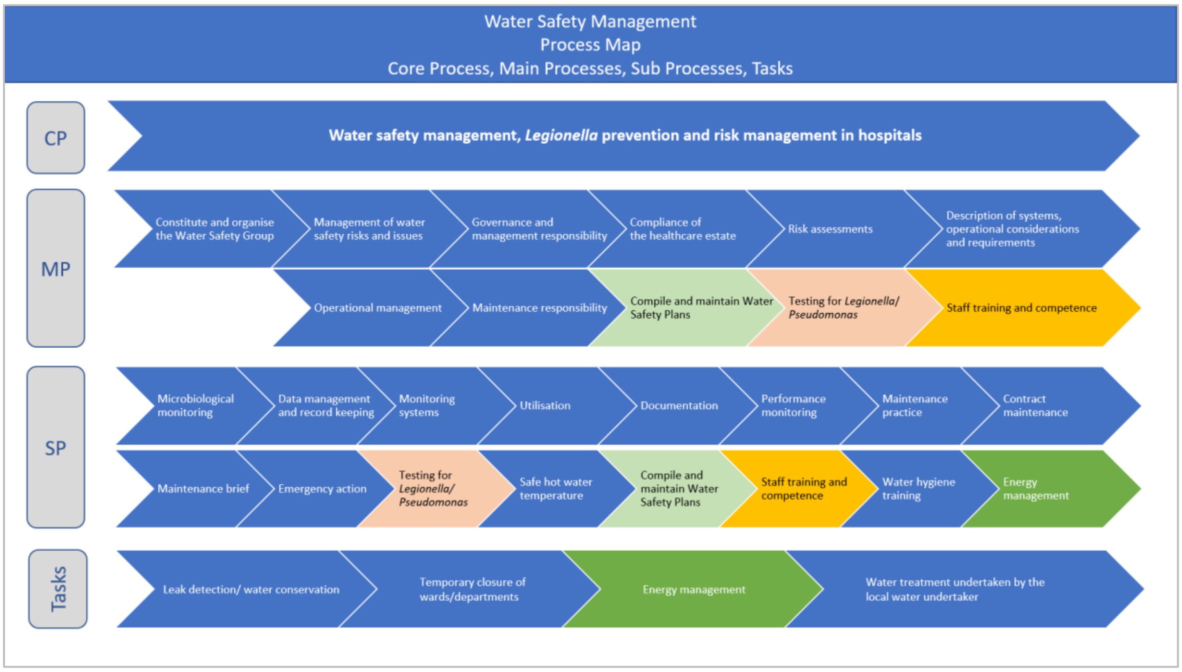


Figure 7-57: Water safety management process map according to analysis of phase II

7.6.2 Stakeholder identification and analysis

In England (in the United Kingdom), principles of the Water Safety Plan are implemented and brought in line with the managerial structures in hospitals. Whereas in Germany and Switzerland the "Hygiene Commission" is the pivot of infection prevention activities. Whilst common and different structures in managing *Legionella* prevention processes in hospitals in different countries were observed, key responsibilities are common to be identified and assigned to an organisation's process thinking and collaboration, defined by an organisation meeting their obligations (Figure 7-58).

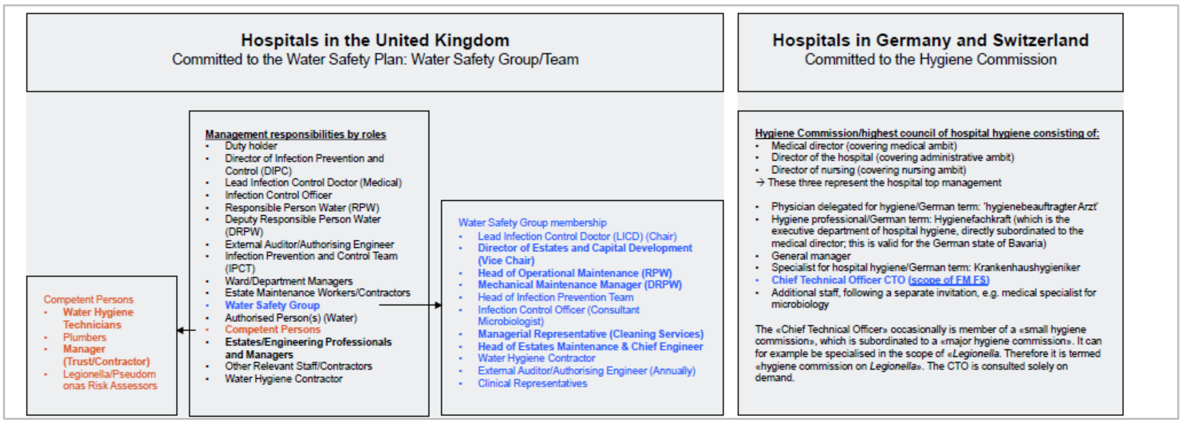


Figure 7-58: Stakeholders in WSM in hospitals in the UK, Germany and Switzerland (Leiblein et al., 2017b)

For better understanding, a clarifying statement must be made to distinguish between 'process owners' and 'stakeholders'. The term 'stakeholders' means those people involved throughout one or more tasks or process elements, contributing to the proper functioning of the entire process of water safety management and *Legionella* prevention. The term 'process owners' means those people, who are responsible for the overall process or for specific process steps or tasks, that can be considered elements of the entire process. In order to specify the different roles and responsibilities more precisely than already done in previous chapters, this chapter and chapter 7.6.3 detail further analyses. Specific outputs are summarised in the summary table of chapter 7.6.4.

Table 7-33 characterises management responsibilities by role. The list has been compiled after content analysis from a document received during phase Ia from IP06 'WaterSafetyRiskManagementPolicyandProcedures', a document received during phase Ib from IP01 'Water Safety Policy v1.2 (latest draft)' and from a document received during phase Ib from IP 07 'WSHAE3121C10 - Final Draft Policy Water Hygiene v8 20170411'.

Table 7-34 presents details on where overlapping duties are experienced. The list has been compiled from answers given through free text entries of participants on question 22 during research phase II. Both analyses and characterisations feed into the framework, specifically after the validation phase (chapter 7.7) and have been considered in the final framework elements #5, #7, #8 and process flowcharts of elements #11, #14, #15 and #16.

Table 7-33: Management responsibilities by role and their characterisation

Management responsibilities by role	**Characterisation**
Duty Holder	The Chief Executive is the duty holder, in a large/complex organisation it is expected that the Duty Holder will delegate duties to suitably qualified and experienced persons. The Director of Estates and Capital Development (for example) is the Delegated Duty Holder for the built environment.
Director of Infection Prevention and Control (DIPC)	The Director of Infection Prevention and Control (DIPC) is a role required by all registered NHS care providers under current legislation. The DIPC will have the executive authority and responsibility for ensuring that strategies are implemented to prevent avoidable healthcare associated infections (HCAIs) at all levels in the organisation. The Trust's/hospital's DIPC is the Director of Nursing (as for example).
Lead Infection Control Doctor (Medical)	A Consultant Medical Microbiologist, the lead Infection Control Doctor chairs the water safety group and is the person nominated by management to advise on infection control policy and to have responsibility for the maintenance of water quality. (Source HTM-04-01 Part-B 6.3)
Infection Control Officer	The Infection Control Officer (Water) provides microbiological expertise and will head the Outbreak Control Team, as determined in Appendix 1 of the "Operational Management" volume of HTM 04-01. The function of the Infection Control Officer (Water) is to: a) take responsibility for ensuring water quality. b) advise on any review and updates to this policy document and the associated written procedures and provision of the Water Safety Plan (WSP). c) carry out the necessary action if an outbreak of disease due to water borne pathogens is suspected in conjunction with the Responsible Person (Water).

	d) attend appropriate training sessions at least every three years. e) attend and review outcomes and actions of quarterly review meetings and report to the strategic infection prevention and control committee. f) inform the Responsible Person (Water) if circumstances change within any ward/department that might affect water hygiene risks.
Responsible Person Water (RPW)	The owner/ operator of a publicly accessible water system is the ‘duty holder’ who must comply with legislation that requires proper management, maintenance and treatment of water systems in its premises. The ‘Duty Holder’ should appoint a person to take day-to-day responsibility for controlling any identified risk from legionella bacteria. The appointed ‘Responsible Person’ should be a manager, director, or have similar status and sufficient authority, competence and knowledge of the installation to ensure that all operational procedures are carried out in a timely and effective manner. The RPW is responsible for implementing/managing the water safety policy and producing and managing a water safety plan, agreed and ratified by the Water Safety Group (WSG), including: a) identifying any necessary changes over time to this policy document and the associated written procedures; b) ensuring that sufficient resources are available, so far as is reasonably practicable for the continued management of water safety by ensuring: - that training needs are identified and fulfilled; - that risk assessments are completed and re-assessments are undertaken annually within all high-risk patient areas and at least every two years for all other areas (sooner if there is a change in the use, occupation or systems within a building) - that remedial works are completed in line with risk minimisation schemes; c) that the Water Safety Plan (WSP) is completed in line with current guidance;

	d) that in conjunction with the Infection Control Officer, all necessary actions, should an outbreak of disease be due to water borne pathogens be suspected, are instructed and carried out; e) attend appropriate training sessions, at least every three years or as required. In the event that the Responsible Person (Water) is not available the Trust/hospital appointed deputy will ensure the aforementioned responsibilities are undertaken as required.
Deputy Responsible Person Water (DRPW)	The appointed 'Deputy Responsible Person' should be a manager and have sufficient authority, competence and knowledge of the installation to ensure, in the absence of the RPW that all operational procedures are carried out in a timely and effective manner.
External Auditor/Authorising Engineer	Responsible for undertaking periodic reviews of the Trust's/hospital's management of water safety and providing the WSG with a report on the efficacy of the management arrangements at periodic intervals, normally at 12-14 month intervals The auditor/authorising engineer (Water), will be an independent water safety expert commissioned to provide specialist advice and assistance to the organisation and the staff associated with water hygiene issues, and shall: a) Advise on a risk assessment programme. b) Undertake an annual risk management audit and issue audit report to Chair of the Water Safety Group. c) Periodically review the policy document and associated written procedures, for compatibility with current legislation and guidance d) Review sampling protocols and assist with the interpretation of any results and actions required. The external auditor/authorising engineer will be appointed by the Chief Engineer or Director of Estates and Capital Development (as for example). • The appointment will be ratified by the Water Safety Group;

	• Interim audit reports will be submitted to the Director of Estates and Capital Development and Head of Estates Maintenance (as for example) for comment; • Finalised audit reports will be issued to the water safety group via the Chair of the water safety group.
Infection Prevention and Control Team (IPCT)	The IPCT are responsible for supporting the prevention and control of infection for people receiving healthcare within Trust/hospital premises or from Trust/hospital healthcare professionals. Comprising the Head of Infection Prevention Team, the Infection Prevention Matron, Infection Prevention Nurses and the Consultant Microbiologist.
Ward/Department Managers	Managers of wards/departments are responsible for ensuring that • little used outlets are regularly flushed; • Estate Maintenance are informed of any unused appliances or outlets so that the pipework can be modified to reduce risk; • attend relevant water hygiene training sessions provided by Estates department; • where blind ends (i.e. blanked-off pipes that do not serve outlets) are found they should be reported to the Responsible Person (Water) and/or his deputy; • carry out routine flushing of outlets three times per week and completing flushing record sheets and returning to Estates Department. • Estate Maintenance are informed of any areas taken out of regular use so that additional precautions such as isolating and draining can be undertaken to prevent proliferation and or contamination. • All persons in their area under their control comply with the Trust's/hospital's Hand-Hygiene Policy • That clinical wash hand basins are properly cleaned and disinfected in accordance with the Strategic Environmental Cleaning Policy

Estate Maintenance Workers/Contractors	All estate maintenance workers must undertake *Legionella*/*Pseudomonas* awareness training irrespective of their trade/vocation and be vigilant when undertaking their general duties, drawing to the attention of local managers and their line management of any non-compliance that they become aware of. All estate maintenance trade staff/contractors that are or are likely to be working on systems or parts thereof identified or referred to in HSG 274 Parts 1-3 shall undertake specific training appropriate to their trade/duties and such periodic refresher training as is necessary or required. No person shall • Undertake work on the Trust's/hospital's water systems, or; • Instruct others to undertake any work on the Trust's/hospital's water systems, or: • Commission or instruct alterations or adaptions to any of the Trust's/hospital's water systems unless they are competent to do so and have appropriate and in-date training to signify their competence to do so.
Water Safety Group (WSG)	The Water Safety Group is a sub group of the Infection Prevention and Control Committee set up to monitor the management of water safety for the Trust/hospital and is chaired by the lead infection control doctor. The water safety group membership should include (as for example) • Lead Infection Control Doctor (LICD) (Chair) • Director of Estates and Capital Development (Vice Chair) • Head of Operational Maintenance (RPW) • Mechanical Maintenance Manager (DRPW) • Head of Infection Prevention Team • Infection Control Officer (Consultant Microbiologist)

	• Managerial Representative (Cleaning Services) • Head of Estates Maintenance & Chief Engineer • Water Hygiene Contractor • External Auditor/Authorising Engineer (Annually) • Clinical Representatives
Authorised Person(s) (Water)	The Authorised Person(s) (Water) will be nominated by the Responsible Person (Water) and appointed in writing by the duty holder or delegated duty holder. All such appointments to be noted at the Water Safety Group meetings. The Authorised Persons (Water) will have responsibility for: a) Implementation and the day-to-day monitoring and maintenance of risk systems. This will include the overseeing of any specifically appointed contractors / service providers. b) Managing the risk assessment and re-assessment programme. c) Implementation of any necessary remedial works in-line with the risk minimisation scheme. d) Liaising with the water user and ensure that equipment that is permanently connected to the water supply is properly installed. e) Ensuring only UKAS approved laboratories are used for *Legionella*/*Pseudomonas* testing, and; - that all routine sample results are distributed directly to the Water Safety Group by email; - in the event of a non-conformance, that action is taken to address the non-conformance and appropriate resampling is undertaken in conjunction with Infection Prevention, and any follow-up sample results are likewise distributed to the members of the water safety group.

	- Where sampling is undertaken as part of an investigative process; sample results are to be sent directly to Infection Prevention for onward dissemination. - In the event of a non-conformance, the senior manager of the ward/area/department will be advised. f) Resolving operational issues as they occur and ensuring that incident report forms are completed in full, and where necessary escalating water safety related issues to the water safety group for review and if necessary, inclusion on an appropriate risk register. g) Maintenance of the record keeping system. h) Assist with the annual risk management audit and periodic record audits. i) Attend appropriate training sessions, at least every three years.
Competent Persons	Persons need to be competent for the tasks they undertake which can range from basic water hygiene to full risk assessments, indicative competency requirements are detailed below Water Hygiene Technicians • Water Management Society or equivalent institution; • *Legionella* Awareness; • Basic Water Chemistry; • Cooling Tower Maintenance; • Asbestos Awareness; • Confined Space (access/egress).

	Plumbers • NVQ Level 2 plus a minimum of 2-years in an acute health care setting with augmented care areas with Water Management Society or equivalent in; • *Legionella* Awareness; • Basic Water Chemistry; • Cooling Tower Maintenance; • Asbestos Awareness; • Confined Space (access/egress). Manager (Trust/hospital/Contractor) • IOSH qualification; • Proven track record of managing complex water services in a large organisation/site with experience of sitting on water safety groups within a health care setting. *Legionella*/Psuedomonas Risk Assessors • Minimum qualification C&G plus; • *Pseudomonas* and responsible person accredited and in date training.
Estates/Engineering Profession-als and Managers	Any person who undertakes or commissions others to design, alter/adapt existing systems or the design/installation of new systems must do so in full compliance with the applicable legislation and guidance. If for any reason it is deemed impracticable to achieve full compliance, then a derogation request must be made using the estates derogations policy.

Other Relevant Staff/Contractors	Any Trust/hospital employee or contractors employed by the Trust/hospital who can affect water safety by how they conduct their tasks/daily duties are deemed relevant for the purposes of this policy. All persons that can affect water hygiene risks must; • carry out their tasks in full accordance with the appropriate guidance; • report any defects, suspicions or concerns regarding the design, condition, operation or performance of water systems that might increase the risk of *Legionella* proliferation.
Water Hygiene Contractor	All operational maintenance activity, (excluding *Legionella* and *Pseudomonas* risk assessments), sampling, dosing, flushing etc. will be undertaken by site-based Water Hygiene Technicians (Water Management Society Accredited) and Plumbers. Risk assessments will be undertaken as required by the water hygiene contractor, ideally using in-house resource. The water hygiene contractor will report against programme all planned activity for each reporting period, any exceptions and will in the event of non-conformities provide such resource and support as is necessary to enable any non-conformities to be managed and resolved.

In research phase II participants of the survey study were asked to answer whether or not certain management responsibilities by role are present in their Trust/hospital. They were also asked to mention if there's collaboration and, in case there is, indicate overlapping duties with the own role or responsibility. Clarification about the characteristics of the roles there were given with the explanations from Table 7-33: Management responsibilities by role and their characterisation for each role and responsibility. Table 7-34 specifies the way and the areas where overlapping duties are experienced.

Table 7-34: Specifictions where overlapping duties are experienced, answers given by free text entires of participants on question 22 fom research phase II.

Perspective	**Specifications replied where overlapping duties are experienced**	**Stated by**
Duty holder	Chief executive is not interested unless something goes wrong, so I tend to take the lead on water issues	Director/Head of Estates and Facilities
	Head of Operational Estates, Responsible Person, WMWG Vice Chair, Estates Reporting Person to IP&C Committee and Trust Governance, Organiser of and Initial Review of *Legionella* Sampling Results, *Pseudomonas* sampling Results and Microbiological sampling Results.	Head of Operational Maintenance
	All members of the WSG have a responsibility to manage the water system	Water Safety Manager, RPW
	A lot of work/role is delegated to the RP	Director/Head of Estates and Facilities
	If a matter arises I need to operationally take action	Director/Head of Estates
	Duty of care	Authorising Engineer/External Auditor
Director of Infection Prevention and Control (DIPC)	DIPC advise is provided from a local acute Trust via an SLA	Director/Head of Estates and Facilities
	This is a director of nursing who has no interest	Director/Head of Estates and Facilities
	I liaise with and advise / consult with DIPC or DIPC representative	Head of Operational Maintenance
	All members of the WSG have a responsibility to manage the water system	Water Safety Manager, RPW

	In review of microbiological tests and operational solutions. Water safety plan developed jointly agreed processes and reviewed jointly through WSG. All processes and changes reviewed jointly.	Director/Head of Estates
	Infection Control provide guidance on capital projects	Capital Design Team Leader
	Our DIPC is the Director of Nursing. She is guided by the consultant microbiologist and ICD who has responsibility for overseeing day to day IPC activities. Myself and ICD attend WSG but I may deputise and act on his behalf e.g. in the first instance I provide IPC/ micro input to capital project and the estates maintenance team.	Infection Control Officer
	Infection prevention and control from water systems	Authorising Engineer/External Auditor
	Same speciality	Director/Head of Infection Prevention and Control
Lead Infection Control Doctor (Medical)	Advice is provided from a local acute Trust via an SLA.	Director/Head of Estates and Facilities
	New person in role who is very proactive	Director/Head of Estates and Facilities
	Liaison is direct via Water Management Working Group (Water Safety Group) & IP&C Committee & Professional liaison / contact - good working relationship.	Head of Operational Maintenance
	All members of the WSG have a responsibility to manage the water system	Water Safety Manager, RPW
	Involvement in WSG as well as raising incidents/problems that need operationally addressing.	Director/Head of Estates

	Our DIPC is the Director of Nursing. She is guided by the consultant microbiologist and ICD who has responsibility for overseeing day to day IPC activities. myself and ICD attend WSG but I may deputise and act on his behalf e.g. in the first instance I provide IPC/ micro input to capital project and the estates maintenance team	Infection Control Officer
Infection Control Officer	Little used outlets, frequency of testing for *Legionella*, design of new water services, etc.	Director/Head of Estates and Facilities
	Cleanliness of water outlets. flushing regimes	Director/Head of Estates and Facilities
	Liaison is direct via Water Management Working Group (Water Safety Group) & IP&C Committee & Professional liaison / contact - good working relationship.	Head of Operational Maintenance
	All members of the WSG have a responsibility to manage the water system	Water Safety Manager, RPW
	Through collaborative working and partnership	Director/Head of Estates and Facilities
	Attend WSG and raises awareness/monitors occupied areas	Director/Head of Estates
	The ICD would take this role. I would support	Infection Control Officer
Responsible Person Water (RPW)	Across all estates related operational areas	Director/Head of Estates and Facilities
	All aspects of estates maintenance	Director/Head of Estates and Facilities
	This is effectively my role	Head of Operational Maintenance
	All members of the WSG have a responsibility to manage the water system	Water Safety Manager, RPW

	This person resides under my management	Director/Head of Estates
	Provide guidance on the design and installation of capital projects	Capital Design Team Leader
	Control of water systems	Authorising Engineer/External Auditor
Deputy Responsible Person Water (DRPW)	Across all estates related operational areas	Director/Head of Estates and Facilities
	All aspects of estates maintenance	Director/Head of Estates and Facilities
	My deputy undertakes this role - obvious overlap between RPW & DRPW - very close liaison	Head of Operational Maintenance
	All members of the WSG have a responsibility to manage the water system	Water Safety Manager, RPW
	Under my management	Director/Head of Estates
	Will hopefully be appointed tomorrow	Authorising Engineer/External Auditor
External Auditor/Authorising Engineer	Strategy, direction, communication	Director/Head of Estates and Facilities
	Liaison is direct via Water Management Working Group (Water Safety Group) & IP&C Committee & Professional liaison / contact - good working relationship. This external independent role must be employed.	Head of Operational Maintenance
	All members of the WSG have a responsibility to manage the water system	Water Safety Manager, RPW
	Appointed by me	Director/Head of Estates

Infection Prevention and Control Team (IPCT)	Little used outlets, frequency of testing for Legionella, design of new water services, etc.	Director/Head of Estates and Facilities
	Liaison is direct via Water Management Working Group (Water Safety Group) & IP&C Committee & Professional liaison / contact - good working relationship.	Head of Operational Maintenance
	All members of the WSG have a responsibility to manage the water system	Water Safety Manager, RPW
	Estates and IPC work collaboratively on many water issues	Director/Head of Estates and Facilities
	Monitors occupied areas and raises issues or awareness as appropriate.	Director/Head of Estates
	Infection Control provide guidance on capital projects	Capital Design Team Leader
	I am the scientific and technical lead for the IPCT re: water and other engineering /environment aspects of IPC	Infection Control Officer
	I am in this team	Lead Infection Control Doctor
Ward/Department Managers	Little used outlets.	Director/Head of Estates and Facilities
	Shared ownership	Director/Head of Estates and Facilities
	Liaison is often via email or meetings as / when required	Head of Operational Maintenance
	All members of staff have a responsibility to manage the water system	Water Safety Manager, RPW
	Ensuring good hygiene practice and water flushing	Authorising Engineer/External Auditor

Estate Maintenance Workers/Contractors	All aspects of estates maintenance	Director/Head of Estates and Facilities
	As head of Operational Estates, I have responsibility for the tasks undertaken by our Es-tates workforce and contractors.	Head of Operational Maintenance
	All members of staff have a responsibility to manage the water system	Water Safety Manager, RPW
	Under my team's management	Director/Head of Estates
	Coordination between capital projects and estates when working on water systems	Capital Design Team Leader
	Ensuring maintenance tasks completed (via CP)	Authorising Engineer/External Auditor
Water Safety Group (WSG)	All aspects of water safety as Chair I need to understand and drive the improvments	Director/Head of Estates and Facilities
	Vice Chair - my deputy chairs this group	Head of Operational Maintenance
	All members of staff have a responsibility to manage the water system	Water Safety Manager, RPW
	Chair	Director/Head of Estates
	Attendance at the WSG and advising the group on Capital Projects	Capital Design Team Leader
	I provide support and deputise the ICD, acting as the scientific and technical lead for the IPCT re: water and other engineering /environment aspects of IPC	Infection Control Officer
	On WSG	Lead Infection Control Doctor

	Member	Authorising Engineer/External Auditor
Authorised Person(s) (Water)	All aspects of estates maintenance	Director/Head of Estates and Facilities
	Liaison is direct via Water Management Working Group (Water Safety Group) & Professional liaison / contact - good working relationship.	Head of Operational Maintenance
	This is my role	Water Safety Manager, RPW
	Under my management - Estates Compliance Manager	Director/Head of Estates
	Co ordination when arranging water shutdowns	Capital Design Team Leader
	This is the same position as RP for water	Authorising Engineer/External Auditor
Competent Persons	All aspects of estates maintenance	Director/Head of Estates and Facilities
	As Head of Operational Estates - tasks are delegated to Estates Site Managers, Officers and our Estates staff.	Head of Operational Maintenance
	Competent persons must be managed by Estates/Engineering Professionals and Managers	Water Safety Manager, RPW
	Under my Operational manager and supported by my Compliance Manager	Director/Head of Estates
	Design of water systems	Director/Head of Estates and Facilities
	All aspects of estates maintenance	Director/Head of Estates and Facilities

Estates/Engineering Professionals and Managers	Shared responsibility in delivering safe water management	Head of Operational Maintenance
	I am a Chartered Engineer and leading the Estates and Capital Projects on site.	Director/Head of Estates
	Coordination between capital projects and estates when working on / designing water systems	Capital Design Team Leader
	Control and design of water systems	Authorising Engineer/External Auditor
Other Relevant Staff/Contractors	All aspects of estates maintenance	Director/Head of Estates and Facilities
	Shared responsibility in delivering safe water management	Head of Operational Maintenance
	All members of staff have a responsibility to manage the water system	Water Safety Manager, RPW
	Domestic lead reports to WSG and carry out little used outlet flushing and reporting	Director/Head of Estates
	Coordination between capital projects and 3rd party providers when working on / designing water systems	Capital Design Team Leader
	Well if they are relevant I must work with them	Authorising Engineer/External Auditor
Water Hygiene Contractor	All aspects of estates maintenance	Director/Head of Estates and Facilities
	Contact is at times direct or indirect via Estates Managers Shared responsibility in delivering safe water management	Head of Operational Maintenance
	All members of staff/Contractors have a responsibility to manage the water system	Water Safety Manager, RPW

	Under the management of the AP and Compliance Manager	Director/Head of Estates
	We are working towards shared aims and we learn from and support each other. This may not quite be overlap	Infection Control Officer
	Attend annual compliance audit to review monitoring and maintenance	Authorising Engineer/External Auditor

7.6.3 Process owners

The purpose of doing a stakeholder analysis, as introduced in chapter 6.10.2.4, is seen in identifying the perceived ‘power’ and ‘interest’ of management responsibilities by roles and water safety group members in the 11 different hospitals. The identification of presence or absence in the respective hospital was made by each of the interview partners, who are in job positions of the type described in chapter 6.9.7.1, Table Appendix A-15.

Figure 7-59 explains the colour-coded legend for the management responsibilities by roles and Figure 7-60 explains the colour-coded legend for water safety group members for the subsequent figures.

Element	Management responsibilities by roles
A	Duty holder
B	Director of Infection Prevention and Control (DIPC)
C	Lead Infection Control Doctor(Medical)
D	Infection Control Officer
E	Responsible Person Water(RPW)
F	Deputy Responsible Person Water(DRPW)
G	External Auditor/Authorising Engineer
H	Infection Prevention and Control Team (IPCT)
I	Ward/Department Managers
J	Estate Maintenance Workers/Contractors
K	Water Safety Group
L	Authorised Person(s) (Water)
M	Competent Persons (Water Hygiene Technicians, Plumbers, Manager (Trust/Contractor), Legionella Risk Assessor
N	Estates/Engineering Professionals and Managers
O	Other Relevant Staff/Contractors
P	Water Hygiene Contractor

Figure 7-59: Legend for management responsibilities by roles

Element	Water safety group member
A	Lead Infection Control Doctor (LICD) (Chair)
B	Director of Estates and Capital Development (Vice Chair)
C	Head of Operational Maintenance (RPW)
D	Mechanical Maintenance Manager (DRPW)
E	Head of Infection Prevention Team
F	Infection Control Officer (Consultant Microbiologist)
G	Managerial Representative (Cleaning Services)
H	Head of Estates Maintenance & Chief Engineer
I	Water Hygiene Contractor
J	External Auditor/Authorising Engineer (Annually)
K	Clinical Representatives

Figure 7-60: Legend for WSG members

They have been identified through document analysis, as described in chapter 7.3. For each hospital, with the exception of hospital number 9, for which no data was available, data was collected and results presented in a matrix and spider chart. Figure 7-61 gives an impression about the structured analysis to oversee the total data collected.

In order to understand the diagrams correctly, they must be read in the manner as explained in chapter 6.10.2.5. For the stakeholder analysis matrices and spider charts there were some elements (either ‘management responsibilities by roles’ or ‘water safety group members’) on top of another. Consequently they are not fully visible with the respective colour in the diagram.

In order to indicate where such elements lay on top of one other, corresponding numerical coordinates in a scheme (x;y) complement the figures. The first value (‘x’) giving the coordinate for ‘interest’, the second value (‘y’) giving the coordinate for ‘power’. Remarkable values are then gouped into three categories ‘low’, ‘high’, and ‘check role’.

Explained with the data of hospital 01 for ‘management responsibilities by roles’ (Figure 7-62 and Table 7-35):

- interest and power for all ‘management responsibilities by by roles’ varies between low and high.
- on top of the other are B, C, D, M which are, according to the legend of Figure 7-59, ‘Director of Infection Prevention and Control (DIPC)’, ‘Lead Infevtion Control Doctor (Medical)’, ‘Infection Control Officer’ and ‘Competent Persons’. These four present the numerical coordinates (3;2) in the scheme (x;y). As per definition presented in chapter 6.10.2.5 they belong to the group ‘high’, which is located in the stakeholder quality level ‘engage closely’.
- In the group ‘low’ there are I, J and O, which are, according to the legend of Figure 7-59, ‘Ward/Department managers’, ‘Estate Maintenance Workers/Contractors’ and ‘Other Relevant Staff/Contractors’.
- In the group ‘check role’, which either represents strong interest and low lower (3;1) or low interest and strong power (1;3) there are F, G and P, which are, according to the legend of Figure 7-59, ‘Deputy Responsible Person Water (DRPW)’, ‘External Auditor/Authorising Engineer’ and ‘Water Hygiene Contractor’.

The proposed procedure of interpretation can be applied to the ‘water safety group members’ and to all other hospitals likewise with the corresponding data.

An overall view presents the variations in perceived power and interest of ten interviews delivering data for analysis (Figure 7-61). Detailed analyses are presented in Appendix C, from Figure Appendix C-6 to Figure Appendix C-27 and from Table Appendix C-1 to Table Appendix C-22.
These findings present a real image from and about stakeholders in practice of eleven hospitals.

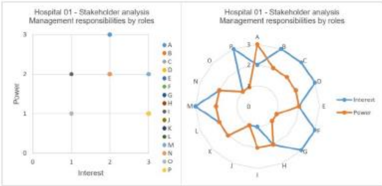


Figure 3: Stakeholder analysis hospital ID01: Management responsibilities by roles

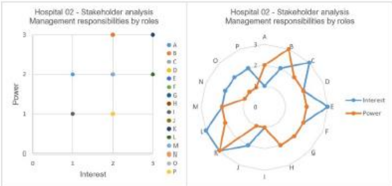


Figure 5: Stakeholder analysis hospital ID02: Management responsibilities by roles

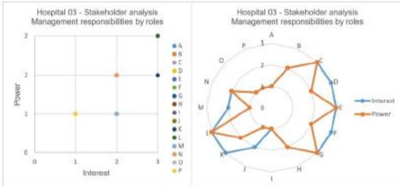


Figure 7: Stakeholder analysis hospital ID03: Management responsibilities by roles

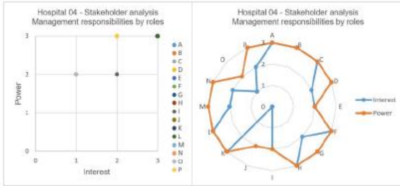


Figure 9: Stakeholder analysis hospital ID04: Management responsibilities by roles

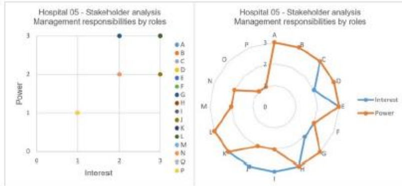


Figure 11: Stakeholder analysis hospital ID05: Management responsibilities by roles

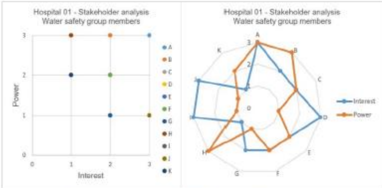


Figure 4: Stakeholder analysis hospital ID01: WSG members

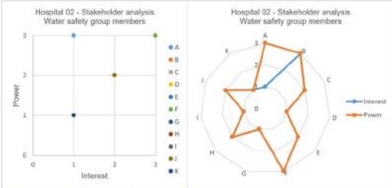


Figure 6: Stakeholder analysis hospital ID02: WSG members

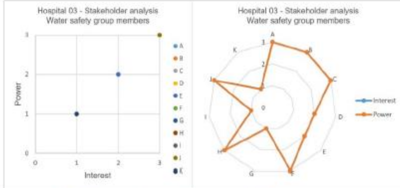


Figure 8: Stakeholder analysis hospital ID03: WSG members

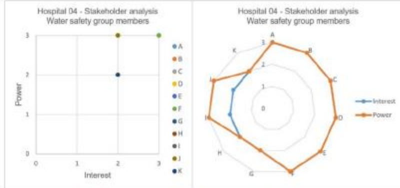


Figure 10: Stakeholder analysis hospital ID04: WSG members

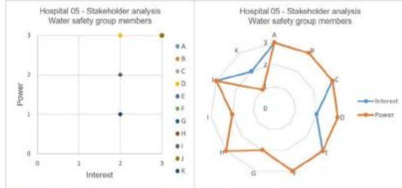


Figure 12: Stakeholder analysis hospital ID05: WSG members

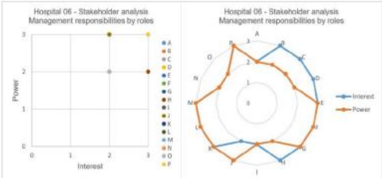


Figure 13: Stakeholder analysis hospital ID06: Management responsibilities by roles

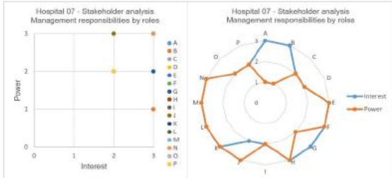


Figure 15: Stakeholder analysis hospital ID07: Management responsibilities by roles

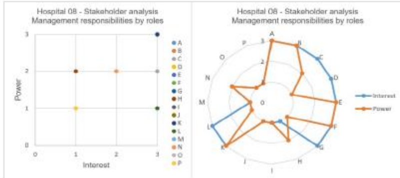


Figure 17: Stakeholder analysis hospital ID08: Management responsibilities by roles

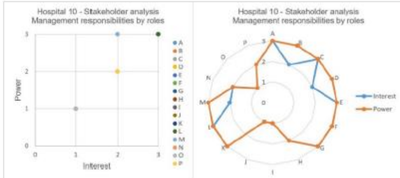


Figure 19: Stakeholder analysis hospital ID10: Management responsibilities by roles

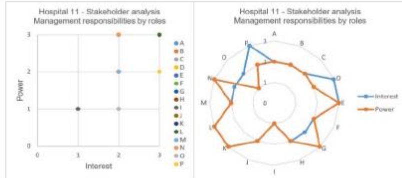


Figure 21: Stakeholder analysis hospital ID11: Management responsibilities by roles

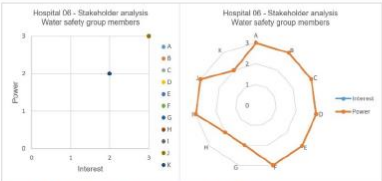


Figure 14: Stakeholder analysis hospital ID06: WSG members

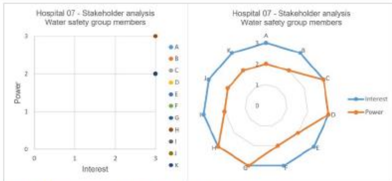


Figure 16: Stakeholder analysis hospital ID07: WSG members

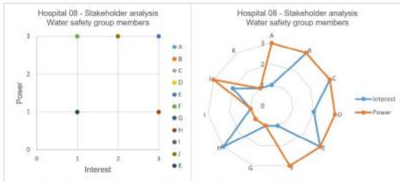


Figure 18: Stakeholder analysis hospital ID08: WSG members

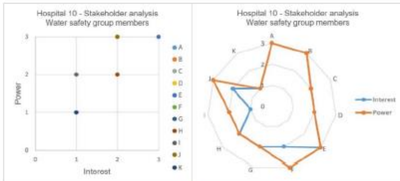


Figure 20: Stakeholder analysis hospital ID10: WSG members

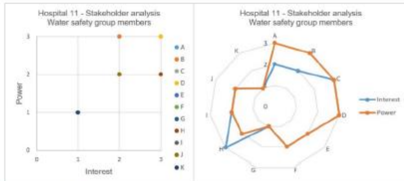


Figure 22: Stakeholder analysis hospital ID11: WSG members

Figure 7-61: Stakeholder analysis overall view. Interview study (N=11, of which 10 interviews led to results for analysis).

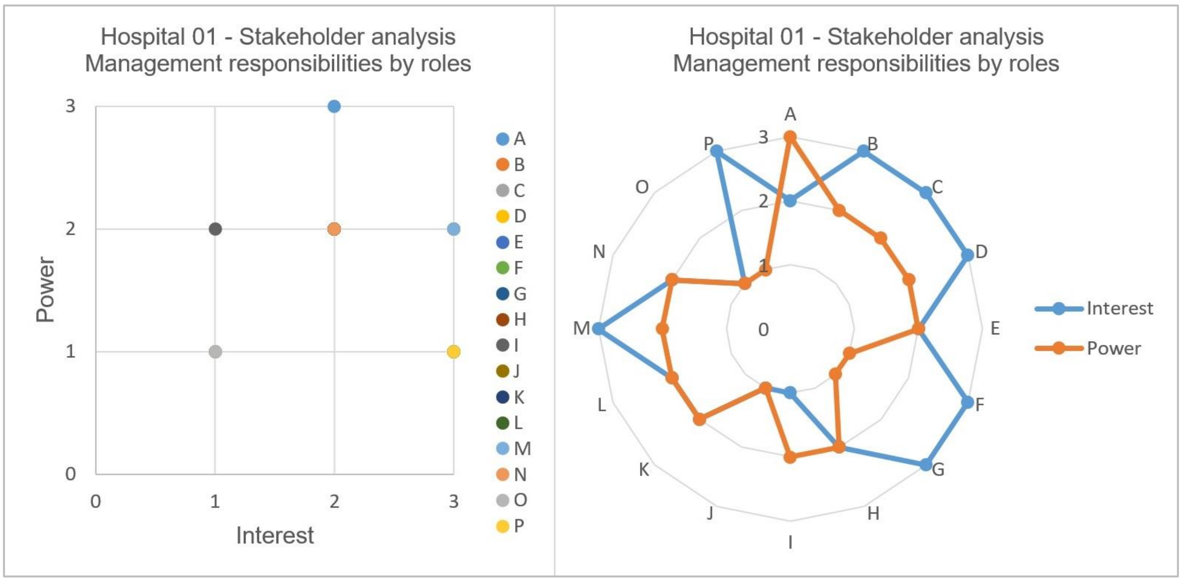


Figure 7-62: Stakeholder analysis hospital ID01: Management responsibilities by roles

One on top of the other are (3;2)=B, C, D, M; (2;2)=E, H, K, L; (3;1)=F, G, P; (1;1)=J, O.

Table 7-35: Stakeholder analysis hospital ID01: Management responsibilities by roles

Group 'low'	I, J, O
Group 'high'	A, B, C, D, M
Group 'check role'	F, G, P

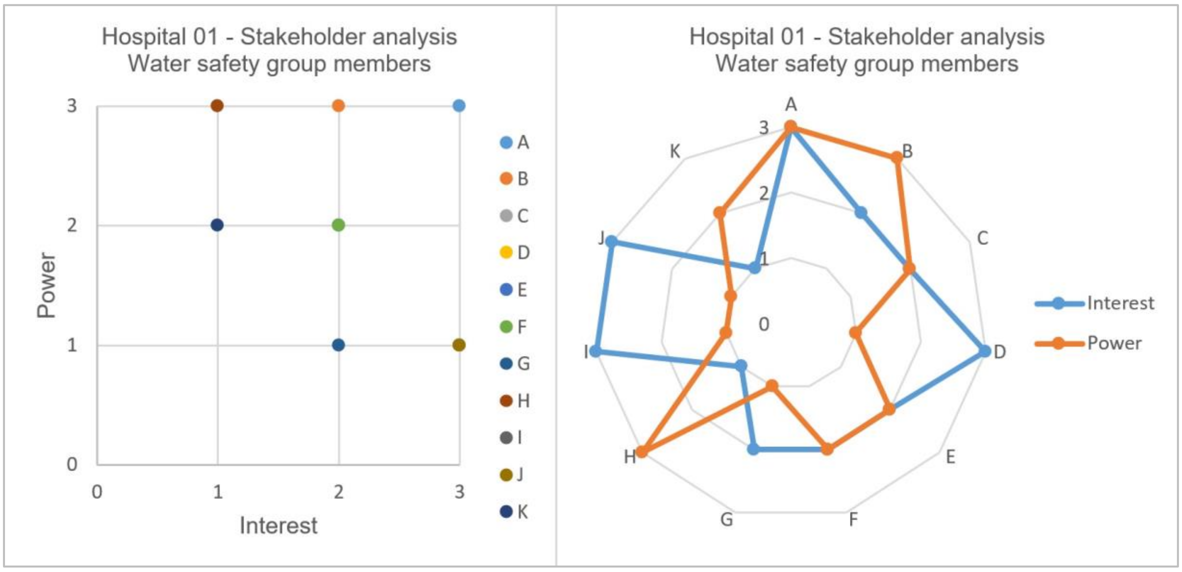


Figure 7-63: Stakeholder analysis hospital ID01: WSG members

One on top of the other are (2;2)=C, E, F; (3;1)=D, I, J

Table 7-36: Stakeholder analysis hospital ID01: WSG members

Group 'low'	G, K
Group 'high'	A, B
Group 'check role'	D, H, I, J

Table 7-37 and Table 7-38, a well as Figure 7-64 and Figure 7-65, summarise the detailed analyses that were presented by Figure Appendix C-6 to Figure Appendix C-27 and Table Appendix C-1 to Table Appendix C-22, giving structured the details for interpretation. They indicate where there are assessed relations by distinguishing quality levels such as ‘engaged closely’ (group 'high') and rather ‘passive’ roles (group 'low'). The 'check role' group represents roles where, based on the interviewees’ assessment, there is either strong interest and low power (3;1) or low interest and strong influence (1;3). This group is here classified with 'check role' and can be interpreted as worth and critical for reviewing by management responsibilities in organisations. Probably these roles inhere a potential for changes in management routines. According to the results there are numbers of roles identified with ‘low’ or ‘check role’. As long as those roles belong to management responsibilities in Estates and FM, there is potential to strengthen their recognition by means of good management instruments and good managed processes.

Table 7-37: Stakeholder analysis summary. Management responsibilities by roles.

	Representation of group		
Role	Low	High	Check role
A - Duty holder	2	5	1
B - Director of Infection Prevention and Control (DIPC)	0	7	1
C - Lead Infection Control Doctor (Medical)	0	8	0
D - Infection Control Officer	0	7	1
E - Responsible Person Water (RPW)	0	8	0
F - Deputy Responsible Person Water (DRPW)	0	6	1
G - External Auditor/Authorising Engineer	0	7	2
H - Infection Prevention and Control Team (IPCT)	1	4	0
I - Ward/Department Managers	6	1	0
J - Estate Maintenance Workers/Contractors	5	3	0
K - Water Safety Group	0	9	0
L - Authorised Person(s) (Water)	0	8	1
M - Competent Persons (Water Hygiene Technicians, Plumbers, Manager (Trust/Contractor), *Legionella* Risk Assessor	2	5	0
N - Estates/Engineering Professionals and Managers	1	3	0
O - Other Relevant Staff/Contractors	8	0	0
P - Water Hygiene Contractor	4	3	1

11 interviews held. 10 replied answers on the stakeholder analysis.

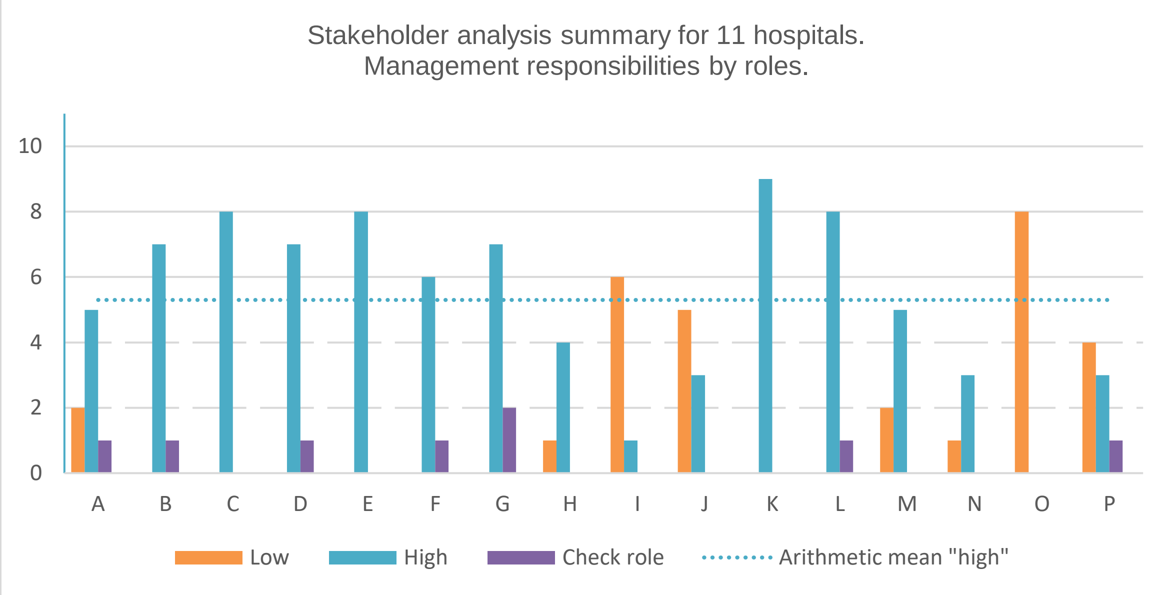


Figure 7-64: Stakeholder analysis summary. Management responsibilities by roles.

Table 7-38: Stakeholder analysis summary. WSG members.

	Representation of group		
Role	Low	High	Check role
A - Lead Infection Control Doctor (LICD) (Chair)	0	8	2
B - Director of Estates and Capital Development (Vice Chair)	0	10	0
C - Head of Operational Maintenance (RPW)	0	6	0
D - Mechanical Maintenance Manager (DRPW)	1	6	1
E - Head of Infection Prevention Team	0	6	0
F - Infection Control Officer (Consultant Microbiologist)	0	7	1
G - Managerial Representative (Cleaning Services)	5	1	0
H - Head of Estates Maintenance & Chief Engineer	0	4	2
I - Water Hygiene Contractor	4	3	1
J - External Auditor/Authorising Engineer (annually)	0	7	1
K - Clinical Representatives	7	1	0

11 interviews held. 10 replied answers on the stakeholder analysis.

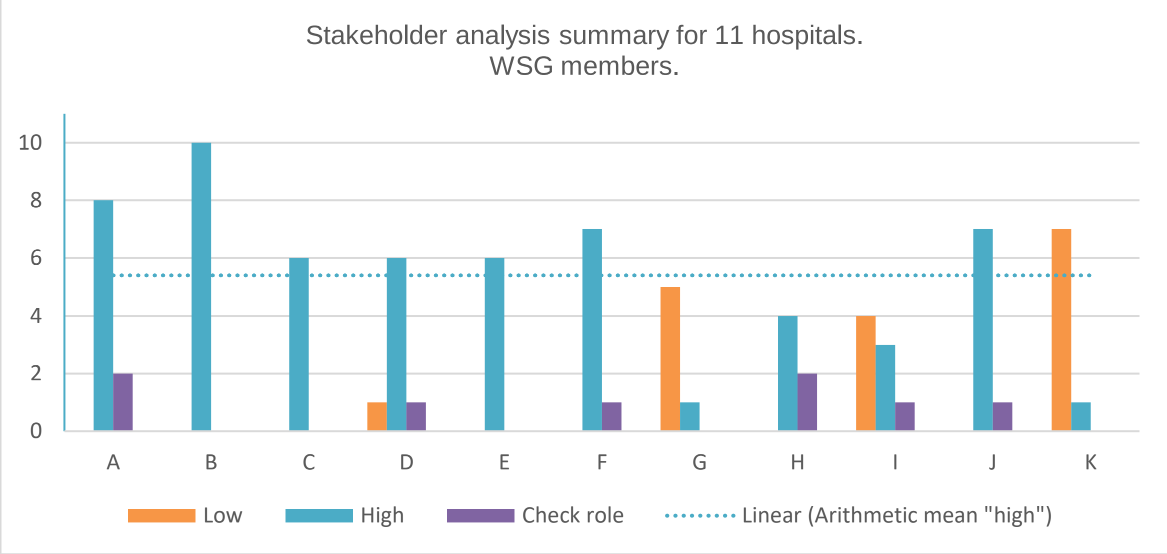


Figure 7-65: Stakeholder analysis summary. WSG members.

In research phase I b participants from hospitals 01 to 11 were asked about the presence of different roles in the hospital. Data are presented in Figure 7-66, Figure 7-67 and Figure 7-68. They show the presence of roles, grouped into 'management responsibilities', 'Water safety group (WSG)' and 'competent person' respectively, as identified through document analysis as described in chapter 7.3. Multiple answers were possible for qualifying the 'type of active role in process' for a role. For some roles this caused exceeding 100% absolute in sum of replies on 'type of active role in process'.

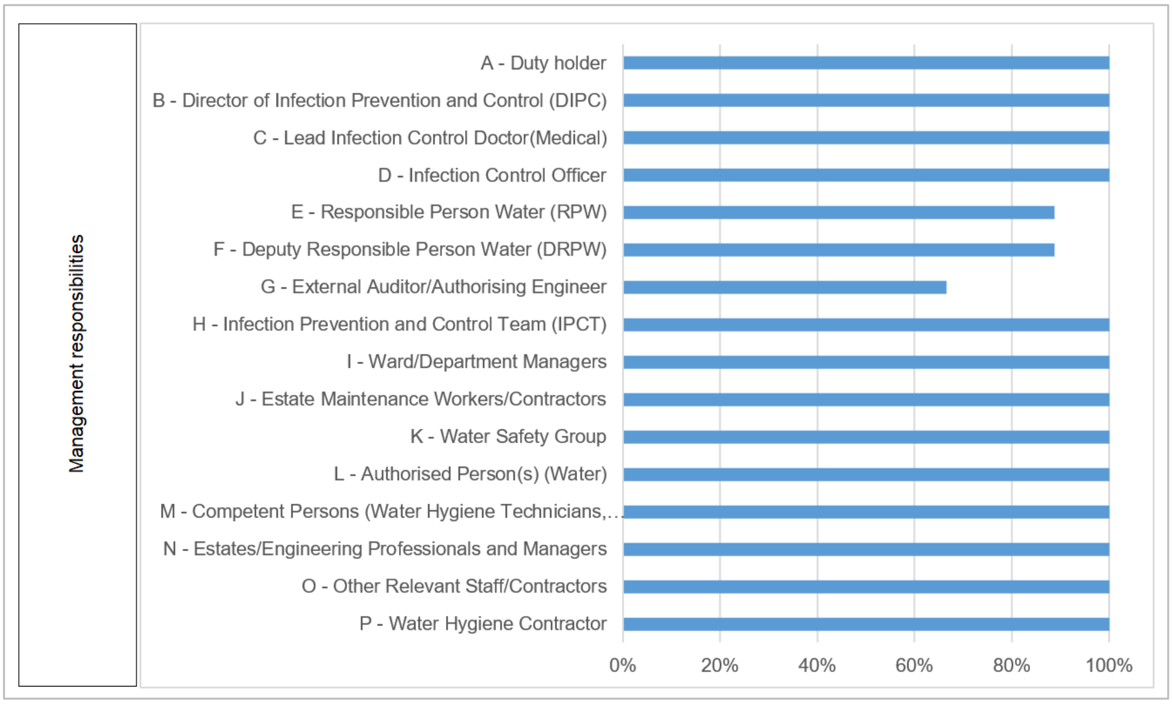


Figure 7-66: Presence of roles in hospital – management responsibilities

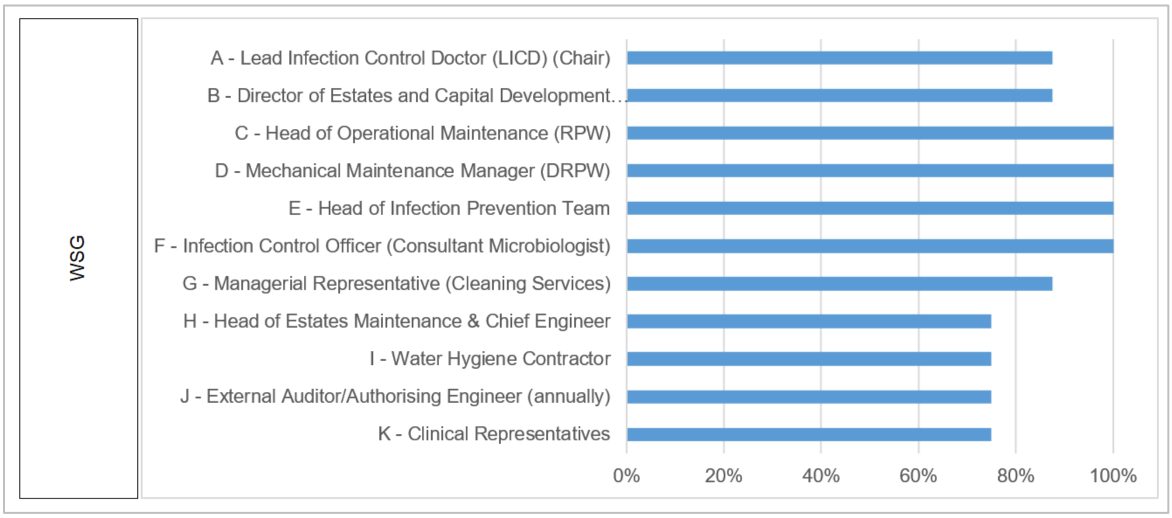


Figure 7-67: Presence of roles in hospital – WSG

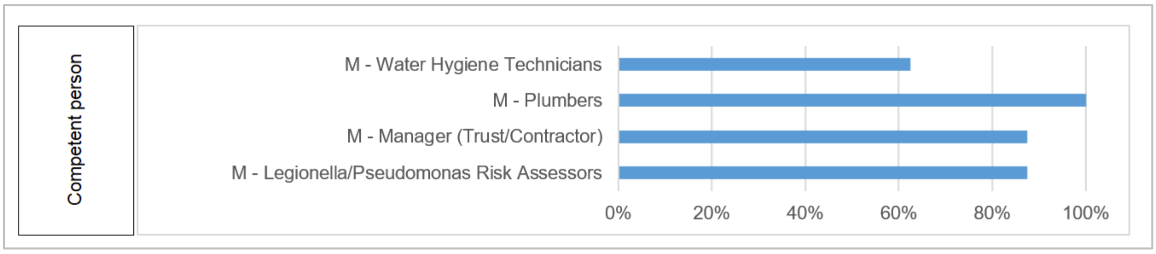


Figure 7-68: Presence of roles in hospital – competent person

Data presented in Appendix C (Table Appendix C-23, Table Appendix C-24, Table Appendix C-25) show the relative distribution of the total number of types (harmonised values in percent) and below the tables comments on the response rate. Additional to the assessment on the presence or absence of different roles, the roles and members are qualified into the four categories 'process enabler', 'process owner', 'process contributor', and 'process blocker'. Table Appendix C-23 summarises that 44.4% of the participants see the duty holder to be the process owner. 44.4% see the WSG, 33.3% the RPW, 33.3% the DRPW and 22.2% see the Authorised Person(s) Water in that role. The Ward/Department Managers, Estates/Engineering professionals and managers, DIPC, Lead Infection Control Doctor (Medical) and IPCT are seen in the role of the process owner by 11.1%. There is great variation in the roles for 'process contributor' (11.1% to 88.8%) and process enabler (11.1% to 66.6%). Remarkable is the 22.2% and 11.1% roles being categorised as 'process blocker'. They comprise Estates/Engineering Professionals and Managers, Other Relevant Staff/Contractors, Ward/Department Managers and the WSG. In general, there is not a very clear recognition about the actual owner of the process. A good starting point for a positive culture of actively lived processes is having links to the presumed process contributors and enablers. The final framework will consider some of those roles.

Table Appendix C-24 summarises that within the WSG 71.4% of the participants see the Director of Estates and Capital Development to be the process owner. 28.6% see the Head of Estates Maintenance & Chief Engineer and the Mechanical Maintenance Manager in that role.

In a descending order, the Head of Infection Prevention Team and Infection Control Officer (Consultant Microbiologist) (both 100%), Lead Infection Control Doctor, Managerial Representatives (Cleaning Services) (both 85.7%) are seen as process contributors by the participants. The Water Hygiene Contractor, External Auditor/Authorising Engineer and Clinical Representatives are seen as process contributors by 71.4% of the participants. The Head of Operational Maintenance (42.9%), Director of Estates and Capital Development (28.6%), and Head of Estates Maintenance and Chief Engineer are seen as process contributors by 28.6%. There is variation in the role for ‘process enabler’ ranging from 85.7% to 14.3% comprising Head of Operational Maintenance (85.7%), Mecanical Maintenance Manager (57.1%), External Auditor/Authorising Engineer (28.6%), Head of Estates Maintenance and Chief Engineer (14.3%), Water Hygiene Contractor (14.3%), Lead Infection Control Doctor (14.3%), Director of Estates and Capital Development (14.3%), Head of Infetion Prevention Team (14.3%) and Infection Control Officer (Consultant Microbiologist) (14.3%). A ‘process blocker’ was mentioned by 14.3% and seen in the Mechanical Maintenance Manager, Head of Infection Prevention and Clinical Representatives. A high percentage (71.4%) recognises the Director of Estates and Capital Development as process owner.

Table Appendix C-25 summarises the type of active role in the process for the group of ‘Competent Persons’. Within the ‘Competent Persons’ group 28.6% of the participants see the Manager (Trust/Contractor) to be the process owner. 14.3% see the Water Hygiene Technicians and the Plumbers respectively in that role. In a descending order, *Legionella/Psedomonas* Risk Assessors, Water Hygiene Technicians, Plumbers and Mangers (Trust/Contractor) are seen as process contributors by 100%, 57.1%, 57.1%, and 57.1%. ‘Process enabler’ is the description of Plumbers and Manager (Trust/Contractor) (28.6%), and Water Hygiene Technicians (14.3%) and *Legionella/Psedomonas* Risk Assessors (14.3%). A ‘process blocker’ was not mentioned.

7.6.4 Summary table for aggregated analyses

For aggregated analyses Table 7-39 presents how the PESTLE and CTAAPM categories are assigned to the RMP analysis categories, according to chapter 6.15, Table 6-16.

Table 7-39: Total occurence of category nodes derived from analysis (described in chapter 7.4) for consideration for framewort output

Analysis	Category	Occurrence	R M P analysis categories
PESTLE	PP	38	Management and processes
	PEc	42	Management and processes
	PS	90	Roles and responsibilities, Processes and collaboration
	PT	36	Management and processes
	PL	76	Roles and responsibilities, Management and processes
	PEn	100	Management and processes
CTAAPM	CC	84	Management and processes, Processes and collaboration
	CT	32	Management and processes
	CAc	60	Roles and responsibilities
	CAw	98	Management and processes, processes and collaboration

	CP	81	Management and processes, processes and collaboration
	CM	121	Management and processes

Table 7-40 summarises analyses of chapter 7.6. It brings together the aim elements of the research focus, the corresponding procedure of analysis, and builds a bridge to the objectives of chapter 1.5, providing answers to subquestions of chapter 1.3, and indicates whether or not elements feed into the final framework output of chapter 8.

Table 7-40: Summary of fieldwork phase II referred to into research question context

Aim element	**Analysis procedure**	**Refers to research objectives no. of chapter 1.5**	**Delivers answers to subquestion no. of chapter 1.3**	**Elements feed into framework of chapter 8**
Prioritisation of process elements	Pairwise comparison	Objectives 2, 3, 6	Yes: SQ1, SQ2, SQ4	Yes
Identification of overlapping duties	free text entries from research phase II	Objectives 2, 5, 6	Yes: SQ1, SQ2, SQ3, SQ4	Yes
Stakeholder analysis	Matrix opposite and spider diagram	Objectives 1, 2, 3, 5, 6	Yes: SQ1, SQ2, SQ3, SQ4	Yes
Identification of processes and stakeholders	PESTLE	Objectives 1, 2, 3, 4, 5, 6	Yes: SQ1, SQ2, SQ3, SQ4	Yes
Identification of processes and stakeholders	CTAAPM	Objectives 1, 2, 3, 4, 5, 6	Yes: SQ1, SQ2, SQ3, SQ4	Yes

7.7 Phase III – focus group: framework validation (QUAL)

The focus group for framework validation was finally held with a board of five experts plus the researcher. Initially the researcher, likewise as host and moderator, introduced the formal aspects and the procedural rules. Then he presented the elements of the framework. With a total of eight questions following after the presentation of the framework, two different perspectives for answering the questions were specified:

- Perspective one is from the process of *Legionella* prevention and risk management for water safety in healthcare organisations that may include the perspective of their hospital or even at Trust level;
- Perspective two is the one of the process owners, the people responsible for *Legionella* prevention and risk management for water safety in healthcare organisations.

The condensed answers extracted from the full transcript of the focus group is presented hereafter for each question one to eight (Table 7-41 until Table 7-48), indicating the value and potential for revisions of the framework with the title *“Water safety management, Legionella prevention and risk management in hospitals: a framework for Estates and Facilities Management in England”*. Their comments are made on the drafted framework, as presented in appendix D, Figure Appendix D-2.

Table 7-41: Focus group question 1: What is good / helpful?

Speaker	**Extracted feedback**
1	From a completeness point of view everything's there. It's quite complex. It's prescriptive and complex, so you covered everything. When you look at it, first impressions are that it might not be too accessible for someone if you just handed it over to them and asked them to follow it. But that's also a helpful thing because you've covered every single aspect of it, so it's quite sort of linear, just follow the process.
2	The structure is very good. It looks very *Legionella* specific, which I guess that's what you've designed it for. Where I would see it being used is in the development of water safety plans and perhaps expand that in some ways for other organisms in the future as well. The process is good. To process owners it would be very much for getting that structure of your water safety plan in place.
3	It's a lot to take in, but I think it is good, in an aspect, if it was perhaps a brand new hospital. There may be some difficulties in an existing hospital which may have issues. It is good, but I think it's just how you would actually run it with an existing hospital. That's my only concerns.

4	It's very detailed, which is good. It's probably the most detailed schematic that I've seen, which is a positive for me. I do think just to put this in front of people and expect them to understand it and follow it straight away, would be difficult. There needs to be some training given on it and for people to really understand it. There needs to perhaps be areas where you can be a little bit flexible in terms of being able to modify parts of it because each hospital will have slightly different practices and ways of doing things. And there may be some additional things that need to be included which are hospital specific. The hospital needs to ensure all the roles that you've listed are actually covered. When I go to some water safety groups, they're lacking some of the roles. Now that's not a good thing, but I think for this to work right and correctly, you need to have all those roles there. And I think there was some very detailed information on a flushing regime, which was great to see. But probably you need to expand it out to cover some of the other countermeasures such as thermoflushing, UV ozone, etc., chemical flushing, in equally as much detail.
5	I tend to agree in that for a hospital that has already got its framework in place, I think they might find it difficult to follow this. As a framework, it's very detailed, which is good. As a framework, I think there's maybe a little bit too much detail. But on the other hand, the good point is that people can actually see and take out of this areas that they may not have considered within their water safety plan. So having all that detail in there is good for reference to see whether people have actually included everything they maybe should have. I think, obviously, an awful lot of work has gone into this. I think the way that you've put this over is that this is an overview of everything that should be there and that hospitals should take from it what is applicable to them and pick and choose the bits that actually fit into their overall procedures. I can appreciate the effort that's gone into that. Well done.

Table 7-42: Focus group question 2: Where is the greatest added value for Estates and Facilities Management?

Speaker	**Extracted feedback**
1	It's probably the framework could be used as a reference tool. You could have the framework. You could run through it, and you could use it as a sort of check sheet. There are things on there that maybe other organisations haven't considered. And they could be implemented, or you could just take the bits out of it that you haven't thought of before.

2	I think, when you've got complex organisations, it does give you a framework to explain the process flow for other parts of it such as the soft FM team, the cleaning teams. Or if you're working with - maybe you've got patients or staff on other sites who are working- or basically that the other site is under somebody else's water safety group, which perhaps isn't working as efficiently, then I think that framework is very helpful to explain the detail that's required to be reported back to the trust water-safety group.
3	The greatest added value would be if this was up front or the tender stage for estates and facilities management because that's where these things [seem?] to be missed. And again, there are situations where you would have the main hospital, and then you have satellite sites that quite often get forgotten. So, yeah, I think it would be helpful. But again, with most facilities management companies, it would need to be in the framework at tender stage so that they do cover everything and every aspect.
4	The greatest added value is in the detail, its use as a reference or checklist, especially with regards to the procedural side. Things like having detail on flushing, I think, is really important, and if some of the other countermeasures are added, I think that will be equally useful. I think there's a lot of benefit in the training side of this to get people to really understand the process but also the real detail behind it, and in understanding and planning for the different roles required to really make this happen, and the structure of the organisation.
5	I think the greatest added value has probably already been covered in that you have sort of looked at all the aspects as a good reference, particularly when setting up new hospitals. But I think there's an added value too that if this was presented to the board and CEO level, that they would actually get a better understanding of the complexity that is involved in water safety management, which I think, at present, they really underestimate just how much input is needed and the range of expertise and personnel that are needed in a large hospital for water safety management on complex sites. So I think presenting at high-level management, this framework would maybe make them realise better just how much resources it really requires.

Table 7-43: Focus group question 3: Are all relevant processes mapped?

Speaker	Extracted feedback
1	The focus, the whole framework, was definitely *Legionella* biased, so I didn't see anything around *Pseudomonas* and other organisms. The other thing, flushing was definitely focused upon and in great detail. Obviously, there are other measures that could be taken that weren't focused on in as great detail. So I think all processes were mentioned, but not were all mapped in the same level of detail.

2	I agree with the *Legionella* focused. I think it's going to be an almost impossible job to map all processes because of the complexity of buildings. It may be that you need something a little bit further up front where you start to map what the different hazards are and then have a bit more flexibility in those processes because it was quite specific that some of the flushing which may not be appropriate for those particular buildings, because you sometimes get different ownerships within that. So I think I'd like to see a bit more possibility to have the hazards up front and then a more flexible process mapping. But perhaps what you've done is a more complete example for people to understand those processes.
3	Again, with the flushing, flushing normally comes off the back of issues. And I think there being a little bit more concentration on the sort of investigation aspect of any issues with sampling.
4	I think the detail in the flushing is very good. However, I do think, with regards to flushing, there probably needs to be a process map of deciding how and when you flush, what outlets you should flush, and also a process, potentially, of how you should flush. And that should include any kind of risk assessment and health and safety with regards to flushing and the operatives who do flush. I think that other countermeasures could be done in the same way. That includes thermal, chemical, UV, ozone, etc. And also it might be useful to do something to get maybe more on sampling as well because obviously that's really key to any water safety plan. Something else you might want to include is how you decide which countermeasure to issue. What's the process of that risk assessment to decide which countermeasure in any instance is the right thing?

5	Coming back to the point, Thomas's thesis is on *Legionella* and was never designed to incorporate the other hazards, and that sort of section has grown since Thomas started that. I think there is too much emphasis on flushing, Thomas, and there's not enough on looking at your target parameters to verify. So I would have like to have seen verification and validation of water treatment measures there and that your verification, it more focused on making sure that you're achieving your temperatures and your target biocide levels at the point of use. Identifying where your high-risk patients are so that you might want to have more emphasis on making sure that those areas are well managed. And maybe a mention of how to prioritise any remedial actions should be coming out of your risk assessment. The other thing that I think could have been incorporated is a decision tree as what to do when you get positive samples, and where you should be going with your remedial measures, depending on the positivity of those samples, and when you might resample, where you might do some immediate remedial measures where you may need to protect patients by not allowing them access to those areas. And I would like to have seen HTM 04-01 mentioned in there, not just concentrating on the HSE documents. But with all that information that you've got in there, I think those areas would be quite easy to incorporate and just make it a bit more complete from a *Legionella* perspective.

Table 7-44: Focus group question 4: Are all process owners sufficiently identified and represented?

Speaker	**Extracted feedback**
1	When we were going through the presentation, nothing stood out to me that a process owner was missing. Yeah. But to fully sort of answer the question, I would probably have to spend more time with the processes and to review. But off the top of my head, my memory, and from the way you presented it, I would say, yes, there was nothing that stood out, going through the framework, that I thought there was one missing.
2	From my side, there were a couple of things that I instantly noticed. When you have what we call the PFI, the private finance initiative, that's quite a complex situation, and it's obviously not the same for every trust. So there may need to be some reference to that. There was also a little bit when we'd been discussing about tenant liaison managers and landlords. Tenant liaison manager is quite a specific, which I would remove. But I think the landlord aspect of it is useful. I don't think it was in the right place. And I think the landlord is almost the PFI in some cases. The other thing that I picked up is, I think there needs to be a lot more engagement with the design teams. And also I think the cleaning teams, the soft FM, tend to get put in at the bottom of the page, and I think they ought to be a lot higher. I think there needs to be a lot more engagement, the cleaning teams, and a lot more responsibility.
3	Most hospitals will have a department where they have sort of ongoing project purview. I might have missed it.
4	I can't recall seeing a microbiologist within there. That definitely is a role that I see in a lot of water safety groups and, for me, is a really important role. I know you specified private contractors, but I think that should be a little bit more detailed. We need to include where applicable PFI contractors, the main contractor in charge of PFI for that building. But then also, that's usually subcontracted, both a hard FM side - they're looking after all of the fixtures including the taps, showers, washbasins, etc. - and then also the soft FM side, which is looking after the cleaning, then the supply of soap, hand gels, etc. Also, there needs to be potentially specialist department heads included. So these include things like ICU, nursing, dialysis, etc. And then from time to time, I know that water safety groups will bring in certain key manufacturers and suppliers and products so that they can explain to the group, in more detail, how their product works and also how their product potentially can solve some of the risks.

5	Just taking flushing, I think the emphasis is too high there. That is often managed by the patient-support services, so the cleaning regimes, and rarely these days do I see nursing staff. In fact, if nursing staff are responsible, there is more likelihood that it won't get done. From a contractor's point of view, there needs to be contractor and subcontractor management and a process for appointing them to make sure that they are competent. You did have microbiologists in there. But what you didn't have and I think was being alluded to before you do mention capital teams, but you don't mention refurbishments. And that is a big area that is ongoing and ends up in all sorts of things going wrong. So I think there needs to be a process in there. I think overall, you should consider not just the owners that you might have identified, but there is some flexibility in how water safety groups appoint their core leaders and members. But I think people can actually use this as a framework and go with it where they want to. PFIs is always a really difficult one. And gladly, we're not going to have any new ones of those, for which I'm really pleased. Maybe some input from public health microbiologists as well, particularly if there's an incident management. maybe something that you could focus on a bit more is the atypical operating systems - what if something goes wrong? - so that you have the incident and communication management in there, which I think probably wasn't addressed in enough detail.

Table 7-45: Focus group question 5: Is there a need for adjustments / additions?

Speaker	**Extracted feedback**
1	I think all the adjustments and additions have already been mentioned by others.
2	I think without going through each slide in a lot more detail, I think we've probably covered most of it now.
3	I agree with both of those.
4	I also agree with the others.
5	Without the time to actually spend looking in more detail, I think we've covered most of where we have suggested that there could be some improvements.

Table 7-46: Focus group question 6: Will the framework be considered by you or colleagues as soon as it has been published?

Speaker	Extracted feedback
1	I would use it as a review tool. I wouldn't implement it completely, but I would definitely use it as a reference tool and something to check my own processes against to make sure everything that you had included on your framework is then included on my local procedures and policies and plans.
2	I think where it will become very valuable is probably to authorising engineers as an audit tool. And I also like the idea of taking certain elements of it and incorporating it into more specific training modules as well.
3	I would use it as a tool to compare what other trusts have in place, but it would not be down to myself to actually put it into use. But, yes, it would be a good tool for me to use.
4	I think if it could be made more complete with the amendments and additions that we've talked about today, I think it would make an excellent tool for both daily use but also for incorporating into training as well.
5	I think it's more likely to be used as a checklist for agents to make sure that they have got all the processes in place. And agreeing with the others, I think taking aspects out of it as a training and support tool. I particularly like your training matrix, so I think certain aspects of it will be picked out, I think, in reality, but used as a checklist to make sure that those processes are in place.

Table 7-47: Focus group question 7: Do you know about similar works that have been published scientifically?

Speaker	Extracted feedback
1	I'm aware of processes in the HTM, and I think there's processes in L8, not to the level of detail that you have presented here today. But yeah, I think there are frameworks and processes out there to guide Estates managers and these sorts of managers.
2	I think you should also - I mean, CIBSE have created guides of British standards as well, and I think it complements all of those and perhaps gives a little bit - well, a lot more detail than are in those documents.
3	I agree with S1 and S2, nothing to add.
4	n/a.

5	I don't know of anything that has been published in this format, other than what has already been talked about. But there is nothing in as much detail, as far as I'm aware, that you have included in this. So I don't think you should have any problem publishing it.

Table 7-48: Focus group question 8: Would it be worth considering setting up an organised, independent networking platform in the UK for the exchange of knowledge for Water Safety Group Members?

Speaker	**Extracted feedback**
1	I think a UK-wide exchange, a networking platform would be a little bit too ambitious. I'm aware of independent networking platforms on a regional basis. You also have CIBSE. That's what they do. They have networking forums and that sort of thing. So I don't think it would be worth setting up another one, to be honest. They're already there, in my experience.
2	There is a really good independent, local network down in the South West that has been set up. And it's not specific to water safety groups per se, but it's a fantastic knowledge transfer. And you almost need to have the local networks. It's almost like having a giant water safety group for the UK. So you've got all the small teams working around, and there may be one member from each team sitting down at a higher level. But that would be a massive ask. So it's just how to communicate between those different organisations really.
3	RICS down in the South West and Wales, which is very good. I think it would be useful if there were perhaps more regional sort of get-togethers. How that would work, I don't know. But yeah, perhaps if there were more regular regional meetings and then one person from that region perhaps could then go to another region throughout the year. How you would set that up, I don't know, because it would all be voluntary.
4	I think it would be really good if there were some regional groups and then one representative from each of those groups to maybe sit on a more national group. I think it would definitely be worth setting something like that up because then they can exchange information and swap best practice, etc.

5	I think the concept is a nice idea. There are already some regional networking groups that look at all aspects of water safety management and even look at tendering together for certain areas of water safety management. Whilst I think it's a good idea, as some of the others have said, in reality, I don't think people have got the time to be going to extra groups, on top of the groups that they already do network through, so the Infection Prevention Society and IHEEM. And there are various groups or societies out there which already have networking capabilities for water safety group members. I think the theory is really nice. But in reality, I think it's just one more group that I think would find it very difficult for people to attend on a regular basis.

The panel’s feedback has been recognised worthwhile to improve the framework in terms of a) refine content to the targeted applicant of the framework, b) the purpose of the framework to be considered as a guiding reference for management levels, and c) considering inclusion of some additional elements in order to deliver a powerful instrument.

Aspects of the presented framework that were found positive by the focus group haven’t been changed. Nevertheless, the following aspects for improving have been considered. Each highlighted bulletpoint states a specific feedback, that may also represent repeatedly occurring opinions during the focus group. The feedback is quoted and brought into a form that does not address the researcher personally. The original source is coded in brackets after the summarising feedback, indicating first the number of question (Q1 to Q8) and second the number of participant (i.e. speaker S1 to S5):

- Potentially the need to expand it out to cover some of the other countermeasures such as thermoflushing, UV ozone, etc., chemical flushing, in equally as much detail. (Q1-S4)
    - Comment of the researcher for achieving improvement: For this point the framework will contain existing recommendations of official documents and publications, used as guiding references.
- Hazards up front and then a more flexible process mapping. (Q3-S2)
    - Comment of the researcher for achieving improvement: Highlighting hazards and the importance of hazard analysis will be given more attention. Additional documents will complement framework, wich can be used as a structured guidance for hazard analysis.
- Temperature testing; verification and validation of water treatment measures; decision tree; HTM04-01 documents (Q3-S5)
    - Comment of the researcher for achieving improvement: The framework will be complemented by a risk assessment process, specifically with respect to water temperature treatment measures.
- Potentially specialist departments’ heads included; bring in key manufacturers and suppliers and products (Q4-S4)
    - Comment of the researcher for achieving omprovement: This is too specific and has not been element of investigation of the research. It needs further research and further expert’s knowledge.

Thus, there will be no such content available in the final framework, but suppliers and products generally should meet the needs of the customer, here, the hospital.

- Refurbishments; incident management; atypical operating systems; incident and commmunication management (Q4-S5)
    - Comment of the researcher for achieving improvement: Communication pathways are already described in the framework, but only considering process management between the stakeholders. There might be the need for a case or crisis management team communication scheme. This is very individual to each organisation. Generally the communication schemes must be clear to all people responsible involved in the process, but no specific example for that will be provided. With respect to atypical systems and refurbishments. An additional document will be elaborated as amendment to the framework describing types of defects, prioritisation and actions.
- Review tool (Q6-S1); to authorising engineers as an audit tool (Q6-S2); training matrix (Q6-S5)
    - Comment of the researcher for achieving improvement: In order to make it easier to use the framework in the sense of a review, training or audit tool, two compliance monitors will complement the framework. One is to measure compliance against the framework elements, one is to measure compliance against process elements.
- Focus on *Legonella*; maybe include other organisms, such as *Pseudomonas* (Q3-S1)
    - Comment of the researcher for achieving improvement: There will be included a statement that *Legionella* is just one of several bacteria in drinking water systems that may occur and that need to be critically reflected and risk assessed where necessary.

The summary of changes, presented as a snap shot before and after circling the differences, is shown in Figure 7-69

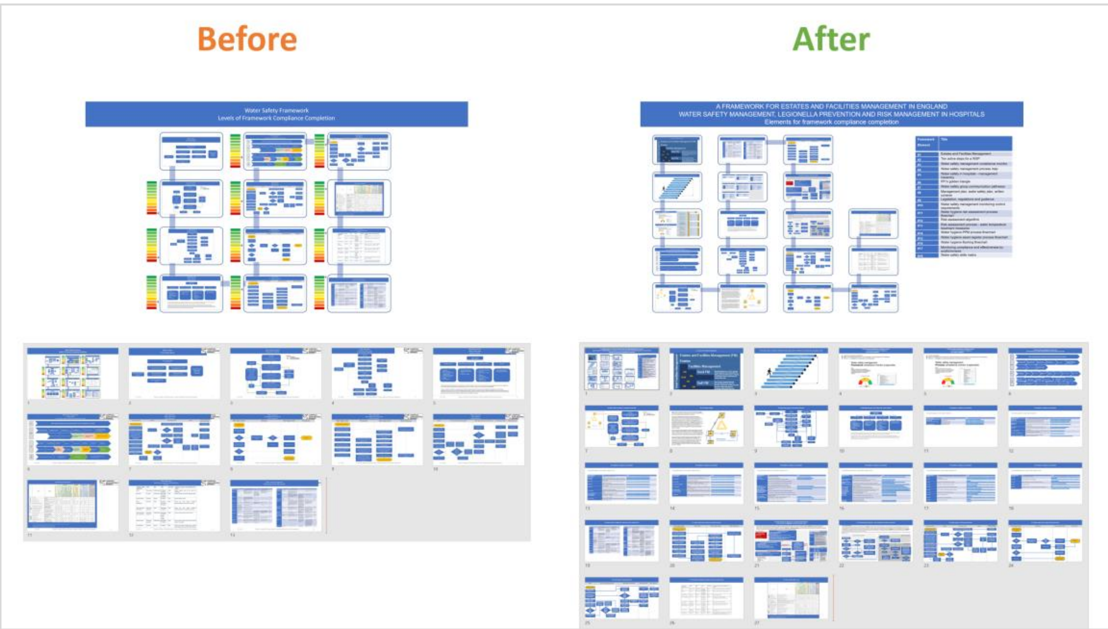
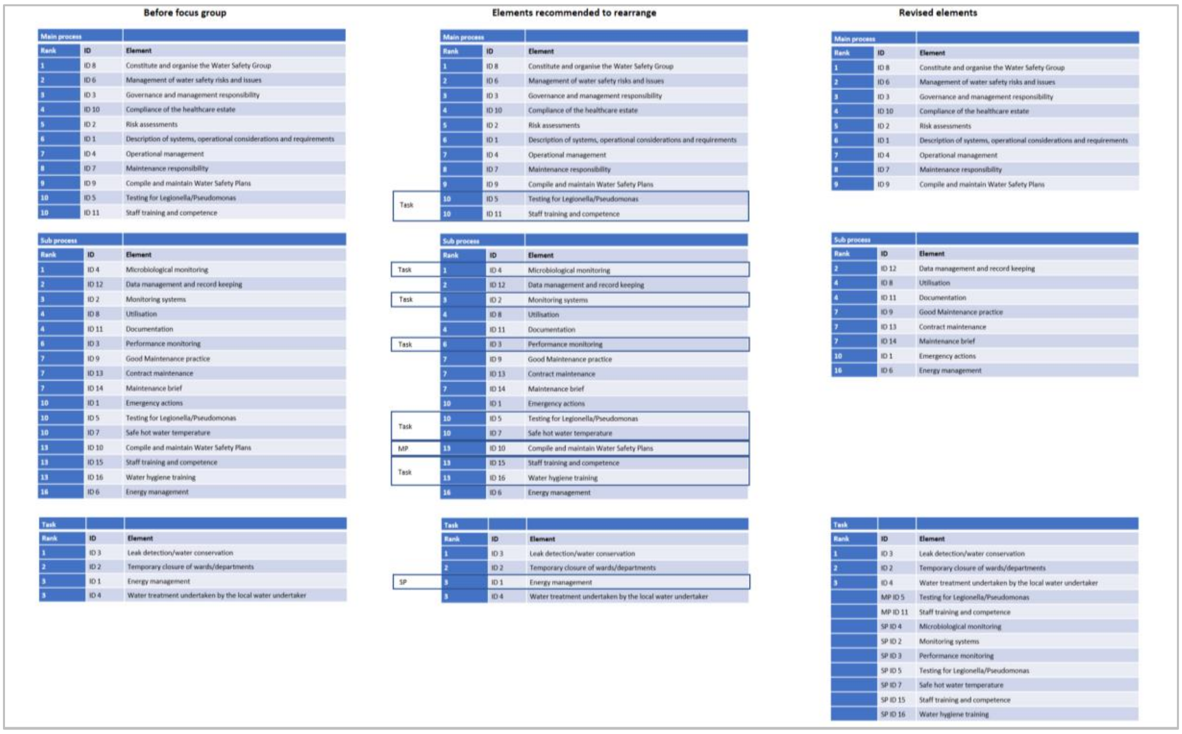


Figure 7-69: Framework development and extension after revisions

7.8 Revised process map water hygiene for *Legionella* prevention

The framework content and structure are detailed in the following sections. It is the finally compiled output result of all previous research phases of the research project. The earlier developed raw version serving the framework (chapter 7.6.1), was validated during the focus group. Validation steps and revisions made are described in chapter 7.7. The final version of the framework and related explanations are presented in this chapter.

The hierarchy of the process elements analysed in chapter 7.6.1 have undergone a modification after the focus group validation. In a closing discussion during the focus group some remarks have been recommended being advised for rearranging some of the process elements. The 'Task' was termed 'Work step' in chapter 7.6.1, the terms 'Main process' and 'Sub process' remained the same. Figure 7-70 shows from the left column to the right the revisions made to the initially identified processes. More 'tasks' came resulted, which reduced the number of main process and sub process elements.



Before focus group

Main process		
Rank	ID	Element
1	ID 8	Constitute and organise the Water Safety Group
2	ID 6	Management of water safety risks and issues
3	ID 3	Governance and management responsibility
4	ID 10	Compliance of the healthcare estate
5	ID 2	Risk assessments
6	ID 1	Description of systems, operational considerations and requirements
7	ID 4	Operational management
8	ID 7	Maintenance responsibility
9	ID 9	Compile and maintain Water Safety Plans
10	ID 5	Testing for Legionella/Pseudomonas
10	ID 11	Staff training and competence

Sub process		
Rank	ID	Element
1	ID 4	Microbiological monitoring
2	ID 12	Data management and record keeping
3	ID 2	Monitoring systems
4	ID 8	Utilisation
4	ID 11	Documentation
6	ID 3	Performance monitoring
7	ID 9	Good Maintenance practice
7	ID 13	Contract maintenance
7	ID 14	Maintenance brief
10	ID 1	Emergency actions
10	ID 5	Testing for Legionella/Pseudomonas
10	ID 7	Safe hot water temperature
13	ID 10	Compile and maintain Water Safety Plans
13	ID 15	Staff training and competence
13	ID 16	Water hygiene training
16	ID 6	Energy management

Task		
Rank	ID	Element
1	ID 3	Leak detection/water conservation
2	ID 2	Temporary closure of wards/departments
3	ID 1	Energy management
3	ID 4	Water treatment undertaken by the local water undertaker

Elements recommended to rearrange

	Main process		
	Rank	ID	Element
	1	ID 8	Constitute and organise the Water Safety Group
	2	ID 6	Management of water safety risks and issues
	3	ID 3	Governance and management responsibility
	4	ID 10	Compliance of the healthcare estate
	5	ID 2	Risk assessments
	6	ID 1	Description of systems, operational considerations and requirements
	7	ID 4	Operational management
	8	ID 7	Maintenance responsibility
	9	ID 9	Compile and maintain Water Safety Plans
Task	10	ID 5	Testing for Legionella/Pseudomonas
	10	ID 11	Staff training and competence

	Sub process		
	Rank	ID	Element
Task	1	ID 4	Microbiological monitoring
	2	ID 12	Data management and record keeping
Task	3	ID 2	Monitoring systems
	4	ID 8	Utilisation
	4	ID 11	Documentation
Task	6	ID 3	Performance monitoring
	7	ID 9	Good Maintenance practice
	7	ID 13	Contract maintenance
	7	ID 14	Maintenance brief
	10	ID 1	Emergency actions
Task	10	ID 5	Testing for Legionella/Pseudomonas
	10	ID 7	Safe hot water temperature
MP	13	ID 10	Compile and maintain Water Safety Plans
Task	13	ID 15	Staff training and competence
	13	ID 16	Water hygiene training
	16	ID 6	Energy management

	Task		
	Rank	ID	Element
	1	ID 3	Leak detection/water conservation
	2	ID 2	Temporary closure of wards/departments
SP	3	ID 1	Energy management
	3	ID 4	Water treatment undertaken by the local water undertaker

Revised elements

Main process		
Rank	ID	Element
1	ID 8	Constitute and organise the Water Safety Group
2	ID 6	Management of water safety risks and issues
3	ID 3	Governance and management responsibility
4	ID 10	Compliance of the healthcare estate
5	ID 2	Risk assessments
6	ID 1	Description of systems, operational considerations and requirements
7	ID 4	Operational management
8	ID 7	Maintenance responsibility
9	ID 9	Compile and maintain Water Safety Plans

Sub process		
Rank	ID	Element
2	ID 12	Data management and record keeping
4	ID 8	Utilisation
4	ID 11	Documentation
7	ID 9	Good Maintenance practice
7	ID 13	Contract maintenance
7	ID 14	Maintenance brief
10	ID 1	Emergency actions
16	ID 6	Energy management

Task		
Rank	ID	Element
1	ID 3	Leak detection/water conservation
2	ID 2	Temporary closure of wards/departments
3	ID 4	Water treatment undertaken by the local water undertaker
	MP ID 5	Testing for Legionella/Pseudomonas
	MP ID 11	Staff training and competence
	SP ID 4	Microbiological monitoring
	SP ID 2	Monitoring systems
	SP ID 3	Performance monitoring
	SP ID 5	Testing for Legionella/Pseudomonas
	SP ID 7	Safe hot water temperature
	SP ID 15	Staff training and competence
	SP ID 16	Water hygiene training

Figure 7-70: Rearranging of main process, sub process and task elements

7.9 Reduction of complexity and fitting to manageability

By reviewing and referencing to the findings of the mini review on the framework steps (chapter 6.14) for setting up and structuring a framework ‘Water safety management, Legionella prevention and risk management in hospitals: a framework for Estates and Facilities Management in England.’ as well as the respective elements were identified. According to the ten steps of the PDCA-WSP, described by Bereskie et al. (2017), the context of hospitals (chapter 7) is reviewed in this research and brought into the perspective of water safety and *Legionella* prevention, based on present, existing organisational structures and management practice. To summarise findings, column 4 of Table 7-49 suggest specific elements in the context of hospital organisations with a perspective taken for the development of the current framework. Nevertheless, this is a possible theoretical derivation for guiding the researcher giving a structure to the framework. By referencing the steps in the final framework output, the PCDA elements (Table 7-49) can be identified in the framework (Figure 7-71).

Table 7-49: The ten steps of the PDCA-WSP, described by Bereskie et al. (2017), adapted and contextualised into the perspective on water safety in the healthcare environment (hospital) based on present, existing organisational structures

Step	**Description**	**PDCA element**	**Contextualised into the perspective on water safety in the hospital environment (hospital) based on present, existing organisational structures**
Step 1	Assemble the team to prepare the PDCA-WSP	Plan	Constitute and organise the Water Safety Group
Step 2	Document and describe the system		Description of systems, operational considerations and requirements; Compile and maintain Water Safety Plans; Documentation
Step 3	Document and describe compliance and performance monitoring		Compliance of the healthcare estate; Water treatment undertaken by the local water supplier
Step 4	Develop supporting programs		Management of water safety risks and issues; Monitoring systems

Step 5	Performance maintenance and monitoring	Do	Good maintenance practice; Maintenance brief; Performance monitoring; PPMs
Step 6	Enforce	Check	Governance and management responsibility; Maintenance responsibility
Step 7	Audit and develop performance benchmarking		Data management and record keeping
Step 8	Corrective actions	Act	Operational management
Step 9	Perform management review		Annual process review: water safety management, Legionella prevention and risk management
Step 10	Continuous performance improvement		Audits, annual reviews; Staff training and competence; Water hygiene training

Taking into consideration the structuring elements of Table 7-49, the PDCA elements of the final framework of this research would look like as presented in Figure 7-71. This water safety management process map is different to the version presented in the last section of chapter 7.6.1. It shows the final structure after editing revisions () from the focus group validation, research phase III, which is described in chapter 7.7.

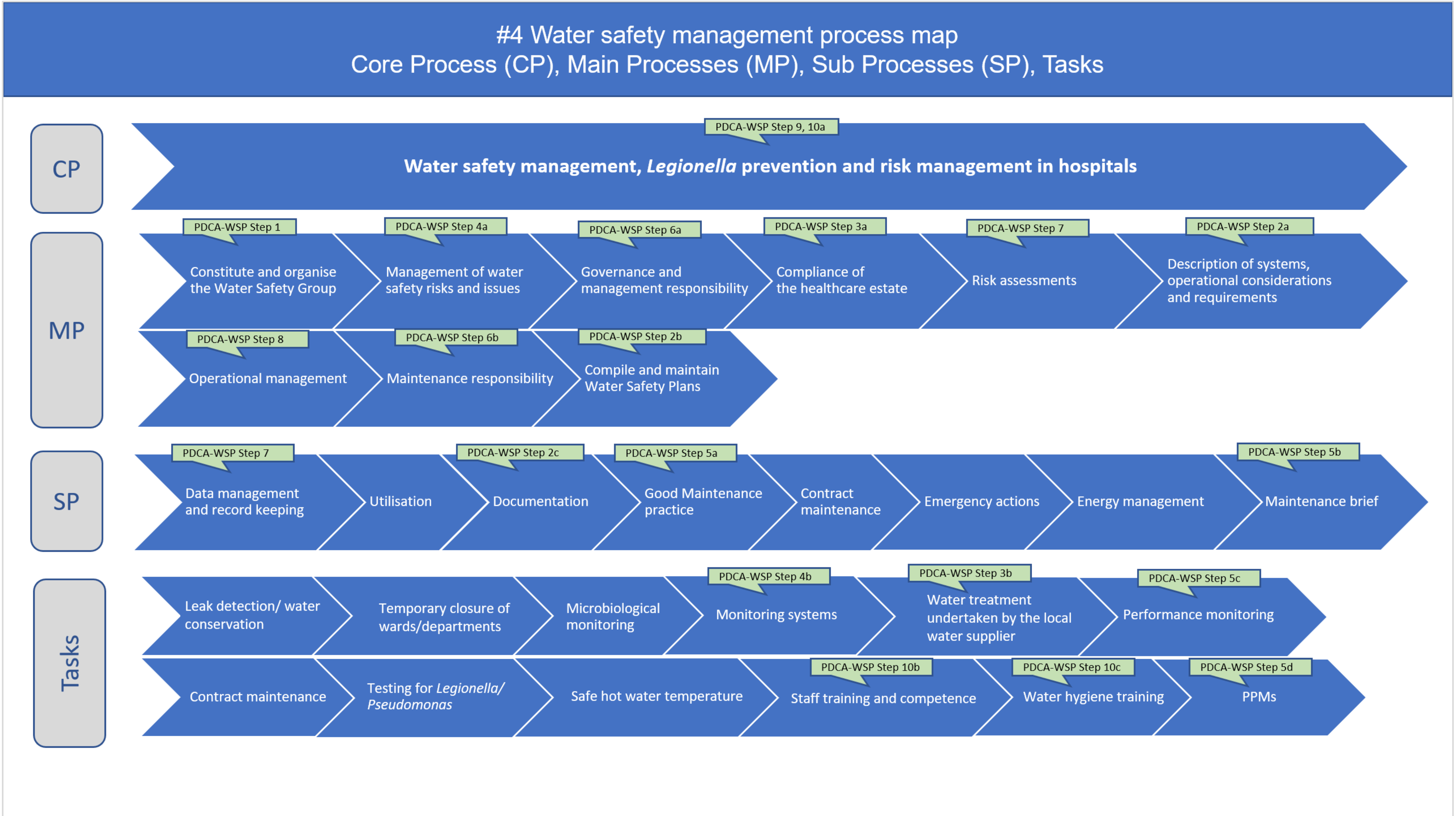


Figure 7-71: Water safety management process map with identified PDCA-elements, after phase III

8 Output: Framework for estates and facilities management

The previous chapter 7.9 described how the intended framework structure is fitted into manageability by attributing PDCA-elements. The structure of the framework is hence not designed arbitrarily, but with close consideration of the theoretical elements (chapter 6.14) and elements found in our own analyses (chapter 7). Taking into consideration the findings of the process analysis (chapters 7.6.1 and 7.6.2) the final process map of the framework approaches professionals at management levels of Estates and Facilities Management, fed by real case rooted findings. It presents the UK specific framework 'Water safety management, *Legionella* prevention and risk management in hospitals', created for Estates and Facilities Management. This framework is supplemented by a framework completion compliance monitor as well as a process compliance monitor. Summary Table 8-1 lists all elements of the framework in a chronological order, Figure 8-1 presents the framework extent in one figure.

The framework is the final output of this research. It is meant to be a self-explaining guiding document, based on practice. It is designed to be applied, for example, as a structurd guiding presentation consisting of numbered elements from #1 to #18 (Figure 8-1). Each self-standing slide is easy to read, understand and interpret for professionals in the specific field of Estates and Facilities Management. Figure 8-2 therefore gives a summary on aspects of total facilities management, which considers hard and soft FM and Estates, wich can fulfil its duties best by applying principles of Quality Management (QM), Risk Management (RM), Business Continuity Management (BCM), Process Management (PM), Knowledge Management (KM) and Environmental Management (EM), With these areas there is essentially professional interaction and collaboration. In order to achieve the full development, maintaining and continoulsy improving an effective water safety plan according to WHO to manage water safety of an organisation, ten consecutive steps and the essential loop is presented (Figure 8-3). The framework represents an evaluated current state-of-the-art target group specific guidance document containing information and knowledge necessary for management responsibilities. It is tailored specifically to the context of hospitals (healthcare organisations) and the perspective of Estates and Facilities Management. In combination with two self-assessment compliance monitors (Figure 8-4and Figure 8-5), of which one is to measure and monitor compliance to the process elements of the framework element #4, and the other is to measure and monitor compliance to the framework elements #1 to #18, it can be applied as an effective management instrument. People responsibe for water safety management can quest the framework elements against their own processes and check the presence and structure of their persisting management practices in place. The use is comparing against elements of the framework, which is not a necessarily a sequential order, but in its logic ordered from top to down management perspective, from strategic to operative. Even single framework elements can be extracted for training procedures or internal audits. With the aid of three specific template documents presented in chapter 8.3 that can be used for own business practices, risk management practices may also be given a impulse for improving practices in place.

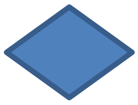
The framework is a tribute to applicability. Research produced something tangible.

Table 8-1: Summary table framework elements

Framework Element	Title	Figure, page in this thesis
#1	Estates and Facilities Management	Figure 8-2, p. 279
#2	Ten active steps for a WSP	Figure 8-3, p. 280
#3	Water safety management compliance monitor	Figure 8-5, p. 282
#4	Water safety management process map	Figure 8-6, p. 283
#5	Water safety in hospitals - management hierarchy	Figure 8-7, p. 284
#6	PFI's golden triangle	Figure 8-8, p. 285
#7	Water safety group communication pathways	Figure 8-9, p. 286
#8	Management plan, water safety plan, written scheme	Figure 8-10, p. 287
#9	Legislation, regulations and guidance	Figure 8-11, p. 288
#10	Water safety management monitoring control requirements	Figure 8-12, p. 289
#11	Water hygiene risk assessment process flowchart	Figure 8-13, p. 290
#12	Risk assessment algorithm	Figure 8-14, p. 291
#13	Risk assessment process - water temperature treatment measures	Figure 8-15, p. 292
#14	Water hygiene PPM process flowchart	Figure 8-16, p. 293
#15	Water hygiene asset register process flowchart	Figure 8-17, p. 294
#16	Water hygiene flushing flowchart	Figure 8-18, p. 295
#17	Monitoring compliance and effectiveness by audits/reviews	Figure 8-19, p. 296
#18	Water safety skills matrix	Figure 8-20, p. 297

Prior to presenting the framework elements, an explanation must be given for understanding symbols of the language of process mapping (Table 8-2).

Table 8-2: Process shapes explanation for process flow charts Figure 8-13, Figure 8-14, Figure 8-15, Figure 8-16, Figure 8-17, and Figure 8-18

Element	**Description**
	Process, either main-process or sub-process
	Process start / end point. Instruction, guidance, recommendation.
	Decision with options “yes” or “no” to proceed

A FRAMEWORK FOR ESTATES AND FACILITIES MANAGEMENT IN ENGLAND
WATER SAFETY MANAGEMENT, LEGIONELLA PREVENTION AND RISK MANAGEMENT IN HOSPITALS
Elements for framework compliance completion

Framework Element	Title
#1	Estates and Facilities Management
#2	Ten active steps for a WSP
#3	Water safety management compliance monitor
#4	Water safety management process map
#5	Water safety in hospitals - management hierarchy
#6	PFI's golden triangle
#7	Water safety group communication pathways
#8	Management plan, water safety plan, written scheme
#9	Legislation, regulations and guidance
#10	Water safety management monitoring control requirements
#11	Water hygiene risk assessment process flowchart
#12	Risk assessment algorithm
#13	Risk assessment process - water temperature treatment measures
#14	Water hygiene PPM process flowchart
#15	Water hygiene asset register process flowchart
#16	Water hygiene flushing flowchart
#17	Monitoring compliance and effectiveness by audits/reviews
#18	Water safety skills matrix

Figure 8-1: Water safety management framework – elements for framework compliance achievement

Figure 8-2: Estates and Facilties Management

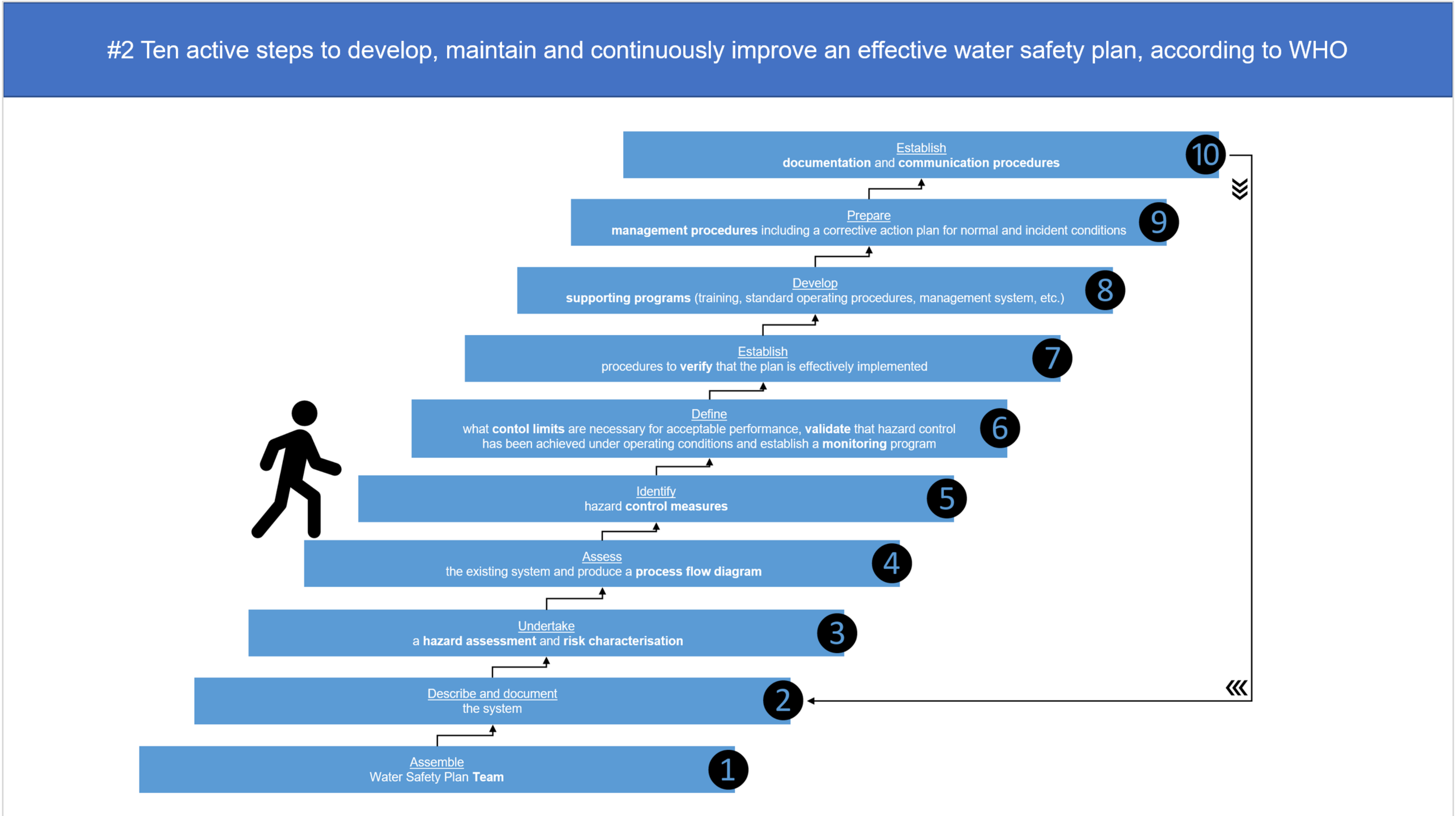


Figure 8-3: Ten active steps for a WSP

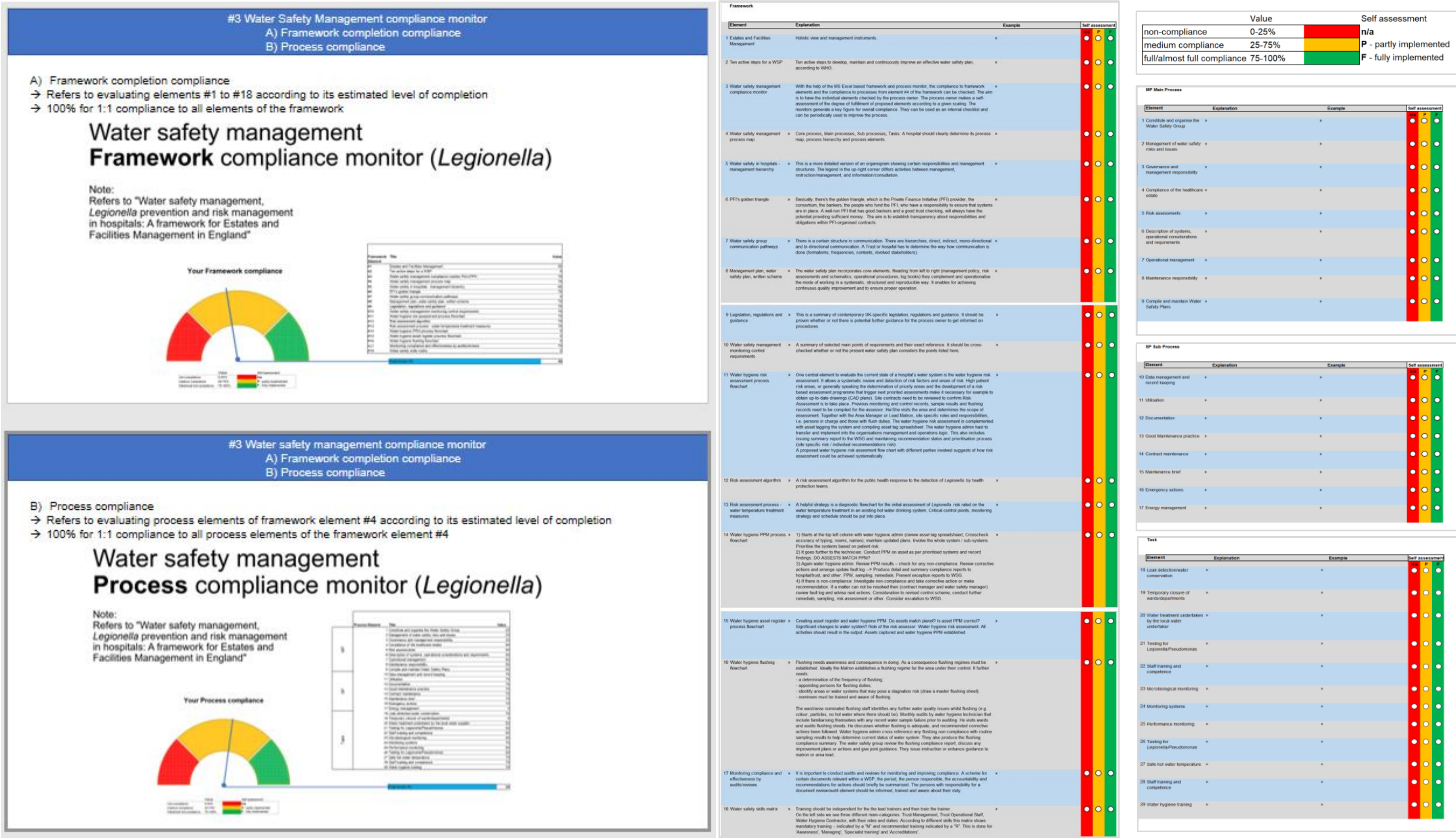


Figure 8-4: Framework and Process compliance monitor

Figure 8-5: Detailed view on MS Excel based compliance monitor

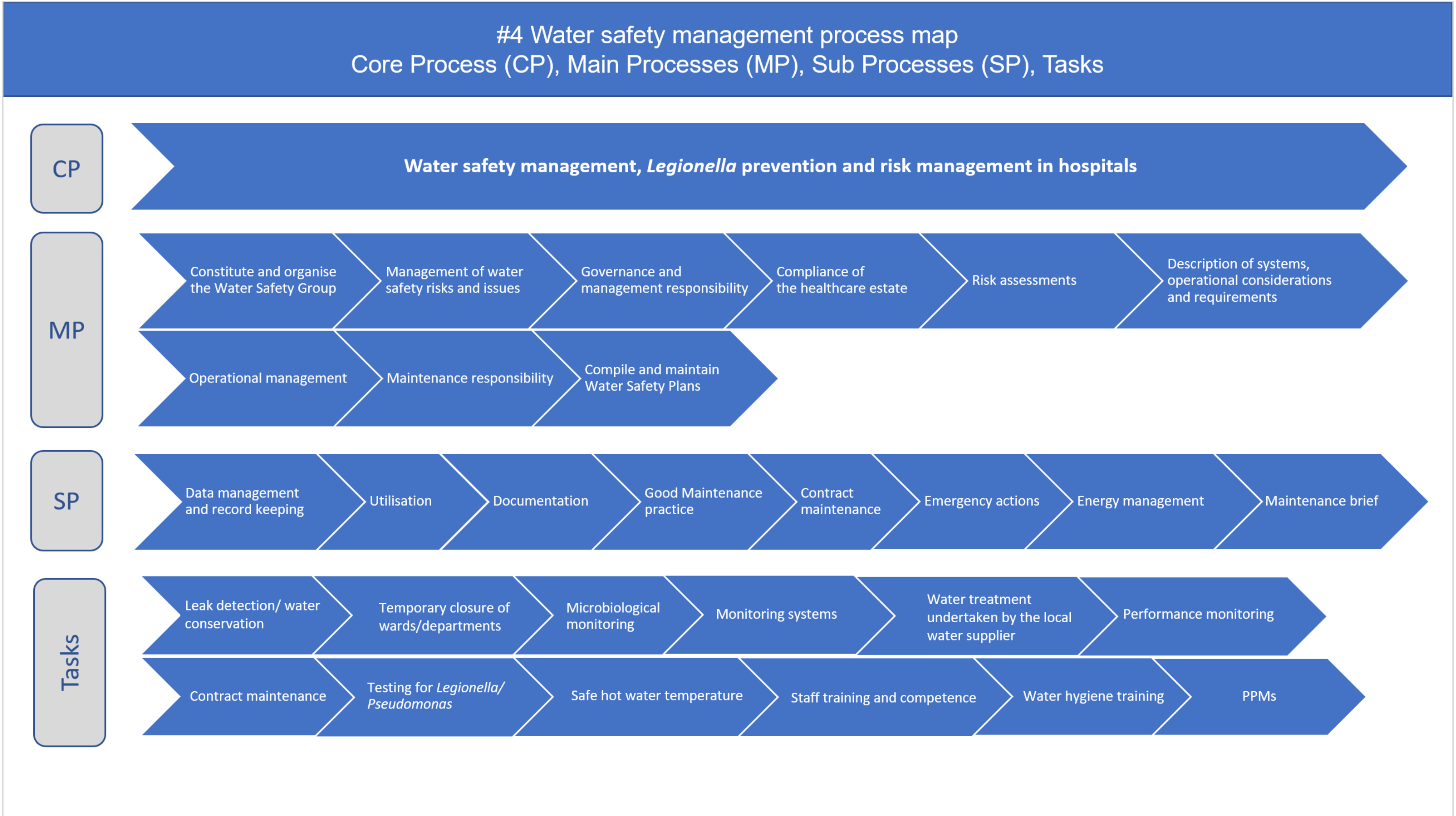


Figure 8-6: Water safety management process map

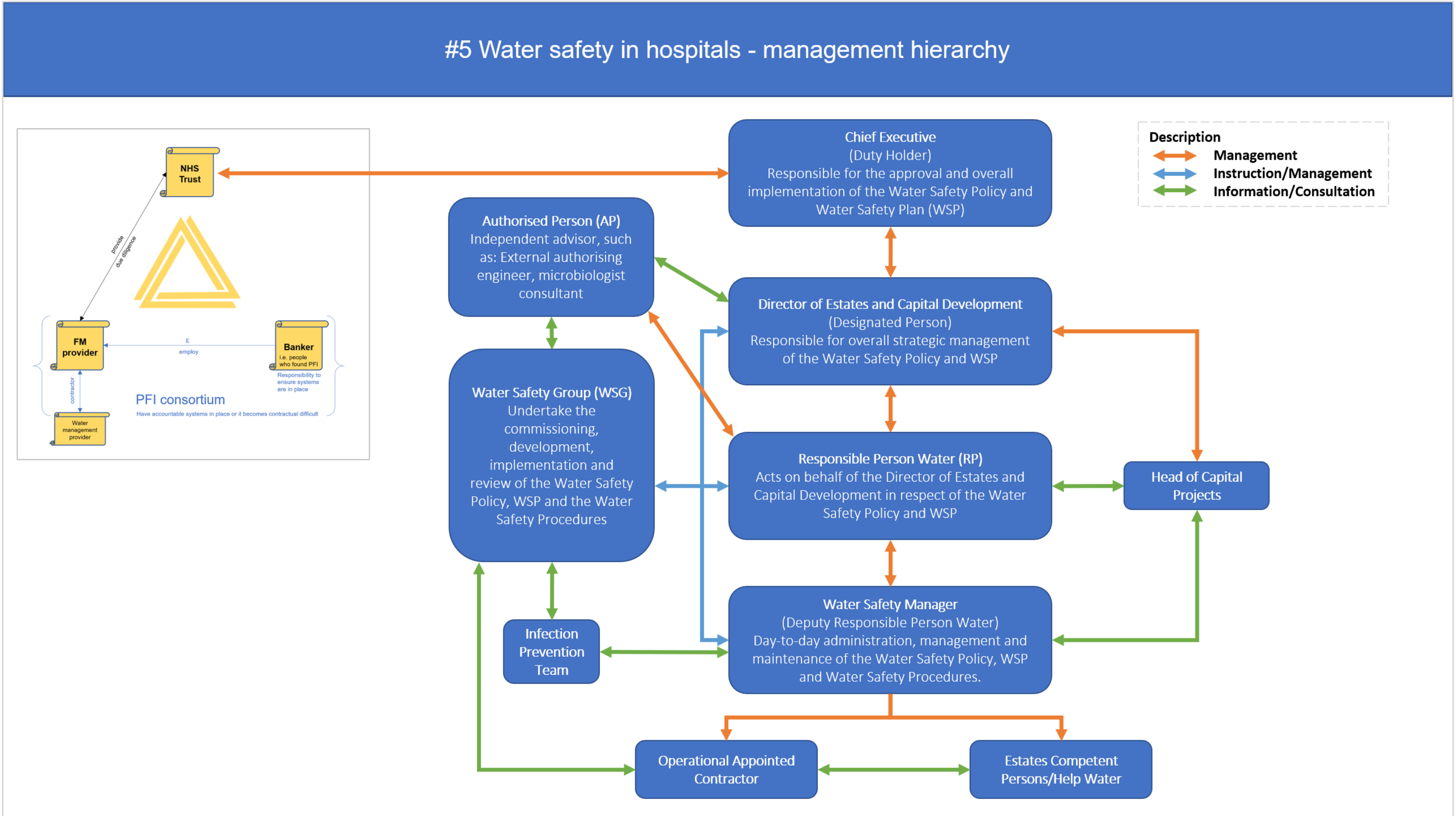


Figure 8-7: Water safety in hospitals - management hierarchy

#6 PFI's golden triangle

Basically, there's the golden triangle, which is the Private Finance Initiative (PFI) provider, the consortium, the bankers, the people who fund the PFI, who have a responsibility to ensure that systems are in place.

And if you give that triangle pretty good costs, they're usually pretty reasonable. Cost will only spiral if, one, it's proved that somebody is not doing what they should be doing, providing service and maintenance and all that, and then it becomes a blame culture of, "It wasn't in the contract." That's heard very often. Of course, on the other side, with PFIs, you probably know if there's any variations to contract, i.e., opening up a new ward or extensions, that becomes a variation to the basic PFI contract that we signed off. And, of course, cost can be very hefty when you go beyond costs calculated with a PFI. So that is the downside to it. If you could ever build a hospital for 35 years and never change it, PFI would be the best thing. It's when you change it.

A well-run PFI that has good backers and a good trust checking, will always have the potential providing sufficient money. The stakeholders will always have the money to give to ensure that all systems are adequately financed for maintenance and life cycle. Whereas if you look at a standard NHS foundation trust, they never have the money to finance replacements or modifications.

It can go the other way, and that usually can be where the FM provider of water systems doesn't uphold current standards of maintenance and service, or even install, like the HTM that we work to. So then it becomes the consortium's job to pull them up and ensure that they're doing it. And then, after that, you've got the trust shouting at the consortium that contractually they're not doing what they did, and then it becomes very much a contractual issue, which you don't ever want to get into because they get so protracted.

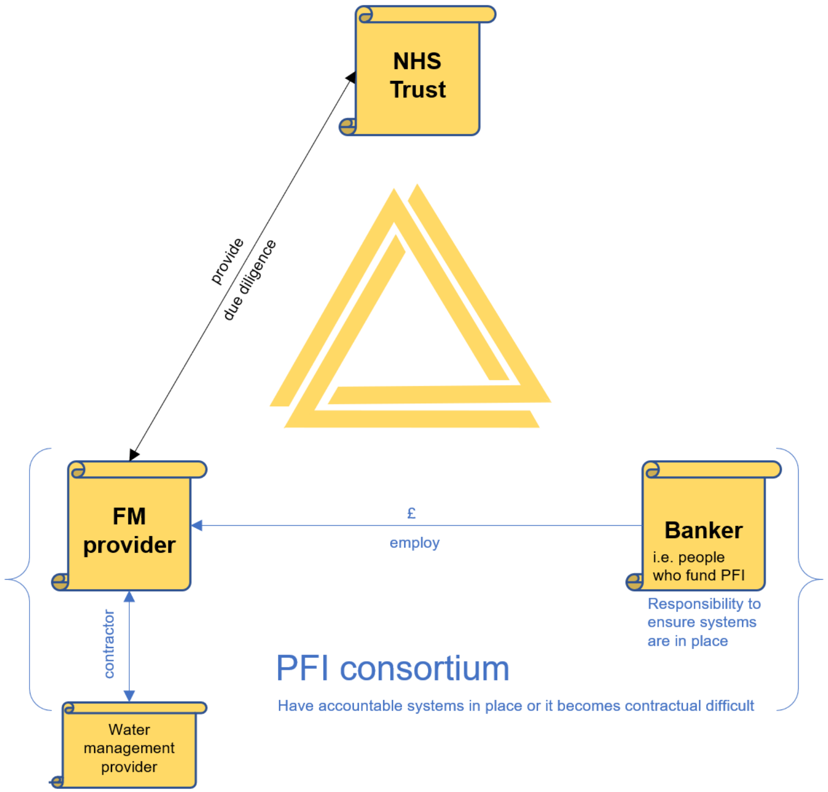


Figure 8-8: PFI's golden triangle

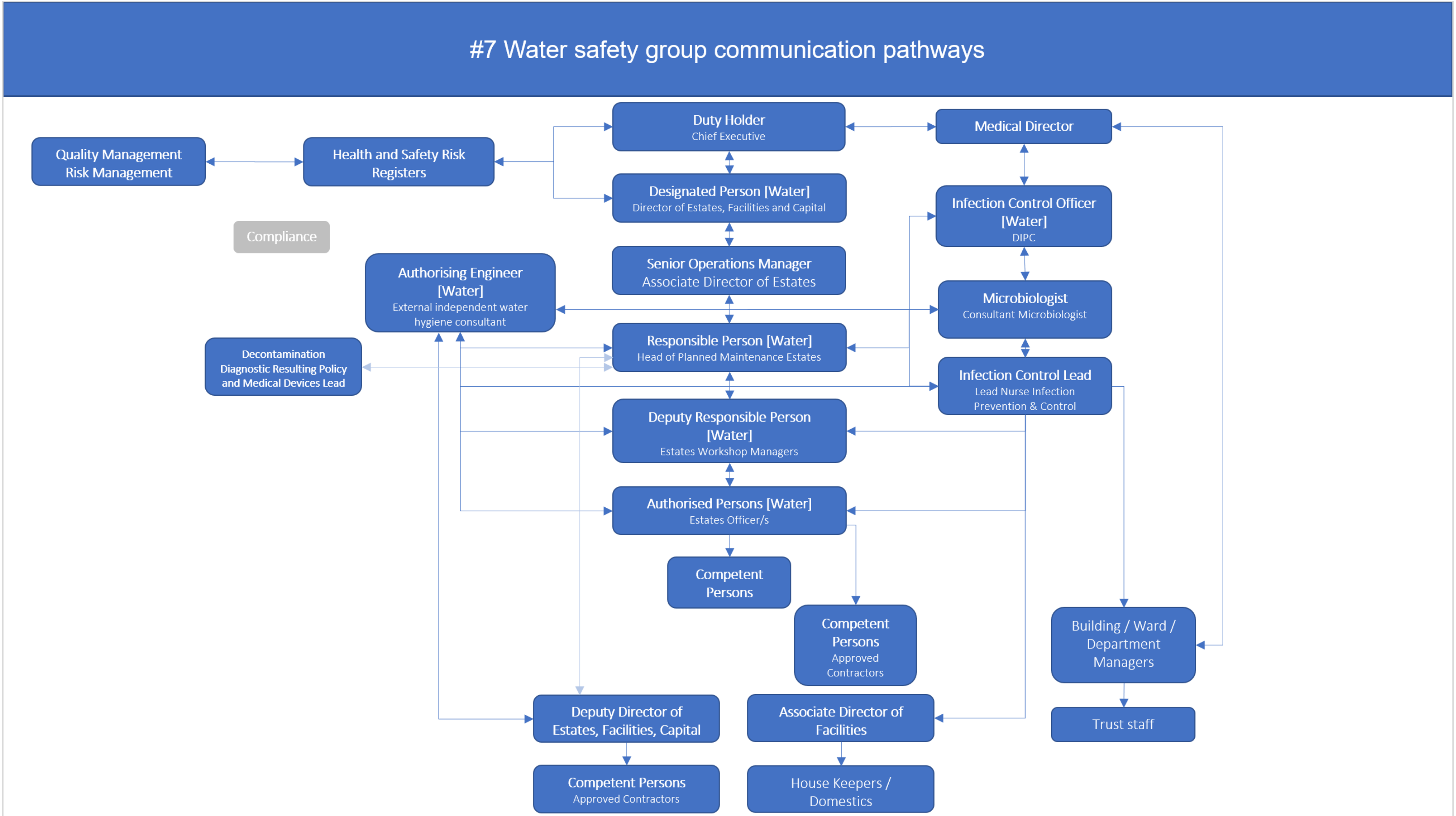


Figure 8-9: Water safety group communication pathways

The Water Safety Plan (WSP) [referred to by the HSE as the 'Written Scheme'] for the Trust is a defined suite of supporting documents, which are designed to ensure Water Safety is being proactively managed within the Trust. The WSP is made up of the documents mentioned above.

The Water Safety Group (WSG): To comply with the HTM 04-01 and the HCAI Code of Practice recommendation that management and monitoring arrangements are in place, the Trust has an established WSG and WSP. The WSG is chaired e.g. by the Senior Operations Manager. Formal Minutes are taken. Reports on performance, risk minimisation action plans, sampling results and incidents are summarised and reported to the quarterly Estates, Facilities and Capital's Health, Safety and Compliance (EFC) meetings.

Figure 8-10: Management plan, water safety plan, written scheme

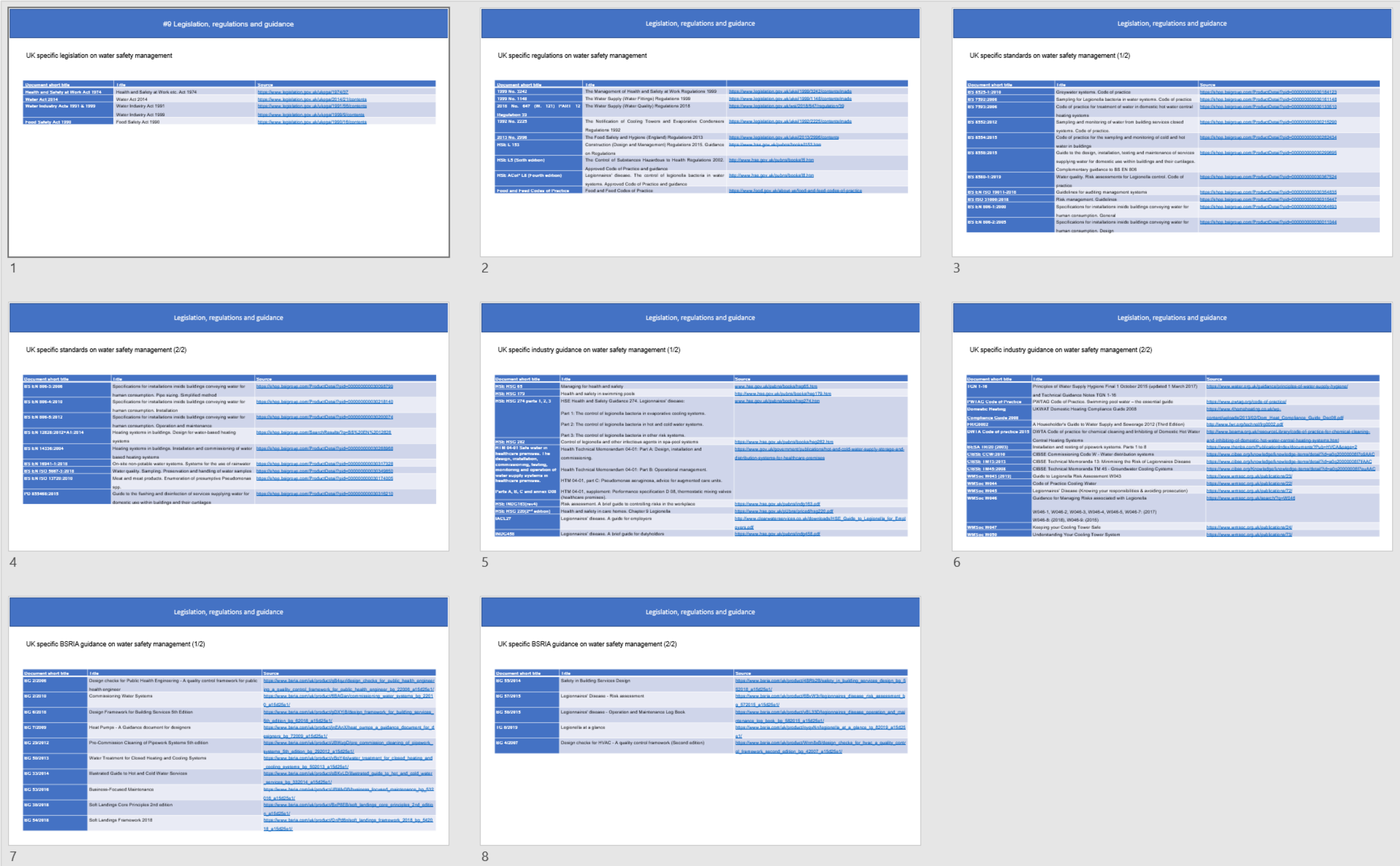


Figure 8-11: Legislation, regulations and guidance

#10 Water safety management monitoring control requirements

Reference	Asset type	Requirements	Further detail requirements	Notes	Frequency
L8 ACOP, HSG274 Part 2, Para 2.79, Table 2.1	Calorifier	Check Calorifier flow temperatures (thermostat settings should modulate as close to 60°C as practicable without going below 60°C)	Check Calorifier return temperatures (not below 50°C).	Ensure temperatures are taken at a reasonable distance (2m) on flow an return pipes - this will help over false readings.	Monthly
L8 ACOP, HSG274 Part 2, Para 2.79, Table 2.1	Calorifier	Collect the initial flush from the base of hot water heaters to inspect clarity, quantity of debris, and temperature. Obtain and record photographic evidence of internal inspections conducted by others.	Inspect Calorifier internally by removing the inspection hatch or using a boroscope and clean by draining the vessel. The frequency of inspection and cleaning should be subject to the findings and increased or decreased or decreased based on conditions recorded. (Estates to fulfil)	Where there is no inspection hatch or unable to open calorifier, purge any debris in the base of the Calorifier to a suitable drain	Annual
L8 ACOP, HSG274 Part 2, Para 2.79, Table 2.1	Cold Water Storage tank	Check tank water temperature remote from the ball valve and the incoming mains temperature. Record the maximum temperatures of the stored and supply water recorded by fixed maximum/minimum thermometers where fitted.			Six Monthly
HTM 04 - Part B, 7.55	Cold Water Storage tank	Conduct drop test / capacity check during normal working day (load).	Record findings of drop test.		Annual
HTM 04 - Part B, 7.55	Cold Water Storage tank	Inspect cold water storage tank integrity and advise on any remedial works as necessary	Cleanliness externally, close fitting lid, insulated, safe access, cleanliness internal, overflow and warning pipe, insect screens.	Document findings with photographic evidence	Six Monthly
HTM 04 - Part B, 7.11-7.48	Dosing equipment Chlorine Dioxide Dosing, Copper silver, Chlorine (Domestic water)	Check chemical stocks and calibration in accordance with manufacturers recommendations		Report condition of plant	Monthly
HTM 04 - Part B, 7.11-7.48	Dosing equipment Chlorine Dioxide Dosing, Copper silver, Chlorine (Domestic water)	monthly – check dosing concentrations at sentinel outlets;			Monthly
HTM 04 - Part B, 7.11-7.48	Dosing equipment Chlorine Dioxide Dosing, Copper silver, Chlorine (Domestic water)	annually – check dosing concentrations at representative taps selected on a rotational basis once each year;			Annual
L8 ACOP, HSG274 Part 2, Para 2.79, Table 2.1	Expansion Vessel	Where practical, flush through and purge to drain.	Bladders should be changed according to the manufacturer's guidelines or as indicated by the risk assessment. (report age of vessel / bladder)	Only necessary on vessels above 10ltr capacity (under 10 ltr should be replaced within expiry dates – estates. Consider installation of flow through valve instead of routine flushing.	Six Monthly (or as indicated by risk assessment)
L8 ACOP, HSG274 Part 2, Para 2.79, Table 2.1	Flushing log Audits	Audit that sufficient flushing regimes are in place, sufficient for the local water system and its use and being properly documented – collect flush records for central archiving	Refer to Ward Environment folder - Provide audit report to WSG on flushing regime (missed, complete, details of any comments , persons spoken to)	Quarterly audit per Ward	Quarterly
N/A	Instantaneous water heater	Low volume (<5ltr) instant water heaters - No test required on these as insignificant volume of water / risk.	No temp test necessary requirements		N/A
HTM 04 - Part B, 7.41-7.44	POU Filtration	Where fitted POU filters should be replaced as per manufacturers recommendations	A register should be kept noting serial numbers, exchange dates - monthly check that all filters in use are in date.	Exchange in accordance with manufacturer directions or sooner flow rates significantly reduce	Monthly
l8 ACOP, HSG274 Part 2, Para 2.79, Table 2.1 (Para2.68)	POU Heater unvented	(>5ltr) - Check water temperatures on outlet pipework to confirm the heater operates at 50-60°C (55°C in healthcare premises).	Or at nearest tap outlet to confirm the heater operates above 50°C or (55°C Healthcare).	If testing at nearest tap ensure the supply pipe is not trace heated (giving a false reading)	Monthly
L8 ACOP, HSG274 Part 2, Para 2.79, Table 2.1	POU Heater Vented	Check water temperatures on outlet pipework to confirm the heater operates above 60°C.	Or at nearest tap outlet to confirm the heater operates above 60°C.		Monthly

Reference	Asset type	Requirements	Further detail requirements	Notes	Frequency
L8 ACOP, HSG274 Part 2, Para 2.79, Table 2.1	POU Heater Vented	Clean and disinfect the integral cold water header tanks			Annual
L8 ACOP, HSG274 Part 2, Para 2.79, Table 2.1	Principal return loops	For circulating systems: take temperatures at return legs of principal loops (sentinel points) to confirm they are at a minimum of 50 °C (55 °C in healthcare premises). Temperature measurements may be taken on the surface of metallic pipework		Typical PRL locations on each riser, each floor.	Monthly
L8 ACOP, HSG274 Part 2, Para 2.79, Table 2.1	Rotational outlets	All HWS systems: take temperatures at a representative selection of other points (intermediate outlets of single pipe systems and tertiary loops in circulating systems) to confirm they are at a minimum of 50°C (55°C in healthcare premises to create a temperature profile of the whole system over a defined time period .	Take temperatures at a representative selection of other points to confirm they are below 20°C to create a temperature profile of the whole system over a defined time period. Peak temperatures or any temperatures that are slow to fall should be an indicator or a localised problem.	Where TMV's fitted sentinal checks should take place from pipework upstream of TMV.	Annual
Reference	Asset type	Requirements	Further detail requirements	Notes	Frequency
Trust Water Safety Policy	Scale Audits	Audit sufficient outlet cleanliness	Document findings, person spoken to, comments made and response	Quarterly audit per Ward	Quarterly
L8 ACOP, HSG274 Part 2, Para 2.79, Table 2.1	Sentinel Outlets	For non-circulating systems: take temperatures at sentinel points (nearest outlet, furthest outlet and long branches to outlets) to confirm they are at a minimum of 50°C within one minute (55°C in healthcare premises). For circulating systems: take temperatures at return legs of principal loops (sentinel points) to confirm they are at a minimum of 50°C (55°C in healthcare premises). Temperatures measurements may be taken on the surface of metallic pipe work.	Check temperatures at sentinel taps (typically those nearest to and furthest from the cold tank, but may also include other key locations on long branches to zones or floor levels). These outlets should be below 20°C within two minutes of running the cold tap. To identify any local heat gain, which might not be apparent after one minute, observe the thermometer reading during flushing.	Where TMV's fitted sentinel checks should take place from pipework upstream of TMV. Where return loops are not readily accessible temperature measurements may be taken at outlets within sentinel areas (as detailed on schematic / fittings list)	Monthly
L8 ACOP, HSG274 Part 2, Para 2.79, Table 2.1	Shower	Dismantle, clean and descale removable parts, heads, inserts and hoses where fitted.	Identify whether more frequent descaling is necessary and log comment	Follow Trust shower colour coding protocol	Quarterly
L8 ACOP, HSG274 Part 2, Para 2.79, Table 2.1	Subordinate Test point	For circulating systems: take temperatures at return legs of subordinate loops, temperatures measurements can be taken on the surface of pipes.	Where pipe are not accessible, the temperature of the water from the last outlet on each loop may be measured and this should be greater than 50°C within one minute of running (55°C in healthcare premises).	If the temperature rise is slow, it should be confirmed that the outlet is on a long leg and not that the flow and return has failed in the local area. Typical SRL locations are upstream principle return loops where two or more returns join to serve the principle returns.	Quarterly
HTM 04 - Part B, 7.67	Strainers	Remove and clean strainers	Report findings to help determine ongoing frequency of PPM	Photographic evidence if strainers compromised	Six Monthly
L8 ACOP, HSG274 Part 2, Para 2.79, Table 2.1	Thermostatic mixer valve & TMT Taps	Inspect, clean, descale and disinfect any strainers or filters, test backflow, fail safes and re-calibrate	Allow to replace seals i.a.w. manufacturers recommendations	Make minor adjustments as necessary.	12 Monthly
L8 ACOP, HSG274 Part 2, Para 2.79, Table 2.1 (Trust Policy - 6 month high risk)	Thermostatic mixer valve & TMT Taps (high risk)	Inspect, clean, descale and disinfect any strainers or filters, test backflow, fail safes and re-calibrate	Allow to replace seals i.a.w. manufacturers recommendations	Make minor adjustments as necessary.	Six Monthly
HTM 04 - Part B, 7.37, 7.78	Trace Heat	Verify each length of trace heating system is operating correctly.	Check that system is maintaining hot above 50°C degrees within pipework (55°C Healthcare) : Note: The system should elevate temps above 60°C for at least 1 hour per day.	Ensure timers are not in use. If an electronic management covers the monthly checks then obtain records.	Monthly
Trust Water Safety Policy	Water Conditioner	Inspect and report condition. Allow to flush through any bypass arrangements and cleaning of strainers.	On small diameter cartridge types report on age, use by date & condition. On larger type report any electronic readouts i.e. % condition status.	Water conditioners or softeners usually need to be serviced at 6 month intervals, this is to ensure a build of sediment does not occur which could taint the incoming supply to the premises. It is essential that these fittings are maintained in accordance with the manufacturers recommendations or if this is not achievable consideration should be given to their removal. Some non-maintainable cartridge type conditioners need to be replaced approximately every 5 years.	Six Monthly
Trust Water Safety Policy	Waste Traps (removable Hygiene Siphon)	Remove and exchange for reconditioned insert	To be routinely maintained on 'High patient risk wards only'	Follow WSP Procedure for removal and replacement	Quarterly

Figure 8-12: Typical water safety management monitoring control requirements

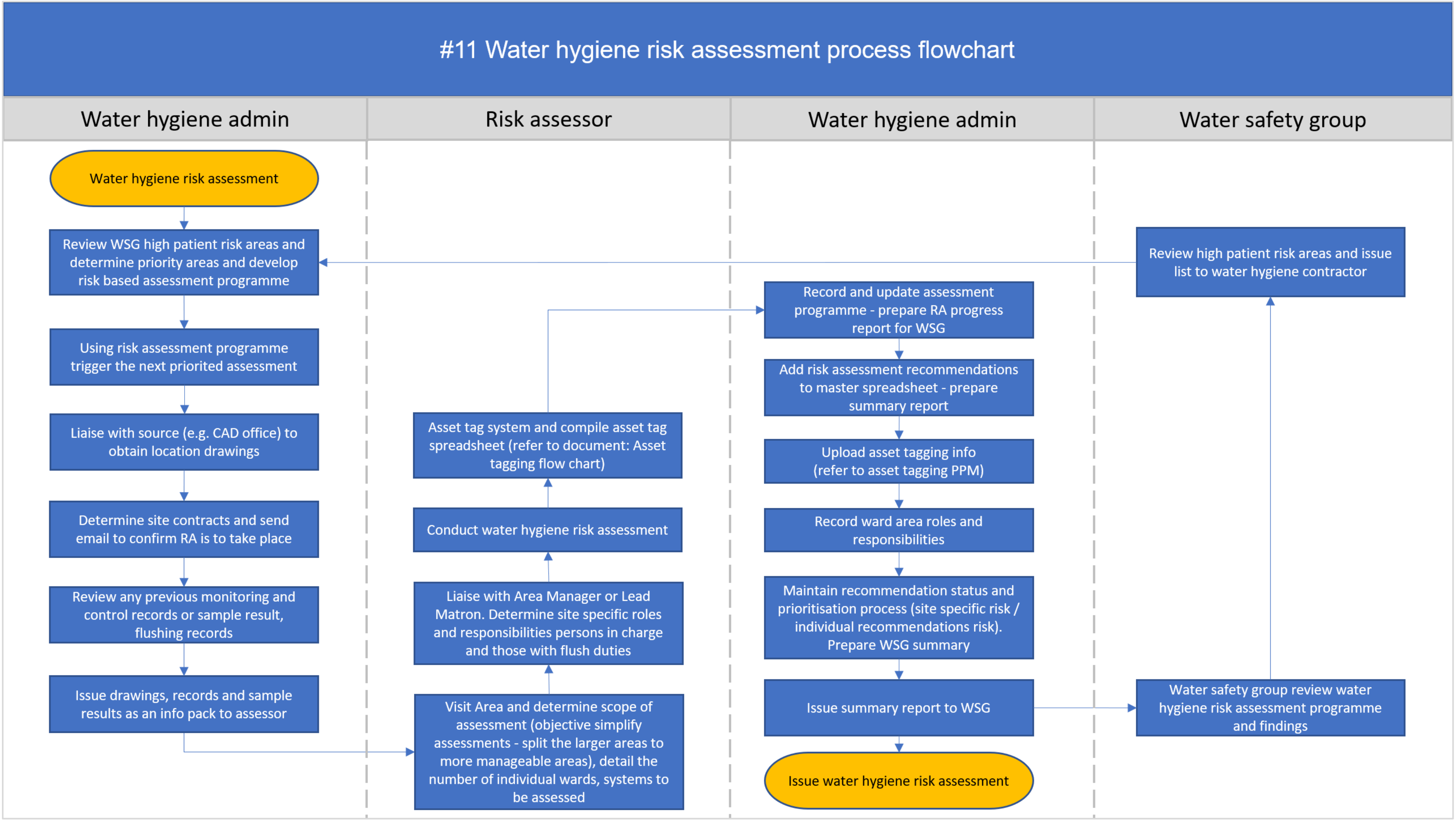
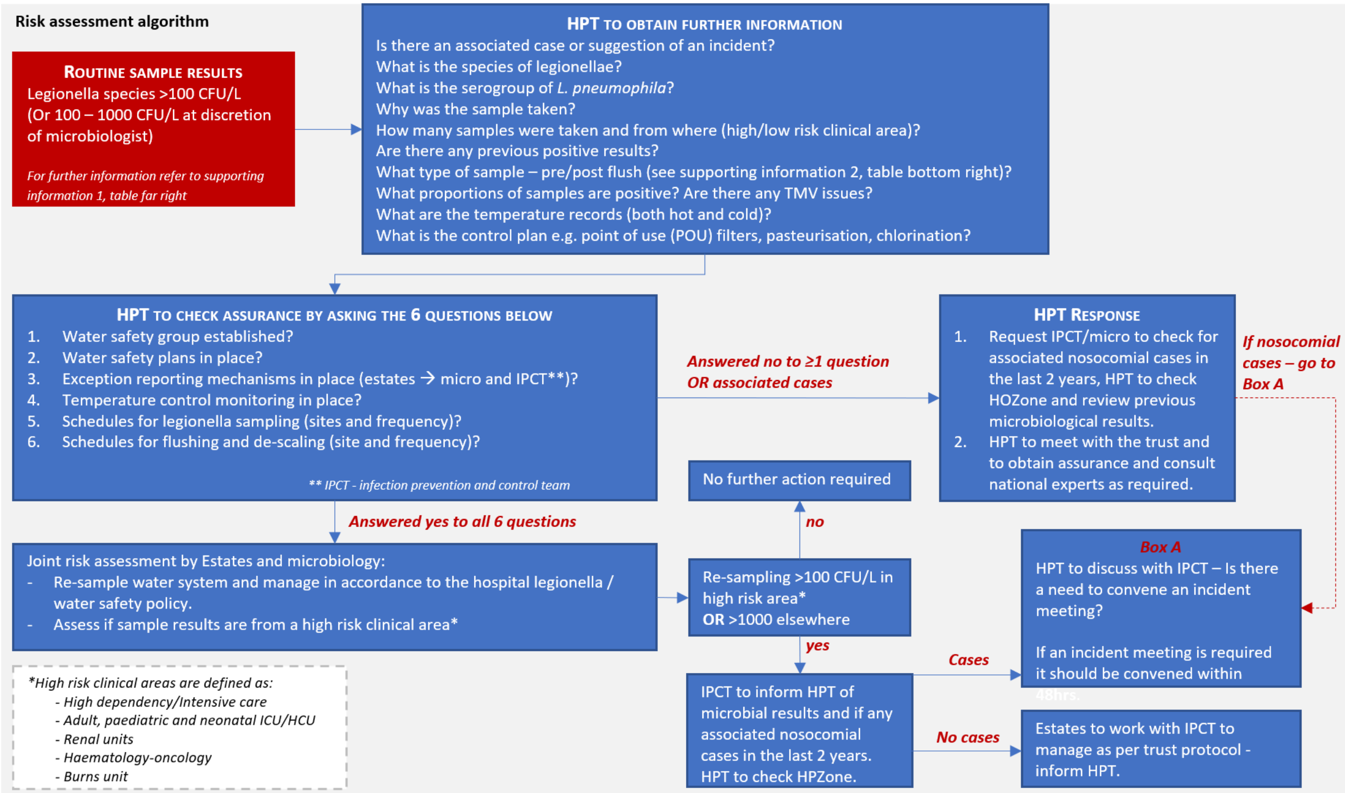


Figure 8-13: Output WSP water hygiene risk assessment process flowchart

#12 Risk assessment algorithm for the public health response to the detection of *Legionella* by health protection teams

In August 2015 Public Health England produced a guidance document for local Health Protection Teams (HPT) in the event of a report to them of elevated *Legionella* positives in healthcare facilities. The document is titled: “Responding to the detection of legionella in healthcare premises Guidance for PHE health protection teams”. It suggests an algorithm, which is used as guidance in determining if communication to PHE is required. Decision is made in consultation with the consultant microbiologist and/or DIPC. As a general rule for the operation of water systems in buildings, the question has to be risen whether or not for the facility has been conducted a risk assessment to identify where *Legionella* spp., *Legionella pneumophila* and other opportunistic waterborne pathogens (e.g. Pseudomonas, Acinetobacter, Burkholderia, Stenotrophomonas, nontuberculous mycobacteria, fungi, Biofilms) could grow and spread in the facility?



Supporting information 1

Legionella bacteria (CFU/L)	Recommended actions
Not detected or up to 100 CFU/L	In healthcare, the primary concern is protecting susceptible patients, so any detection of legionella should be investigated and, if necessary, the system resampled to aid interpretation of the results in line with the monitoring strategy and risk assessment.
>100 CFU/L and up to 1000 CFU/L	Eiter: - if the minority of samples are positive, the system should be resampled. If similar results are found again, review the control measures and risk assessment to indetify any remedial actions necessary or - if the majority of samples are positive, the system may be colonised, albeit at a low level. An immediate review of control measures and a risk assessment should be carried out to identify any other remedial action required. Disinfection of the system should be considered.
>1000 CFU/L	The system should be resampled following an immediate review of the control measures and risk assessment carried out to identify any remedial actions, including possible disinfection of the system. Retesting should take place a few days after disinfection and at frequent intervals thereafter until a satisfactory level of control is achieved.

Supporting information 2

	Presence of legionella bacteria (CFU/L) in pre-flush samples	Presence of legionella bacteria (CFU/L) in post flush samples	Comments on legionella positive outlets
Contamination of water system	Levels (CFU/L) are similar to post flush	Usually levels (CFU/L) are similar to pre-flush	A high proportion of outlets may be positive but this will be dependent upon the local water system and other risk factors e.g. temperature control, flushing regimes and presence of dead legs.
Contamination at the outlet	Usually higher than post flush	Usually low or absent	May be interspersed with positive and negative outlets, but this will be dependents upon the local water system and other risk factors, e.g. temperature control, flushing regimes and presence of dead legs.

Figure 8-14: Risk assessment algorithm

#13 Risk assessment process - water temperature treatment measures

Risk assessment process

A helpful strategy is a diagnostic flowchart for the initial assessment of *Legionella* risk rated on the water temperature treatment in an existing hot water drinking system (Bédard, 2015). Critical control points, defined as a) the water heater outlet as initial part of the main recirculation system, b) the main recirculation system itself, c) the subordinate return loop system or ejection line for each floor and d) representative at risk points-of-use (not reaching control temperature, farthest from the water heater or serving vulnerable patients) are prioritised for sectors or systems identified at risk by the initial risk assessment. The stepwise approach can help directing efforts towards high risk areas and optimise resource allocation, especially costly *Legionella* monitoring. Nevertheless, an ongoing *Legionella* monitoring strategy and schedule should be put into place through a water safety plan once initial assessment is completed and corrective measures have been completed. The flow chart presented hereafter is adapted from Bédard et al. (2015 p.254, figure 6), modified.

Source: BÉDARD, E., FEY, S., CHARRON, D., LALANCETTE, C., CANTIN, P., DOLCÉ, P., LAFERRIÈRE, C., DÉZIEL, E. & PRÉVOST, M. 2015. Temperature diagnostic to identify high risk areas and optimize *Legionella pneumophila* surveillance in hot water distribution systems. *Water Research*, 71, 244-256.

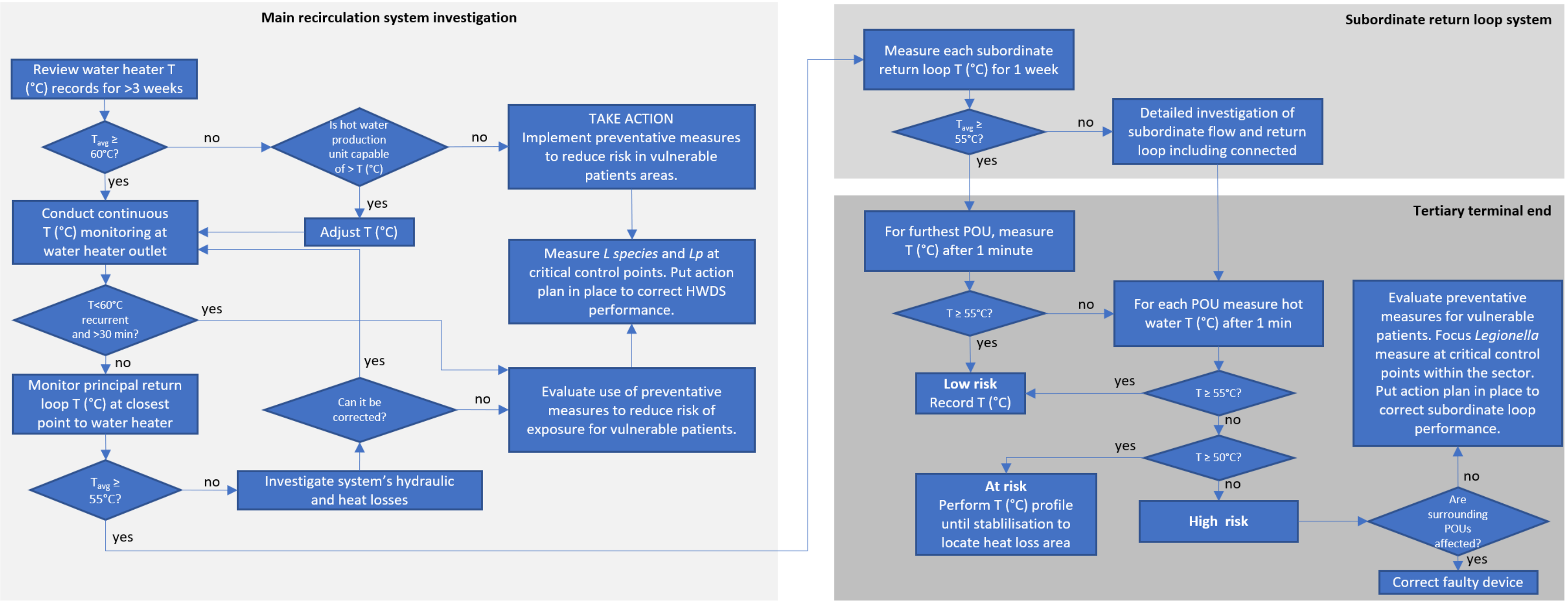


Figure 8-15: Risk assessment process - water temperature treatment measures

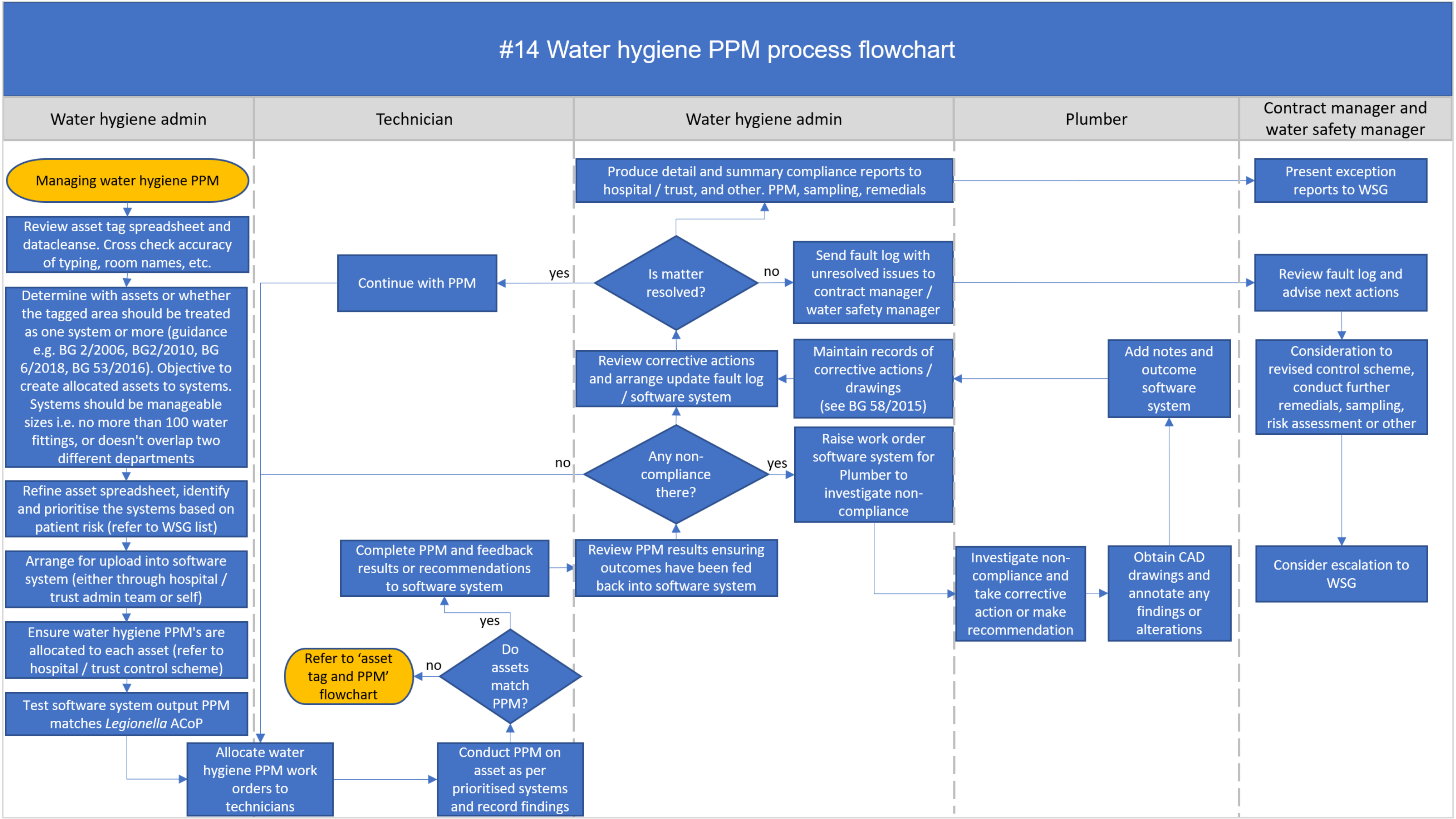


Figure 8-16: Water hygiene PPM process flowchart

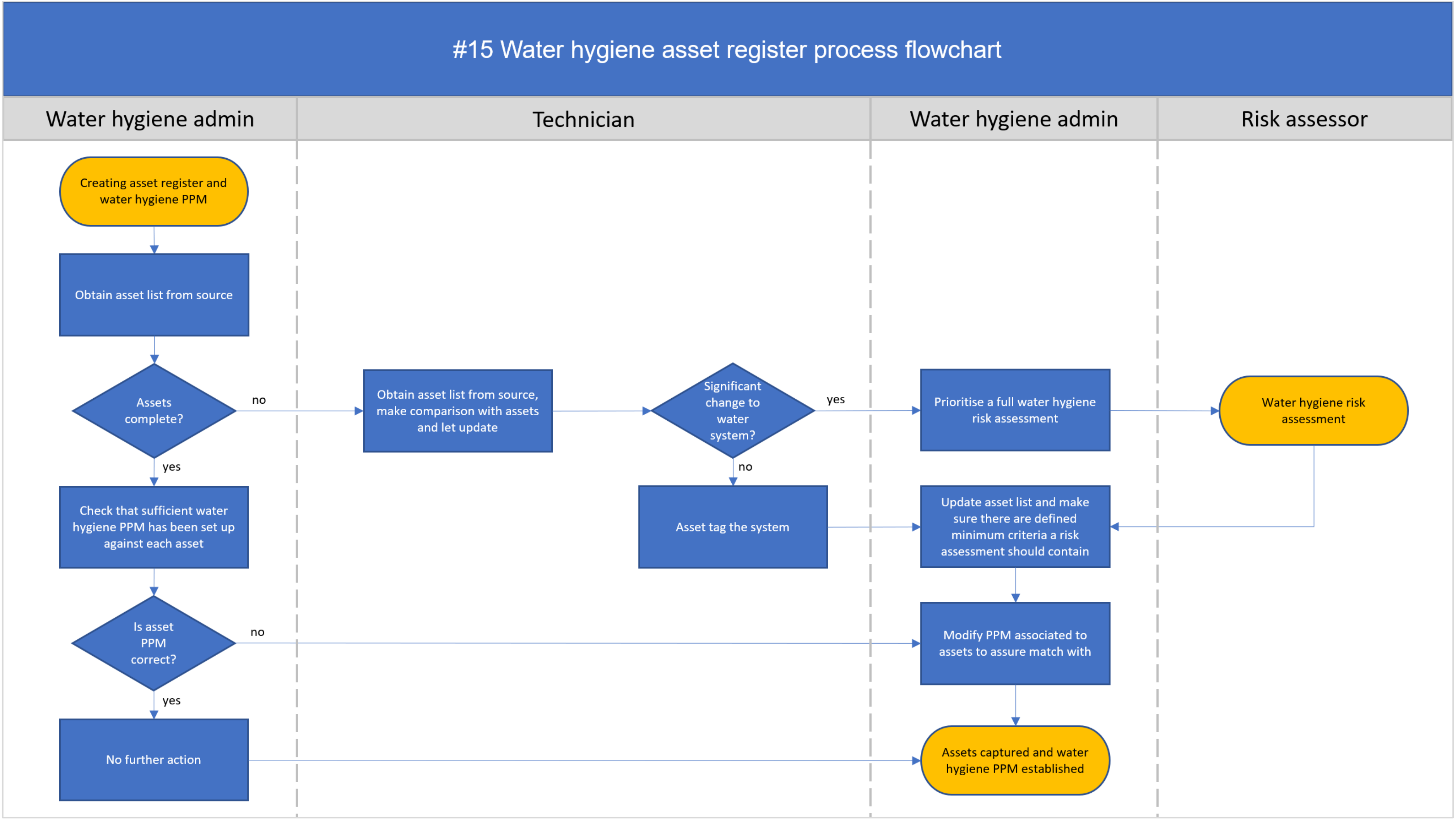


Figure 8-17: Water hygiene asset register process flowchart

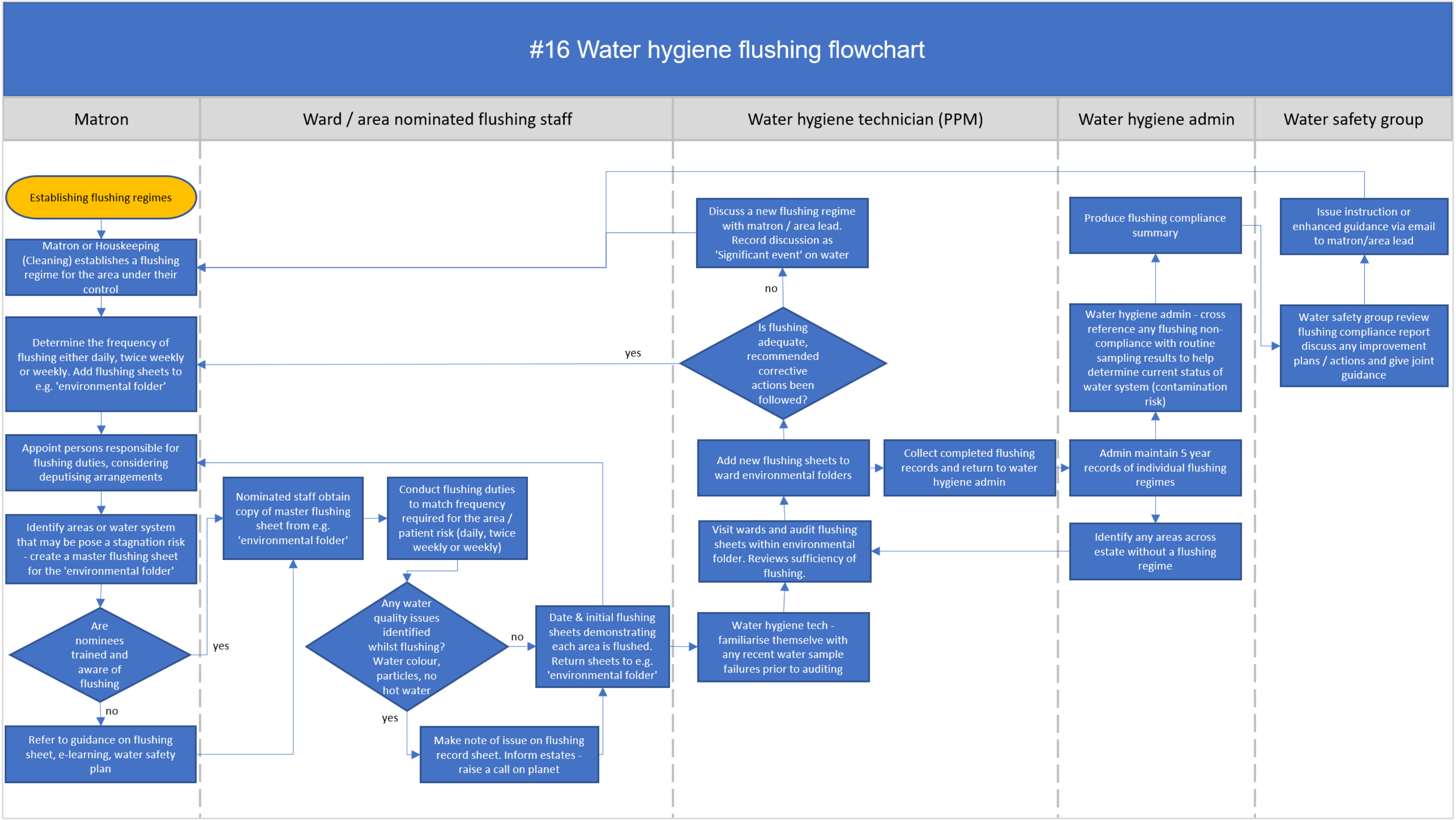


Figure 8-18: Water hygiene flushing flowchart

#17 Monitoring compliance and effectiveness by audits/reviews

Element of Water Safety Plan	When	How	Who	Reports to	Deficiencies / gaps / recommendations and actions
Policy	Every 3 years	Audit/review	RP [Water] AE [Water]	WSG	Review, update, sign off and send for ratification
WSP/Tech	Annually	Audit/review	DRP [Water] AP [Water] AE [Water]	WSG	Review, update, sign off and adopted by WSG
Incident Reports	Quarterly	Review	RP [Water]	WSG	Review, update, sign off
Audit - Management	Annually	Audit	RP [Water] DRP [Water] AE [Water]	WSG	Ensure the Trust remain compliant. Recommendations on to Water Issues Log.
Audit - Records & Performance	Monthly & Quarterly	Audit	DRP [Water] AE [Water]	WSG	Ensure the Trust remain compliant. Recommendations on to Water Issues Log.
Risk Assessments (RA) [incl. schematics]	Monthly & Quarterly	Audit/review	DRP [Water] AP [Water] Capital Projects IC Lead	WSG	Ensure risk assessments remain current.
RA Action Plans	Monthly & Quarterly	Audit/review	DRP [Water] AP [Water]	WSG	Ensure actions arising from WSG and annual audits are complete.
Training Matrix	Quarterly	Review	RP [Water]	WSG	Ensure each person involved with ensuring water safety remains up to date with training.

Figure 8-19: Monitoring compliance and effectiveness by audits/reviews

#18 Water safety skills matrix

				Awareness							Managing		Specialist training				Professional memberships		
	Role	Duties	Trust induction and mandatory training	L8 ACop awareness	*Pseudomonas* awareness	*Legionella*: Hot and cold water systems	*Legionella*: Cooling towers and air conditioning equipment	*Legionella* risk assessment of water systems	Disinfection of water supply systems in buildings	*Legionella*: Water systems refresher	Role of the Responsible Person/Duty holder/Landlord	*Legionella*: Hot and cold water systems, cooling towers and air conditioning systems including disinfection	Water supply (water fittings) Regulations	Thermostatic mixing valves	Healthcare premises hot and cold water systems	Management and maintenance of pool systems	Water Management Society (or similar)	*Legionella* Control Association	National Water Hygiene Scheme
Trust Management	Duty Holder	Overall duty of care responsibility for compliance	M								R								
	Water Safety Group	Water safety consultation and assure compliance	M	M	M					R	R								
	Responsible Person (RP)	Develop policy and quality assurance	M		M	M	M	M	M		M	M	R		M				
	Deputy Responsible Person (DRP)	Develop plans, procedures (day to day management)	M		M	M	M	M	M		M	M	M		M		R		
PFI	Enabling consortium	Ensure that accountable systems are in place. Fulfil duties according to contractual arrangements outlined according to "PFI golden triangle"	M	R	R	R	R	R	R	R									
AP	Authorised Person (AP) Independent advisor, such as: authorising engineer, microbiologist consultant	Nominated by the RP. Managing risk (re-)assessment programme. Implementation of any necessary remedial works in-line with risk minimisation scheme. Ensuring only UKAS approved laboratories are used for Legionella/Pseudomonas testing	M	M	M	M	M	M	M	M		M	R	R	M	R			
Trust Operational Staff	Estates Maintenance Manager (CH)	Promote water safety through installation and repairs	M	M	M					M									
	Ward/Area/Building Managers (CH)	Appoint competent cleaners/housekeepers	M	M	M					M									
	Cleaning/Housekeeping (CH)	Flushing cleanliness of outlets	M	M	M					M									
	Estates Maintenance (CH)	Maintenance, repair of plant and water fittings (incl. pools)	M	M	M	M	R			M				M		M			
Water Hygiene Contractor	Contract Manager (CH)	Resource Legionella ACop requirements (HSG274)	M		M	M	M	M	M		M	M			M		R	M	
	Admin Staff (CH)	Coordinate contract resource & record keeping	M	M	M					M									
	Risk Assessor (CH)*	Prepare assessments and schemes of control	M		M	M	R	M	M	M		M	M		M			M	
	Water Hygiene Technician (CH)*	Fulfil schemes of control	M		M	M	R		R	M		M	M	M	M			M	
	Plumber (CH)*	Maintain water fittings and investigation non-compliance	M		M	M			R	M			M	M	M			M	M

*This training is Trust specific and on the provision that the Water Hygiene Contractor has appointed professionally competent persons
Note: It is recommended that refresher training should occur every 3 to 5 years.
RP = Responsible Person, DRP = Deputy Responsible Person, CH = Competent Help
M = Mandatory training, R = Recommended training where relevant to the role

Figure 8-20: Water safety skills matrix

8.1 Framework compliance monitor

The compliance to the framework monitor enables the person responsible to apply an excel based list and self-assess the level of compliance for every framework element by a value in a given range interval (Figure 8-21).

	Value		Self assessment
non-compliance	0-25%		**n/a**
medium compliance	25-75%		**P** - partly implemented
full/almost full compliance	75-100%		**F** - fully implemented

Figure 8-21: Values for compliance level categories and self assessment categories

The speedometer indicates the level of compliance (Figure 8-22). The person responsible can apply the framework compliance monitor for continuously measuring and monitoring the compliance to the framework that he might want to achieve. For each framework element (Figure 8-23, Figure 8-24 and Figure 8-25) created for the framework there is given specific explanation. He can assign each framework element organisation specific (hospital / trust) examples to clarify specifications for each element of the framework.

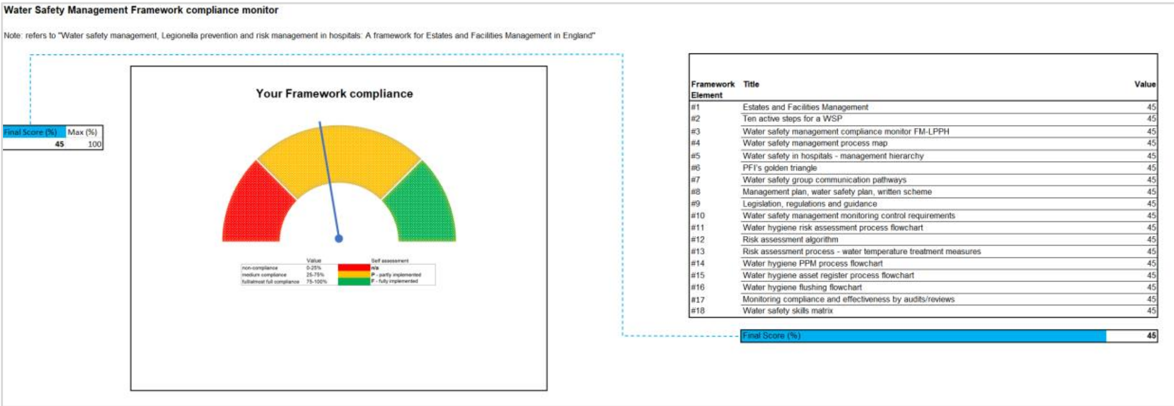


Figure 8-22: Water safety management Framework compliance monitor (*Legionella*)

Framework

	Element		Explanation		Example	Self assessment n/a	P	F
1	Estates and Facilities Management		Holistic view and management instruments.	»				
2	Ten active steps for a WSP		Ten active steps to develop, maintain and continuously improve an effective water safety plan, according to WHO.	»				
3	Water safety management compliance monitor		With the help of the MS Excel based framework and process monitor, the compliance to framework elements and the compliance to processes from element #4 of the framework can be checked. The aim is to have the individual elements checked by the process owner. The process owner makes a self-assessment of the degree of fulfillment of proposed elements according to a given scaling. The monitors generate a key figure for overall compliance. They can be used as an internal checklist and can be periodically used to improve the process.	»				
4	Water safety management process map	»	Core process, Main processes, Sub processes, Tasks. A hospital should clearly determine its process map, process hierarchy and process elements.	»				
5	Water safety in hospitals - management hierarchy	»	This is a more detailed version of an organogram showing certain responsibilities and management structures. The legend in the up-right corner differs activities between management, instruction/management, and information/consultation.	»				
6	PFI's golden triangle	»	Basically, there's the golden triangle, which is the Private Finance Initiative (PFI) provider, the consortium, the bankers, the people who fund the PFI, who have a responsibility to ensure that systems are in place. A well-run PFI that has good backers and a good trust checking, will always have the potential providing sufficient money. The aim is to establish transparency about responsibilities and obligations within PFI-organised contracts.	»				
7	Water safety group communication pathways	»	There is a certain structure in communication. There are hierarchies, direct, indirect, mono-directional and bi-directional communication. A Trust or hospital has to determine the way how communication is done (formalisms, frequencies, contents, involved stakeholders).	»				
8	Management plan, water safety plan, written scheme	»	The water safety plan incorporates core elements. Reading from left to right (management policy, risk assessments and schematics, operational procedures, log books) they complement and operationalise the mode of working in a systematic, structured and reproducible way. It enables for achieving continuous quality improvement and to ensure proper operation.	»				

Figure 8-23: Framework compliance elements self assessment, elements 1-8

9 Legislation, regulations and guidance	»	This is a summary of contemporary UK-specific legislation, regulations and guidance. It should be proven whether or not there is potential further guidance for the process owner to get informed on procedures.	»	
10 Water safety management monitoring control requirements	»	A summary of selected main points of requirements and their exact reference. It should be cross-checked whether or not the present water safety plan considers the points listed here.	»	
11 Water hygiene risk assessment process flowchart	»	One central element to evaluate the current state of a hospital's water system is the water hygiene risk assessment. It allows a systematic review and detection of risk factors and areas of risk. High patient risk areas, or generally speaking the determination of priority areas and the development of a risk based assessment programme that trigger next priorited assessments make it necessary for example to obtain up-to-date drawings (CAD plans). Site contracts need to be reviewed to confirm Risk Assessment is to take place. Previous monitoring and control records, sample results and flushing records need to be compiled for the assessor. He/She visits the area and determines the scope of assessment. Together with the Area Manager or Lead Matron, site specific roles and responsibilities, i.e. persons in charge and those with flush duties. The water hygiene risk assessment is complemented with asset tagging the system and compiling asset tag spreadsheet. The water hygiene admin hast to transfer and implement into the organisations management and operations logic. This also includes issuing summary report to the WSG and maintaining recommendation status and prioritisation process (site specific risk / individual recommendations risk). A proposed water hygiene risk assesment flow chart with different parties involved suggests of how risk assessment could be achieved systematically.	»	
12 Risk assessment algorithm	»	A risk assessment algorithm for the public health response to the detection of *Legionella* by health protection teams.	»	
13 Risk assessment process - water temperature treatment measures	»	A helpful strategy is a diagnostic flowchart for the initial assessment of *Legionella* risk rated on the water temperature treatment in an existing hot water drinking system. Critical control points, monitoring strategy and schedule should be put into place.	»	
14 Water hygiene PPM process flowchart	»	1) Starts at the top left column with water hygiene admin (review asset tag spreadsheed; Crosscheck accuracy of typing, rooms, names); maintain updated plans. Involve the whole system / sub-systems. Prioritise the systems based on patient risk. 2) It goes further to the technician. Conduct PPM on asset as per prioritised systems and record findings. DO ASSESTS MATCH PPM? 3) Again water hygiene admin. Review PPM results – check for any non-compliance. Review corrective actions and arrange update fault log --> Produce detail and summary compliance reports to hospital/trust, and other. PPM, sampling, remedials. Present exception reports to WSG. 4) If there is non-compliance: Investigate non-compliance and take corrective action or make recommendation. If a matter can not be resolved then (contract manager and water safety manager) review fault log and advise next actions. Consideration to revised control scheme, conduct further remedials, sampling, risk assessment or other. Consider escalation to WSG.	»	

Figure 8-24: Framework compliance elements self assessment, elements 9-14

15 Water hygiene asset register process flowchart	»	Creating asset register and water hygiene PPM. Do assets match planet? Is asset PPM correct? Significant changes to water system? Role of the risk assessor: Water hygiene risk assessment. All activities should result in the output: Assets captured and water hygiene PPM established.	»	
16 Water hygiene flushing flowchart	»	Flushing needs awareness and consequence in doing. As a consequence flushing regimes must be established. Ideally the Matron establishes a flushing regime for the area under their control. It further needs: - a determination of the frequency of flushing; - appointing persons for flushing duties; - identify areas or water systems that may pose a stagnation risk (draw a master flushing sheet); - nominees must be trained and aware of flushing. The ward/area nominated flushing staff identifies any further water quality issues whilst flushing (e.g. colour, particles, no hot water where there should be). Monthly audits by water hygiene technician that include familiarising themselves with any recent water sample failure prior to auditing. He visits wards and audits flushing sheets. He discusses whether flushing is adequate, and recommended corrective actions been followed. Water hygiene admin cross reference any flushing non-compliance with routine sampling results to help determine current status of water system. They also produce the flushing compliance summary. The water safety group review the flushing compliance report, discuss any improvement plans or actions and give joint guidance. They issue instruction or enhance guidance to matron or area lead.	»	
17 Monitoring compliance and effectiveness by audits/reviews	»	It is important to conduct audits and reviews for monitoring and improving compliance. A scheme for certain documents relevant within a WSP, the period, the person responsible, the accountability and recommendations for actions should briefly be summarised. The persons with responsibility for a document review/audit element should be informed, trained and aware about their duty.	»	
18 Water safety skills matrix	»	Training should be independent for the the lead trainers and then train the trainer. On the left side we see three different main-categories. Trust Management, Trust Operational Staff, Water Hygiene Contractor, with their roles and duties. According to different skills this matrix shows mandatory training – indicated by a "M" and recommended training indicated by a "R". This is done for 'Awareness', 'Managing', 'Specialist training' and 'Accreditations'.	»	

Figure 8-25: Framework compliance elements self assessment, elements 15-18

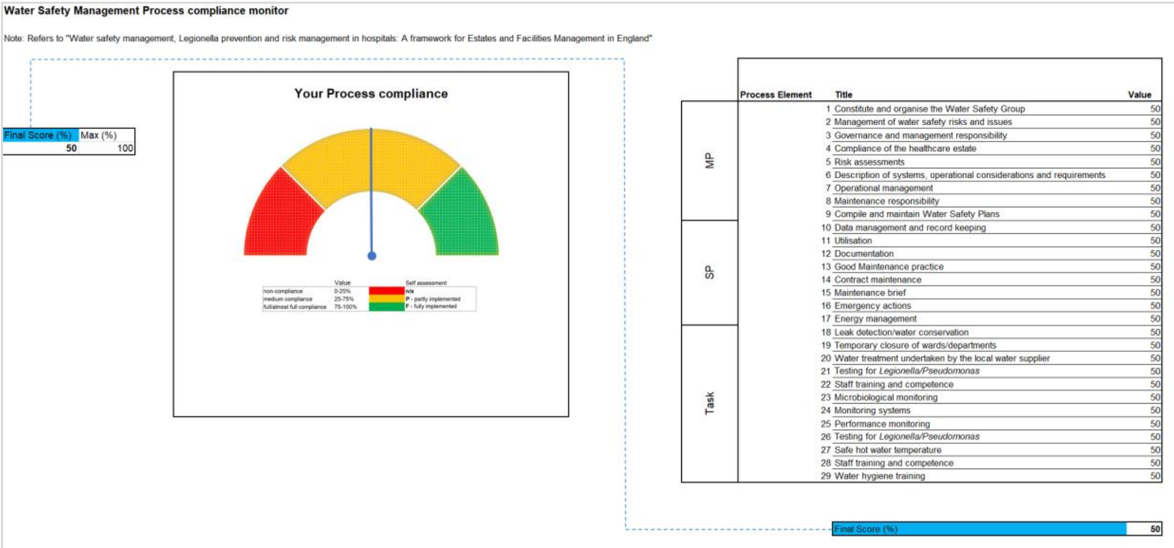
8.2 Process compliance monitor

The process compliance monitor enables the person responsible to apply an excel based list and self-assess the level of compliance for every process element by a value in a given range interval (Figure 8-26).

	Value		Self assessment
non-compliance	0-25%		**n/a**
medium compliance	25-75%		**P** - partly implemented
full/almost full compliance	75-100%		**F** - fully implemented

Figure 8-26: Values for compliance level categories and self assessment categories

The speedometer indicates the level of compliance (Figure 8-28). The person responsible can apply the process compliance monitor for continuously measuring and monitoring the process compliance, according to the main processes (Figure 8-28), sub processes (Figure 8-29) and tasks (Figure 8-29) identified in this research and being part of the framework. For each process element he can attribute organisation specific (hospital / trust) explanations and give examples to clarify specifications relevant for each element.



	Process Element	Title	Value
MP	1	Constitute and organise the Water Safety Group	50
	2	Management of water safety risks and issues	50
	3	Governance and management responsibility	50
	4	Compliance of the healthcare estate	50
	5	Risk assessments	50
	6	Description of systems, operational considerations and requirements	50
	7	Operational management	50
	8	Maintenance responsibility	50
	9	Compile and maintain Water Safety Plans	50
SP	10	Data management and record keeping	50
	11	Utilisation	50
	12	Documentation	50
	13	Good Maintenance practice	50
	14	Contract maintenance	50
	15	Maintenance brief	50
	16	Emergency actions	50
	17	Energy management	50
Task	18	Leak detection/water conservation	50
	19	Temporary closure of wards/departments	50
	20	Water treatment undertaken by the local water supplier	50
	21	Testing for *Legionella/Pseudomonas*	50
	22	Staff training and competence	50
	23	Microbiological monitoring	50
	24	Monitoring systems	50
	25	Performance monitoring	50
	26	Testing for *Legionella/Pseudomonas*	50
	27	Safe hot water temperature	50
	28	Staff training and competence	50
	29	Water hygiene training	50

Figure 8-27: Water safety management Process compliance monitor (*Legionella*)

MP Main Process

Element	Explanation	Example	Self assessment n/a	P	F
1 Constitute and organise the Water Safety Group	»	»			
2 Management of water safety risks and issues	»	»			
3 Governance and management responsibility	»	»			
4 Compliance of the healthcare estate	»	»			
5 Risk assessments	»	»			
6 Description of systems, operational considerations and requirements	»	»			
7 Operational management	»	»			
8 Maintenance responsibility	»	»			
9 Compile and maintain Water Safety Plans	»	»			

Figure 8-28: Process compliance: Main process self assessment

SP Sub Process

Element	Explanation	Example	Self assessment n/a	P	F
10 Data management and record keeping	»	»			
11 Utilisation	»	»			
12 Documentation	»	»			
13 Good Maintenance practice	»	»			
14 Contract maintenance	»	»			
15 Maintenance brief	»	»			
16 Emergency actions	»	»			
17 Energy management	»	»			

Figure 8-29: Process compliance: Sub process self assessment

Task

Element	Explanation	Example	Self assessment n/a	P	F
18 Leak detection/water conservation	»	»	○	○	○
19 Temporary closure of wards/departments	»	»	○	○	○
20 Water treatment undertaken by the local water undertaker	»	»	○	○	○
21 Testing for Legionella/Pseudomonas	»	»	○	○	○
22 Staff training and competence	»	»	○	○	○
23 Microbiological monitoring	»	»	○	○	○
24 Monitoring systems	»	»	○	○	○
25 Performance monitoring	»	»	○	○	○
26 Testing for *Legionella/Pseudomonas*	»	»	○	○	○
27 Safe hot water temperature	»	»	○	○	○
28 Staff training and competence	»	»	○	○	○
29 Water hygiene training	»	»	○	○	○

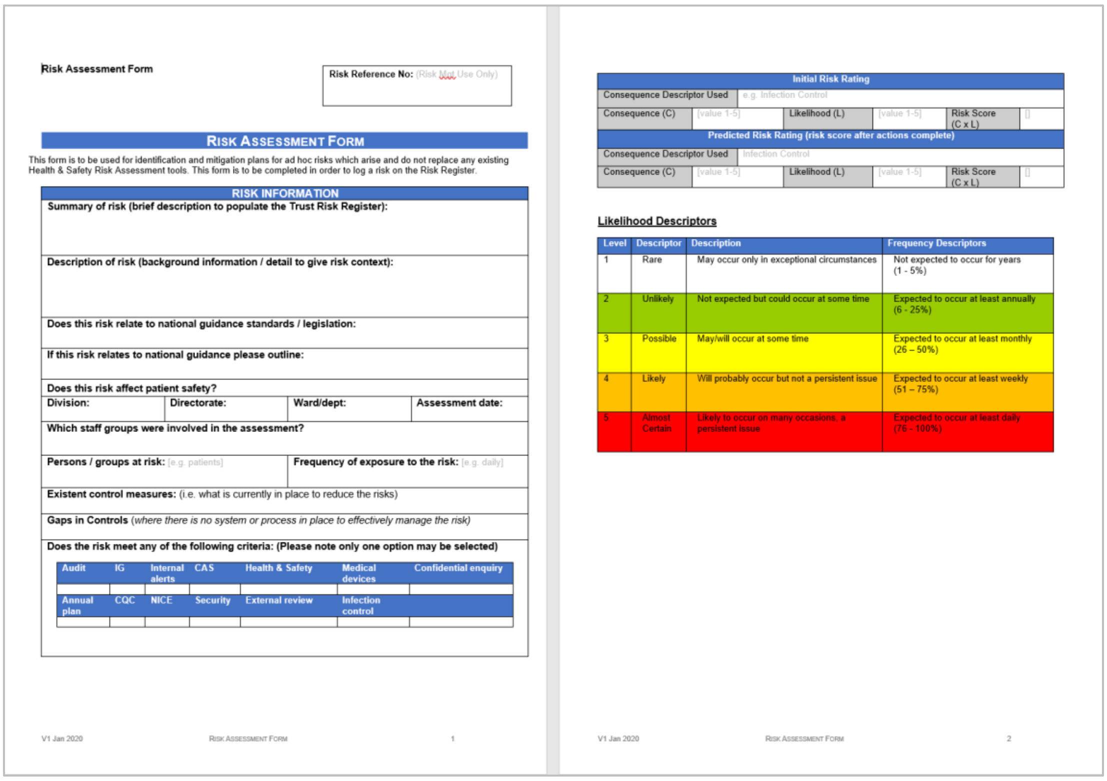
Figure 8-30: Process compliance: Task self assessment

8.3 Templates and additional documents

The following three chapters complement the framework by presenting three template documents. The template documents are intended to be made available in combinaton with the framework by one independent actor of those presented in chapter 4.6.

The three documents are attached electronically each as an MS Word document and referenced in chapter Appendix G.

8.3.1 Risk assessment form template (8 pages)



Risk Assessment Form

Risk Reference No: (Risk Mgt Use Only)

RISK ASSESSMENT FORM

This form is to be used for identification and mitigation plans for ad hoc risks which arise and do not replace any existing Health & Safety Risk Assessment tools. This form is to be completed in order to log a risk on the Risk Register.

RISK INFORMATION			
Summary of risk (brief description to populate the Trust Risk Register):			
Description of risk (background information / detail to give risk context):			
Does this risk relate to national guidance standards / legislation:			
If this risk relates to national guidance please outline:			
Does this risk affect patient safety?			
Division:	**Directorate:**	**Ward/dept:**	**Assessment date:**
Which staff groups were involved in the assessment?			
Persons / groups at risk: [e.g. patients]		**Frequency of exposure to the risk:** [e.g. daily]	
Existent control measures: (i.e. what is currently in place to reduce the risks)			
Gaps in Controls (*where there is no system or process in place to effectively manage the risk)*			
Does the risk meet any of the following criteria: (Please note only one option may be selected)			

Audit	IG	Internal alerts	CAS	Health & Safety	Medical devices	Confidential enquiry
Annual plan	**CQC**	**NICE**	**Security**	**External review**	**Infection control**	

V1 Jan 2020 RISK ASSESSMENT FORM 1

Initial Risk Rating					
Consequence Descriptor Used	e.g. Infection Control				
Consequence (C)	[value 1-5]	Likelihood (L)	[value 1-5]	Risk Score (C x L)	[]
Predicted Risk Rating (risk score after actions complete)					
Consequence Descriptor Used	Infection Control				
Consequence (C)	[value 1-5]	Likelihood (L)	[value 1-5]	Risk Score (C x L)	[]

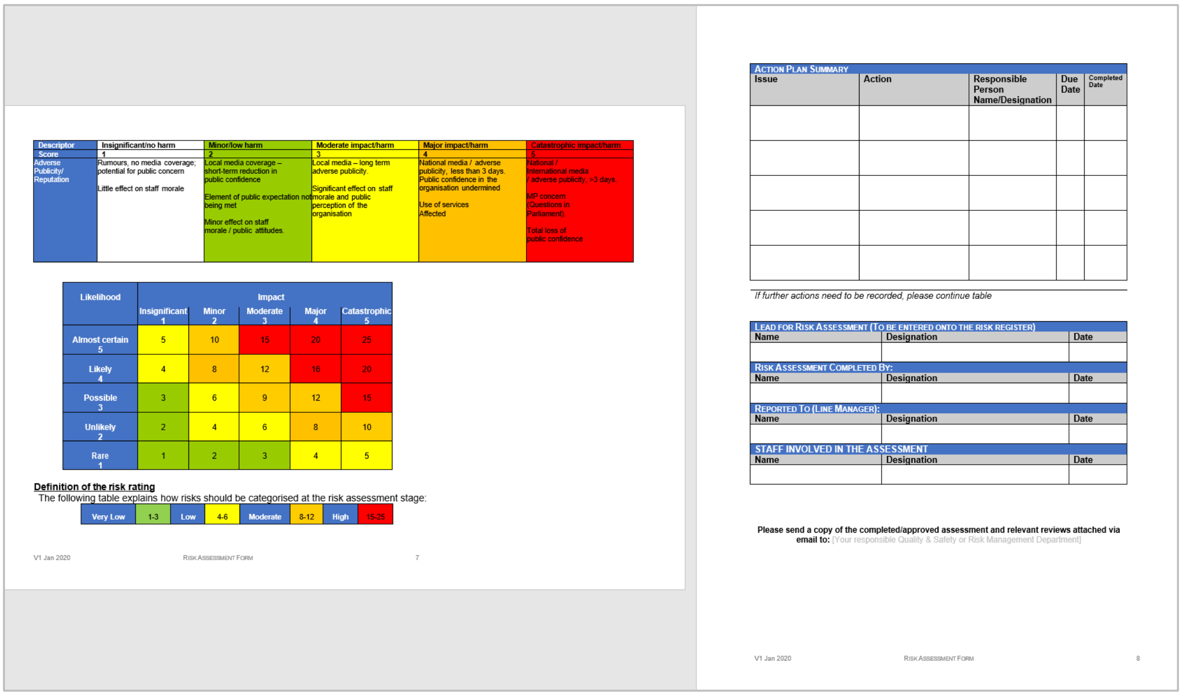
Likelihood Descriptors

Level	Descriptor	Description	Frequency Descriptors
1	Rare	May occur only in exceptional circumstances	Not expected to occur for years (1 - 5%)
2	Unlikely	Not expected but could occur at some time	Expected to occur at least annually (6 - 25%)
3	Possible	May/will occur at some time	Expected to occur at least monthly (26 – 50%)
4	Likely	Will probably occur but not a persistent issue	Expected to occur at least weekly (51 – 75%)
5	Almost Certain	Likely to occur on many occasions, a persistent issue	Expected to occur at least daily (76 - 100%)

V1 Jan 2020 RISK ASSESSMENT FORM 2

Figure 8-31: Framework additional document - Template Risk Assessment Form, pages 1-2

Figure 8-32: Framework additional document - Template Risk Assessment Form, pages 3-6



Likelihood	Impact: Insignificant 1	Minor 2	Moderate 3	Major 4	Catastrophic 5
Almost certain 5	5	10	15	20	25
Likely 4	4	8	12	16	20
Possible 3	3	6	9	12	15
Unlikely 2	2	4	6	8	10
Rare 1	1	2	3	4	5

Definition of the risk rating

The following table explains how risks should be categorised at the risk assessment stage:

Very Low	1-3	Low	4-6	Moderate	8-12	High	15-25

ACTION PLAN SUMMARY				
Issue	Action	Responsible Person Name/Designation	Due Date	Completed Date

If further actions need to be recorded, please continue table

LEAD FOR RISK ASSESSMENT (TO BE ENTERED ONTO THE RISK REGISTER): Name | Designation | Date

RISK ASSESSMENT COMPLETED BY: Name | Designation | Date

REPORTED TO (LINE MANAGER): Name | Designation | Date

STAFF INVOLVED IN THE ASSESSMENT: Name | Designation | Date

Please send a copy of the completed/approved assessment and relevant reviews attached via email to: [Your responsible Quality & Safety or Risk Management Department]

Figure 8-33: Framework additional document - Template Risk Assessment Form, pages 7-8

8.3.2 Corrective and remedial actions (4 pages)

WATER SAFETY PLAN - CORRECTIVE AND REMEDIAL ACTIONS

The hospitals/Trusts Responsible Person (RP) for water is responsible for ensuring issues are managed appropriately and ensure the Deputy Responsible Person (DRP) has sufficient resources available to address issues as they arise and in a timely and sufficient manner.

The Water Safety Manager (DRP) is responsible for documenting, prioritising and coordinating a water system improvement plan. Water system design issues may be captured through various procedures; risk assessment, sampling, schemes of control and normal day-to-day observations.

All defects are reported to the Water Safety Manager who maintains a central register. Details will include date identified, assessed risk, location details, recommended actions, priority of works, work order reference numbers, date complete and any other relevant comments.

The prioritisation of defects can be determined by considering:

- Will the defect affect a 'High Patient Risk Area'?
- Is there an immediate *Legionella* or *Pseudomonas* risk?
- Is there an immediate scald risk?
- Is there a risk of exposure to contaminated water aerosol?
- Is the system currently operating in compliance with standards or recommendations (ACoP, HSG274, HTM 04-01, BS 8580-1:2019)?

There are many considerations to take into account when priority defects. Therefore it is important that only persons experienced in identifying and controlling water safety risks should assess defects, determine remedial actions and the priorities.

Dependant on severity and likelihood of risk the remedial actions could take several routes.

- Immediate risks, typically resolved by the Water Safety Contractor as 'reactive works', an immediate action will occur to mitigate risk, such as a local disinfection and installation of POU water filters to retain any bacteria present in the water system.
- Minor defects encountered whilst fulfilling the planned schemes of control such as broken taps, faulty valves, sink blockages, flexible hoses, small redundant pipes, etc may be dealt with either by the Water Safety Contractor on volume of work and if a 'quick fix' is possible or by Estates Maintenance where the task is likely to be more than an hour or involve several trades.
- More significant issues such as poor water circulation, redundant pipes, non-compliant installations, etc. shall be investigated and risk assessed initially by the Water Safety Contractor, or better an independent risk assessor. This investigation shall provide the detailed information necessary to determine any recommendations to improve compliance, immediate additional controls to mitigate risk and how to resource the remedial actions.

Certain issues which cannot be addressed in a timely manner due to cost, access, safety, etc. will be recorded as recommendations on the Water Safety Database. Significant issues will be discussed at the Water Safety Group, where any additional precautions may be agreed to mitigate risk.

V1 Jan 2020 CORRECTIVE AND REMEDIAL ACTIONS 1

DEFECT	TYPE OF DEFECT AND ACTIONS	RECTIFICATION PERIOD
PRIORITY 1	Issues that pose an immediate risk when considering severity of issue and vulnerability of persons potentially affected. *Typically: Legionella, Pseudomonas, scald or contaminated aerosol risks identified by water discolouration, water sample failure, repeat water or temperature issues, unclean strainers ,biofilm, no TMV3, stagnation risks.* *Actions: Plumber / Technician to liaise with Contract Administrator to verify current workloads to attempt to resolve as Reactive Works or raise an Estates Call. Consult with Water Safety manager, risk assess situation, consider clinical risk, determine solution, prepare audit trail by documenting defects and actions taken.*	Immediate (90% of actions taken by water safety contractor as 'Reactive works') or (10% work order for Estates Maintenance) (10 day response)
PRIORITY 2	Issues that pose a foreseeable but not immediate risk, which will improve compliance and ability to control and manage a water system. *Examples – Removal of small diameter saunders valves which are restricting flow or circulation, replacing deteriorated flexible hoses(> 1 year old), improving hot water circulation, adding pipe insulation, removing plastic plumbing.* *Action: Risk assess situation, consider clinical risk, report defects, location and recommendations to Water Safety Contract Administrator. Log a call on Planet for Estates to resolve.*	Within 3 months (90 day) (Majority dealt with by Estates Maintenance) or (Utilising any spare capacity within Water Safety Contract)
PRIORITY 3	Requirements which will bring compliance with current best practices or policy. *Typically actions to address non compliances which although do not pose an immediate risk would be likely to cause water quality risks in the long term. (ie Sensor taps valves which are safe to use in the short term but due to their complex nature can deteriorate over time and encourage conditions for legionella growth, lack of balancing valves).* *Action: Risk assess, report defects, location and recommendations to Water Safety Contract Administrator. Log issue and details on defect register. Water Safety Manager to add defects to central water safety database and combined with Risk Assessment Recommendations for future works.*	Within 12 months (typically sub contracted work packages)
PRIORITY 4	Issues which would have low water quality risk or would improve other Health and Safety. Ie installation of ladders, safe access or removal of large diameter saunders valves which have a high flow of water and low risk but which may involve major shutdowns to replace. *Action: Risk assess, report defects, location and recommendations to Water Safety Contract Administrator. Log issue and details on defect register. Water Safety Manager to add defects to central water safety database and combined with Risk Assessment Recommendations for future works.*	When appropriate (Typically addressed through Projects through refurbishment)

The above list is not exhaustive and each defect or issue will need to be assessed to determine the priority of remedial works.

V1 Jan 2020 CORRECTIVE AND REMEDIAL ACTIONS 2

Figure 8-34: Framework additional document - Corrective and remedial actions, pages 1-2

Example a redundant live water pipe is identified and needs to be managed. Dependant on location, orientation, material, size, temperature this pipe could be prioritised in many ways. This is why it is essential that trained staff assess risks and assign priorities.

ISSUE	CLINICAL RISK OF AREA AFFECTED	PRIORITY	ACTION
Deadleg identified	High	1	Remove immediately
Deadleg identified	Medium	2	Remove next 3 months
Deadleg identified	Low	3	Remove next 12 months
Deadleg and water discolouration evident	High	1	Remove immediately
Deadleg and water discolouration evident	Medium	1	Remove immediately
Deadleg and water discolouration evident	Low	2	Remove next 3 months
Deadleg (Copper, short, pointing upwards)	High	2	Remove next 3 months
Deadleg (Copper, short, pointing upwards)	Medium	3	Remove next 12 months
Deadleg (Copper, short, pointing upwards)	Low	4	Remove when appropriate

CREATING WORK ORDERS

Where a work order is produced this must convey sufficient information for any engineer to understand the defect, requirement, recommendation, risk and priority.

The following gives a guide on the information that should be included within a work order:

WORK ORDER 1

Instruction: Please remove deadleg located above shower panel, trace back to point of origin and remove from source (including 'T')'.

Engineering risk: Likely to promote water stagnation and promote Legionella growth.

Clinical Risk: High Patient risk area.

Priority 1: (10 days) This poses an immediate Legionella exposure risk

WORK ORDER 2

Instruction: Please investigate hot water system associated with sink no. 123456, temperatures do not reach 55°C within 1 minute. Suggest poor hot water circulation balancing valves may need attention.

Engineering risk: Likely to promote water stagnation and promote Legionella growth.

Clinical Risk: Medium patient risk area.

Priority 2: (90 days) Likely to deteriorate if not addressed within a reasonable time.

WORK ORDER 3

Instruction: Please remove flexible hoses serving basin taps, replace with copper. (sink 123456).
Engineering risk: Flexible hoses are known to develop biofilms which support Legionella, Pseudomonas growth.

Clinical Risk: Medium Patient risk area.

V1 Jan 2020 CORRECTIVE AND REMEDIAL ACTIONS 3

Priority 3: (12 Months) Foreseeable water quality risk (Legionella).

WORK ORDER 4

Instruction: Please remove flexible hoses serving basin taps, replace with copper. (sink 210234).
Engineering risk: Flexible hoses are known to develop biofilms which support Legionella, Pseudomonas growth.

Clinical Risk: High Patient risk area.

Priority 1: (10 days) This poses an immediate Legionella, Pseudomonas exposure risk

WORK ORDER 5

Instruction: Please install a TMV3 thermostatic mixing arrangement to Shower (121212).
Engineering risk: The hot water is not sufficient governed giving temperatures above 55°C.

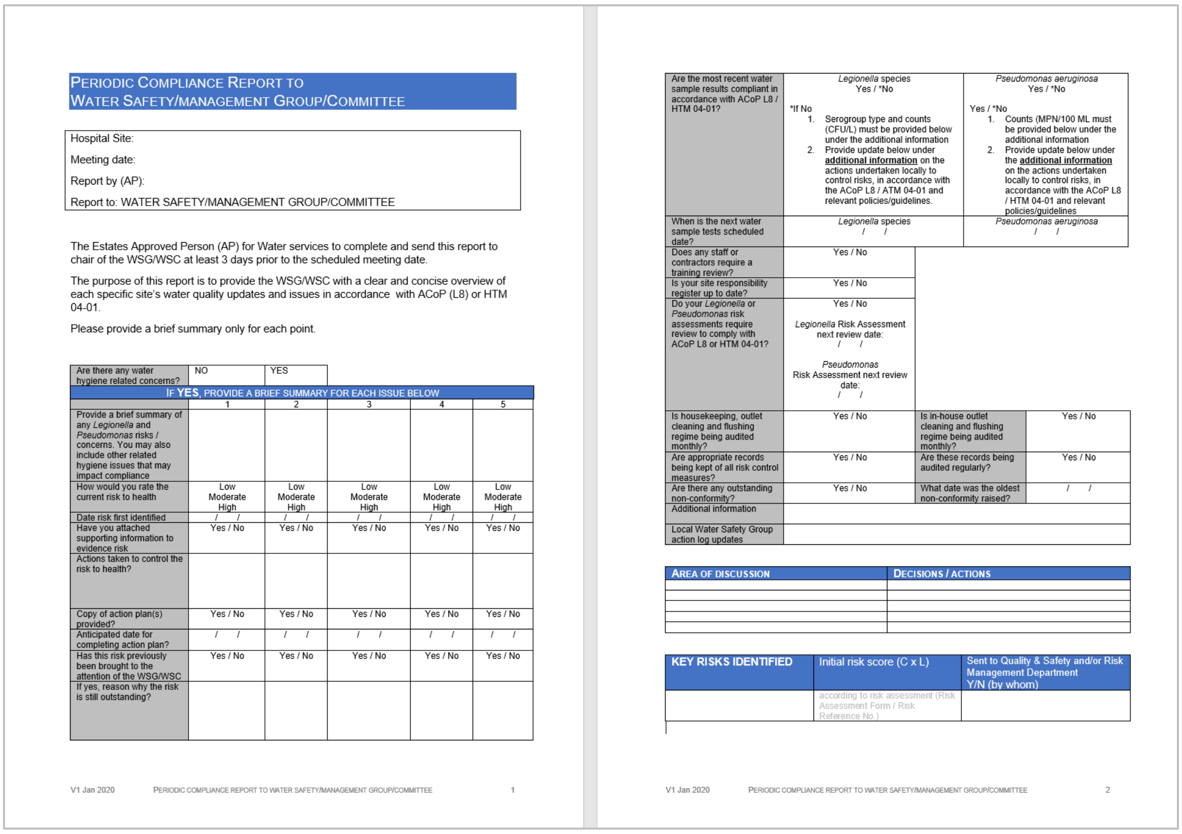
Clinical Risk: Low Patient risk area.

Priority 1: (10 days) There is an immediate scald risk.

V1 Jan 2020 CORRECTIVE AND REMEDIAL ACTIONS 4

Figure 8-35: Framework additional document - Corrective and remedial actions, pages 3-4

8.3.3 Compliance report (2 pages)



PERIODIC COMPLIANCE REPORT TO
WATER SAFETY/MANAGEMENT GROUP/COMMITTEE

Hospital Site:
Meeting date:
Report by (AP):
Report to: WATER SAFETY/MANAGEMENT GROUP/COMMITTEE

The Estates Approved Person (AP) for Water services to complete and send this report to chair of the WSG/WSC at least 3 days prior to the scheduled meeting date.

The purpose of this report is to provide the WSG/WSC with a clear and concise overview of each specific site's water quality updates and issues in accordance with ACoP (L8) or HTM 04-01.

Please provide a brief summary only for each point.

Are there any water hygiene related concerns?	NO	YES			
IF YES, PROVIDE A BRIEF SUMMARY FOR EACH ISSUE BELOW					
	1	2	3	4	5
Provide a brief summary of any *Legionella* and *Pseudomonas* risks / concerns. You may also include other related hygiene issues that may impact compliance					
How would you rate the current risk to health	Low Moderate High	Low Moderate High	Low Moderate High	Low Moderate High	Low Moderate High
Date risk first identified	/ /	/ /	/ /	/ /	/ /
Have you attached supporting information to evidence risk	Yes / No	Yes / No	Yes / No	Yes / No	Yes / No
Actions taken to control the risk to health?					
Copy of action plan(s) provided?	Yes / No	Yes / No	Yes / No	Yes / No	Yes / No
Anticipated date for completing action plan?	/ /	/ /	/ /	/ /	/ /
Has this risk previously been brought to the attention of the WSG/WSC	Yes / No	Yes / No	Yes / No	Yes / No	Yes / No
If yes, reason why the risk is still outstanding?					

V1 Jan 2020 PERIODIC COMPLIANCE REPORT TO WATER SAFETY/MANAGEMENT GROUP/COMMITTEE 1

Are the most recent water sample results compliant in accordance with ACoP L8 / HTM 04-01?	*Legionella* species Yes / *No *If No 1. Serogroup type and counts (CFU/L) must be provided below under the additional information 2. Provide update below under **additional information** on the actions undertaken locally to control risks, in accordance with the ACoP L8 / ATM 04-01 and relevant policies/guidelines.		*Pseudomonas aeruginosa* Yes / *No Yes / *No 1. Counts (MPN/100 ML must be provided below under the additional information 2. Provide update below under the **additional information** on the actions undertaken locally to control risks, in accordance with the ACoP L8 / HTM 04-01 and relevant policies/guidelines
When is the next water sample tests scheduled date?	*Legionella* species / /		*Pseudomonas aeruginosa* / /
Does any staff or contractors require a training review?	Yes / No		
Is your site responsibility register up to date?	Yes / No		
Do your *Legionella* or *Pseudomonas* risk assessments require review to comply with ACoP L8 or HTM 04-01?	Yes / No *Legionella* Risk Assessment next review date: / / *Pseudomonas* Risk Assessment next review date: / /		
Is housekeeping, outlet cleaning and flushing regime being audited monthly?	Yes / No	Is in-house outlet cleaning and flushing regime being audited monthly?	Yes / No
Are appropriate records being kept of all risk control measures?	Yes / No	Are these records being audited regularly?	Yes / No
Are there any outstanding non-conformity?	Yes / No	What date was the oldest non-conformity raised?	/ /
Additional information			
Local Water Safety Group action log updates			

AREA OF DISCUSSION	DECISIONS / ACTIONS

KEY RISKS IDENTIFIED	Initial risk score (C x L)	Sent to Quality & Safety and/or Risk Management Department Y/N (by whom)
	according to risk assessment (Risk Assessment Form / Risk Reference No.)	

V1 Jan 2020 PERIODIC COMPLIANCE REPORT TO WATER SAFETY/MANAGEMENT GROUP/COMMITTEE 2

Figure 8-36: Framework additional document - periodic compliance report, pages 1-2

8.4 Applicability of the framework

The overall aim of this research was to systematically reveal the present situation of *Legionella* risk management and prevention in water systems in selected organisations (hospitals) in healthcare and create a framework guiding people responsible for Estates and Facilities Management in healthcare organisations to identify, understand and properly take action on *Legionella* prevention and risk management for water safety.

Taking into consideration the results, the review on the research process (chapter 9.1) and on the objectives that have been achieved by applying the research method presented in this thesis, the aim was achieved with, finally, the framework output. Before the final framework version has been created, a previous version was validated by a panel of experts. This early version already contained elements that have been seen appreciable. The panel of experts attending the focus group framework validation, as described in chapter 7.7, question 6, Table 7-46 saw a practical benefit for the applicability of the framework. In the evaluation of the applicability of the framework in its early version, the experts' highlighted as follows:

> Expert 1: "I would use it as a review tool […], as a reference tool and something to check my own processes against to make sure everything that you had included on your framework is then included on my local procedures and policies and plans".

Expert 2: “Where it will become very valuable is probably to authorising engineers as an audit tool. […] I also like the idea of taking certain elements of it and incorporating them into more specific training modules”.

Expert 3: “I would use it as a tool to compare what other trusts have in place”.

Expert 4: “If it could be made more complete with the amendments and additions that we've talked about today, I think it would make an excellent tool for both daily use but also for incorporating into training as well”.

Expert 5: “It's more likely to be used as a checklist for agents to make sure that they have got all the processes in place. […] I think taking aspects out of it as a training and support tool. […] I particularly like your training matrix, so I think certain aspects of it will be picked out, but used as a checklist to make sure that those processes are in place.”

Concluding the aforementioned coments a general positive tendency for the applicability of the framework is predictable. Taking into consideration elements for improvement, that have been worked out during the focus group (see chapter 7.7), the framework has undergone specific revisions, which make it more complete in the final version of this thesis and thus “fit for applicability into practice”. This framework may help bridging the gap between theory and practice, between research and industry, and for future times support in training and education on the topic of *Legionella* prevention, and risk management in water systems in hospitals.

But i'ts not just documents that make processes work. It's the people and their commitment in serving for a specific target. Fot that it essentially needs awareness, identity, collaboration and properly deployed resources. May this framework contribute in generating whats’s needed.

9 Conclusion

Water hygiene in hospitals and, in general, the health care context bears sensitive information, not only at management levels. Any water safety group, which collaborates in an interdisciplinary team, is a professionalists group consisting of specialists of different fields of knowledge and responsibility. The purpose of their activities, according to their mission, intends to be proactive rather than reactive. Thus, they ideally follow an organisation's underlying risk management concept to structure their own work effectively, of course, provided that an organisation maintains one that is tailored to the organisation's processes and strategy. In order to give orientation and a common sense of understanding, it is important to have definitions of clear processes and management responsibilities, their roles and competencies in place.

Training, continuous improvement and the education of working group members is of great importance to develop a common 'language', easy to understand by everyone supporting the process, and to achieve success.

Business processes are important to keep any organisation running. Hygiene, which serves health, needs prevention strategies, which realise life saving measures. All activities should be guided by John Last's basic principles for hygiene and public health (Last, 1997), which are:

- calculate risks
- not only money is the driving factor
- awareness for people who are responsible.
- provision of sufficient resources
- respect for the autonomy of the individual (human dignity, freedom, rights of the individual)
- non maleficiency (principle of damage avoidance - primum non nocere)
- benefit (principle of "wanting to create good" for the general public)
- justice in an ethical sense (social justice and distributive justice)
- virtues such as prudence, honesty, compassion, integrity

This research has had a mission to investigate certain elements of management practices in hospitals at present, find evidence about processes and stakeholders serving water hygiene, *Legionella* prevention and risk management in hosptals, with a focus on Estates and Facilities management. For that, several principles of mixed methods research design, data collection and analysis methods have been successfully and purposefully applied throughout the duration of research.

9.1 Review on the research process

This research aimed at achieving the following research objectives:

(1) to identify stakeholders involved in the process of water safety management, *Legionella* prevention and risk management in hospitals,

(2) to analyse fields and functions of responsible management in the process of water safety management, *Legionella* prevention and risk management in hospitals,

(3) to identify and analyse processes in water safety management, *Legionella* prevention and risk management in hospitals from the perspective of responsible management, with special interest in Estates and Facilities Managementand stakeholders (focus: non-clinical),

(4) to review and consider current state and conformity to standards, legislation and regulations. The discussion therefore spots on risk management from an Estates and Facilities Management perspective,

(5) to identify points of overlapping duties in the process of *Legionella* prevention in water systems,

(6) to identify similarities and differences between hospitals in the process of water safety management, Legionella prevention and risk management with respect to management responsibilities by roles, commitment to role, and process elements.

By underlying the strategy for analysis for gaining evidence (chapter 6.10.2) and the recognition of the objectives in the respective analysis strategy for answering the subquestions for each phase, presented in chapter 6.15, and considering the triangulation approach presented in chapter 6.12.2, and therefore also performing aggregated analyses (chapter 7.6), the objectives have all been achieved in a systematic way.

The summary table of chapter 7.6.4 (Table 7-40 on page 259) presents very detailed the aims and purposes of the analyses procedures. Figure 6-3 presents the interplay of the sequences of the research phases and analyses. Pairwise comparison therefore was performed for achieving objectives 2, 3, and 6, free text entries from research phase II were helpful for achieving objectives 2, 5, and 6, with a focus on the identification of overlapping duties. The stakeholder analysis, matrix opposite and spider diagram analyses made possible achieving objectives 1,2,3,5, and 6. Elements of the PESTLE analysis (extrinsic focus) made possible to achieve objectives 1,2,3,4,5, and 6 having the focus on the identification of processes and stakeholders. The CTAAPM analysis (intrinsic focus) made possible to achieve objectives 1,2,3,4,5, and 6 having a focus on the identification of processes and stakeholders.

There is not a clear identification on full conformity to all current standards, legislation and regulations. It may be a lack of water safety policies and plans referencing selected elements only. It may aso be the present challenge of covering all recommendations with a gap in sufficient budgets of financing necessary and systematic remedial works on critical infrastructure (as water systems are). As identified, management procedures and the progress of completion had an orientation towards HTM 04-01. Aggregated analysis (chapter 7.6) realised process identification with 27 elements determining a process hierarchy with ‘main process’, 'sub-process' and 'tasks', being mapped in a process hierarchy. Stakeholder identification found 16 management responsibilities by role and its characterisation. Specifications were found where overlapping duties are experienced. Process owners, power and interest of process owners, presence of roles in organisations, and type of active role in processes have been identified and analysed.

As individual as people and oranisations are, as individual are the spider charts. In a descending order assigned to the goup of 'high interest and power', there are highlighted the WSG, the RPWs, APs and Lead Infection Control Doctor, followed by the DIPC, ICO, External Auditor/Authorising Engineer. Assigned to the group of 'low interest and power', there are highlighted 'Other Relevant Staff/Contractors', 'Ward/Department Managers' and 'Estate Maintenance Workers/Contractors'.

A 'check role' category was evidenced for External Auditor/Authorising Engineer, Duty holder, DIPC, ICO, DRPW, APs and Water Hygiene Contractor. Within the water safety group members the Director of Estates and Capital Development, the Lead Infection Control Doctor, the Infection Control Officer and the External Auditor/Authorising Engineer were assigned to the goup of 'high interest and power'. Assigned to the group of 'low interest and power', there are highlighted Clinical Representatives, Managerial Representatives (Cleaning Services) and Water Hygiene Contractor. A 'check role' category was evidenced for LICD, Head of Estates Maintenancen and Chief Engineer, Mechanical Mainenance Manager (DRPW), Infection Control Officer (Consultant Microbiologist), Water Hygiene Contractor, External Auditor/Authorising Engineer.

With respect to objective 6 there were found to be different software systems in place, electronic faucets, and also the use of outsourced services. Similar to all is the need that points of overlapping duties must be clarified by process relevant documents such as policies, instructions, SOPs, statutes, plans, schemes.

There are five further research process review statements on the early stage of the research process. The consequence of the experiences made during the interview patricipants recruiting phase Ia and the results of preliminary analysis led into a modification of the data collection process before proceeding with phase Ib, which meant a modification of the ‘case’. The study object for further data collection in the research project was chosen to be limited to England. This required a modification of the initial case study environment. After the pilot study, there were identified clear reasons for selecting health-care in England as a case, specified by the unit of analysis seen in the ‘hospitals’ Estates and Facilities Management department’, focusing on ‘process’. The original case study environment before the pilot stage was characterised in an earlier publication (Leiblein et al., 2016). At that moment there were considered hospitals in three different countries representing the case. They were located in England, Germany, and Switzerland. The proposed unit of analysis and the object of analysis remained unchanged. The ‘case’, as such, was focused at and considered to be modified into the UK only, after this pilot study.

The following observations are highlighted being the main reasons for modifying the case study environment at an early stage:

Research process review 1: No clear structures or roles for a precise affiliation to Estates and FM departments were found for the cases in Germany and Switzerland. In Germany, for example, an executive department with clinical background (i.e. hygiene commission) is in the lead and has responsibility for infection prevention. It holds the managerial lead in the combined risk management perspective of healthcare associated infections, water safety and *Legionella* risk management.

Research process review 2: The commitment on managerial actions was led by either the water safety plan or by the hygiene commission. Rated as a ‘proactive’ approach, the England representatives share experiences more openly and explain structures of the hospital. Transparency is given about structures, processes and process owners (responsible people). The water safety group is recognised as a management instrument, organised in a round table, where discussions are conducted on an equal footing between clinical and non-clinical perspectives.

Rated as ‘reactive’, Germany and Switzerland share less openly descriptions or structures. There is little transparency about processes and process owners. There is evidenced a stronger hierarchical structure where the technical services are subordinate to the hygiene commission. They are consulted as an advisory body in clarifying cases of *Legionella* contamination in order to confirm or refute water systems as a possible cause of contamination. In fact, the hygiene commission is the authority in infection prevention and risk management, which is reflected in the statements of the interview partners from Switzerland and Germany.

Research process review 3: The professional discipline of Estates and Facilities Management is visibly represented in hospitals in the UK, with their own departments, with a clear remit that falls under the understanding of Estates and Facilities Management duties. This is for example evidenced in the function of the “Head of Estates and Facilities”. FM or Estates are members of the water safety group.

Research process review 4: Based on the interviews and documents analysis, in England there seem to be clearer structures of transparency regarding roles and duties in terms of water safety management, than observed in Germany or Switzerland. For the first of these two the responsible person is affiliated not clearly in an Estates and/or FM-department related function, the last is in a transformation phase of developing awareness about and regocnition of *Legionella* prevention strategies and structures in hospitals.

Research process review 5: For the procedure of data collection, geography did not matter. There were the same challenges to be managed in all three countries. But accessibility to relevant data and the willingness to participate and support of research during the interviews was experienced stronger in the UK context. Research can only investigate and report on the basis of data available for analysis. The sharing of information (e.g. documents as secondary data) brings up more relevant information available for research.

All the work done delivers the entity for the framework output that has been validated during a focus group with experts and underwent further revisions, based on the experts’ feedback.

This section reviewed on the research process and the objectives aimed at achieving. The next section will provide the answers to the subquestions and the research question.

9.2 Answer to the research question

Grounded in the underlying strategy of developing a framework presented in chapter 6.14 and with special attention on Table 6-16, Table 6-19, Table 6-20, Table 6-21 in chapter 6.14, and Table 7-39 in chapter 7.6.4, and relying on the methodology approach chosen (chapter 6) and considering the results and analyses of research (chapter 7), the following answers on the sub questions (SQ1 to SQ4) and to the research question (RQ) can be given:

Answers to subquestions

- SQ1: Are there processes defined in hospitals in terms of *Legionella* prevention in water systems?

Answer to SQ1: Yes, every hospital actually has structures, such as a Water Safety Policy or a Water Safety Plan, in which areas of responsibility and processes are defined. However, none of the items examined shows a clear process map that depicts all sub-processes or describes a process hierarchy. More precise references or indications to existing legislation or guidance could be added in order to highlight necessities and obligations. Existing documents differ in their readability, their scope and their structure.

- SQ2: Who are the process owners and what are their roles and duties from the perspective of Estates and Facilities Management and Facility Services processes?

Answer to SQ2: A number of different stakeholders are involved. These could be identified very precisely. Their roles and tasks were distinguished and described. The Water Safety Group has a special role as an interdisciplinary body with a weight in the implementation of measures and as a control body.

- SQ3: Are there points of overlapping duties and how can they be identified or be characterised?

Answer to SQ3: In some cases, yes. However, this is probably less the result of the assignment of roles than of the organisation's own communication structure and the identification of those responsible with their own activities (corporate process identity). They can be clarified by interface demarcations and supplemented into a communication scheme. In addition, clarity about the need, provision and use of resources creates additional clarity, especially in PFIs.

- SQ4: Are there management strategies comparable between organisations (hospitals)?

Answer to SQ4: Yes, strategies are comparable, as they usually follow the WHO water safety plan by formally forming a corresponding interdisciplinary grouping (WSG). There are differences in the implementation and understanding of individual stakeholders involved. A particular challenge is posed by given the partly outdated building stock, which requires renovation in order to operate existing systems as intended. The basis for target-oriented action should be risk assessments that critically and comprehensively examine the current situation of the entire system. This is in contrast to simple, non-systematic monitoring activities or uncoordinated measures which, although they meet certain control obligations, cannot bring the water system to a safe and sustainable level in a systematic and sustainable manner.

Answer to research question

- RQ: With the perspective of Estates and Facilities Management and Facility Services, is there a generalisable or transferable «process» of *Legionella* prevention of water systems in hospitals possible or is risk management subject to parameters or criteria specific to each organisation?

Answer on RQ: It was possible to identify and map certain process elements in a generalised manner. From this a process map was drawn, which gives orientation. It was developed under the aspects of process and stakeholder identification and was based on a risk prevention approach.

Nevertheless, the management structures of an organisation, and the buildings themselves, are so different in their construction and use, that it must be possible to set individual priorities in the context of assessments. So "yes" to the process, but also "yes" to subjecting parameters of risk management for an organisation.

The previous has all been achieved with a mixed methods research approach. Statistically robust analyses would need the participation of a larger population and potentially would be a step for picturising the present situation for the UK.

9.3 A significant contribution to knowledge

"For a pragmatist, the value of research lies in its practical relevance; the purpose of theory is to inform practice" (Sekaran and Bougie, 2016 p.29).

In the sense of the quote of Sekaran and Bougie (2016), the research produces evidence of originality by firstly qualitatively working out issues, which have discovered a significant research gap through an intensive literature review. Secondly, the research delivers novelty by developing a practice-motivated and practice-fed, and practice-oriented framework, which can be considered as a reference system, termed 'Water safety management, *Legionella* prevention and risk management in hospitals: a framework for Estates and Facilities Management in England'. It comprises likewise guiding information, a framework compliance monitor for self assessment, and additional document templates for considering to integrate them into their own business or management practice.

The framework, which is a result of a passionate and systematic application of mixed methods research covering different phases, and is a result of intense endeavour, aims at providing guidance to professionals in healthcare organisations (hospitals) to strengthen the role of estates and facilites management in hospitals with respect to *Legionella* prevention and risk management of water systems. Most important characteristics are seen in helpful guidance and management instruments for becoming compliant and remaining compliant for a long time when spending awareness to the topic appropriately.

In future times the framework shall be applied within organisations to contribute likewise to public health, patient safety and occupational health. Dealing with this it spends recognition and motivation not only thoughout the research process, but also downstream, by providing helpful instrumentation, spending orientation, and providing material for education.

Results may have impact serving a wide audience of researchers and professionals conjunct with or employed at hospitals, or working in heathcare with focus in infection prevention, hygiene, business management, estates and facilities management, stakeholder management, process management, water safety management, risk management, engineering, knowledge management and consulting.

10 Further research

As a result of this research project, the framework, data and reviews presented here

- systematically reveal the present situation of *Legionella* risk management and prevention in water systems in selected HC organisations (hospitals). Research developed a reference system (framework) guiding people responsible for Estates and Facilities Management in HC organisations to identify, understand and properly take action on *Legionella* prevention and risk management for water safety.
- specifically identified stakeholders and functions; analysed functions and fields of activity; identified and analyses processes and stakeholders (focus: non-clinical); reviewed and considered current state and conformity to standards, legislation and regulations / discussion in terms of risk management from an Estates and Facilities Management perspective; identified points of overlapping duties in the process of *Legionella* prevention in water systems; and identify similarities and differences between hospitals.
- Provides helpful guidance and document templates with respect to risk management and process review for integration into business routines
- Provides a contemporary framework and process compliance monitor that could be applied as additional management instrument to help systematically structure and analyse relevant process elements.

Based on the aforementioned achievements of the research, it may be a fair starting point for the development of a United Kingdom wide PDCA-WSP, which would be a different endeavour for research and development. To the knowledge of the researcher a framework of that kind has not been described yet for England or the United Kingdom, but basic elements have been identified for Canada and the USA. The Canadian framework, suggested by Bereskie et al. (2017), contains ten steps and describes nine critical elements, of which one was highlighted as ‘management’. In the course of this thesis’ research focus all the other eight elements have also been recognised as core elements to be considered and with linkage to other disciplines, management levels, process owners, and people responsible. Similarly, elements of a basic framework for a water management program compiled for the USA, as described in the literature review of chapter 4.3.1, discusses worthwhile elements for considering framework-specific additional checklists. It outlines the importance of the latest version of the ASHRAE Standard 188 standard, the CDC toolkit and the CMS memorandum. Nevertheless, it still remains in the area of responsibility of the the people responsible for estates and facilities to determine the specific policies, procedures, and control measures, and with which of these to fulfil any framework given. A framework can only be a guidance with a special focus in achieving.

Giving orientation and guidance is one core element of learning and in understanding duties, responsibilities and relationships to topics of interest to be considered. With this perspective given, the framework ‘Water safety management, Legionella prevention and risk management in hospitals: a framework for Estates and Facilities Management in England’ represents a specific element of guidance for people responsible at management levels in healthcare organisations. The framework guides people responsible and could easily be integrated into training courses on water safety of any independent institution of further education and training in England.

A panel of experts participating in the focus group for framework validation agree that a framework of this kind and with this specific focus is completely new (chapter 7.7, Table 7-47). As a stand-alone framework it would guide people responsible in the form of a comprehensive reference with a check-list character to review their own field of responsibility. They could compare own structures against the framework and critically review their process for completeness.

Integrated into a United Kingdom-wide PDCA-WSP framework, the presented framework would complement a wider perspective. It is well known that management levels ideally plan and decide on the basis of management instruments, such as skilled management summaries, risk assessment reports, budget and project plans analysing and presenting a basis for making decisions. Thinking out of the box, a benefit of a UK-wide PDCA-WSP framework would be the specific addressing of people at management levels to give them a better contextual “translation” of their duties in water safety, more awareness and a structured instrument for business planning and for the allocation of resources. More emphasis in a UK-wide perspective, following a systematic way, could attract NHS, RSPH or HIS/FIS or any other organisation to further develop a national programme. It would be the installation of a surveillance/compliance monitoring system in the health-care system, in which health care institutions (e.g. hospitals, nursing homes, dental practices) are given exclusive access to consultancy mandates from recognised consultants through membership by interest. By such consulting mandates:

- responsible persons of an organisation must be involved (management, estates, facilities management, technical service, infection prevention) in order to know the latest state of the art regarding legislation/requirements regarding the topic of drinking water hygiene/regional prevention
- NHS or any hosting institution can collect key data on a senior level within a given framework to generate a benchmarking of organisations in the health-care sector in terms of water hygiene and prevention of legionnaires' disease.

A necessary prerequisite for achieving this is the support and the will of management. A surveillance/compliance monitoring system of the type presented here could be used to generate comparisons between institutions and to derive specific focal topics that contribute to further clarification in the form of publications, lectures and focus training courses.

In addition, the topic of water hygiene and prevention would receive a different recognition and weighting in the corporate context. In some cases, management arrangements and planning must consider necessary measures coming from risk-based analyses, which claim resources. *Legionella* and other water borne organisms possess potential for serious health implications. Maybe it would promote a type of a ‘*Legionella’* or, going beyond, a ‘water borne pathogens‘ supervised water system certification as a new vision for public health. Any national programme would support thoughts presented here, and support continous development in terms of the quality of water hygiene and public health.

“The bitterness of poor quality remains long after the sweetness of low price is forgotten” (unknown)

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Appendix A

Table Appendix A-1: Summary of regulations and guidelines in European countries (adapted from WHO) (HSE, 2013, CIBSE, 2013, Deans, 2006, British Standards Institution, nd, ISSO-publicatie, 2013, ISSO-publicatie, 2019, Health Protection Surveillance Centre, 2009), modified

Country	Object of regulations / guidelines						Critical levels if deviant from EWGLI	Context of regulation	Document
	Drinking water systems	Spa pools	Swimming pools	Cooling towers	Air conditioning systems	Process water			
England and Wales	x	x	x	x	x	x		• Health and (management of) satefy at work • Health	• Primary legislation: Approved Code of Practice and Guidance (HSE, 2013) • Other legislation: reporting of diseases, water supply (water fittings), notification of cooling towers, TM13 (CIBSE, 2013), HPA (Deans, 2006), HPSC (Health Protection Surveillance Centre, 2009), BS (British Standards Institution, nd)
Germany	x	x	x	x	x	x	10,000 CFU/100 mL	• Public health • Drinking water	• Code of practice (DVGW, 2004), (DVGW, 2015), (VDI/DVGW, 2013)
Switzerland	x	x	x	x	x	-	Threshold level for *Legionella* in tap water in hospitals: 1,000 CFU/L	• Drinking water • Bathing hygiene • Public health	• Mandatory regulations and general recommendations: (FC, 2014, FC, 2016a, FC, 2016b, BAG/BLV, 2018), Swiss SIA 385-9 and SIA 385-1, Swiss SVGW Standards and Recommendations (W)

Table Appendix A-2: Compilation of international regulations on drinking water requirements in building installation systems to reduce the growth of *Legionella. Adapted, translated and modified from (Mathys, 2018)*

Country	**Document (legislation, regulation)**	**Context of regulation**	**PWC**	**PWH, PWH-C**	**Action value / recommendation**
Switzerland	Schweizerischer Verein des Gas- und Wasserfaches SVGW: Legionellen in Trinkwasserinstallationen – Was muss beachtet werden? W10002d	Gebäude risikogestaffelt	<=20°C	Speicher>=60°C Peripherie>=50°C Verteil- und Steigleitungen>=55°C	• Kein stagnierendes Wasser • Tägliche Erneuerung Wassererwärmerinhalt • Optimale Fliessgeschwindigkeiten • Gute Durchspülung • Kurze Leitungslängen • Werkstoffe mit glatten Oberflächen und Temperaturbeständigkeit • Einmal täglich mindestens einer Stunde >60°C
Switzerland	Bundesamt für Gesundheit BAG Abteilung übertragbare Krankheiten Bern März 2009 Legionellen und Legionellose	Gebäude risikogestaffelt	<=20°C	Wassererwärmer 60°C Verteilsystem 55°C nach zwei Minuten	• Risikoanalyse • Gute Dämmung zwischen den Warm- und Kaltwasserleitungen unerlässlich
Switzerland	FEA Fachverband Elektroapparate für Haushalt und Gewerbe Schweiz: Legionellen im Warmwasser	n/a	<=20°C	Wassererwärmer / Speichersystem >=60°C Peripherie >=55°C	n/a

The United Kingdom	Legionnaires' disease: The control of legionella bacteria in hot and cold water systems HSG274 Part 2 Published 2014. HSE (Health and Safety Executive) INDG458, published 04/12 Legionnaires' disease: Technical Guidance – A brief guide for dutyholders Legionnaires' disease. The control of legionella bacteria in other risk systems HSG274 Part 3 2013 HSE: Legionnaires' disease. The control of legionella bacteria in water systems. Approved Code of Practice and guidance on regulations L8 (fourth edition) 2013w	Rechlich Verantwortlicher für Gesundheit und Sicherheit wie Arbeitgeber und alle mit Verantwortung für gewerbliche Gebäude (Vermieter) Rechtlich Verantworticher für Gesundheit und Sicherheit wie Arbeitgeber und alle mit Verantwortung für gewerbliche Gebäude (Vermieter)	<=20°C nach 2 Minuten	Speicher >=60°C Verteilung >50°C bei Hospitälern >55°C nach 1 Minute Laufzeit Siehe HSG part 2	• Risikoanalyse • Keine Stagnation im gesamten system • Leitungslänge so kurz wie möglich • Entfernung von redundanten Teilen und Totleitungen • Kein Einsatz von Materialien, die Mikroorganismen enthalten oder Nährstoffe an das Wasser abgeben (Water Fittings and Materials Directory), getestet nach BS 6920 • Monitoring aller Kontroll-Massnahmen • Regelmässige Wasserbewegung • Alle 12h Austausch gesamt Kaltwasser • WSP für Risikobereiche • Risikoanalyse • Präventivmassnahmen zu Verhinderung von LEgionellenwachstum • Reduzierung der Expositon gegenüber Aerosolen • Keine Temperaturen zwischen 20°C und 45°C und keine Bedingungen, die das Wachstum von Legionella begünstigen • Keine Stagnation • Keine Materialien, die Nährstoffe abgeben

The United Kingdom	Water systems: Health Technical Memorandum The control of Legionella, hygiene, "safe" hot water, cold water and drinking water systems 04-01 The control of Legionella etc. – Part A: Design, installation and testing Department of Health 2006	Krankenhäuser, Gebäude Gesundheitswesen	<25°C, besser <=20°C nach 2 Minuten	Speicher 60°C Verteilung 55°C 50°C Minimum Eintritt Zirkulation nach 1 Minute	• Wasseraustausch alle 24h PWC • Alle Materialien nach «Water Fittings and Materials Directory» • Vermeidung von Temperaturgradienten im Speicher
The United Kingdom	CIBSE (The Chartered Institution of Building Service Engineers). TM13: 2013: Minimising the risk of Legionnaires' disease	allgemein	<=20°C >25°C unbefredigend >30°C kritisch	Speicher 60°C Zirkulation 55°C mind. 50°C	• Keine Stagnation Kaltwasser • Wärmeübergänge vermeiden • Speicherung in kühlen Räumen • Monatliche Temperaturkontrollen PWC, PWH • PWC Temperaturmessung nach 1 Minute
The United Kingdom	Health and safety in care homes. HSE 2nd edition London 2014	Krankenhäuser, Heime	<=20°C	Speicher 60°C Peripherie 50°C	• Monatliche Temperaturkontrolle • Keine Stagnation • Wöchentliche Spülung
The United Kingdom	Guidance on Legionella in Fire Fighting Systems and Equipment. FIA Guidance for the Fire Protection Industry January 2013	Feuerlöschanlagen	<=20°C	n/a	• Risikomatrix für Geräte und Tätigkeiten

The United Kingdom	BSI Standards Publication BS 8580:2010 Water quality – Risk assessments for Legionella control – Code of practice	allgemein	Möglichst <=20°C nach 2 Minuten	Speicher 60°C Verteilung >=50°C nach 1 Minute	• Präventive Risikoanalyse • Risikomatrix: Temperatur >20°C und <50°C risikosteigernd • Wachstumsbedingungen für allgemeine Bakterienflora und deren Konzentration • Wachstumsbedingungen für Legionellen und deren Konzentration • Menge und Zeit Aerosolproduktion • Übergang Aerosol in Atmosphäre • Anzahl betroffener Personen und deren Immunlage • Erhöhtes Risiko • Alle Systemteile mit Wachstumstemperaturen • Totleitungen • Wenig genutzte Auslässe, Duschen, Thermostate • Quellen für Wärmetransfer (Heizung, gemeinsame Kanalführung)
European Union	ECDC Gesundheitsinformationen. Informationen zur Legionärskrankheit für Leiter von Reiseunterkünften. 2016	Reiseunterkünfte	dauerhaft <20°C	Gesamtes System 50-60°C	• Mind. 1x wöchentlich alle Auslässe spülen • Tägliche Messung von Parametern wie Temperatur
European Union	ECDC: European Technical Guidelines for the Prevention, Control and Investigation, of Infection Caused by Legionella species. June 2017	Touristische Einrichtungen	<25°C besser<20°C nach 2 Minuten	An Auslässen >50°C, besser >55°C nach 1 Minute	• 15 Punkte WSP • Risikoanalyse präventiv von grösster Bedeutung • Temperatur • Stagnation • Regelmässige Temperaturmessungen • Wöchentliches Spülen aller Auslässe mehrere Minutne bis zur Temperaturkonstanz

					• Bei Nichteinhaltung der Temperaturen laufende Desinfektion notwendig • Materialauswahl
WHO	Legionella and the prevention of legionellosis. World Health Organisation 2007	n/a	<25°C, besser <20°C nach 2 Minuten Wenn Kaltwasser dauerhaft >20°C, dann als Warmwasser betrachten	Speicher >60°C Peripherie >50°C nach 1 Minute	• Keine Stagnation oder geringe Fliessgeschwindigkeit • Periodische Spülungen • Reduzierung von Biofilm/Protozoen • Geeignete Materialien • Kein Wärmeübergang auf Kaltwasser durch Isolierung und räumliche Trennung Warm-Kalt • Regelmässige Messung der Temperatur
Germany	Verordnung über die Qualität von Wasser für den menschlichen Gebrauch. (Trinkwasserverordnung), Bundesgesetzblatt Jahrgang 2018 Teil I Nr. 2, ausgegeben zu Bonn am 8. Januar 2018	n/a	n/a	n/a	• Reaktive Überprüfung Einhaltung a.a.R.d.T • Reaktive Risikoanalyse (Gefährdungsanalyse) • Sanierungsmassnahmen
Germany	Trinkwassererwärmungs- und Trinkwasserleitungsanlagen; Technische Massnahmen zur Vermeidung des Legionellenwachstums; Planung, Errichtung, Betrieb und Sanierung von Trinkwasser-Installationen Technische Regel Arbeitsblatt W 551 April 2004. DVGW Bonn DVGW-Informatione Wasser Nr. 90 Juli 2016. Informationen und Erläuterungen zu Anforderungen des DVGW Arbeitsblattes W551	Grossanlagen Trinkwassererwärmung: öfentlich und privat genutzte Gebäude (Wohn-, Büro- und Verwaltungsgebäude, Arbeits- und Sportstätten, Hotels sowie Krankenhäuser). Nicht: Hoch-Risiko-Bereiche, Kleinanlagen	<=20°C optimal <=25°C nach 1 L	Speicher >=60°C Vorwärmstufe 1x/d 60°C Peripherie >=55°C Temperaturabfall im System max. 5K	• Anforderungen an Trinkwassererwärmer, Werkstoffe, Leitungsanlagen, Armaturen • Temperaturmessungen bei Probenahme • Erweiterte Temperaturmessung bei Sanierung • Risikofaktoren: Wärmeübertragung Kaltwasser, unzureichender Wasseraustausch Kaltwasser

Germany	DIN 1988-200. Technische Regeln für Trinkwasser-nstallationen-Teil 200: Installation Typ A (geschlossenes System)-Planung, Bauteile, Apparate, Werkstoffe; Technische Regel des DVGW, Mai 2012	allgemein	<=25°C nach 30 Sek.	Speicher>=60°C Peripherie >=55°C Temperaturabfall im System max. 5K Vorwärmstufen 1x/d 60°C Ein- und Zweifamilienhäuser unter besonderen Bedingungen >=50°C	• Bestimmungsgemässer Wasseraustausch • Verminderung Wärmeübergang • Einzelzuleitung PWC u. PWH möglichst kurz, max. 3 L Inhalt • Hydraulischer Abgleich notwendig
Germany	DIN EN 806-2. Specification for Installations inside Buildings conveying water for human consumption. Part 2 Design. June 2005	allgemein	möglichst <=25°C nach 30 Sek.	<=60°C	• Möglichst räumliche Trennung PWC und PWH • Wärmeübergänge vermeiden
Germany	CEN: Empfehlungen zur Verhinderung des Legionellenwachstums in Trinkwasser-Installationen. DIN CEN/TR 16355 (DIN SPEC 19810): 2012-09	allgemein	<=25°C	Rücklauf Zirkulation in jedem Kreis >55°C Entnahmestelle 60°C nach 30 Sek.	• Risikofaktoren: Wassertemperatur zwischen 20°C und 50°C, Stagnation des Wassers, Nährstoffe, Biofilm und Sediment, Kaltwasserleitungen und Endstränge von Warmwasserleitungen, nicht zirkulierend, nicht in Räumen, an Stellen mit Temperatur >=25°C • Von Wärmestrahlquellen (z.B. unterhalb von Glaskuppeln, in Technikräumen und Messkammern mit Wärmequellen) fernhalten • Wasseraustasuch mindestens wöchentlich • Nicht zirkulierendes Wasservolumen möglichst klein, keine Dämmung • Potential von Materialien zur Biofilmbildung wichtig • Sediment regelmässig entfernen

Table Appendix A-3: Selected international guidelines for *Legionella* prevention (adapted from Ditommase et al., 2010), modified (CDC, 1997, CDC, 2004, UK Health and Safety Commission, 2000, OFSP, 2005, BAG/BLV, 2018)

	Environmental testing purpose					
Location/entity	**Primary prevention**	**Sevondary prevention**	**Monitoring program**	**Sample**	**Sampling method**	**Limit values for *Legionella* concentration**
CDC (CDC, 1997, CDC, 2004)	No	Yes	• Investigation of an outbreak • Periodic sampling where persons at high risk might be exposed (e.g. transplantation unit) • Validation of the effectiveness of decontamination	Water and biofilm	Faucets and showerheads: biofilm samples and water samples Water (1 L): preflushing samples	
UK (UK Health and Safety Commission, 2000)	Yes	Yes	• Weekly in system where temperature and biocide levels are not being achieved • Monthly in water systems treated with biocides • Investigation of an outbreak	Water	Faucets and showerheads: water samples Water (1 L): preflushing samples	1,000 CFU/L
Switzerland (OFSP, 2005) (BAG/BLV, 2018)	Yes	Yes	• Annually in all health care facilities • Every 6 months in health care facilities where at-risk patients are hospitalised • Investigation of an outbreak	Water and biofilm	Faucets and showerheads: biofilm samples and water samples Water (1 L): preflushing samples; postflushing (after running water a few minutes to obtain constant water temperature)	30% of samples are culture-positive

Table Appendix A-4: UK specific legislation on water safety management

Document short title	Title	Source
Health and Safety at Work Act 1974	Health and Safety at Work etc. Act 1974	https://www.legislation.gov.uk/ukpga/1974/37
Water Act 2014	Water Act 2014	https://www.legislation.gov.uk/ukpga/2014/21/contents
Water Industry Acts 1991 & 1999	Water Industry Act 1991 Water Industry Act 1999	https://www.legislation.gov.uk/ukpga/1991/56/contents https://www.legislation.gov.uk/ukpga/1999/9/contents
Food Safety Act 1990	Food Safety Act 1990	https://www.legislation.gov.uk/ukpga/1990/16/contents

Table Appendix A-5: UK specific regulations on water safety management

Document short title	Title	
1999 No. 3242	The Management of Health and Safety at Work Regulations 1999	https://www.legislation.gov.uk/uksi/1999/3242/contents/made
1999 No. 1148	The Water Supply (Water Fittings) Regulations 1999	https://www.legislation.gov.uk/uksi/1999/1148/contents/made
2018 No. 647 (W. 121) PART 12 Regulation 39	The Water Supply (Water Quality) Regulations 2018	https://www.legislation.gov.uk/wsi/2018/647/regulation/39
1992 No. 2225	The Notification of Cooling Towers and Evaporative Condensers Regulations 1992	https://www.legislation.gov.uk/uksi/1992/2225/contents/made

2013 No. 2996	The Food Safety and Hygiene (England) Regulations 2013	https://www.legislation.gov.uk/uksi/2013/2996/contents
HSE L 153	Construction (Design and Management) Regulations 2015. Guidance on Regulations	https://www.hse.gov.uk/pubns/books/l153.htm
HSE L5 (Sixth edition)	The Control of Substances Hazardous to Health Regulations 2002. Approved Code of Practice and guidance	http://www.hse.gov.uk/pubns/books/l5.htm
HSE ACoP L8 (Fourth edition)	Legionnaires' disease. The control of legionella bacteria in water systems. Approved Code of Practice and guidance	http://www.hse.gov.uk/pubns/books/l8.htm
Food and Feed Codes of Practice	Food and Feed Codes of Practice	https://www.food.gov.uk/about-us/food-and-feed-codes-of-practice

Table Appendix A-6: UK specific standards on water safety management

Document short title	**Title**	**Source**
BS 8525-1:2010	Greywater systems. Code of practice	https://shop.bsigroup.com/ProductDetail?pid=000000000030184123
BS 7592:2008	Sampling for Legionella bacteria in water systems. Code of practice	https://shop.bsigroup.com/ProductDetail?pid=000000000030161148
BS 7593:2006	Code of practice for treatment of water in domestic hot water central heating systems	https://shop.bsigroup.com/ProductDetail?pid=000000000030133510

BS 8552:2012	Sampling and monitoring of water from building services closed systems. Code of practice.	https://shop.bsigroup.com/ProductDetail?pid=000000000030215290
BS 8554:2015	Code of practice for the sampling and monitoring of cold and hot water in buildings	https://shop.bsigroup.com/ProductDetail?pid=000000000030282434
BS 8558:2015	Guide to the design, installation, testing and maintenance of services supplying water for domestic use within buildings and their curtilages. Complementary guidance to BS EN 806	https://shop.bsigroup.com/ProductDetail?pid=000000000030299695
BS 8580-1:2019	Water quality. Risk assessments for Legionella control. Code of practice	https://shop.bsigroup.com/ProductDetail?pid=000000000030367524
BS EN ISO 19011-2018	Guidelines for auditing management systems	https://shop.bsigroup.com/ProductDetail?pid=000000000030354835
BS ISO 31000:2018	Risk management. Guidelines	https://shop.bsigroup.com/ProductDetail?pid=000000000030315447
BS EN 806-1:2000	Specifications for installations inside buildings conveying water for human consumption. General	https://shop.bsigroup.com/ProductDetail?pid=000000000030064693
BS EN 806-2:2005	Specifications for installations inside buildings conveying water for human consumption. Design	https://shop.bsigroup.com/ProductDetail?pid=000000000030011044
BS EN 806-3:2006	Specifications for installations inside buildings conveying water for human consumption. Pipe sizing. Simplified method	https://shop.bsigroup.com/ProductDetail?pid=000000000030098799

BS EN 806-4:2010	Specifications for installations inside buildings conveying water for human consumption. Installation	https://shop.bsigroup.com/ProductDetail?pid=000000000030218140
BS EN 806-5:2012	Specifications for installations inside buildings conveying water for human consumption. Operation and maintenance	https://shop.bsigroup.com/ProductDetail?pid=000000000030200074
BS EN 12828:2012+A1:2014	Heating systems in buildings. Design for water-based heating systems	https://shop.bsigroup.com/SearchResults/?q=BS%20EN%2012828
BS EN 14336:2004	Heating systems in buildings. Installation and commissioning of water-based heating systems	https://shop.bsigroup.com/ProductDetail?pid=000000000030288968
BS EN 16941-1:2018	On-site non-potable water systems. Systems for the use of rainwater	https://shop.bsigroup.com/ProductDetail?pid=000000000030317328
BS EN ISO 5667-3:2018	Water quality. Sampling. Preservation and handling of water samples	https://shop.bsigroup.com/ProductDetail?pid=000000000030349850
BS EN ISO 13720:2010	Meat and meat products. Enumeration of presumptive Pseudomonas spp.	https://shop.bsigroup.com/ProductDetail?pid=000000000030174005
PD 855468:2015	Guide to the flushing and disinfection of services supplying water for domestic use within buildings and their curtilages	https://shop.bsigroup.com/ProductDetail?pid=000000000030316210

Table Appendix A-7: UK specific industry guidance on water safety management

Document short title	Title	Source
HSE HSG 65	Managing for health and safety	www.hse.gov.uk/pubns/books/hsg65.htm
HSE HSG 179	Health and safety in swimming pools	http://www.hse.gov.uk/pubns/books/hsg179.htm
HSE HSG 274 parts 1, 2, 3	HSE Health and Safety Guidance 274. Legionnaires' disease: Part 1: The control of legionella bacteria in evaporative cooling systems. Part 2: The control of legionella bacteria in hot and cold water systems. Part 3: The control of legionella bacteria in other risk systems.	www.hse.gov.uk/pubns/books/hsg274.htm
HSE HSG 282	Control of legionella and other infectious agents in spa-pool systems	https://www.hse.gov.uk/pubns/books/hsg282.htm
HTM 04-01 Safe water in healthcare premises. The design, installation, commissioning, testing, monitoring and operation of water supply systems in healthcare premises. Parts A, B, C and annex D08	Health Technical Memorandum 04-01: Part A: Design, installation and commissioning. Health Technical Memorandum 04-01: Part B: Operational management. HTM 04-01, part C: Pseudomonas aeruginosa, advice for augmented care units. HTM 04-01, supplement: Performance specification D 08, thermostatic mixing valves (healthcare premises).	https://www.gov.uk/government/publications/hot-and-cold-water-supply-storage-and-distribution-systems-for-healthcare-premises

HSE INDG163(rev4)	Risk assessment. A brief guide to controlling risks in the workplace	https://www.hse.gov.uk/pubns/indg163.pdf
HSE HSG 220(2nd edition)	Health and safety in care homes. Chapter 9 *Legionella*	https://www.hse.gov.uk/pUbns/priced/hsg220.pdf
IACL27	Legionnaires' disease. A guide for employers	http://www.clearwaterservices.co.uk/downloads/HSE_Guide_to_Legionella_for_Employers.pdf
INDG458	Legionnaires' disease. A brief guide for dutyholders	https://www.hse.gov.uk/pubns/indg458.pdf
TGN 1-16	Principles of Water Supply Hygiene Final 1 October 2015 (updated 1 March 2017) and Technical Guidance Notes TGN 1-16	https://www.water.org.uk/guidance/principles-of-water-supply-hygiene/
PWTAG Code of Practice	PWTAG Code of Practice. Swimming pool water – the essential guide	https://www.pwtag.org/code-of-practice/
Domestic Heating Compliance Guide 2008	UKWAT Domestic Heating Compliance Guide 2008	https://www.4homeheating.co.uk/wp-content/uploads/2013/02/Dom_Heat_Compliance_Guide_Dec08.pdf
FR/G0002	A Householder's Guide to Water Supply and Sewerage 2012 (Third Edition)	http://www.fwr.org/technol/frg0002.pdf
DWTA Code of practice 2015	DWTA Code of practice for chemical cleaning and Inhibiting of Domestic Hot Water Central Heating Systems	http://www.beama.org.uk/resourceLibrary/code-of-practice-for-chemical-cleaning-and-inhibiting-of-domestic-hot-water-central-heating-systems.html

BESA TR/20 (2003)	Installation and testing of pipework systems. Parts 1 to 8	https://www.thenbs.com/PublicationIndex/documents?Pub=HVCA&page=2
CIBSE CCW:2010	CIBSE Commissioning Code W - Water distribution systems	https://www.cibse.org/knowledge/knowledge-items/detail?id=a0q20000008I7o9AAC
CIBSE TM13:2013	CIBSE Technical Memoranda 13: Minimising the Risk of Legionnaires Disease	https://www.cibse.org/knowledge/knowledge-items/detail?id=a0q20000008I7lfAAC
CIBSE TM45:2008	CIBSE Technical Memoranda TM 45 - Groundwater Cooling Cystems	https://www.cibse.org/Knowledge/knowledge-items/detail?id=a0q20000008I7euAAC
WMSoc W043 (2019)	Guide to Legionella Risk Assessment W043	https://www.wmsoc.org.uk/publications/23/
WMSoc W044	Code of Practice Cooling Water	https://www.wmsoc.org.uk/publications/22/
WMSoc W045	Legionnaires' Disease (Knowing your responsibilities & avoiding prosecution)	https://www.wmsoc.org.uk/publications/72/
WMSoc W046	Guidance for Managing Risks associated with *Legionella* W046-1, W046-2, W046-3, W046-4, W046-5, W046-7: (2017) W046-8: (2018), W046-9: (2015)	https://www.wmsoc.org.uk/search/?q=W046
WMSoc W047	Keeping your Cooling Tower Safe	https://www.wmsoc.org.uk/publications/24/

WMSoc W050	Understanding Your Cooling Tower System	https://www.wmsoc.org.uk/publications/73/

Table Appendix A-8: UK specific BSRIA guidance on water safety management

Document short title	Title	Source
BG 2/2006	Design checks for Public Health Engineering - A quality control framework for public health engineers	https://www.bsria.com/uk/product/qB4qzr/design_checks_for_public_health_engineering_a_quality_control_framework_for_public_health_engineer_bg_22006_a15d25e1/
BG 2/2010	Commissioning Water Systems	https://www.bsria.com/uk/product/6BAGan/commissioning_water_systems_bg_22010_a15d25e1/
BG 6/2018	Design Framework for Building Services 5th Edition	https://www.bsria.com/uk/product/gDXYjB/design_framework_for_building_services_5th_edition_bg_62018_a15d25e1/
BG 7/2009	Heat Pumps - A Guidance document for designers	https://www.bsria.com/uk/product/jnEAnX/heat_pumps_a_guidance_document_for_designers_bg_72009_a15d25e1/
BG 29/2012	Pre-Commission Cleaning of Pipework Systems 5th edition	https://www.bsria.com/uk/product/JBWzgD/pre_commission_cleaning_of_pipework_systems_5th_edition_bg_292012_a15d25e1/
BG 50/2013	Water Treatment for Closed Heating and Cooling Systems	https://www.bsria.com/uk/product/vBoY4n/water_treatment_for_closed_heating_and_cooling_systems_bg_502013_a15d25e1/
BG 33/2014	Illustrated Guide to Hot and Cold Water Services	https://www.bsria.com/uk/product/oBKvLD/illustrated_guide_to_hot_and_cold_water_services_bg_332014_a15d25e1/

BG 53/2016	Business-Focused Maintenance	https://www.bsria.com/uk/product/JBWkGB/business_focused_maintenance_bg_532016_a15d25e1/
BG 38/2018	Soft Landings Core Principles 2nd edition	https://www.bsria.com/uk/product/BxP8EB/soft_landings_core_principles_2nd_edition_a15d25e1/
BG 54/2018	Soft Landings Framework 2018	https://www.bsria.com/uk/product/QnPd6n/soft_landings_framework_2018_bg_542018_a15d25e1/
BG 55/2014	Safety in Building Services Design	https://www.bsria.com/uk/product/4BRb2B/safety_in_building_services_design_bg_552018_a15d25e1/
BG 57/2015	Legionnaires' Disease - Risk assessment	https://www.bsria.com/uk/product/6BvW3r/legionnaires_disease_risk_assessment_bg_572015_a15d25e1/
BG 58/2015	Legionnaires' disease - Operation and Maintenance Log Book	https://www.bsria.com/uk/product/vBL33D/legionnaires_disease_operation_and_maintenance_log_book_bg_582015_a15d25e1/
TG 8/2019	*Legionella* at a glance	https://www.bsria.com/uk/product/nyqvNn/legionella_at_a_glance_tg_82019_a15d25e1/
BG 4/2007	Design checks for HVAC - A quality control framework (Second edition)	https://www.bsria.com/uk/product/Wrm8xB/design_checks_for_hvac_a_quality_control_framework_second_edition_bg_42007_a15d25e1/

Table Appendix A-9: Collection of German statutes, standards and other documents guiding for design, operation and maintenance to minimise risks caused by Legionella in building (drinking) water systems (Leiblein et al., 2018) p.40-41.

	Germany
Statutes / regulations	*TrinkwV (BGBl, 2016, BMG/FMH, 2016)* *GefStoffV* *IfSG (IfSG, 2000)* *AVBWasserV* *ArbStättV*
Standards / Supporting guidance / best practice & other documents	*UBA Recommendations (UBA, 2006, UBA, 2012a, UBA, 2012b)* *Guideline for hospital hygiene and infection prevention (RKI, 2003)* *VDI/DVGW 6023 (VDI/DVGW, 2013)* *DVGW W551 (DVGW, 2004)* *DVGW W556(A) (DVGW, 2015)* *GEFMA 922 (GEFMA, 2004c)* *GEFMA 190 (GEFMA, 2004b)* *GEFMA 192 (GEFMA, 2013)* *DVGW W 1001 (H) DVGW W 1001 (H), Sicherheit in der Trinkwasserversorgung – Risikomanagement im Normalbetrieb* *DVGW W 270 (A)* *UBA KTW-Leitlinie, Leitlinie zur hygienischen Beurteilung von organischen Materialien in Kontakt mit Trinkwasser (KTW-Leitlinie)* *DIN CEN/TR 16355:2012-09* *DIN 1988-100; DIN 1988-200; DIN 1988-300; DIN 1988-500; DIN 1988-600; DIN 2000; DIN 18381; DIN EN 806-1; DIN EN 806-2; DIN EN 806-3; DIN EN 806-4; DIN EN 806-5; DIN EN 1717; DIN EN 16421; DIN EN ISO 19458*
Key points of TrinkwV and GEFMA 922-1B	
TrinkwV (BGBl, 2016, BMG/FMH, 2016) *§ 14 Untersuchungspflichten:* *(1) Kriterien Untersuchungspflicht.* *(2) Umfang und Häufigkeit.* *(3) Probennahmestellen und Probennahmen nach den allgemein anerkannten Regeln der Technik.* *(6) Untersuchung durch Untersuchungsstellen, die nach § 15(4) zugelassen sind.* *§ 15(3) Dokumentationspflicht.* *§ 15(4) Die [...] Untersuchungen einschliesslich der Probennahmen dürfen nur von dafür zugelassenen Untersuchungsstellen durchgeführt werden. Hinweis auf Veröffentlichung der zugelassenen Untersuchungsstellen auf Landesliste § 15(5) Überprüfung der Untersuchungsstellen.* *§ 16(7) Massnahmen bei Überschreitung des technischen Maßnahmenwertes.* *§ 24 Straftaten und § 25 Ordnungswidrigkeiten: Hier sind alle Auflagen, gegen die verstoßen werden kann, einzeln aufgeführt.*	

GEFMA 922-1B (GEFMA, 2016) *Aufzeichnung(en) der Ergebnisse der vorgeschriebenen oder angeordneten Wasseruntersuchungen (Trinkwasser-Versorgungsanlagen). Source: TrinkwV 2001; § 15 Untersuchungsverfahren und Untersuchungsstellen; § 15 Abs. 3 Satz 1-3.* *Aufzeichnung(en) über ergriffene Massnahmen zum Schutz der Gesundheit der Verbraucher (Trinkwasser-Versorgungsanlagen). Source: TrinkwV 2001; § 16 Besondere Anzeige- und Handlungspflichten; § 16 Abs. 7 Satz 3.* *Betriebsbuch (Trinkwasser-Installation). Source: VDI/DVGW 6023; 3 Begriffe; 3 [9]; VDI/DVGW 6023; 8.2 Instandhaltungsplanung; 8.2 [7-8].* *Gefährdungsanalyse (Trinkwasser-Installation). Source: TrinkwV 2001; § 16 Besondere Anzeige- und Handlungspflichten; § 16 Abs. 7 Satz 1 Nr. 2.* *Instandhaltungsplan (Trinkwasser-Installation). VDI/DVGW 6023; 6.5 Betriebsanweisung, Instandhaltungs- und Hygieneplan; 6.5 [1, 6-7]; VDI/DVGW 6023; 8.2 Instandhaltungsplanung; 8.2 [5g].* *Massnahmenplan (Trinkwasser-Installation). Source: TrinkwV 2001; § 16 Besondere Anzeige- und Handlungspflichten; § 16 Abs. 5*

Table Appendix A-10: Collection of Swiss statutes, standards and other documents guiding for design, operation and maintenance to minimise risks caused by Legionella in building (drinking) water systems (Leiblein et al., 2018) p.39-40.

	Switzerland
Statutes / regulations	*Bundesgesetz über Lebensmittel und Gebrauchsgegenstände Lebensmittelgesetz, LMG) vom 20. Juni 2014* *Lebensmittel- und Gebrauchsgegenständeverordnung (LGV) vom 16. Dezember 2016* *Verordnung über den nationalen Kontrollplan für die Lebensmittelkette und die Gebrauchsgegenstände (NKPV) vom 16. Dezember 2016* *Verordnung über den Vollzug der Lebensmittelgesetzgebung (LMVV) vom 16. Dezember 2016* *Verordnung über Trinkwasser sowie Wasser in öffentlich zugänglichen Bädern und Duschanlagen (TBDV)* *Hygieneverordnung (HyV)* *Wassergesetz des Kantons Zürich (legislative process by consultation)* Kantonale Verordnungen *Verordnung über allgemeine und Wohnhygiene (vom 20. März 1967)*
Standards / Supporting guidance / best practice & other documents	*W3d Richtlinie für Trinkwasserinstallationen (inkl. W3 Ergänzung 1+2)* *W4d Richtlinie für Wasserverteilung* *W3/E2d Richtlinie; Betrieb und Unterhalt von Sanitäranlagen* *W3/E1d Richtlinie; Rückflussverhinderung in Sanitäranlagen* *W1000d Empfehlung für die Reinigung und Desinfektion von Trinkwasserleitungen*

	SIA Norm 385/9: Wasser und Wasseraufbereitungsanlagen in Gemeinschaftsbädern (gültig seit 1. Mai 2011) *SIA Norm 385/1:2011 Anlagen für Trinkwarmwasser in Gebäuden – Grundlagen und Anforderungen* *SIA Norm 385/2:2015 Anlagen für Trinkwarmwasser in Gebäuden – Warmwasserbedarf,Gesamtanforderungen und Auslegung*
Key points of SVGW	
SVGW guidelines are a measure of correct behaviour and may also be relevant in case of legal action	

Table Appendix A-11: Standards for Reporting Qualitative Research (SRQR) with reference to methods, according to O'Brien et al. (2014)

No.	Topic	Item
S5	Qualitative approach and research paradigm	Qualitative approach (e.g., ethnography, grounded theory, case study, phenomenology, narrative research) and guiding theory if appropriate; identifying the research paradigm (e.g., postpositivist, constructivist/ interpretivist) is also recommended; rationale
S6	Researcher characteristics and reflexivity	Researchers' characteristics that may influence the research, including personal attributes, qualifications/experience, relationship with participants, assumptions, and/or presuppositions; potential or actual interaction between researchers' characteristics and the research questions, approach, methods, results, and/or transferability
S7	Context	Setting/site and salient contextual factors; rationale
S8	Sampling strategy	How and why research participants, documents, or events were selected; criteria for deciding when no further sampling was necessary (e.g., sampling saturation); rationale
S9	Ethical issues pertaining to human subjects	Documentation of approval by an appropriate ethics review board and participant consent, or explanation for lack thereof; other confidentiality and data security issues
S10	Data collection methods	Types of data collected; details of data collection procedures including (as appropriate) start and stop dates of

		data collection and analysis, iterative process, triangulation of sources/methods, and modification of procedures in response to evolving study findings; rationale
S11	Data collection instruments and technologies	Description of instruments (e.g., interview guides, questionnaires) and devices (e.g., audio recorders) used for data collection; if/how the instrument(s) changed over the course of the study
S12	Units of study	Number and relevant characteristics of participants, documents, or events included in the study; level of participation (could be reported in results)
S13	Data processing	Methods for processing data prior to and during analysis, including transcription, data entry, data management and security, verification of data integrity, data coding, and anonymization/deidentification of excerpts
S14	Data analysis	Process by which inferences, themes, etc., were identified and developed, including the researchers involved in data analysis; usually references a specific paradigm or approach; rationale
S15	Techniques to enhance trustworthiness	Techniques to enhance trustworthiness and credibility of data analysis (e.g., member checking, audit trail, triangulation); rationale

Table Appendix A-12: Summary studies of phases Ia and Ib

Step	Elements	Characteristics	Support	Period
1st step – Interview study **Phase Ia**	**Semi-structured interviews** held in England, Germany and Switzerland with representatives working in hospitals being responsible for water systems. Duration 80 to 120 min for each interview, one with 30 min duration. 2 to 3 interviews per country. Interviewee: Target group: Gatekeeper to the hospital organisation, role: «typical» Estates and FM/FS. Request for additional documents for document analysis.	8 interviews completed. Of these 3 were located in the UK, 3 in GER and 2 in SUI	Different recruiting strategies applied: -Requesting professional network contacts who came up during conferences, workshops, seminars, interviews, etc. -Flyer & project homepage available at http://tleiblein.wixsite.com/legionella-fm (Figure Appendix A-5) -Recruiting in UK, GER, CH	Interview dates: 10 August 2016, 22 August 2016, 24 October 2016, 29 March 2017, 22 May 2017, 19 July 2017, 17 August 2017, 26 September 2017
2nd step – Interview study **Phase Ib**	**Semi-structured interviews** with 10-15 gatekeepers to hospitals in England = Head of Estates and Facilities (NHS Trust). Duration 55-105 min for each interview. Random sampling. Interviewee: *Head of Estates and Facilities (NHS Trust)*. Request for additional documents for document analysis.	11 interviews completed.	Support was required: -in getting contacts of 10-15 new interview partners, different to these of 1st step interview study. Focus England. LinkedIn profile to contact.	Interview dates: 28 February 2018, 08 March 2018, 13 March 2018, 19 March 2018, 19 March 2018, 20 March 2018, 3 April 2018, 17 April 2018, 19 June 2018, 21 June 2018, 23 July 2018

Table Appendix A-13: Summary studies of phases II and III

Step	Elements	Characteristics	Support	Period
3rd step – Online Survey **Phase II**	**Online Survey** target population: Hospitals, Estates and FM department representatives. Identified management responsibilities by roles for the process of water safety management and Legionella infection prevention. Access: Distribution of the online survey link via gatekeepers, who have been interviewed in fieldwork phase 1. They are asked to forward the link to their Water Safety Group Members or to other people/groups working on Infection Prevention/Water Safety from the Interview-studies. Filter questions included. The link also be provided to institutions with professionals working in the specific environment (Access further Heads of Estates and Facilities by NHS Trusts, BIFM, IHEEM, WMSoc, CIBSE, etc.).	N=172, 17 completed = response rate of 10%, survey closed end of February 2019	Support required: -getting access to target population for a fair population sample size -Requesting professional network contacts who came up during conferences, workshops, seminars, interviews, etc. -direct requests to organisations, institutions, professional bodies, societies and associations who potentially are interested in the topic of *Legionella* prevention and water safety.	After successful pilot test, online survey/Link made available → Invitation of participants via E-Mail to participate the survey. Survey available from 22nd November 2018 until 10th February 2019
4th step – Framework validation **Phase III**	**Focus Group** with 6 participants. Framework presented in a concise and adequate way. 8 questions asked on the proposed framework with respect to reliability and validity. Answers recorded with audio recording device, transcribed and analysed qualitatively.	5 experts plus researcher	Participants invited after research of expert status	11 October 2019

Table Appendix A-14 Job descriptions and affiliations included in the recruitment for interviews of phase Ib

Job descriptions (affiliation anonymised)
Deputy Director of Estates at [redacted] NHS Foundation Trust
Associate Director of Estates at [redacted] Hospitals NHS Trust
Water Safety Manager at University [redacted] NHS Foundation Trust
Director of Estates and Facilities at [redacted] Hospitals NHS Trust
Director of Estates & Facilities [redacted] NHS Trust
Head of Facilities Management at [redacted] NHS Foundation Trust
Associate Director Estates and Facilities at [redacted] Hospitals NHS Trust
Associate Director of Estates & Facilities at [redacted] Hospital NHS Foundation Trust
Head of Estates & Facilities at [redacted] Hospitals NHS Foundation Trust
Associate Director of Capital Development at [redacted] NHS Foundation Trust
Director of Estates & Facilities at [redacted] NHS Trust
Head of Facilities [redacted] NHS Foundation Trust
Deputy Director of Estates at [redacted] NHS Foundation Trust
Associate Director of Estates at [redacted] Hospitals NHS Trust
Water Safety Manager at [redacted] NHS Foundation Trust
Director of Estates and Facilities at [redacted] Hospitals NHS Trust
Director of Estates & Facilities [redacted] NHS Trust

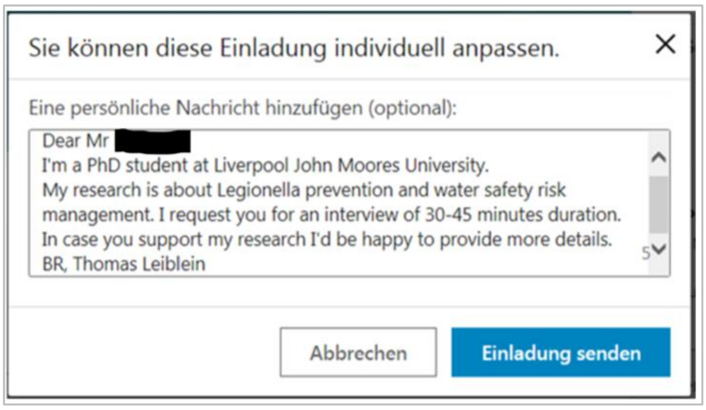

Figure Appendix A-1: Invitation request for interwiew via LinkedIn

Leiblein, Thomas
Tue 27/02/2018, 09:34
[redacted]

You forwarded this message on 21/03/2018 13:16

PI_I2_ParticipantInfo_20... 125 KB
PI_I2_ParticipantConsen... 259 KB

2 attachments (384 KB) Download all

Dear [redacted]

Thank you for considering my LinkedIn contact request and thank you for your reply.
You were mentioning your head of estates responsible for water safety.
In case you decide to delegate the interview, please forward my email to the right person.

I hereby send you some further information on my PhD research project.
Attached you find the official information sheet and the consent form.
I kindly ask you to read both carefully.

In case of participating as an interview partner, we schedule the interview (telephone or Skype) for a date between 28 February and 30 March 2018, meeting your or the delegated person's agenda.

For that, please return me a proposed date and the pdf scan of the signed consent form: t.w.leiblein@2014.ljmu.ac.uk
Should you be happy about preparing for the interview, I hand out you the structure of the interview guideline/questions.

I'm very much looking forward to your reply.
Thank you for considering my request and supporting FM research.

Best Regards
Thomas

Thomas Leiblein
Liverpool John Moores University
Faculty of Engineering and Technology
Department of the Built Environment
Phone: +41 79 369 01 23
Mail: T.W.Leiblein@2014.ljmu.ac.uk

Figure Appendix A-2: Invitation request for interwiew by e-mail

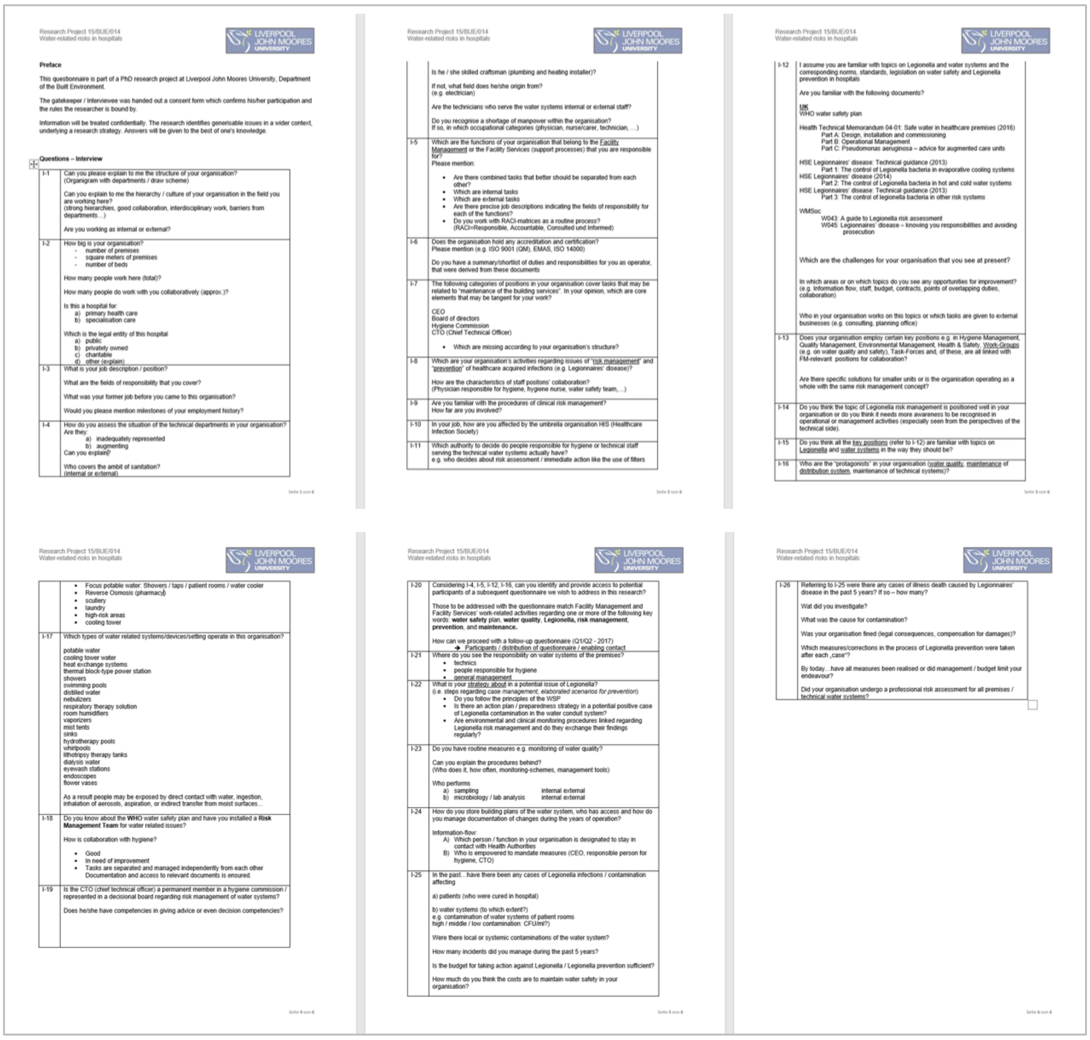

Figure Appendix A-3: Interview guide of research phase, example of phase Ia

RESEARCH PROJECT

"*Legionella* and water systems in healthcare (HC) facilities - a framework for built environment and implications for facility management (FM)"

PROBLEM

In the **hospital environment**, several stakeholders work in a complex and interdisciplinary HC setting.

Duties and responsibilities towards third parties need to be fulfilled with respect to *Legionella* detection and prevention. Among the stakeholders there might be Facility Managers and Facility Services staff, whose **responsibilities** include **risk management** approaches to maintenance, monitoring, assessment and **prevention** of *Legionella* contamination of **water systems**.

Some hospitals employ external Facility Management (FM) / Facility Services (FS), others operate in-house. To manage tasks properly their **roles and duties need to be evident**. For that collecting, analysing and reviewing **"best practices"** help guiding professionals through the process of *Legionella* risk management.

BENEFITS

Results contribute to a better **guidance** for people **responsible** about their duties and processes. Research may help promoting mandatory risk management activities within your organisation.

Phase 1
Interview study
Phase 2
Questionnaire study
Dissemination
Results

PARTICIPATE – HOW TO?

Recruitment of interview partners of healthcare facilities (hospitals)

You meet target interviewee criteria if you are responsible for healthcare facilities (hospitals) with a FMs perspective, that means you are either

a) **Director/Head of Estates and Facilities** (UK)
b) **FM with highest rank of responsibility for water systems** within the organisation (CH, GER)

CONTACT

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Department of the Built Environment, United Kingdom

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FURTHER INFORMATION

For further information about the research project either:

- get immediate (mobile) access via QR code alongside
- visit the project homepage at http://tleiblein.wixsite.com/legionella-fm

Figure Appendix A-4: Research project teaser for recruiting interview participants during research phase Ia

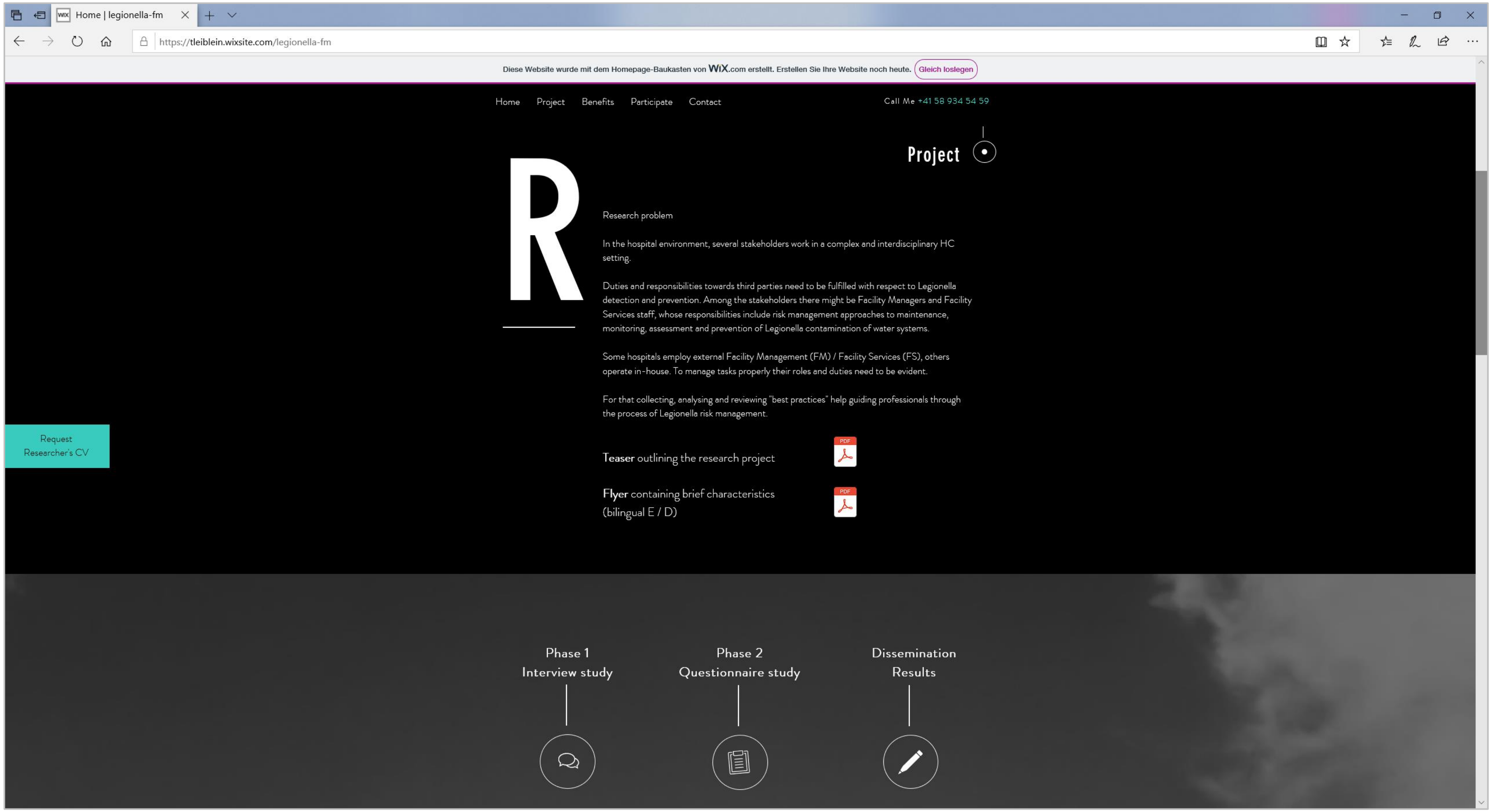

Figure Appendix A-5: Project homepage intended for advertising the research project during recruitment of interview participants

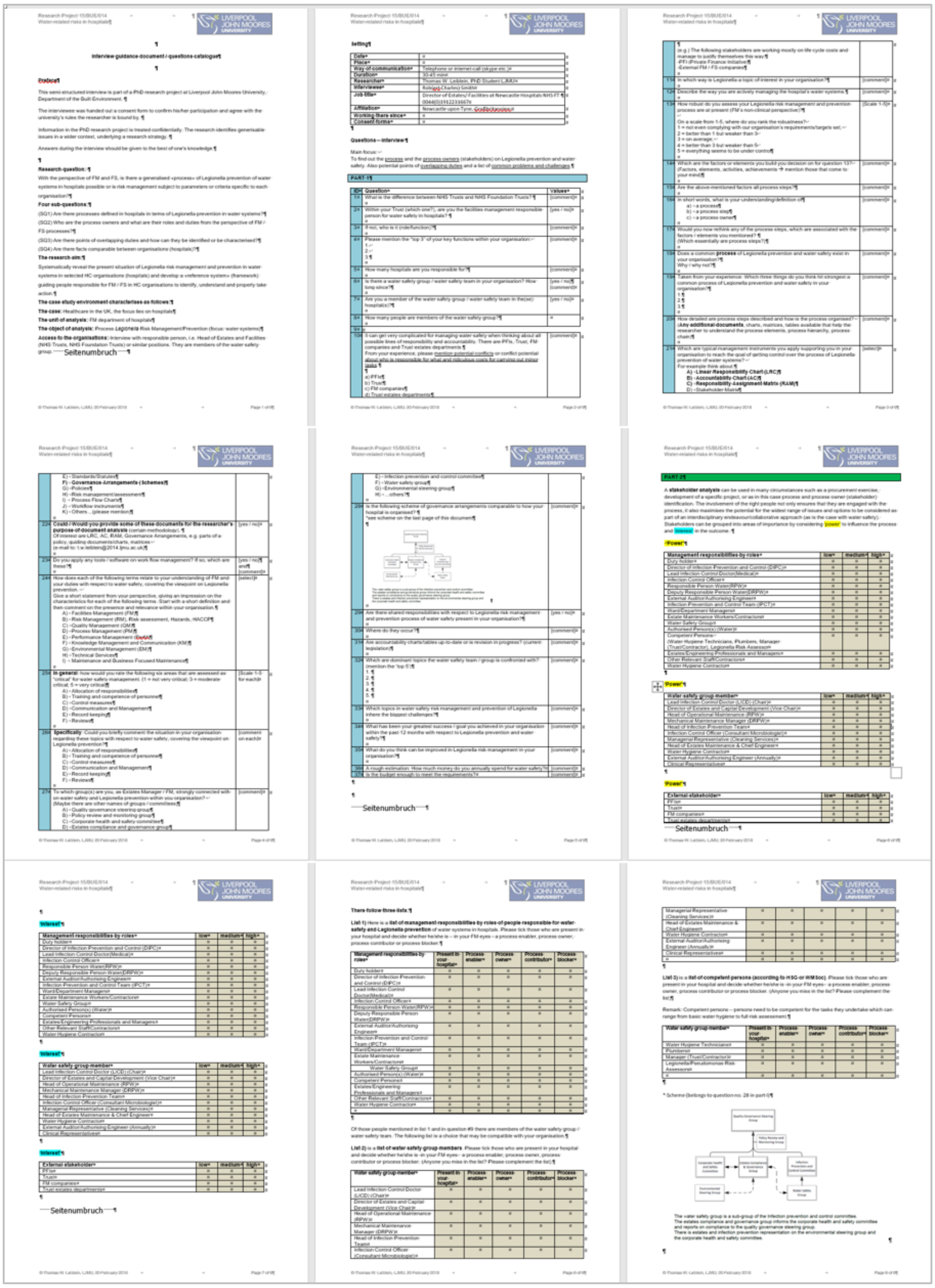

Figure Appendix A-6: Questions and categories in the interview guide of phase Ib

Table Appendix A-15: Participants, date and time of the interview study phase Ib

Interview Participant	**Job description (affiliation anonymised)**	**Date of interview**	**Duration [mm:ss]**	**Pages *(Words)* of transcribed material**
IP1	Water Safety Manager Estate Maintenance Department	28th February 2018	55:04	14 *(6,530)*
IP2	Associate Director of Estates & Facilities	8th March 2018	53:14	16 *(6,870)*
IP3	Head of Estates and Facilities	13th March 2018	32:06 + 25:45	15 *(6,852)*
IP4	Director Estates, Facilities and Capital	19th March 2018	47:36 + 10:00	12 *(6,853)*
IP5	Managing Director [redacted] Healthcare Facilities Management	19th March 2018	72:10	15 *(9,996)*
IP6	Director of Estates / Facilities	20th March 2018	01:50 + 57:30	14 *(7,043)*
IP7	Acting Head of PPM	3rd April 2018	83:01	21 *(11,247)*
IP8	Group Associate Director of Estates	17th April 2018	63:30	16 *(8,320)*
IP9	Deputy Head of Operational Estates	21st June 2018	104:44	20 *(12,730)*
IP10	Interim Head of Estates	19th June 2018	80:16	16 *(8,269)*
IP11	Operations Manager Estates Department	23rd July 2018	50:19	12 *(6,544)*

Table Appendix A-16: Institutions, organisations and societies for distributing the online survey

(A)CIOB	- Chartered Institute of Building ([redacted]) Invitation mail sent to: [redacted]@ciob.org.uk; [redacted]@ciob.org.uk
IET	- Institution of Engineering and Technology ([redacted]) Invitation mail sent to: [redacted]@theiet.org; [redacted]@theiet.org
CIBSE	- Chartered Institution of Building Services Engineers ([redacted]) Invitation mail sent to: [redacted]@cibse.org
SoPHE	- Society for Public Health Education ([redacted]) Invitation mail sent to: [redacted]@sophe.org; [redacted]@sophe.onmicrosoft.com
HIS	- Healthcare Infection Society Invitation mail sent to: [redacted]@his.org.uk
FIS	- Federation of infection Societies Invitation mail sent to: [redacted]
BIA	- British Infection Association Invitation mail sent to: [redacted]
NHS	- National Health Service [redacted](NHS) Invitation mail sent to: [redacted]@nhs.net; [redacted]@nhs.net
IHEEM	- Institute of Healthcare Engineering and Estate Management ([redacted]) Invitation mail sent to: [redacted]@iheem.org.uk
LCA	- *Legionella* Control Association ([redacted]) Invitation mail sent to: [redacted]@legionellacontrol.org.uk
CIPHE	- Chartered Institute of Plumbing and Heating Engineering ([redacted]) Invitation mail sent to: [redacted]@ciphe.org.uk; [redacted]@ciphe.org.uk
BSRIA	- Building Services Research and Information Association ([redacted]) Invitation mail sent to: [redacted]@bsria.co.uk
then: BIFM now: IWFM	- British Institute of Facilities Management - Institute of Workplace and Facilities Management ([redacted]) Invitation mail sent to: [redacted]@iwfm.org.uk; [redacted]@iwfm.org.uk
RSPH	- Royal Society for Public Health ([redacted]; [redacted]) Invitation mail sent to: [redacted]@rsph.org.uk; [redacted]@rsph.org.uk; [redacted]@rsph.org.uk
HEFMA	- Health Estates and Facilities Management Association ([redacted]) Invitation mail sent to: [redacted]@nhs.net
WMSoc	- The Water Management Society ([redacted]) Invitation mail sent to: [redacted]

Table Appendix A-17: Replied characteristics of institutions, organisations and societies being contacted (n/a=not available)

Organisation	Members total	Connection to Water Safety Groups
IWFM	17,000	"No data on affiliations to any water safety groups via head office"
(A)CIOB	45,000 globally	“It isn't possible to obtain a true figure of UK members - as many of our members move location as part of their job role”
IET	130,701	“Unfortunately we don't hold any statistics on any affiliation with a water safety group”
CIBSE	n/a	n/a
SoPHE	36 members/contacts from the UK	“Unfortunately we do not maintain any information about the members' affiliation to any water safety group”
HIS	1,100	"We do not collect data regarding members affiliations to other Societies"
FIS	n/a	n/a
BIA	1,400	"WSG is not noted or captured specifically on our membership criteria"
NHS	n/a	n/a
IHEEM	1794	“I do not hold the information you require regarding membership of Water Safety Groups”
LCA	356	“Unfortunately we do not have any information on Water Safety Groups”
CIPHE	5,642	n/a
BSRIA	782 corporate members	“We don’t hold information about our members’ affiliation to any water safety group”
then: BIFM now: IWFM	n/a 17,000	n/a “We don't have any affiliations to any water safety groups via head office”
RSPH	4,500	“The organisation also has a members-only special interest group on water, which has approximately 60 members”
HEFMA	151 member organisations	“Our system of membership is probably unusual for an association for professionals as it is based on organisations, i.e. the NHS trust/organisation is the member, rather than the individuals employed there who are just representatives of that organisation. Although we also have an 'Individual' membership category, there are only a handful of these members as this category is mainly for retired 'members' and/or people who previously worked at a member trust. Unfortunately, using the branch distribution lists to calculate

		the number of individuals involved would not provide a particularly accurate figure either. I know in the case of the West Midlands Branch, although the distribution list has over 90 names only a third actually engage in any way and for some of these it's only responses to diary invites advising they won't be attending branch meetings. I can't be certain but presume the other branches will be much the same"
WMSoc	2,000	"No data regarding affiliation to WSGs"

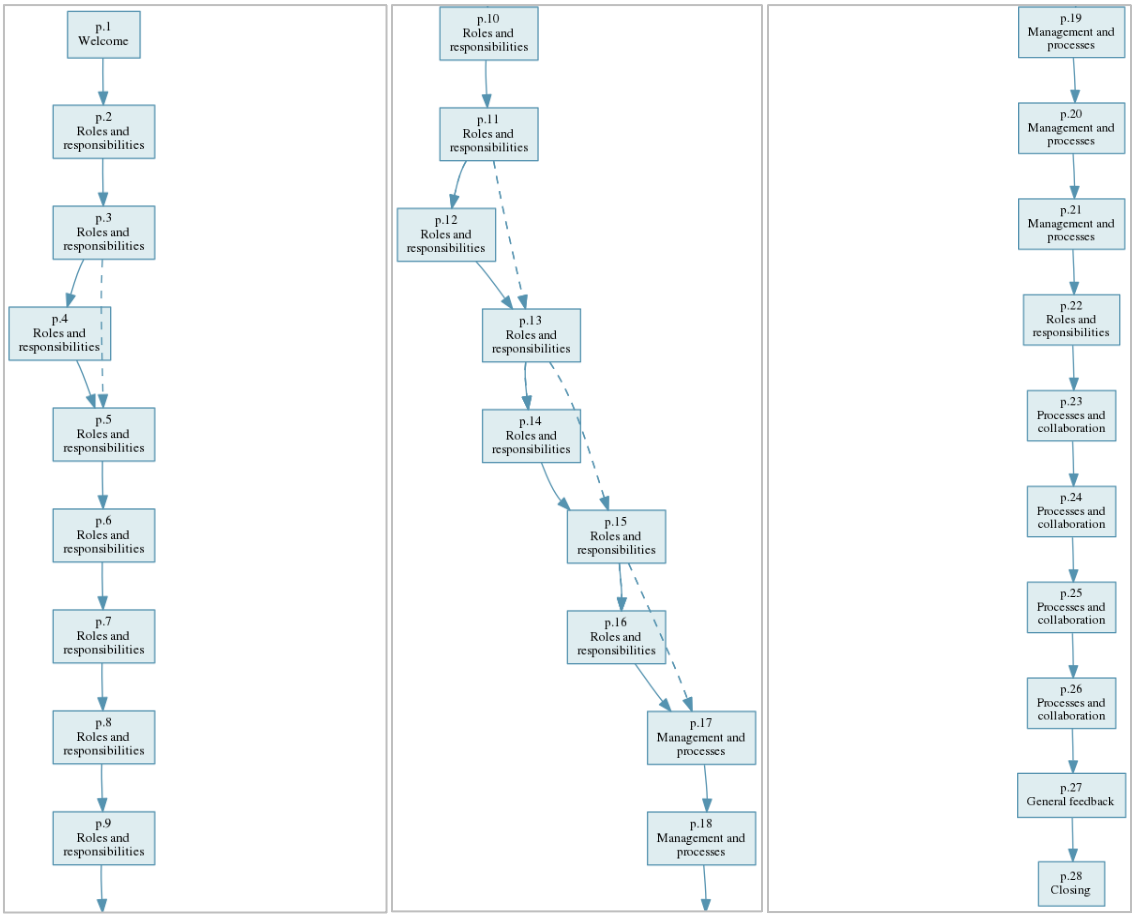

Figure Appendix A-7: Survey map of the web-based survey of phase II

Table Appendix A-18: Survey structure and question characteristics

Survey page number	**Question number**	**Question characteristics**
p.1	-	Welcome
p.2	1	Multiple choice (multiple answer) question (list of 17 answer options).

p.3	2	Selection list question (2 answer options); Question with a logic. It is a non-applicable answer. If answer is 'no' and was selected, jump to question 4.
p.4	3	Multiple choice (multiple answer) question (list of 21 answer options); question has validation
p.5	4	Grid question
p.6	5	Multiple choice (multiple answer) question (list of 6 answer options)
p.6	5a	Single line free text question
p.6	5b	Grid question
p.6	5c	Grid question
p.6	5d	Multiple line free text question
p.7	6	Selection list question (3 answer options)
p.8	7	Scale/rank question (6 scale/rank values); question has validation
p.9	8	Multiple choice (single answer) question (5 answer options)
p.10	9	Selection list question with scale/rank (5 scale/rank values)
p.10	10	Selection list question with scale/rank (5 scale/rank values)
p.11	11	Selection list question (3 answer options); Question with a logic. Non-applicable answers. If answer is 'no' and was selected, jump to question 12. If answer is 'yes' or 'I prefer not to answer' and was selected, jump to question 13.
p.12	12	Multiple line free text question
p.13	13	Selection list question (4 answer options); Question with a logic. Non-applicable answers. If answer is 'no' or 'more or less' and was selected, jump to question 14. If answer is 'yes' or 'I prefer not to answer' and was selected, jump to question 15. Proposed accountability chart and explanations.
p.4	14	Scale/rank question (9 scale/rank values); question has validation
p.14	14a	Multiple line free text question
p.15	15	Selection list question (4 answer options); Question with a logic. Non-applicable answers. If answer is 'no' or 'more or less' and was selected, jump to question 16. If answer is 'yes' or 'I prefer not to answer' and was selected, jump to question 17. Proposed scheme of governance arrangements and explanations.
p.16	16	Scale/rank question (9 scale/rank values); question has validation
p.17	17	Grid question combined with selection list question (4 answer options)
p.18	18	Grid question combined with selection list question (4 answer options)

p.19	19	Grid question combined with multiple choice (single answer) question (7 answer options)
p.20	20	Grid question combined with a) multiple choice (multiple answer) question (11 answer options) and b) selection list question (7 answer options)
p.21	21	Grid question combined with two selection list questions (3 answer options and 7 answer options)
p.22	22a-p	Grid questions combined with a) multiple choice single answer question (3 answer options) and b) multiple choice (single answer) question (4 answer options) and c) multiple choice single answer question (3 answer options) and d) multiple line free text question.
p.23	23	Multiple choice (multiple answer) question (11 answer options)
p.23	23a	Single line free text question
p.24	24	Multiple choice (single answer) question (5 answer options)
p.24	25	Multiple line free text question
p.24	26	Multiple line free text question
p.24	27	Single line free text question
p.24	28	Multiple line free text question
p.25	29	Scale/rank question (7 scale/rank values); question has validation
p.26	30	Multiple choice (single answer) question (5 answer options)
p.27	31	Multiple line free text question
p.28	-	Closing

Table Appendix A-19: Summary of question types of survey

Question type	**Frequency of occurrence in the survey**
Multiple choice	7
Free text	10
Scale/rank	6
Grid	3
Selection list	7
Grid combined with selection list	2
Grid combined with multile choice (single answer) and free text	16
Grid combined with multiple choice	1

Grid combined with multiple choice and selection lsit	2

Table Appendix A-20: Constitution of focus group for framework validation

Expert no.	**Job title / Affiliation / Expertise**	**Level of experience**
1	Head of Estates at an acute hospital in the South West	Responsible person for water management at current estate. He has held similar positions for the previous 4-5 years at a number of acute healthcare sites, prior to that he has held various management positons within operational estates teams responsible for developing, implementing and recording planned preventative maintenance strategies on water systems.
2	Managing Partner of [redacted] and an independent consultant specialising in healthcare water safety management	She has served as Chair of the Water Management Society and was awarded Fellowship in recognition of services to both the Society and the Industry. She is an active BSI committee member and was on the steering group for Department of Health HTM 04-01: Safe water in healthcare premises.
3	Technical director of a private company providing water and air hygiene services	He has 39 years' progressive technical experience within the water hygiene, water treatment industry, including Health Care. He managed the water treatment and water hygiene across the Rolls-Royce account in Europe, which included some very unusual process and test equipment as well as the steam boilers and cooling towers. He has also been technical lead for some nuclear processing plants and power stations for the water treatment and water hygiene for the companies he has worked for.
4	[redacted] expert consultant in sanitaryware and infection control	With over 32 years' experience in sanitaryware and potable water systems he has worked with hospitals, nursing homes, as well as retail, office, factory and educational establishments across the world to help them manage the safety of their systems and specify and develop products that can reduce the risks of water-borne pathogens.

5	Independent consultant specialising in healthcare water safety management	Over 20 years experience as a water safety advisor to NHS trusts and auditor, advisor and trainer on national and international basis to healthcare premises following cases and deaths from waterborne infections. An author / editor of the WHO publications on *Legionella* and the prevention of legionellosis and Water safety in Buildings. Member of working groups producing national guidelines including L8/ HSG 274 part 2, HTM 04-01, BS 8580 part 1, BS 7592. Chair of the working groups producing EU technical guidelines for the prevention of travel associated LD, BS 8680 Code of Practice for Water Safety Plans, BS 8580 part 2 Risk assessment for *Pseudomonas* and other waterborne pathogens.
Researcher	Head of Infection Prevention at a private acute hospital in Switzerland	Over the past 10 years, he has continuously sharpened his professional profile in the areas of hygiene, risk management and infection prevention as Graduate Engineer (UAS) in Nutrition and Hygiene Technology and with a MSc in Life Sciences ZFH. He has worked for about 9 years at the Institute for Facility Management at a Swiss University of Applied Sciences. In early 2019 he moved into the healthcare sector. He is particularly interested in the *Legionella* issue, which he pursues internationally, mainly in Switzerland, Germany and the United Kingdom. In his PhD he intents to develop a framework guiding people to better understand the process, perspective and role of those responsible for water safety and *Legionella* prevention in hospitals in England.

Table Appendix A-21: The one-to-one interview analysis process of phases Ia and Ib

Data analysis step	Explanation of step and application to the study
Planning for recording the data	It entails the researcher planning systematically for the recording of the one-to-one interviews prior to data collection. This specifically implies that the researcher should obtain prior permission from the participants to record the interview and familiarise himself with the audio taping device that will be used for recording. During interview phase Ia also visiting the research setting will take place where the interviews will be conducted. For phase Ib a more convenient mode of doing all interviews will be defined, as phase Ia could also be understood as a pretest to the interview data collection procedure. Research categories should already be in place as well as the coding method(s) that will be used. In this study, the interview guide of phase Ia was specifically categorised according to findings of an exhaustive literature review detecting the demand for process understanding and stakeholder participation. Subcategories that have been developed were informed by the literature review. Coding in phase Ib was further developed on preliminary analyses of the interviews and rare documents that have been collected during phase Ia. The phases of data collection had been tested by means of pilot tests. This stage also underscored the importance of developing further subcategories for each of these categories that would be utilised in the data coding stage of the following web-based survey analysis and to essentially validate the proposed phases of the framework.
Data collection and preliminary analyses	Qualitative data analysis is a twofold process. The researcher first analyses data at the research site. Secondly he analyses data away from the site. The second phase of the data collection process would occur between the various interviews and on different days. The researcher would endeavour to transcribe each interview after it was conducted. In cases where no direct transcription was possible, he has to organise himself to clearly identify each data collection that was made to be able to reference it back to its source. Data collection and analysis is an intertwined process to build coherent interpretations of the data since the researcher is guided by initial understandings that have been derived from the literature review and from each previous phase. This is the case, for example, in phase Ib in which the preliminary results of phase Ia were developed further. Further research progress then either affirms, amends or expands findings during the respective data collection and analysis phase.

Managing and organising data	This represents the first step of the data analysis process when data is collected. It includes organising the data by starting with an inventory of what has been obtained. The researcher determines whether possible notes that were taken during data collection are complete and whether there is a need for possible further qualitative data collection. The interview records must be properly labelled to indicate the specific case and the participants interviewed. The researcher needs to ensure that back-up copies of the recordings are made. This step also entails the finalisation of the interview transcription process.
Reading and writing memos	After the data have been organised the researcher needs to obtain a holistic picture of all the data collected and become immersed in the data. The researcher needs to read through the transcripts several times. He makes minor editing changes where necessary to make the data more manageable. Writing memos entails writing down short phrases, ideas or key concepts while studying the set of transcripts. The memo writing for this study would specifically involve the categories and subcategories relating to identifying the processes and stakeholders in water safety management.
Generating categories, themes and patterns	This process requires the researcher to establish grounded categories of meaning. The process of creating categories involves the identification of regularities among the participants from the various organisations. Meaning emerges from these categories. They have internal convergence and external divergence, which implies that the categories are internally consistent but not separated. Since preliminary questions for the interviews were already loosely categorised according to key phrases found in literature, it made easier the following steps of the data analysis processes. Furthermore, the consecutive steps and the triangulation process helped in aggregating further and complementary data. For the purpose of this study these steps required the researcher to critically review, quest and integrate new themes or patterns obtained from the participants. If found necessary, subcategories and/or more categories required were added to existing categories or have been replaced by more convenient category terms for the purpose of each analysis step.

Coding the data	A coding scheme is needed to be applied to the interview categories. In this study, the coding scheme would be informed by the various elements and sub-elements of each of the interview categories. They represent the analytical pathway for identifying processes, process elements and stakeholders for the final framework. Data would thus be labelled according to these elements and organised into the various categories. Coding is subject to change. As the researcher codes the data, new understandings may emerge which could result in amendments to the original plan. For the purpose of answering the subquestions of this research, the researcher compiled a comprehensive scheme of coding, which is explained in chapter 6.14
Testing emergent understandings	During the development of categories, themes and the process of coding, the researcher should start to evaluate the credibility of insights obtained from the data. This stage would involve the researcher starting to expand on the findings obtained from the intervews to further develop the question cataloque for the web-based survey. During this he determines whether these findings were in line with the literature. This stage is essential to determine whether the initial research question is still in line with the aim of developing a framework for estates and FM, and to question the saturation of the results obtained.
Searching for alternative explanations	Other explanations and linkages in the data would also need to be explored which should be identified and described, for example in side analyses. The participants may have mentioned other perceptions and views depending on their position and understanding and experience in the field of managing water safety and *Legionella* risks. It could possibly be used to integrate new findings or reject and/or amend certain arguments proposed by earlier phases of this study or which could suggest needs for future research.
Presentation of data	This stage would entail the presentation of the qualitative findings and the quantifiable elements, according to the research design. For the purpose of this study it would also entail obtaining a holistic view of both the qualitative and quantitative findings which would result in the presentation of a framework for estates and facilities management with the focus on the process of water safety management, *Legionella* prevention and risk management in hospitals in England.

Category	Included words ask for	Words included for queries (also stemmed words)
Actors	WHO?	Responsibility, Role, Stakeholder, Water Safety Group
Drivers	THROUGH?	Authority (Legislation, Legal), Guidance (Recommendation), Standard
Professional field	WHAT?	Estates, Facilities/Facility Management, Health care (Health authorities, NHS, Trust, Health & Safety), Legionella (Legionella management, Legionella prevention, Legionella risk management), Water Management (Water Safety, Water Safety Team, Water Safety Group, Water Systems)
Organisation's instruments	HOW?	Prevention (Monitoring, Sampling, Audit, Control), Process (Documentation, Matrix, Accountability), Strategy (Risk, Structure, Duty)
Clinical Instruments	HOW?	Hygiene commission, hospital hygiene, infection prevention

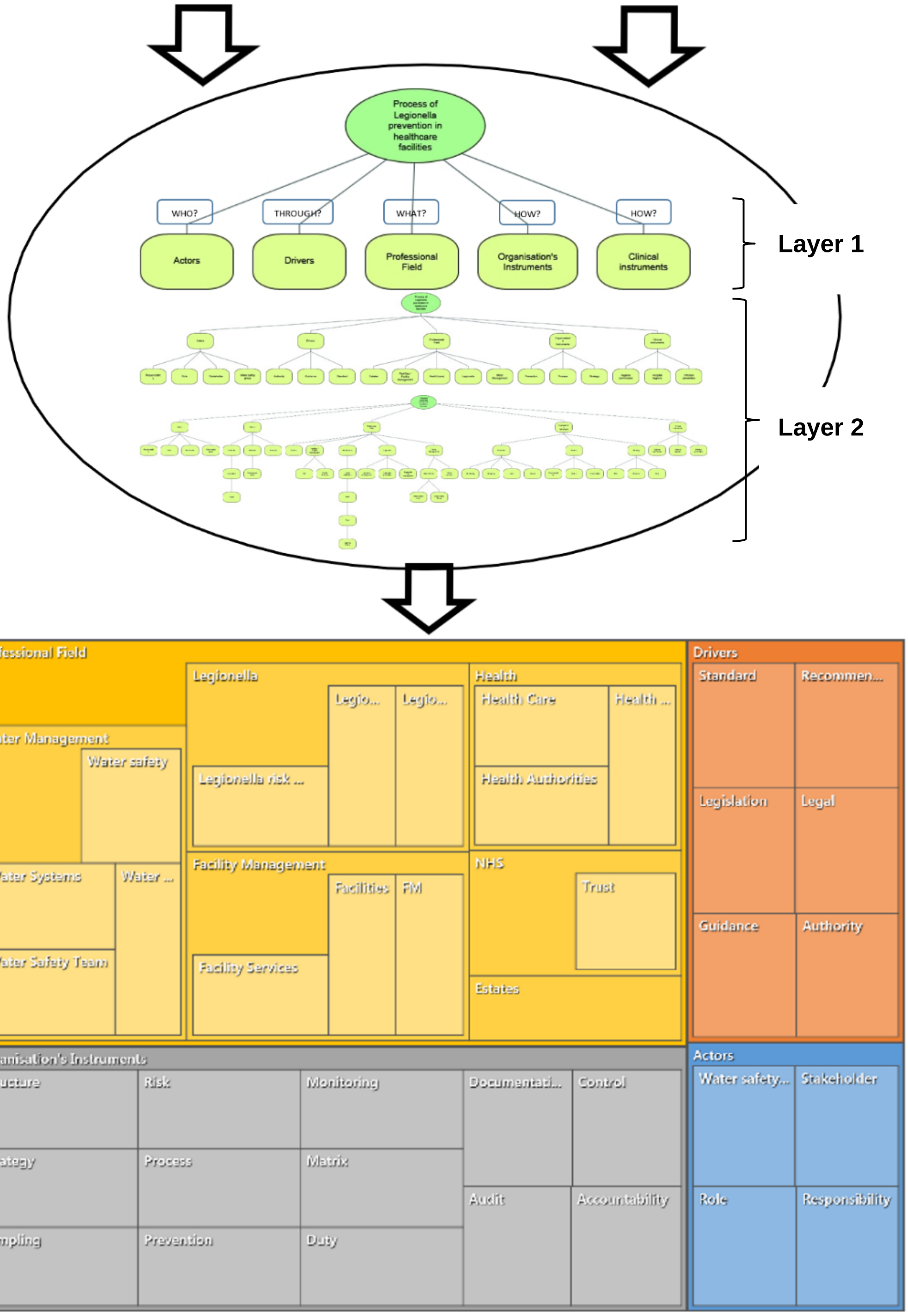

Figure Appendix A-8: Illustration of ordering and analysing data of phase Ia with NVivo

Table Appendix A-22: The focus group analysis process

Data analysis step	**Explanation of step and application to the study**
Planning for recording the data	A focus group for the purpose of a framework validation of this research output. The focus group starts with an online presentation (10-12 min) followed by a question and answer session in a web-based conference room with optional recording feature. Participants have been selected prior to the focus group session according to specific criteria of expertise and invited independently to a specific web-based conference room by sharing URL (see Figure Appendix D-1). In total there are six people participating, who are the researcher (moderator), and five experts. Eight questions are addressed to each participant. There is opportunity for general and specific comments on the framework. The researcher is the host and moderator. Each participant is requested to answer every question. Participants close their answers by terminal speaking "answer complete". The moderator shifts to the next participant/question. No answer should exceed one minute time in speaking, but include specific feedback on the framework. Should any participant feel he/she missed giving certain central feedback, he/she may complete the answer by sending an email to the researcher within 24 hours after closing the focus group session. He/she should clearly reference these answers to the corresponding question.
Data collection	Answers are to be recorded with audio recording feature of the web-based conference room, then exported, transcribed and analysed qualitatively. Findings are extracted to further develop the framework presented by revisions and amendments. Audio taping was started after receiving participant's informed consent.
Managing and organising data	Data was organised by question number and participant identification. Tables enable for analysis procedures.
Coding the data	Coding is closely aligned to the question. Each participant is requested to give a brief and specific answer on a qualifying question.
Presentation of data	Data is presented in Tables. Aspects that were found positive of the presented framework won't be changed. Identified aspects for improving the framework were considered and commented. A revised version of the framework will be the final research output.

Table Appendix A-23: Data collecting tools and sampling frames for each level according to the triangulation design

Level	Phase	Data collecting tool and sampling frame
1	I b	Semi-structured telephone interviews with 11 gatekeepers to hospitals in England (UK). Each of the interviewees held a position with managerial responsibility in an NHS hospital trust responsible for one or more hospitals in England (UK). Their jobs are characterised with a clear focus in the field of estates and facilities and water safety management responsibility (see Table Appendix A-14 and Table Appendix A-15). In these hopitals, in which there is implemented a water safety group, all interviewees were members of a water safety group. Some of them chairing it. Details on the structure and content of the interviews are explained in chapter 6.10.2.1.
	II	A web-based online survey was launched in England (UK). It was built of a questionnaire with closed and open questions. Details on the structure of the survey and the types of questions are explained in chapter 6.10.2.3. The response rate was 10%. 17 people of the target group completed the survey.
2	I a	Semi-structured telephone interviews (3) and one-on-one face-to-face (5) interviews with 8 gatekeepers to hospitals in UK (3), GER (3) and SUI (2). Each of the interviewees held a position with managerial responsibility on water safety and risk management. Their jobs were characterised with a focus in the field of estates and facilities and water safety management responsibility. Yet, no exact job position comparable between those three countries was available. Details on the structure and content of the interviews are explained in chapter 6.10.2.1.
	I b	Document analysis of all water safety plans, water safety policies, process documentation, flow charts, accountability charts, audit plans, reports and terms of reference. The aforementioned types of addidional documents were requested during the interviews held in England (UK). The exact types of documents which have been received from the interviewees are summarised in respectives tables. Furthermore, document analysis was applied on the requested stakeholder analysis assessment and the question about the process category of stakeholders. They have been completed by the interviewee after the interview and been sent to the researcher in a pdf via e-mail.
	III	Focus group validation of the framework with 5 (UK) experts and professionals in water safety and *Legionella* risk management. Participants were randomly selected. Decision criterion was that they have at least 10 years of experience in the relevant field.

3	I a	Document analysis of all possible water safety plans, water safety policies, process documentation, flow charts, accountability charts, audit plans, reports and terms of reference. The aforementioned types of addidional documents were requested during the interviews held in UK, GER and SUI. Document analysis of obtained documents and of personal notes from topic discussions with two advisors (each one a practitioner in the specific field, training sessions, webinars and presentations / summaries received during conferences and other advanced training courses. Document analysis and project evaluation of a case study, see Leiblein et al. (2017a). Focus: testing of accessibility of topic sensitive environment and data collection procedures.

Table Appendix A-24: Framework characteristics – classifications, structural and content elements

Source / reference	Title	Structural elements	Content elements	Editor / Publisher	Pages
Churcher et al. (2018)	BG6/2018 A Design Framework for Building Services	“About”: Introduction, Purpose, Structure “How to use” “Appendices”	Visualisations Definitions Explanations	Test, instruments, research and consultancy organisation	130
Pennycook (2006)	BG2/2006 Design Checks for Public Health Engineering - A quality control framework for public health engineers	Context of applicability / case definition, guidance elements, process definition / elements	Visualisations Examples References Focus topics Checklist elements	Test, instruments, research and consultancy organisation	106
Pennycook (2007)	BG4/2017 Design Checks for HVAC - A quality control framework	Context of applicability / case definition, guidance elements, process definition / elements	Document structure Focus topics Checklist elements	Test, instruments, research and consultancy organisation	163
Contandriopoulos et al. (2015)	A process-based framework to guide nurse practitioners’ integration into primary healthcare teams: results from a logic analysis	Framework overview, process elements, involved people responsible, role definition and consensus building, collaboration, support elements	Visualisations References	Research paper	11

Mounier-Jack (2014)	Measuring the health systems impact of disease control programmes: a critical reflection on the WHO building blocks framework	Framework overview, examples, assessment, limitations	Visualisations References	Research paper	8
Looy et al. (2014)	A conceptual framework and classification of capability areas for business process maturity	Conceptual framework and classification of capability areas for business process maturity, empirical validation, business process design, business process analysis, business process implementation and enactment, business process measurement and control, business process evaluation, business process improvement strategy and KPIs, external relationships and SLAs, roles and responsibilities, skills and training, daily management, values, attitudes and behaviours, appraisals and rewards, top management commitment, process-oriented organisation chart, process-oriented management/governance bodies	Visualisations Exemplifications References	Research paper	37

Helfrich et al. (2010)	A critical synthesis of literature on the promoting action on research implementation in health services (PARIHS) framework	Key elements for implementing evidence, flow diagram, concept and empirical references, limitations	Visualisations References	Research paper	20
Stetler et al. (2011)	A Guide for applying a revised version of the PARIHS framework for implementation	Brief overview, limitations and related issues, description of elements, conceptual definitions, related observations/tips, measurement	Visualisations References	Research paper	10
Eggli and Halfon (2003)	A conceptual framework for hospital quality management	Components, compatibility with existing substantiated models, deployment of quality management, falsifiability, flexibility	Visualisations References	Research paper	10
Liyanage and Egbu (2008)	A performance management framework for healthcare facilities management	Case environment, action plan, performance management and performance measure, target value, responsibility, KPIs	Visualisations References	Research paper	15

Klostermann et al. (2018)	Towards a framework to assess, compare and develop monitoring and evaluation of climate change adaptation in Europe	Evaluation process, focus system of interest, indicators, responsibility, procedures, blocks for a monitoring framework, key elements, challenges for monitoring and adaption monitoring, definition of the system of interest, selection of a set of indicators, identification of those responsible for monitoring, adaptation indicators, definition of monitoring and evaluation procedures, applying and learning from the framework	Visualisations References	Research paper	23
Amaratunga and Baldry (2003)	A conceptual framework to measure facilities management performance	The need for performance measurement systems, problems associated with performance measurements, conceptual framework, measurement, processes, learning and education, financial implications	Visualisations References	Research paper	20
Dobbie and Brown (2014)	A Framework for Understanding Risk Perception, Explored from the Perspective of the Water Practitioner	Construction of risk, nested contextual systems, influences of risk perceptions, information processing, knowledge, attitudes, beliefs, and values, application explanation	Visualisations References	Research paper	16

Agha-Hossein (2018)	BG54/2018 Soft Landings Framework 2018 - Six Phases for Better Buildings	Differentiation of phases, process elements, context of applicability	Visualisations Examples References Focus topics Checklist elements	Test, instruments, research and consultancy organisation	56

Table Appendix A-25: Case characterisitics - classifications and attributes

ID	Position / Job description of gatekeeper (=interview partner)	Legal entity	Number of premises	Square meters of premises	Number of beds	Number of employees	Collaboration	Incidences of *Legionella* infection / contamination	Costs p.a. spent on water safety
01	**Deputy Director of Estates**, accountable to the Chief Operating Officer	Public	One main acute hospital site but also operate from multiple small sites across the County and further afield.	approx. 82,000 square meters for all properties, of which 52,000 is the main acute hospital site.	372	total staff approx. 4'000 across the whole Trust.	The Trust works collaboratively across the whole of (countryside omitted) and further afield so it is very difficult to give a figure but it would be in the 10's of thousands.	Not for patients or water systems. No incidents during the past 5 years.	Budget is sufficient, approx. £50-60,000pa are the costs to maintain water safety in our organisation (estimation).
02	My title as **Associate Director of Estates** I report to the Director of Strategy and Planning. He has no Estates or Engineering background for he is the Board Director that I report to. He sits on the exact board and he reports to our CEO. So that's the upper hierarchy.	Publicly owned. Bu obviously we have two privately owned or privately funded hospital sites.	Operating out of 5 hospital sites	Total footprint is 560,000 square meters of occupied space.	2,000	Total staff number of ca. 15'000 staff.	n/a	I don't know that we've had. I don't believe about any *Legionella* cases in the not too distant past. If your question was: "Do you have Legionella". Then the answer to that is yes. We do get low-call frequencies when we sample. In terms of a Legionella infection, I don't believe we have.	We have, as an Estates Department, an annual budget of £40,000,000. And of that 40 million pounds, in terms of revenue, we stand approximately half million pounds a year on water safety / water management. I the last two years we've spent in excess of £2,000,000(20:16) on remedying our water problems. We've gone through a very expensive and very painful process of balancing the water systems in all of our wings. We have one wing left to be balanced, that wing is going to cost in excess of £400,000 pounds. To put eye on a particular thing is, a number £120,000 roughly is spent on filters for Pseudomonas. We have one wing which we'll about spent £ 400,000.- on.
03	Professionally, this is called a **hygienist** (i.e. specialist in hygiene), but it is **managed as a staff unit for hospital hygiene** (comparable to an administrative department), which reports completely and directly to the medical director. [*] In the past, the hygiene specialist or hygiene was generally subordinated to the Nursing Directorate.	Public	About 64 buildings	The whole area is a few hectares, but I don't know exactly how many there are. I'd have to ask the real estate office. But you can see that it is actually a very large campus. That means all you see on campus is our own water supply.	400 without, 520 inclusive care home beds	About 1100 people. These are the heads	Actually I have to deal with a lot of people. Of course you always have to deal with the managers first, for example the technical manager, ward manager, when it comes to processing or various things. Then quality management, you almost always have to deal with the top of your head first. But then, if one goes on an inspection naturally also with the "normal", like for example the cleaning forces, care forces etc. I would say hundred. But I have contact with many. Almost with all, it depends just who is with the inspections.	No, nothing	Sampling alone costs us well over 20,000 euros a year. Well, as you can see, that's not exactly little money just for sampling. Then we also change all the tap aerators regularly and anything else that belongs to it, terminal filters and all the rinses and so on. I'm almost certain that if you add all this up and add up the money for the positions, we'll be in the six-figure amount. If we then also take the conversion measures (retrofits), which we are now planning to do over the next few years or have already done, then we are in the mid-six-figure amount, certainly 400,000 to 500,000 euros.
04	**Head of Construction Management**	Public	4	94,000 square meters gross floor area	730	2,400	n/a	n/a	We are between 350,000 and 500,000 euros, for *Legionella*
05	**Head of Technical Services**	Foundation business with independent outsourced companies. Foundation business comprises rehab clinic, housing, thermal bath.	1 thermal bath. 3 clinic hotels. 1 rehabilitation clinic (4 wings).	78,500 square meters	343 (over three clinic hotels) 199 (rehabilitation clinic)	The whole foundation with all its employees is about 1,400. Not all of them are permanent employees. The rest is part-time of 30-50% is very much. There is also a group with 80%.	With the department heads, all locations, 30 or so.	I really can't tell you that. This is about the CIRS system (Critical Incidence Reporting System), and only the CIRS manager actually has access to that. What we know for sure is that we always have *Legionella* at certain measuring points in the monitoring system. Not in patient rooms, but certainly at the boiler plants. But legionella hasn't been known to me for the last four years. We have actually been dealing with the *Legionella* topic, we are systematically approaching it.	Well, to all companies, I can tell you that that is 25,000 Swiss Francs for sampling. Separately, I can't tell you that. [**]
06	**Water Safety Manager** Field of responsibility: Domestic water systems - maintaining water quality from supplier to outlets.	Public hospital (Foundation Trust). It's a professional health service, which is publically owned. And it's a Trust.	1 Estate with several small outbuildings	n/a	1,150	A total of 10,500 people work here	Approximately 30 work with me collaboratively.	[Patients] not that I am aware of. [Water systems] affected with local colonisations with generally low contamination. Only worked here for 1 year – I have managed several local colonisations and many single sink contaminations. No cases of illness death caused by Legionnaires' Disease in the past 5 years.	Budget is sufficient for taking action against *Legionella* / *Legionella* prevention. Current spend approx. £400,000 pa but suggest £700,000 is more realistic.
07	[1] Interview partner 1: **Head of Technical Services**. That takes an engineering degree to execute that. From the description I am responsible for the buildings, the facilities and the medical equipment. And everything that has to do with media, supply, management and purchasing somewhere. Interview partner 2: **Sanitary worker**, deputy group leader sanitary and my job is actually mainly the daily business.	Semi-private / public. It's a hybrid solution	We have 98 properties under management	312,000 square meters of gross floor area	900/920 beds that are warm, and about 1,100 that we simply have	Nearly 8,000	120	Well, I can't say anything, I don't know. [***] I have the courage to believe that anyone who has a *Legionella* issue in the health care system is affected by it, and I am deeply convinced of that. So I don't think prevention is that quick. After all, we only ever work after the event. We are actually rather at medium risk according to the FOPH, 100-10,000 CFU/L.	n/a
08	**Head of Building Services** (including the specialist areas: sanitary engineering, heating technology, locksmith's shop, therapy bath, fire extinguishing technology and air conditioning / refrigeration systems). I have to represent all areas of responsibility belonging to the specialist areas. Before I joined this organization, I was a gas and water installer.	Non-profit gGmbH, owner is the city	Approx. 60 buildings at three large locations and several smaller branch offices	Total gross area approx. 135,000 m² at the main location (no access to further data)	1200	Approx. 3,500 -> Subsidiary (100%)	In my department (building services) 8 employees report directly to me. Furthermore I work together with about 70 companies.	No infections are known for patients. For water systems contamination up to 4,600 CFU in the patient area (cause: not used); over 6,000 CFU at the storage tank return flow. There were/are local or systemic contaminations in the water system. Approx. 40 findings in the last two years were recorded by me, the value is realistic and can be extrapolated (many findings due to vacancy).	No information given on costs.

[1] There were two interview partners participating the interview on hospital 07.

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Legionella prevention in water systems in hospitals:
Stakeholders and the process seen from Facility Management and Facility Services

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Background

The aim of an ongoing research project is to systematically identify the present situation of *Legionella* prevention in water systems in selected HC organisations in different countries. The project seeks to develop a 'reference system' (framework) guiding those responsible in healthcare organisations to identify, understand and properly take action for prevention. The study focuses on the organisational structure with respect to the impact on the process of *Legionella* prevention, seen from the Facility Management (FM) or the Facility Services (FS) provider's perspective. In research papers (best) practice and research from the managerial point of view in hospital organisations is neither very well-documented nor easy accessible to FM practicioners or academics [1,2]. This situation motivated for collecting data and outlining differences between hospital organisations in three different countries. Preliminary results are presented here.

Methodology

Rooted in the principles of stakeholder theory [3,4,5], a mixed methods research design was applied. Data collection methods for business research included internet research, interviews (one-to-one interviews, online interviews), visual methods and image-based research, and documentary analysis [6]. Data presented here are obtained from interviews with gatekeepers of six hospitals of three different countries. They comprise each two hospitals from the United Kingdom, Switzerland and Germany. Where possible, additional data from documents provided after the interviews were considered for analysis, too. These included concepts, policies, procedures and organisational charts.

Results

A large number of different stakeholders with respect to management responsibilities by role were identified (Figure 1 and 2). They all are involved in the infection prevention process and thus contribute to the prevention of *Legionella* in water systems. In the United Kingdom principles of the Water Safety Plan are implemented and brought in line with the managerial structures in hospitals. Whereas in Germany and Switzerland the "Hygiene Commission" is the pivot of infection prevention activities. Whilst common and different structures in managing *Legionella* prevention processes in hospitals in different countries were observed, key responsibilities are common to be identified and assigned to an organisation's process thinking and collaboration, defined by an organisation meeting their obligations. Figure 3 is generic for governance arrangements of a hospital in the United Kingdom. Usually a technical operations unit (or similar, internal FM Dept. or external FS provider) is responsible for maintaining water systems and thus, responsible for delivering answers in the information chain of monitoring, risk assessment and other preventive procedures. Potential drivers influencing effective procedures of managing *Legionella* prevention (infection prevention) in practice could be seen in the budgets spent on water hygiene and preventive measures.

Hospitals in the United Kingdom
Committed to the Water Safety Plan: Water Safety Group/Team

Management responsibilities by roles
- Duty holder
- Director of Infection Prevention and Control (DIPC)
- Lead Infection Control Doctor (Medical)
- Infection Control Officer
- Responsible Person Water (RPW)
- Deputy Responsible Person Water (DRPW)
- External Auditor/Authorising Engineer
- Infection Prevention and Control Team (IPCT)
- Ward/Department Managers
- Estate Maintenance Workers/Contractors
- **Water Safety Group**
- Authorised Person(s) (Water)
- **Competent Persons**
- **Estates/Engineering Professionals and Managers**
- Other Relevant Staff/Contractors
- Water Hygiene Contractor

Competent Persons
- **Water Hygiene Technicians**
- Plumbers
- **Manager (Trust/Contractor)**
- Legionella/Pseudomonas Risk Assessors

Water Safety Group membership
- Lead Infection Control Doctor (LICD) (Chair)
- **Director of Estates and Capital Development (Vice Chair)**
- **Head of Operational Maintenance (RPW)**
- **Mechanical Maintenance Manager (DRPW)**
- Head of Infection Prevention Team
- Infection Control Officer (Consultant Microbiologist)
- **Managerial Representative (Cleaning Services)**
- **Head of Estates Maintenance & Chief Engineer**
- Water Hygiene Contractor
- External Auditor/Authorising Engineer (Annually)
- Clinical Representatives

Figure 1: Management responsibilities by roles for infection prevention in hospitals in the United Kingdom

Hospitals in Germany and Switzerland
Committed to the Hygiene Commission

Hygiene Commission/highest council of hospital hygiene consisting of:
- Medical director (covering medical ambit)
- Director of the hospital (covering administrative ambit)
- Director of nursing (covering nursing ambit)

→ These three represent the hospital top management

- Physician delegated for hygiene/German term: 'hygienebeauftragter Arzt'
- Hygiene professional/German term: Hygienefachkraft (which is the executive department of hospital hygiene, directly subordinated to the medical director; this is valid for the German state of Bavaria)
- General manager
- Specialist for hospital hygiene/German term: Krankenhaushygieniker
- **Chief Technical Officer CTO (scope of FM FS)**
- Additional staff, following a separate invitation, e.g. medical specialist for microbiology

The «Chief Technical Officer» occasionally is member of a «small hygiene commission», which is subordinated to a «major hygiene commission». It can for example be specialised in the scope of «*Legionella*. Therefore it is termed «hygiene commission on *Legionella*». The CTO is consulted solely on demand.

Figure 2: Management responsibilities by roles for infection prevention in hospitals in Germany and Switzerland

Conclusion

Hospitals are organisations of individual uniqueness in their design and operation (construction, country-specific norms and standards, maintenance approaches, budgets, training of staff, collaboration). Undoubtedly there is the need of managing potential risks properly and with a long-term perspective. For that the United Kingdom follows recommendations of the WHOs water safety plan by maintaining a groups of specialists (water safety group/team). In Germany and Switzerland the 'hygiene commission' claims decision-making and takes responsibility for infection prevention measures. Potentially the organisational structures and stakeholders in the management processes have an impact on the awareness of topics and the efficiency of measures related to infection prevention. Present-day economically-driven budget cuts, delayed (re-)construction works, maintenance or incomplete risk assessments may be recognised and counteracted by those in scope of liability. Liability is a consequence of statutory and normative duties. For that reason, clear role assignments and a common process-scheme for *Legionella* prevention in water systems may be helpful to identify any stakeholder working for the joint process. It may also be helpful considering Facility Management's needs and duties on *Legionella* prevention within the context of healthcare organisations as there are service providers managing processes in a competitive environment.

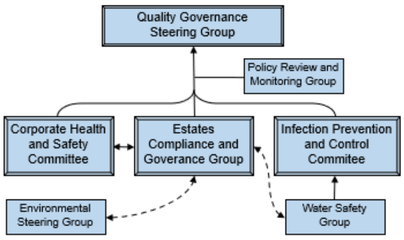

Figure 3: Governance Arrangements. There is estates and infection prevention representation on the environmental steering group and the corporate health and safety committee

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Figure Appendix A-9: Poster presentation of preliminary results of phase Ia

Table Appendix A-26: Additional documents received from the gatekeepers during interviews phase I a

ID organisa-tion	Type of document	Title of document	Content or category type
01	MS Word, 15 pages	Deputy Director Estates role and responsibilities	1 Job details, 2 Job Summary, 3 Role of Department, 4 Organisational Chart, 5 Key working relationships, 6 Duties and responsibilities of the post, 7 Work setting and re-view, 8 Individual responsibilities, 9 Confindentiality, 10 Infection Control, 11 Health and Safety, 12 Smoking, 13 Risk Management (remark: switch of numbering in origi-nal document), 14 Equal opportunities, 15 Improving working lives, 16 Corporate gov-ernance arrangements, 17 Job description agreement, Person Specification. Qualifications: Technical/Professional, Managerial – Financial; Knowledge: Technical, Experience; Skills: Technical, Managerial, Attitudes, Personal attributes, Corporate governance, Circumstances
01	MS Word, 1 page	Exisiting Estates Structure	Organisational chart 2015
01	MS Word, 1 page	New estates staff structure	Organisational chart 2016, new/changes

01	MS Power Point, 4 pages	Organisation structure clinical directorates	Organisational chart of care units: • Long Term and Unscheduled Care • Planned and Surgical Care • Chlidren’s and Country Wide Community Care
01	MS Word, 1 page	Organisational Structure – Corporate Directorate July 2016	Organisational structure
01	MS Word, 2 pages	Water Safety Group TOR May 2015	Terms of Reference: 1 Accountable to, 2 Purpose of the group, 3 Responsibilities, 4 Membership (core membership ; ad hoc attendance by invitation of the chair), 5 Quorum, 6 Frequency of Meetings, 7 Review, 8 Date
02	Folder containing 2 PDF drawings of hot and cold water services	0707-H&C H&C-0A	
02	PDF, 115 pages	DH_HBN_0002	From: Link to Department of Health, Health Building Note 00-02: Sanitary Spaces https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/525745/DH_HBN_0002.pdf
02	PDF, 1 page	Estates Facilities Senior Team - Aug 2015	Organisational structure

02	PDF, 1 page	Estates Tree - June 2016 ANON	Organisational structure
02	MS Word, 3 pages	IPCC (Water Safety) Assurance Report June 2015	Infection Prevention & Control Committee (June 2015) Water Safety Group – Progress Report: 1 Purpose, 2 Background, 3 Assurance of compliance/performance against DoH requirements (Water Safety Management Group, Dental Unit, Drinking Water Fountains, Ice Machines, Hydrotherapy Pools, Birthing Pools, Endoscopy Water Management, Pseudomonas Results, Legionella Results, **PFI Water Management**) 4 Recommendations
02	MS Word, 3 pages	IPCC (Water Safety) Assurance Report December 2015	Infection Prevention & Control Committee (December 2015) Water Safety Group – Progress Report: 1 Purpose, 2 Background, 3 Assurance of compliance/performance against DoH requirements (Water Safety Management Group, Dental Unit, Water Safety Policy, Water Services Contracts, Pseudomonas, Legionella, Flushing), 4 Recommendation
02	MS Word, 3 pages	IPCC (Water Safety) Assurance Report February 2016	Infection Prevention & Control Committee (February 2016) Water Safety Group – Progress Report: 1 Purpose, 2 Background, 3 Assurance of compliance/performance against DoH requirements (Water Safety Management Group, Water Safety Policy, Water Services Contracts, Pseudomonas, Legionella, Flushing, Underused Outlets), 4 Recommendation

02	MS Word, 5 pages	TERMS OF REFERENCE VERSION 2 July 2016	Water Safety Group – Terms of Reference: 1 Introduction, 2 Purpose, 3 Meetings, 4 Quorum, 5 Objectives, 6 Membership, 7 Responsibilities (Executive Lead, Associate Director of Estates, Lead Infection Control Doctor, Head of Microbiology, Head of Nursing/Nurse Consultant IPC, Heads of Nursing, Infection Prevention and control Nurse, Consultant Microbiologist, PFI Contracts Manager, Deputy Head of Estates, Environmental Manager, Deputy Health and Safety, Deputy Head of Facilities (Patient Environment), Head of Capital Estates Projects, Trust External Advisers, 8 Review
02	MS Word, 5 pages	Water Safety 28.01.2015	Water Safety Group: 1 Minutes of Previous Meeting, 2 Actions Outstanding, 3 Pseudomonas Results, 4 Hydrotherapy Pools, 5 Endoscopy Water Management, 6 AOB (Any Other Business / Actions Outstanding)
02	MS Word, 5 pages	Water Safety 28.10.2015	Water Safety Group: 1 Minutes of Previous Meeting, 2 Actions Outstanding, 3 Pseudomonas Results (Actions Outstanding), 4 Pseudomonas Results, 5 Legionella Results, 6 Flushing, 7 Filters, 8 Underused Outlets, 9 Endoscopy Water Management, 10 AOB
02	MS Word, 5 pages	Water Safety 25.11.2015	Water Safety Group: 1 Minutes of Previous Meeting, 2 Actions Outstanding, 3 Pseudomonas Results, 4 Legionella Results, 5 Flushing, 6 Filters, 7 Underused Outlets, 8 Hydrotherapy Pools, 9 Birthing Pools, 10 Endoscopy Water Management, 11 Dental Unit Responsibility, 12 Policy Update/Review, 13 AOB

02	MS Word, 7 pages	Water Safety 25.05.2016	Water Safety Group: 1 Minutes of Previous Meeting, 2 Actions Outstanding, 3 Pseudomonas Results, 4 Legionella Results, 5 Flushing, 6 Filters, 7 Underused Outlets, 8 Hydrotherapy Pool, 9 Birthing Pools, 10 Endoscopy Water Management, 11 Dental Unit Responsibility, 12 AOB
02	MS Word, 6 pages	Water Safety 29.06.2016	Water Safety Group: 1 Matters arising (Outstanding Actions), 2 Pseudomonas Results, 3 Legionella Results, 4 Flushing, 5 Filters, 6 Underused Outlets, 7 Birthing Pools, 8 Endoscopy Water Management, 9 Dental Unit Responsibility, 10 AOB
05	PDF, 1 page	Organisationsstruktur FM FS Mai2017	
06	MS Word, 22 pages	Water safety plan V1 JC	Water Safety Plan: 1 Water Safety Group, 2 Define Roles and responsibilities, 3 Identification & Description of water systems, 4 Appoint a competent Water Hygiene Contractor, 5 Risk Assess Water Safety, 6 Clinical Risk Assessment, 7 Implement and maintain monitoring and control measures, 8 Review control measures, 9 Sampling Strategy, 10 Corrective Actions, 11 Supportive training and review programme, 12 Actively improving water system compliance, 13 Audit and review of Compliance Levels, Appendix 2 – Accountability Chart, Appendix 3 – Identified Property List, Appendix 4 – High Patient Risk Areas, Appendix 5 – Typical monitoring / control requirements - Domestic Water Systems (Subject to change), Appendix 6: Key corporate water safety training requirements

06	MS Word, 4 pages	WSP - Point of Use Filtration	Water Safety Procedure – Point of use water outlet filtration: Definition, Usage, Risks, Responsibilities, Product Selection, Deployment, Record Keeping, Typical Installation Requirements (Always refer to manufacturers guidance)
06	MS Word, 3 pages	WSP - Thermostatic Mixer Valves	Water Safety Procedure - Thermostatic Mixer Valves: Types of Thermostatic Mixer Valve, Product Selectin, Acceptable temperature ranges, Monitoring and maintenance, TMV / TMT Temp Checks, TMV/ TMT Maintenance
06	PDF, 25 pages	WaterSafetyRiskManagementPolicyandProcedures	1 PURPOSE OF POLICY: 1.1 Summary, 1.2 Introduction, 1.3 Scope, 1.4 Purpose, 2 Definitions, 3 Key Legislation and Guidance, 3.1 Related Trust Policies and Guidance, 4 Roles and Responsibilities, 4.1 Management Roles, 4.2 Water Safety Group, 4.3 Water Hygiene Contractor, 5 Principles, 5.1 Management Plan, 5.2 Risk Assessments, 5.3 Patient Expectations, 5.4 Sampling, 5.5 Escalation procedure, 6 Implementation, 6.1 Education & Support Plan, 7 Process for Monitoring Compliance/Effectiveness, 8 Arrangements for review of the policy, 9 References and Bibliography, 10 Appendices, Appendix-1 Key Personnel, Appendix-2 Action Sheet-1 (Elevated Lp Counts), Appendix-3 Action Sheet-2 (Positive PA Counts), Appendix-4 Action Sheet-3 (UHS Nosocomial Case), Appendix-5 Action Sheet-4 (UHS Nosocomial Case), Appendix-6 Action Sheet-5 (Use of Bacterial Filters), Appendix-7 Flushing Log Sheet, Appendix-8 High-Risk/Augmented Care Areas

Table Appendix A-27: Additional documents received from the gatekeepers during interviews phase I b

ID organisation	Type of document	Title of document	Category type
01	PDF, 1 page	1 WSP Water Hygiene - PPM Process Charts	Process Flowchart [incomplete]
01	MS Word, 62 pages	Water safety plan V1 JC Feb2018	WSP
01	MS Word, 22 pages	Water Safety Policy v1.2 (latest draft)	Policy
01	MS Word, 2 pages	WSP – Checklist for a New System Design or Alteration draft v2	Water Safety Procedure-Checklist
01	MS Word, 3 pages	WSP - Corrective and Remedial Actions	Instruction document Defect, Requirement, Recommendation, Risk and Priority
01	MS Word, 1 page	WSP - Flushing and Scale Audits (example)	Guidance document / Audit document
01	PDF, 2 pages	WSP – Shower Head & Hose Management	Guidance document
01	PDF, 1 page	WSP - Water Hygiene Asset Tagging Flowchart	Process Flowchart
01	PDF, 1 page	WSP - Water Hygiene Flushing Flowchart	Process Flowchart
01	PDF, 1 page	WSP - Water Hygiene PPM Flowchart	Process Flowchart [complete]
01	PDF, 1 page	WSP - Water Hygiene Risk Assessment Flowchart	Process Flowchart
02	PDF, 32 pages	043-Water-Safety-Policy	Policy
02	MS Word, 1 page	AgendaDec17	Agenda / schedule
02	PDF, 3 pages	Client Access Agreement - Provision of Car Parking Design Build Finance and Operation	Client access agreement
02	PDF, 4 pages	Daily Flushing User Manual	Guidance document
02	MS Word, 2 pages	Guidance Note for Flushing underused outlets	Guidance document

02	MS Word, 1 page	L8 Guard Comms	Guidance document
02	MS Word, 8 pages	Risk-Assessment-Form-water safety	Risk assessment form
02	MS Word, 4 pages	TOR – Terms of Reference Water Safety Group 2017	Terms of reference / Water safety group
02	MS Word, 129 pages	Water safety Management Plan - New option - GA - DJ (3)	WSP / Water safety management plan
02	MS Word, 7 pages	Water Sept17c	Action log / Water safety group
03	PDF, 39 pages	Water Safety Policy	Policy, Including documents such as: Monitoring Matrix Communications Pathway Implementation Plan Template Exality Impact Assessment Environmental Impact Assessment
04	PDF, 3 pages	AP Compliance Report Template - WMC	Compliance report
04	PDF, 1 page	WATER HYGIENE MANAGEMENT RESPONSIBILTY CHART - Final	Responsibility chart
04	PDF, 55 pages	Water-Safety Policy	Policy, including documents such as: Responsibility matrix Reporting matrix Property list Outlet flushing sheet Water and Air Systems requirements
04	PDF, 2 pages	WMC TOR	Water Management Committee – Terms of Reference
04	PDF, 98 pages	WATER SAFETY PLAN Draft REV Jan'18 NUH (3)	Water Safety Plan
05	MS Word, 17 pages	Water Safety Policy 18 Oct 17	Water Safety Policy
05	MS Word, 21 pages	Section 001 Dec 2016 (3) - Management and Organisation of the Prevention and Control of Healthcare-associated Infection	Policy Infection Prevention - HAI

06	MS Word, 56 pages	[redacted] Hospital, IoT Log Book including SOP's	Legionellosis Management & Control Log-Book PPM Schedule Tasks and Frequencies
06	PDF, 94 pages	HTM 04-01 Part A Design, install, commission (2016)	
06	PDF, 30 pages	HYR27530---[redacted]RVI---AUDIT-MK@221017 RVI [and previous version: HYR27530---[redacted]RVI---AUDIT-MK@221017]	Risk Management Audit Report
06	PDF, 28 pages	HYR28056---[redacted]AUDIT-MK@221017 [redacted] [and HYR28056---[redacted]AU-DIT-MK@221017]	Risk Management Audit Report
06	PDF, 28 pages	HYR28057---[redacted]CAV---AUDIT-MK@221017 CAV [and HYR28057---[redacted]CAV---AUDIT-MK@221017]	Risk Management Audit Report
06	PFD, 30 pages	HYR28060---[redacted]GOVERNANCE-AUDIT-REPORT-MK@101117	Water Governance Audit Report
06	PDF, 115 pages	Water Safety Plan_v3.1_2017	Water Safety Plan
06	PDF, 10 pages	WaterSafetyPolicy201802	Water Safety Policy
07	PDF, 5 pages	A_New_Approach_HorneCaseStudy	Approach Description
07	MS Word, 4 pages	Management of Water Management Plan Board approval paper	Water Management – Board Approval Paper
07	MS Excel	WSG Action Log - 5 April 2018	WSG – Action Log
07	MS Word, 3 pages	WSG Minutes - 5 April 2018	WSG – Minutes
07	MS Word, 28 pages	WSHAE3121C10 - Final Draft Policy Water Hygiene v8 20170411	Policy
07	MS Word, 98 pages	WSHAE3121C13 - DRAFT WSP-Tech 20170508	Water Safety Plan
07	PDF, 9 pages	WSHAE3896C18 - AE annual audit 20180104	Audit Report
08	MS Word, 5 pages	NCA Terms of Reference Water Safety Committee April 2018	Terms of reference

08	MS Word, 104 pages	PAT - WSP_TECH 20171101 DRAFT AM and PP Comments and Tracked Changes	Water Safety Plan: Operation & Mainte-nance Procedures
08	MS Word, 2 pages	PAT Terms of Reference	Water Safety Plan – Terms of Reference
08	PDF, 57 pages	PAT Water Safety Policy EDE015 V5	Policy
09	n/a	n/a	n/a
10	n/a	n/a	n/a
11	MS Word, 12 pages	Water Safety Plan	Water Safety Plan
11	MS Word, 12 pages	Water systems Policy Dec 2016 DRAFT	Water Systems Policy

Figure Appendix A-10: Totality of additional documents received from the gatekeepers during interviews phase I b

Appendix B

Top 3 key functions

Table Appendix B-1: Extracted and condensed answers on question 4, phase I b

ID hos-pital	Extract of specific answer	PESTLE and CTAAPM category codes
01	Day to day management of water safety. Look the hands on, managing the contractor, cause we employ managing contractor. To make sure they're delivering the full way of compliance. And also trying to drive through compliance. With the ACoP, I see in raising awareness, making sure covering everything we should be covering, and HSG274 / HTM04.	CC, CM PL, CAw
02	Estate development and strategy, compliance and operational management.	PL, CM
03	Managing the PFI contract. And board insurance, make sure the Estates compliance responsibility of the trust is met. And, also on the daily turn is the finance security, capital and emergency planning responsibilities.	CC, CM PL PEc
04	I manage our PFI arrangements. Half of our estate is PFI. It's the largest PFI contract in the country. It manages assets with a book value of about 2.8 billion. And making that value for money, making that relationship work. Another key one would be managing all our estates. Retain the estate and making that compliant, and that includes seeing about fire safety and other environmental hazards and making it fit for patients. And then there's a number of commercial contracts that we hold, not least with our service providers.We've got the biggest soft FM contract in the country that I'm aware of, for cleaning, catering, portering and such like, the things that fall outside of hard FM. The hard FM, the soft FM, PFI contact management that are probably the key functions. I mean, in with the hard FM, it is the responsibility for backlog repair, which is the investment into the estate.	PP PEc CM CC CM PT

05	I've got overall responsibility for all estate's maintenance. I've got overall responsibility for all vicinity services, so that's the likes of catering, domestics, all that kind of stuff. And I've got responsibility for delivering capital projects, so new bills, games, major refurbishments, and that stuff.	PT PEc
06	In terms of function, I look after EBME. I look after fire safety, we look at the construction and capital projects, we look after breakdown, maintenance. And my portfolio for some reason is emergency planning and business continuity. So they are the functions within the directorate that we have from the main functions anywhere.	PEc PEn
07	Ultimately, my number one priority and always will be is the safety of our patients. For the purposes of this conversation, yes, it's patient safety so the water that they are going to use at the point-of-use must be clean and pure so it does not, obviously, give them any hospital-acquired illnesses. Especially when our patients are at their lowest ebb and at their weakest with their immune system. So patient safety is my number one priority followed by statutory and mandatory compliance. So I have got to maintain my <u>risk register</u>. I have to make sure that I am being proactive in my water temperature checks, in my removal of blind ends, in my maintenance of water tanks, so on and so forth. And my third would be if I was honest, looking at the future. The ACoP L8: So we had a <u>risk assessment</u> done a year or so ago and they risk rated the problems they felt were there and then they categorised the risk using a process-- I'm not sure if you're familiar, you probably are, it's called <u>ALARP. So that's as low as reasonably practical</u>. So my criteria for priorities ones would be all of my critical care areas.	CP PL, CM PT, CP PT PL, CT CP PEn, CT CAw
08	Compliance is the top responsibility. Safety is the second key function and governance will be the third. In the UK we've got overarching legislation such as not just the Health and Safety at Work Act but numerous parliamentary acts and mandated instruments that we are legally responsible to adhere to. So at work regulations, the health technical memoranda, which are not enshrined in law but are referred to should you find yourself in front of a judge in court. So it's general compliance with statutory and mandated requirements. And then safety. In terms of water, for example, water safety, is the system safe for us staff and patients to use? And then governance is around about control. So have we got the right systems, policies, processes and procedures in place for one? And then for what we have in place, are we following them resolutely? So should we be subject of a peer review or an audit if we can demonstrate that we have control of our organisation or it might be control of my department?	CM, PL CC PP PL

09	To control and manage all engineering services on the trust. So that would include the hot water generation systems. It would include the pipework that whole distribution system and any control systems that we have installed as well. The second part of my or second key function of my role is to influence or control any alterations that occur to those systems within the trust. So if someone wanted to interact with change part of the hot water system for instance then I would be an influencer on that. So if I needed to I can stop a process or a task from going ahead if it's deemed unsafe as long as I can justify it. And then the third key function would be to ensure compliance. I am not the head of compliance. I have to make sure that we adhere to the regulations and the health technical memoranda in everything that we do and that we have the documentation-- that we create the documentation that gets handed over to the compliance department so they can prove that we are compliant.	PT, CP CM PEn, PP CM CC, PL CT
10	Risk, governance and compliance.	CP, CC, PL
11	Number one is the design, install, commission, test, maintain, and audit of the hospital's water systems. Number two is for the control of *Legionella* and any other waterborne pathogens of the water system. And number three will be for water safety in augmented care areas, which are higher risk areas (even in terms about *Pseudomonas*).	PT, PEn CP CC, CP

Members of the WSG

Table Appendix B-2: Extracted and condensed answers on question 8, phase I b

ID hospital	Extract of specific answer	PESTLE and CTAAPM category codes
01	There is a lot more people on the mailing list than all that do attend. So I would say eight people, approximately.	PS
02	We have a very successful water safety group, that’s been in operation for about five years then. We are a really good balanced team now. There’s some really good debate within that group. I am a member of the chair of the group. We have 10 people.	PS

03	About a dozen, about 12 in different key positions in the hospital. Infections control, estates management, (others). Because we're a PFI hospital, we've also got the PFI project committee, to let us find action, finances of the project.	PS, CAc
04	We created a water management committee, which works trust wide as an organisational group. And then we've got local water safety groups that act locally on the hospital sites. They're interested in the business of their own hospital. What happens is the approved person for each hospital should come to that committee and should provide exception reports, on things, on issues, what's happening in water safety. And then, if there are risks that have not, or the water committee feel that the risk isn't fully mitigated, or there are trends causing concern, then those issues would be escalated to the infection control committee, which is a broader body of people. As the name suggests, it deals with the pertinence of infection control, so there are issues with water safety, which the infection committee would be interested in. Well, I set up the water safety committee (i.e. water safety group), and I used to chair it, but I no longer chair it. So we have a specialist, an engineer, who chairs that committee. He's the head of estate's [redacted] Hospital in his day job. But he also is a specialist in the sense that he's done all the appropriate training and keeps his training up to date.	CAc, PS PP
05	I think there's about seven different sort of departments reporting to the water safety group. So at the moment my deputy will chair the group. And we meet then on a monthly basis about all aspects of everything she does, and water safety is one of them. So I've got sort of indirect access. I've got an overview, but I won't go to the meeting myself.	PS, PP
06	You have some members listed in your list. We will have all of those people as representatives in the group. Plus, we have the external auditing independent engineers role filled, and it's really it's well-established and working correctly with the health technical memorandum. So you would you'd find we will be following an exemplary group.	PS PL
07	The core group would be, obviously, the chair, the responsible person. Then you'd have the workshop managers from each site, and there'd be two. So there's four. We would have infection control and microbiologist. So there's seven. We have the domestics team, that's eight. We would have a decontamination team. So that's nine. I'm going round the room in my head. There's at least 10, 10 people turning up to the meeting every month.	PS CAc

08	For [redacted] here was approximately 12 in the Water Safety Group and for [redacted], there was approximately five in the Water Safety Group. In the new Water Safety Group, there are 20. And 20 different functions. We've got two microbiologists. We've got infection prevention. We've got four senior managers from the estates team. We've got four senior managers from estates delivery operational. We've got health and safety. We've got the authorizing engineer. We have got two senior managers from medical engineering or medical physics. Some people call them EBME, Electro-biomedical Engineering. We've got a head of nursing in there. We've got myself, the director of estates, and we've got a nursing director in there.	PS PP CAc
09	It's only in the last sort of six months to five months that we've really been pushing very hard to bring the correct stakeholders onboard. So currently we have someone from action control who typically comes and sits on the panel. We have the director of estates because he's a board member so he can influence at board level, so he sits on the trust. We have the lead responsible person for water who sits on the trust. We'll normally have a director of nursing, so someone who can affect the clinical decisions and clinical interactions who will sit in the group as well. We would normally have an authorising engineer which is an external person to the trust that's employed by the trust, so a contracted authorising engineer who will come and sit on the group, and then normally anyone else that would be considered like an authorised person or equivalent, so the water safety manager as well.	PS CAc PP
10	The group has not been structured yet. I have the water AE I've appointed yesterday. He was here yesterday. And that's part of the water safety plan going forwards, that we have a quarterly water safety group meeting with the relevant members attending.	PS CAc
11	I am a member of that water systems group. Approximately 10 people sit in there. Infection control chairs the group. A gentleman, and he's over all the hospitals. He's the head of the water systems group. So I just report in to him.	PS CAc

Potential conflicts: PFIs, Trust, FM companies, estates departments

Table Appendix B-3: Extracted and condensed answers on question 10, phase I b.

ID hospital	Extract of specific answer	PESTLE and CTAAPM category codes
01	I'm not really sure about what to say about that one. Skip that question.	n/a
02	I can go through them for you. I don't currently have any PFIs, but in a previous role I've dealt with PFIs. I've not found there have been any conflicts or such, within the PFI on water safety. All indeed, any issues with minor works, to be honest. Although I would say that they always aim for the minimum requirements. That was always the only bit of conflict really. That they action the minimum about that you need to do, but didn't go any further, just to fulfil requirements, but not necessarily that does meet the necessities in place. Trustwise I actually think the introduction of water safety groups is now a recognised group within the Trust. Others think, not honestly so of importance of it. The only conflicts that we have, you know, within Trusts at all are the finances. I would say the'll give us to money this, the water system, that's the only real conflict. FM companies. Nothing at the moment so we do everything in the house what there could reambled. In a previous role at another hospital, we did use an FM company. And I think that they were happy to take the responsibility, but it was in their interest to find problems and issues. Because it derives them with an additional income. And you're up to dig very deep into the results and the information they were providing you, to be able to fully understand whether or not that was a thing you should progress or not. Maybe [they do] not the right things, but available making them to generate a sort of additional income. And finally, Trust Estates Department. Yeah I've been at three or four hospitals now. And I was then in Trusts and Health Department to always be in the lead on water safety. It is quite clear about responsibilities and that's the reason behind that really the Health Technical Memorandum (HTM) they're quite specific in what the requirements are. So I think, from an engineer's point of view, they are, you know, they are defined very well. I think the conflicts you'll find within any Estates Department is around the resource available. So I would say if Health Department is over there looking come back to a minimum level, so there isn't the capacity any more to	CC, CT CAw PL PP PEc PS, CAc CAw, PEc PS, CAc CAc CM

	be able to do perhaps everything that you should be doing. [It's a sort of grey zone]. And they do the priorities. You know, water is only one element in terms of, of all the things we deal, you know, this practice systems, it's asbestos, electrical, air-conditioning, you know, keep your interest, if you like, as well.	PP
03	Yeah, I mean, I think, we're unique in the sense that we are a PFI hospital, so we all escape the push-back from the provider about it's the Trust's responsibility to do certain elements on it. The FM provider just wants a little for their offers. And sometimes things get missed, because it's, well, we thought you were doing it, and we thought they were doing it, whatever. And that's why I think the water safety group is so important which look that governance is right. Due to a further complication here, we got about 30% retain to estate which were built in about 1980s to come on that. And that was built to a certain level of standard of that time as were called the flexible hoses and things. So when we identify flexible hoses in use, we take the estate, they are saying, well, it's your liability to put that ever right. Cause obviously there was a collaborative rumour on flexible hoses, if they properly work. And it then becomes, well, when did we know that in responsibilities, in well, this is going on. It keeps us trying on and on and on.	PP, PEc CC, CM CT PP, PEn PL
04	Yeah, within our policy, the roles and responsibilities are quite clear, even though it's quite-- that's because we've got lots of hospitals. We've also got PFI. PFI creates an ambiguity in those responsibilities because according to the contract, the PFI agreement, there's an estates provider who sits alone, almost, outside of the trust. And so that can be problematic, in terms of the communication. It can create contractual loops around our ability between the client and the service provider. I think our relationship is better than that. Actually, we've managed to put those issues to one side, and I think we've got quite a good governance arrangement on this particular matter, with our FM provider. Mentioning potential conflicts about communication. I'll provide an example which is a real-life example. But the contract that we have was drafted and signed before the emergent problem of Pseudomonas aeruginosa became a problem. And as an emerging problem, there wasn't guidance or policy at the time to deal with that. And it took some time to get the commercial arrangements around the additional duties that that required to get that sorted out. And that's been sorted out now. The contract as a historical artefact, isn't very contemporary, and you see-- so you have to kind of keep changing it to take account of current legislation and guidance. So that was a-- so but in practical terms, what did that mean then?	PS, CT CM PEn PL, CAw CC PL

	Well, for a while, it wasn't easy just to get flushing the outlets done quickly because, I think, we're all waiting for orders, and commercial wanted us to proceed without adequate process. It should just happen. Now, we've moved past that now, and we've got the contract. It's been modified to take account of the current situation, which is a bonus. So we've got robust, I feel anyway, robust systems in place. And so that's an example where contract-- that's a new point in time, and it becomes updated to the current standard of requirement that's needed.	CAw CM CP
05	Okay. I suppose in terms of the [redacted], like I said, we've only got one hospital. It's not a PFI. It's a very traditional NHS hospital, so there's effectively just the clinical side and the corporate services side. So in terms of conflict of dealing with water safety management, there isn't a great deal, to be honest. We've had some sort of-- I wouldn't say conflict. We've had different opinions in the past between my operation estates team and the microbiology, the director of infection prevention control, around the testing for *Legionella*. So it's not been a conflict, but it's something that she's wanted and has had very strong opinions about. Her predecessor didn't. Things weren't tested in the past, but we had a bit of an ongoing debate about, "Well, why do we need it? And what's so worrisome?" and all the rest of it. So that's not so much conflict. And then in terms of any costs for carrying out works. Well, up to the point where this company was formed, everything was affecting the cost of the foundation trust. There was never any real major conflicts about cost. It was the usual thing. If something needs doing, then either you get in your revenue budget, or if it's a major piece of work, then that has to be sort of escalated further up the management chain. Talked about the whys and the wherefores and look at the risk of doing it, the risk of not doing it, and decision's made. So it wasn't conflict. It was just a due process of spending money. It's, I would say, a debate with differing views, but you always ended up agreeing in some shape or form. It was never where one party just wouldn't agree to anything or didn't do anything. It never worked like that. Well, I mean, I've had experience of working with PFIs, like I said, not on this site, this organisation I work for. PFI companies are very much, unless it was in their contract to do, then they wouldn't do it. They just didn't see it as their responsibility and, therefore, wouldn't do it. FM companies, as I mentioned, we've got about 100 and-- well, we're in about 170 properties across [redacted], that sort of area. We're a big community trust, and we rely a lot on the landlords of those properties to give us evidence of compliance, part of which is *Legionella*. And getting information out of them can be very difficult.	PP CM PS, CAc CAw CP PEc PL, CC, CM PT PEn CM PL, CC

	We ask them simple questions. Ask them for evidence and, lots of times, just say, "Yes. We comply." Now, they don't actually show you any evidence. They just say, "We comply." We can't force them to hand out the information, so we have to go on what they tell us, and we hope they're being truthful. But other parties just aren't cooperative. They don't send you anything, other parties seem to think it doesn't apply to them. Well, clearly, they don't understand their obligations, but it's-- for sites they are involved in, I'd say the biggest problem is just getting information out of people. Because they just can't be bothered in some instances.	CAw CAc
06	Unfortunately, you're talking to somebody with-- 29% of us did is PFI private finance. So we've got pockets within the hospital sites that we've got. And some of it's significant. Probably a 100,000 square meters of hospital estate. But the services provider which is [redacted], just so you know, it's not proven to be a very successful service provider to us. Within the contract, we have service failure points and deductions. And we are constantly issuing penalties and warning notes to them. I find speaking personally and candidly about this that the contract is keen with the PFI provider. Patient care and patient centre service is well down their priority list, its contract, its funding. It's higher priority saving their own skin, and making sure they can reduce their services penalty failures to the minimum law by contractual, if you like, interpretation than patient safety. And since I arrived it was-- within the water safety group, for example, we have that relation safety and other safety groups. They weren't allowed in to-- sorry, they were allowed in for the first session to do the peer review. And then they were asked to leave. And I've sort of changed that to try and make sure that everybody's aware of everything that's been discussed. Some people have criticised me a little bit for that. But hey, if you're not going to try and build a partnership-- and then if they don't understand what we're trying to achieve from a policy and a delivery point of view, then it won't get better. It hasn't made a great deal of difference I have to say. They ask me about my skill and experience. I don't find they have-- certainly, the guys that I employed on our PFI contract having enough experience in this area to want me to feel comfortable that I have the assurance that they are doing everything correctly. That might be one example, the changes in current standards-- a good example is flexible hoses, for example. Quite a number of years ago they were outlawed for their ability to harbour *Legionella* and assist the growth. They were all over, even though this was commissioned in 2007. The in-store bit of that-- probably [inaudible] design in the store probably would have been in 2003, 2004. So we ended up-- or the hospitals ended up with a lot of these flexible hoses, but they will not take them out unless	PEc CC, CT CAw PEc PL, CP CT, CM CAw CC, CT CAw, CM PL, CP PEc

	they're paid £270,000, for example. So that's the issue. It's always contractual with them. It doesn't matter if it's a safety issue, really. It's not something that they'll be proactive in trying to assist with unless there's a cost associated with it.	CP
07	Right. So just to clarify, we have no PFI. So we are definitely a B (FM companies) and a D (Trust estates departments). We are the trust estate staff. Well, okay, what we do have on a monthly basis, is a company called [redacted] coming to the site. And they go around and monitor all our temperatures. They don't do any other work other than-- our paint cleaning is done by an external company. So yeah, but as for the day-to-day management and work, that's purely us. Because you're quite right with your statement. It's ridiculous costly.	CC, CT CAc PEc, CP, CM
08	<u>The beauty I think of my organisation is the seniority of the position in which I sit as chair of the Water Safety Group. So as chair, I've got a clear responsibility to ensure that we've got the water safety is of paramount importance to the organisation. So despite having a powerful group of people in the Water Safety Group, as chair, I reserve the right to have the overriding vote in any discussion. So if there's conflict, then I will stop the conflict.</u> What we have to recognise, and what certain stakeholders have to recognise is-- so I've got a mix of PFI and non-PFI sites, and where the trust has bought into a PFI contract, the trust has to accept that-- the principle of the PFI is that in 20 years or 30 years time, you will be handed a building which should be in as good as condition in 30 years time as it was on the day it was built. And so in there, the provider builds in my cycle costs and I think it's-- Well, it looks expensive on the outside looking in. The principles behind life-cycle costs make absolute sense. And so when there's a conflict from the employing trust, my duty as chair of the Water Safety Group, and the associate director, is to remind them what they've bought into. PFI has a specific reason. It has a way of working. And the PFI understand where they sit as well within the organisation. And then in terms of the departments, so anything to do with water all comes through the Water Safety Group so-- put the PFIs to one side. The PFI is still considered through the Water Safety Group, but anything else to do with water will be lead by Estates if it's infrastructure. So if its pikes on the walls, and Estates from a day-to-day perspective will manage that. And if there's a conflict in terms of who's paying for this, typically, if it's fixed to the building, it's usually an Estate cost anyway. So I would say 90% of the water issues in terms of who pays the bill, are met by Estates. But there are other areas where if, for example, a department wants to buy a water cooler so water	PS CT CC, CM PEn PEc CT, CAc PS, CM PEc

	coolers, we don't just buy them anymore in the organisation. The request comes through the Water Safety Group and the Water Safety Group with Estates say whether or not it is feasible, practicable, and reasonable to install a water cooler in that location without impacting on the safety of the water system or the safety of the cooler itself. And we insist that that water cooler is subject to a maintenance contract with an approved provider. So we don't pay those costs then. The department that wants the water cooler pays for those costs. But they have to accept it comes at a cost. So, historically what I've found in this organisation - both of the organisations - is there was an element of lack of control. So departments could just go and order water coolers at will and have them installed. So we stopped that. If you want something that's water-related it must come through the Water Safety Group. So if it's not part of the infrastructure and it's ad hoc to that it comes through Water Safety Group for us to approve. And then we've also got sort of third-party providers such as-- so equipment manufacturers who use water in their system or their machinery as part of their process. So any equipment that uses-- so we won't pay for that. The department user pays for that equipment, but before they purchase it if its got water in it, or it stores water, or it has a reservoir in it, then the equipment has to be fed through the Water Safety Group for them to understand the risks that it's bringing into the organisation and for us to have it risk assessed appropriately by our authorising engineer. So a robust process I'd say. If you want something to do with water, it comes through the Water Safety Group, and you do as you're told otherwise you don't get it.	PEn CT, CAc CAw, CM PT PEc CC PS, CAc PEn, CT CAc PEn, CT
09	No, there's quite a significant amount. So within our Trust, we have a PFI that sits on the Trust [inaudible]. The hospital is divided into three separate sections or government areas if you would like. So we have the main NHS Trust which we are responsible for. The entire site we are responsible for water supply, but we specifically influence the NHS part of the Trust. We then have a PFI. Whilst it is NHS, it's privately funded and managed so there's one whole wing of the hospital which is effectively a private hospital and whilst [inaudible] of the NHS it's run separately to us. So we will supply water up to where it enters their building and from that point onwards, the responsibility sits with them, and then we have the university part of the hospital which is the teaching part, and again this is managed by-- their buildings are managed by their own estate's team and so we're responsible for everything that's supplied to their buildings but as soon as it enters their building it becomes their responsibility and they manage that themselves. So you have, obviously, things happening within those wings or buildings of the hospital, parts of the hospital, that are outside of our	PP CT, CAc PEn CT PEc PEn CAw CP

	control and whilst we can influence it through the lease agreements we can't necessarily control it, so you do have a conflict of interest there because what we potentially want to see happen with water safety may not	CC
	fall within their strategies or their policies you have a third interaction as well, which is whilst we manage and run the estate, we don't run the projects that happen on that estate. So you have a separate department which is the tactical projects department. So any major refurbishments like	PL, CT
	a new ward or ward being refurbished or a new ward being built, a new building being built, if they refurbish or build new theatres, anything like this, would normally be the whole contract from design through to completion, would be run by the tactical projects department. Then they would sign over the finished product to us so we would accept responsibility for it once it was completed. The vast majority of project managers these	PS, CAc
	days are not technically qualified. So they qualify as project managers but they're not qualified in the principles of engineering. So they don't necessarily understand everything that they are working with. They rely very heavily on external consultation. And there's a very large tendency in order to reduce cost and to reduce complexity, for external consultants to	CAw
	view water systems or any system for that matter, it doesn't have to be a water system, but to view systems in isolation of the wider system. So	PEc
	working on that, if they're refurbishing a ward for instance or building a	CC, CP
	new ward, they will look at the pipework that immediately supplies that ward and they will base all of their assumptions on the size of the pipework immediately supplying that ward and the temperatures or pressures available at that exact point. But they won't consider what's happening in the wider system so that same system could be feeding another 40 wards and	CAw, CM
	they won't consider all of the outlets and everything that's happening in the other wards or the system surrounding them, which means that they design specifically for their isolated project without considering the whole system. Which means that when it comes to actually running the system, it may not be compliant to achieve the correct temperatures run to it,	PEn
	achieve the correct flow rates, and that creates obviously, a massive conflict of interest because we can't accept that project over-- well, we shouldn't accept that project over, but if you don't have a strong management team within the department, then very often then they will take on the responsibility of that product, unfinished product, even though it doesn't	CC
	meet requirement. And then that goes on to create additional problems	CAw
	and expenditure later on down the line.	CM
	That only considers the capital projects aspect [inaudible] one other department within the trust. In terms of PFIs-- so for instance within [redacted] you have the [redacted] wing of hospital which is a PFI wing,	

	privately funded investment and then private hospital section. I mean generally with the PFIs what they tend to do is they tend to have a management company run the Estates or engineering side of the [inaudible] facilities side on their behalf which is what happens there. Now obviously within that they've got investment criteria that they need to meet so they'll be looking at return on investment within the period that they remain privately funded. So there's a payback period after which that PFI will then come back under our control within a space and it will no longer be a PFI. It will just form part of the trust. So they have a strategy that they are looking at in order to achieve their return on investment and that strategy may not always line up with ours. So while we may be pushing for certain improvements and certain investment because they are looking to get or gain a return on the investment they've already placed the two strategies are very often misaligned from that perspective. Then within the university side what you have there is you have an FM company. So university essentially just outsources their entire management and maintenance of their estate to a profit oriented company and external consultancy company. And again, their whole view is to ensure that they obviously make money from managing that whole estate. So they're not looking at their part of the estate from the perspective of trying to necessarily always improve it. They are looking to make the most amount of money while staying compliant. So they'll remain compliant but they won't necessarily continuously invest on reinvest into that space. Unless they absolutely have to. So again, that can misalign with the estate strategy of their trust owned water safety team-- what we are. PFIs and external FM or service companies will typically look at the lifecycle cost and justify the position, obviously, there are certain aspects or regulation and compliance that you have to comply with. If they can make something work for as long as possible without having to reinvest into it, they will.	PEc PS PEc CM CM PEc PL, CC PS CT, CAc PEc, CM
10	They're using budget as an excuse not to do something. It's not a reasonable answer in--In risk management. --British court. I think what you've done, actually, in question 10, you've mentioned PFI, trusts, FM companies, and Trust Estates Department. You could take out the Trust Estates Department because that's really under trust. But it should also say it's third-party-managed estate. Because we have some third-party-managed estate here where the hospital is managed for us by a different entity, by another organisation. For instance, we've got a hospital in [redacted] that is managed for us by [redacted] Foundation Trust. And so it's a little bit of a different arrangement than in a private finance initiative, whereas there is an FM provider on the sides, an estates team run by	PEc PP, PL PS, CM CC

	some company to run the hospital. But then our interests are actually represented by another management company on that side. So really, you could talk about third-party-managed sides and landlord sides where we're just a tenant in somebody else's building. So there's two other things that you haven't included. But where the conflict can occur is when-- for instance, it's much easier to control and manage things in wholly-owned premises, such as a trust hospital. It becomes more difficult to control and manage things within some third-party situations, such as PFI or an FM company, because we don't have direct control about what that company's actually doing. They've got a contract, for instance, within the PFI arrangement, but there's a project bible or a project company that provides an estate's resource to run the hospital. But as they don't work for us, we have to look at what the actual project says, what the project bible says. "What does that contractual agreement actually mean? Does that agreement mean that the trusts still carry out water hygiene testing?" Or, "Who is responsible for that testing?". So a lot of the time, the conflict can occur where there's a contract in place, but the people delivering the contract, or the company delivering that contract, say, to the NHS, they think that the contract means one thing, but the NHS thinks it means another thing. And that's the thing about contracts. And especially with the English language, that the contractual description or the narrative within the contract can mean one thing to one person and one other thing to a different person. So the conflicts occur when A, there's some sort of third-party estates delivery, an estates delivery model, such as an outsource model or a third-party model. But also, there can also be conflict within an NHS trust, where the people running the estates department really don't understand what compliance means as laid out in L8 or HSG274 or in HTM 04-01 parts A and parts B. So some people are confused about what it is they should actually be-- which legislation should they be following and how that operational delivery looks like on the ground. And then there's the other factors about third-party-owned or third-party-delivered estates models.	CAw CAc PL, CM PP, PEc, CM CC CM CAw PS CAc PL CAw PL, CC CM
	And I think that that's an insightful thing, that is that without a progressive strategy in place, you don't - in a lot of NHS trusts - they don't have a written strategic estates document. And so then, a lot of, say, the estates subjectives are verbal instead of written down. And then because they're verbal, they can differ from person to person to person. So it's really important to have an estate strategy. And from that strategy, it should caveat into a water safety policy, a water safety plan. So it's very important to have those, again, rigid pieces of governance to tell you what the trust's assets are, and how the water safety planned would be delivered in a compliant way within those assets.	CM, PS CT CAc, CM

		PL, CC, CAc
11	I was the general manager of a PFI for 10 years before semi-retiring and coming over to the trust, so I do see both sides. That's pretty good for your answer. Basically, there's <u>the golden triangle, which is what we call the PFI provider, the consortium, the bankers, the people who fund the PFI, who have a responsibility to ensure that systems are in place.</u> They then employ the PFI FM company to carry out the work, which, in this case, would be to maintain service water systems in accordance with the NHS rules. And then the other side of the triangle is the NHS trust, whom the PFI consortium are providing that for. But they also do due diligence to ensure that the FM provider is doing what they should. So it's the golden triangle. It all works well until one of them links breaks. It's usually a blame then. If something goes wrong and you haven't got accountable systems in place, then it can become contractually difficult. From my personal opinion, I was very lucky. Well, we had a very good system, working both with the consortium, the trust, and the contracted FM provider. There is an add-on to that triangle, the actual water management provider, because in most cases, the FM company don't usually do it all themselves. They bring in a contractor, so you do have a fourth party that can cause issues. But from experience, from my side, it's worked well. But I do know that it can go the other way, and that usually can be where the FM provider of water systems doesn't uphold current standards of maintenance and service, or even install, like the HTM that we work to. So then it becomes the consortium's job to pull them up and ensure that they're doing it. And then, after that, you've got the trust shouting at the consortium that contractually they're not doing what they did, and then it becomes very much a contractual issue, which you don't ever want to get into because they get so protracted. It's the golden triangle. <u>And if you give that triangle pretty good costs, they're usually pretty reasonable.</u> Cost will only spiral if, one, it's proved that somebody is not doing what they should be doing, providing service and maintenance and all that, and then it becomes a blame culture of, "It wasn't in the contract." That's heard very often. Of course, on the other side, with PFIs, you probably know if there's any variations to contract, i.e., opening up a new ward or extensions, that becomes a variation to the basic PFI contract that we signed off. And, of course, cost can be very hefty when you go beyond costs calculated with a PFI. So that is the downside to it. If you could ever	PP, CM CT, CAc PL, CAc CC PS, CAc CM CT, CAc CAw PL CC CAw CT PEc CM PEn CAw

	build a hospital for 35 years and never change it, I think PFI would be the best thing. It's when you change it. I will mention also on the other side, you talk about life cycle. Again, a well-run PFI that has good backers and a good trust checking, you will always have the money to-- the stakeholders will always have the money to give to ensure that all systems are adequately financed for maintenance and life cycle. Whereas if you look at a standard NHS foundation trust, they never have the money to finance replacements or modifications. And I've been in both camps. That is one of the big things with PFI. You never find that a pump's being sweated. If a pump fails, it will be replaced, things like that.	CM PEn CC PEc PT, CT CM

Legionella – a topic of interest

Table Appendix B-4: Extracted and condensed answers on question 11, phase I b

ID hos-pital	Extract of specific answer	PESTLE and CTAAPM category codes
01	That we've got a water safety group, basically. So, it's recognised, I'd say. And I assume we got a duty to comply with, the law. So when I mean that someone raises it.	PS, PL, CM CC, CAc
02	It's not really. It only comes to the form when we got an issue. So if we've identified *Legionella* at the outlets of the system, that's when the organisation becomes interested. Prior to that, they are interested only in understanding we are compliant.	CM PL
03	It is quite topical. Medical Director has just appointed a new microbiologist, and so, the microbiologist is invitant onward to some way of *Legionella*, NHS *Legionella* Guidance. So we are quite interested in what we are doing.	PS, CM PL, CT

04	Well, *Pseudomonas* and *Legionella* are both being covered by the management committee. They do represent water safety in general, *Legionella* and *Pseudomonas*, maybe. And for that matter, any other water contaminant that might be a problem. Total viable bacteria counts that might cause a problem. Where we operate hydrotherapy pools, for example, has a different set of requirements to ordinary domestic water outlets. And we've also had them. We've recently restarted a water extraction borehole. And now what we see it's got quite a lot of external scrutiny from the environment agency because they want to see that the water quality is sufficiently good. I would say the main focus of the Water Management Committee and its safety groups, a little over 60 groups, is concerned with *Legionella* and with *Pseudomonas*.	PS; CM PEn PEn PS, CM
05	I suppose, like a lot of things in hospitals, it falls under the sort of patient safety banner. So it's discussed at water safety group. That report falls into an overarching sort of compliance group for all things estates and facilities. And then that feeds into the senior management team of the trust, and that group's chaired by the chief executive. So it's looked at from the point of view of myself giving the organisation assurance that, with respect to *Legionella*, we are managing the risk. We're not putting either patients, visitors, service users, staff at risk due to, well, basically, not doing what we should be doing. So it's a (patient) safety matter.	PS, CM
06	It's quite high up as a topic of interest. The site I'm on now is called [redacted]. Built in the '70s. So all of the design, single pipe systems with no returns and stuff like that. So we do manage with low counts of *Legionella*. So it's constantly at board. It's constantly there for assurance. It goes through our risk management assurance committee. We have a structure that, as soon as we have any counts, there's a number of executives included in an email alert, and we get responses, and we close the action down. So it is a topic that is of interest in understanding at board-level.	PEn CP PP, CM
07	It's massive. I'm very passionate about the water hygiene here at [redacted]. It's been a lot of hard work. For the purposes of the estates department, is massive because water, as I said to you earlier, plays such a critical part in the health and well-being of my patients. So it has to be high up there. To me, it's as dangerous as asbestos, it's as dangerous as getting an electric shock, because, at the end of the day, you can die from it. We maintained our water in a different way, which was by temperature control. But it was thought prudent based on other areas in other hospitals, that it probably would be a good idea to get a good snapshot of our critical	PS PEn

	care areas to see if there were problems. Sometimes we test weekly. One week it will be gone and then the next week it comes back for no rhyme, no reason. So yes, basically, it became quite a hot potato. I have to reassure, A, the water safety group. I'm also part of another group. If you write the acronym I-C-O-G, ICOG, and that's the Infection Control Operations Group. I have to report to them on a monthly basis what the state of *Legionella* risk is around the Trust. So you can see now where *Legionella* is now moving in towards the hospital in different hierarchies. That report has also been shared at another meeting I go to called TICC, which is T-I-C-C and that's the Trust Infection Control Committee. Which is a very senior management level. And at the last meeting I went to, Public Health England were in the meeting. So you can understand that it's obviously now being reported at a much higher level than just within the Water Safety Group. So the board is getting reassured and if the board is getting reassured, at the same time, the Chief Executive is also getting the reassurance that the water is being managed actively and safely within the Trust.	CP PS, CM PP
08	*Legionella* has not been thought a topic of interest in the organisation. The job of the new Water Safety Group is to get *Legionella* onto the Trust agenda so that our clinical colleagues far and wide understand the importance of *Legionella* and water safety management.	PS, CM
09	*Legionella* is one of the biggest topics of interest in our organisation because of the potential harm from it. I mean, that's across any hospital anywhere in the world. One of the reasons why I had to seek special permission in order to have this interview is because we have as a trust, within the last five years, experience multiple deaths from *Legionella*. So as you can imagine, because of that previous lack of control by the previous management team, it is a very serious topic and there are still ongoing investigations into the trust and the previous management team as to whether or not they had negated their duties and their responsibilities.	PP PL PS, CAw
10	It definitely is a topic of interest within our organisation. But it's the estates and facilities directorates that are the professionals in post, they understand the constraints of *Legionella* management. Other people within the trust, and if you spoke to it, an average English person, they probably wouldn't understand if you asked them, "Do you think that *Legionella* is a form of pneumonia?" They wouldn't know that answer. So the real interest is within the senior team, the board of the hospital, because they're aware that this is an issue. A <u>scheme of control</u> on how to lower the risk of the presence of the bacteria to an acceptable level. I noticed that the questions don't pertain to	PS, CM CC

	anything about *Pseudomonas*. *Pseudomonas*, it's a water-borne bacteria, and we take that very seriously within the NHS. But it's unlike *Legionella* because it's a surface-related bacteria. So it's not a pipe-work system bacteria, like *Legionella*. It's a surface-related bacteria, and it can cause real problems in sort of augmented wards, where people have had operations and they've got lowered immune systems. It can affect them quite badly. But it has different characteristics than the *Legionella*.	
11	It usually comes under either the water management group, obviously, and it's also an agenda item under the hospital's health and safety committee. So it figures under both.	PS, CM

Managing water systems

Table Appendix B-5: Extracted and condensed answers on question 12, phase I b

ID hospital	Extract of specific answer	PESTLE and CTAAPM category codes
01	Overseeing a water safety contractor and trying to implement sufficient schemes of control, auditing wards for scale and flushing, auditing contractor performance and driving through improvements to their compliance.	CM
02	The gentlemen who's responsible for water safety is my estates team. Temperature monitoring is one of our big ones, then we have a planned maintenance regime for numbers of water related tasks. We do bi-annual risk assessments, which are done independently. From that we get, I would say, action plans of the conditions. We then identify which ones of those we can effectively do, with the resources or the finances. Obviously the water safety group is key to all this. We don't sample, as general, a ward, with the exception of very high risk areas, which are things like neonatal, IT, UHTU, and theatres. So we do some regular sampling in those areas. They are treated differently. They are treated with a little bit more priority just because of the susceptible nature of the patients that are potentially in those areas. The water safety group meets bi-monthly. And there, we agree a correction for the following two months if you like. So review what's been done previous two months. We give some direction in clarity of to prioritise the following two months. It pushes you forward, or it	CP CM PS PEc PEn CP CM

	pushes forward, all the members forward to do their tasks to manage things, to solve problems, to identify, or reassess new things. It is the case of, if we don't succeed in a particular task, it's a failure of the group rather than the individual.	CAc
03	Yes, what we do is thermal disinfection, so we set out our water to land it above 60 or below 20 °C. And then we also do *Legionella*, we do temperature checks every month on our electronic systems, temperature is being maintained. Then we do *Legionella* specific and *Pseudomonas* specific microbiological testing. To see if we have any contaminant in the water. Talking about an electronic system, called "zeta safe", it checks the temperatures and electronically records them on data base, and there is a schedule and an escalation level about the process of *Legionella* prevention the HTM-04 gives orientation. The HTM is our guiding document, when looking on processes and responsibilities and there is also the ACoP, it's also a kind of bible and forcing instrument for organisation. So what are the dangers at the end of the day, when it's said to cascade that needing the clinicians to do the hand water flushing. Currently we consider water flushing to be a nursing responsibility.	PT CP PL PS, CAc
04	*Pseudomonas* and *Legionella* are both being covered by the management committee. They do represent water safety in general, *Legionella* and *Pseudomonas*, maybe. And for that matter, any other water contaminant that might be a problem. Total viable counts that might cause a problem. Where we operate hydrotherapy pools, for example, has a different set of requirements to ordinary domestic water outlets. And we've also had them. We've recently restarted a water extraction borehole. It works. And now what we see it's got quite a lot of external scrutiny from the environment agency because they want to see that the water quality is sufficiently good, because that should be. So that's a different matter again. But the main focus of the Water Management Committee and its safety groups, a little over 60 groups, is concerned with *Legionella* and with *Pseudomonas*.	CM PEn PP, PL PS, CAc
05	Well, I suppose from the way we manage it or how I expect it to be managed, obviously we've got the HTM 04-01, which is the base document. And that's where we take our guidance from. And then we've got the HSE guidance document on *Legionella*. We use those as our base documents, as our good-practice documents. And if it says in there that we flush taps that are used on an infrequently basis for 2 minutes, then that's what we'll do. If it says we store water at above 60, and we need it back at 55, that's what we'll do. So it's very much-- water safety management is one of those things where the way we look at it is if we follow the published guidance	PL CP, PL PL

	and whatever those documents say, then we try to achieve. If we can't, first of all, we need to know that we can't. Secondly, we need to know what we can do about it. Thirdly, if there's a cost, we need to make people aware of that cost. But it's basically proving to the organisation that we follow what we would consider to be best practice because that's what it is. It's best practice for a reason, and we should be following it. Like I said, the thing is, if there's mainly a cost issue around something, well, we never say, "Well, we're not do it. We don't have the money." That then becomes my job to say, "Don't have enough money? This is the risk. This is the cost. Let's make an informed decision about what we do do." So in this hospital, it's a very open discussion around risk management then because you've got to have it. You've got to have that discussion.	PEc CM CP
06	The water systems are constantly monitored in line with HTM-04, including things like temperature checks, sentinel outlets, cold water storage temperatures. And we are proactive with *Legionella* sampling is carried out six-monthly. And we also do *Pseudomonas* sampling in augmented care areas. We've had risk assessments done. Risk assessments go through the water safety group. Plan schedules are developed out of those along with the testing regimes for planned preventative maintenance.	PL, CC CP CAw
07	The water samples are taken, I receive the results. I then report those results. First of all, I publish them in an action plan. The gentlemen, I call them gentlemen, in the workshop who do the nuts and bolts, are instructed by myself or by the workshop manager on what I believe to be the correct course of action to resolve the issue. The activity is taken by those chaps and they handwrite in a log book what they have done. I transfer that into a Word document. I report that to the Water Safety Group for reassurance on a monthly basis. And for advice as required, if I believe I'm not finding a way of resolving the issue, that report then goes via the Infection Control Operations Group, and the Trust Infection Control Committee which then through another meeting or process that I'm not invited to, which is at board level, the Infection Control Group and other groups report to the Board of Directors if there are anything that they need to be concerned about. So it certainly does get to the Chief Executive's level, which is good. The Chief Executive is being reassured that we are doing our job and we're not mucking about, we're doing it properly. I think we will clearly see from when I send you the documentation, you will see there's a clear pathway. Also utilising all the documentation that we have around us from the HSG to the HTM-04 and documentation. It gives you a clear, especially with regard to *Legionella*, it gives you a clear pathway. Say you want to take the compliance and the documentation for reassuring should we say,	CM PS, CAc CM PS PS, CAc PL, CC

	we are checking the boxes as we go. We are not noticing there's an issue, shutting the door and walking away and hoping it's just going to go away by itself. It doesn't do it.	
08	It's been a journey of discovery. It's taken time to get around the five hospitals to understand locally how we're managing water and then that local understanding has then informed how I've chaired the previous two water safety groups and how I have allowed other members of the Water Safety Group members to understand why they are sitting around that table. Everyone in both organisations believed that water safety is an estate function or an FM function, and the last five months have been about A, understanding what we are doing currently, and then B, as I say, informing what's on the scene at the Water Safety Group, and then C, then informing the Water Safety Group members - so the microbiologists, the infection prevention, nursing staff, the health and safety staff - who previously have sat around the table and just pointed the finger at estates' thinking, "Well you're all thing's *Legionella*." And I have now educated the Ward Safety Group to say, "No it isn't just about estates. Estates deliver up to the-- deliver water safety up to the point of the tap, but when it comes outside of the tap, it becomes everyone's problem. So they get to know it's a collaborative process and everyone has a responsibility.	CAw CM
09	The estate's department has changed around a lot and we've changed management structures completely, we're constantly trying to find a way forwards which is why we're investing a lot more and why a lot of the old management has now been removed because of mismanagement. So one of the things that we found was that the previous management, whilst they were trying to manage the water safety and they were trying to find a way forwards, they were investing all of their resources into PSA if that makes sense. So if someone came along and said, "Oh, the reason you've got *Legionella* problems is because your water temperatures aren't being achieved and we think it's because of your hot water generation." Then they would spend money on hot water generation, but they would again, look at it from a very isolated point of view, just looking at individual problems instead of trying to look at the whole system. So at the minute, we're going through a reasonably expensive process, but it's already yielding significant discoveries for the trust. We're going through a process where we have had the entire domestic hot water system in our most problematic wing, surveyed and redrawn. So we have complete drawings of how that system is put together. We've had the hot water generation system analysed by an external consultant and then we're tying this in with our offer. I think the engineer, he's done an audit to have a look and see how we	CM PEn PEc PT, CT CP

	are or how the trust is managing in terms of flushing regimes, testing. We've got our own bull hole, so whether or not they're chlorinating correctly or treating the water correctly, all of that sort of thing. So when you tie all of this together into one single strategy, you're no longer looking at individual elements, you're looking at it from the point of, how are we treating the water from the point of being pumped up from the well through to how are we heating it, is that system adequate, is that system heating it correctly? And then looking at, how is that water now being distributed? Have we got dead legs? Are there areas where the system's not balancing and that's why we're having dead service there. Obvious, the pipework of a sufficiently large size to actually handle the capacity that's needed for all those outlets. And you look at the entire system from the point where it enters the site through to the point where the end user's using it. So that is currently how I'm actively managing that water system, is running and directing that whole process. It's a process that I instigated about a month after I started and one that carried on managing all the way through. So it's a much more holistic perspective.	CM PEn CP CP CM, CT CAc
10	The way that I've done that is, I've reviewed where they're at, with water safety compliance. I've also looked at the management structure. I've looked at the governance, the policies and procedures that we've got in place. I've reviewed all of the risk assessments and had other building water risk assessments where they're required. I've got the remedial work scheduled, identified within the building wall risk assessments. I'm sending people on training courses to make sure they're competent in post, to manage water safety within their trust. And I've shared all of that information with the senior team to make it quite clear where they are from, where they are now, to a good level of compliance. And to lower the risk to the organisation. The water safety group. That's one of the things that I'm organising at present, to have a quarterly. It should be. The water safety group should meet on a quarterly basis and have the authorising engineer, infection, prevention and control, some senior states managers, and some senior clinicians that should attend that meeting. But I'm just organising that at the moment. Well, it's actually HTM 04-01, and it's parts A and B. However, that's not legislation. It's a guidance note. What we do follow is ACoP, A-C-O-P, ACoP L8. But L8 has been superseded by something called HSG 274. In the beginning of 04-01, it states that: NHS Trusts or government organisations should meet all the constraints of L8. And so HTM 04-01 is really not required. Although what it does do, it gives a lot more detail around healthcare premises than the ACoP L8. In front of HTM 04-01, it states	PL, CC CM CP CAw PS, CM PS, CAc CM, PS PL, CC

	that: an NHS organisation should meet all the requirements of L8 and HSG274. So in reality, HTM 04-01 is not really required, although it is much more detailed around water hygiene issues, or water safety within healthcare premises. There always is the roles, what you're talking about is roles and responsibilities. And the roles and responsibilities within the HTMs, and within water hygiene are well defined and do not, or should not, differ from each individual NHS organisation. It should always be the same. It should be duty holder, should always be, responsible person, deputy to the responsible person, and then it should be a relationship between authorising engineer, who's the independent person. The authorising engineer nominates and appoints the authorised persons and the competent persons. But it's a bit of a different thing within water hygiene or water safety because there is no authorised person. It's the responsible person and the deputy to the responsible person. And then there is the nominated water hygiene contractor that would carry out some of the works that are required onsite, to do with the monitoring system, like taking water temperatures, cleaning tanks, all that sort of thing. It's not normally done in-house. It's normally a specialised contractor would do these works. So the roles and responsibilities are duty holder which, on paper, is the chief executive. But his responsibilities are devolved to the duty holder, which then, in turn, is devolved to the responsible person and the deputy to the responsible person. And then they have an independent authorising engineer. As I say, within the authorising engineer structure, it's normally authorising engineer, authorised person, and competent person. So the authorising engineer is the independent advisor. The authorised person is the person that issues the permit to work and controls the work. And then the competent person is the person actually carrying out the work. So it's a very rigid structure. And that's because they don't want to have too many people involved on who makes the decisions.	PS, CAc
11	Okay. I was just going to say that we manage all the site's water systems under the designated or responsible person for water. That's somebody who has been trained, and accredited, and also authorised, and also that person has to demonstrate compliance to our NHS rules of the HTM 04-01.	CM, PS PL, CAc

Robustness of *Legionella* risk management and prevention process

Table Appendix B-6: Extracted and condensed answers on question 13 and 14, phase I b

ID hospital	Extract of specific answer	PESTLE and CTAAPM category codes
01	So where we are at the moment. We've reviewed what the contractor is delivering. We all see what HSG274 and the HTM requires. Then conducting audits to prove one by audit eye for what the contractor is delivering and if we identify gaps. And the gaps can only be filled with sufficient budgets, to fund it. So we're in a position now, where we need more funding.	PL PEc
02	We're not perfect, not everything is under control, but we're very close to getting there. we're not perfect, but we're not too bad at all, to be honest. Decisions are made out of finance basis, resource availability, access to actually do the work. This is a working environment that sometimes you are not able to getting done the work itself or you may up to do it in a different way or a short-cut, or, a part of the job rather than doing it all. And I think timing as well. I think when it occurs. When a problem occurs, I think that is a factor that we struggle with sometimes. Properly link back what took resources on our books, and, you know if we have a problem off that we get less resources available to it to be able to react to it. So I think then they are probably the factors that jump out on me.	PEc PEn
03	I think here we're some quite good. Just recently I identified some positive *Legionella* samples. Then we've put in together an incident report to try to understand what and why what comes that our water systems have failed. I think we've got some work to do around flushing the system. We've got lots of the area in estates we don't maintain anything there is unutilised. We've got some flushing challenges. Given what we found, I say, probably a 4. I'd say we've got the governances right. So we've got the water safety group reporting to the Infection Control Committee with appointing an external, independent authorising engineer on water, okay. This gives us the external assurance of things are happening. We do get returned that for water around the unoccupied areas, which is very good wherever we covered it. I like to say what we do test for *Legionella.*	PT, PEn PP, PS PP

	We don’t. All we run that leads us that we’ve not detected any in water systems.	
04	And I think the actual processes are good. There is always a risk that some things aren't being done, and you only know sometimes about a problem and where it is. We're a big organisation with a huge footprint of buildings. So there's always a risk of some treatments in one of our buildings is not being done adequately or correctly. But think our processes are good. I am confident that, if there was an outbreak of Legionnaires' disease, I'd be reasonably confident that we could demonstrate to external agencies that we did have a robust process. My question to people in my team working this area is that you need to follow a set of guidance that is recognised. Otherwise, you have to have your own system which is better than half that guidance that exists. Otherwise, you're subject to legal challenge. And so, obviously, we look to legal guidance. We look to things like document approved code of practice L8 HSE Health and Safety as primary legislative guidance that we follow. And of course, we would refer quite a lot to Healthcare Technical Memorandum 04-01, which is both in design and in the operational management part the only document which helps us in compliance if you follow that. It's difficult then to be criticised because you've done all that's possible. That’s kind of our primary guidance really.	PEn PP, PL PL PL
05	Testing for *Legionella* evidence, temperature, control, flushing regime, tank cleaning. The reason I'm saying-- and the reason I'm saying a four rather than a five is because I know there are things that we struggle with. I suppose the biggest thing that we struggle with is guaranteeing that we've got return water temperatures at all points around the site. It's very easy to get a return water temperature at 55° C or above. That is not difficult. But to absolutely guarantee it at every point in your system is very, very difficult, and to prove on a regular basis. Hospitals naturally grow with services. Come into the organisation on a contract, and getting systems commissioned and recommissioned, that is difficult. Everything else in terms of risk assessment, and identifying little-used outlets, and flushing regimes, and biannual wash inspections, and tank cleaning, and *Legionella* tests, all that kind of stuff, it's in there. It's done. And evidence that it's all working and doing properly. HTM and the HSG274, and the ACoP, yes, those are the three elementary documents.	PT, PEn PP PL

06	I think there's some traditional things here like we've got chlorine dioxide units installed on two main hospital sites but we don't use them, we use the flushing regime. And temperature, as a main controller, I personally think that chlorine dioxide would be a more comfortable place to be for me but that's an organisation’s decision that's come out of water safety management group historically. So I would like them switched on but they don't want to do that and we have got, like I say, low counts of *Legionella* and we're pretty much reacting to that. We've got old systems and old pipes. And it's a bit like the health and safety train, isn't it? You get on the train and you work on health and safety but you never get off it. You're never ever completely 100% good at everything. So I've built in a factor of safety there I guess, Thomas.	PT; PEn
07	So we have had a risk assessment. We have found there's a lot of work to do, but we are in the process, and obviously, finances do play a major part in that. Five would be wrong because although I would say is everything is under control as I've tried to demonstrate by saying we have a report in process, I think there are still slight weakness within us. Our training down the depths so through to competent person could be completed. We could have everything planned and organised, but we haven't because our focus is on our critical care areas. So I would like to say that we are better than average, but we're certainly not. I'd like to say everything's under control because I feel as if it is, but there's always something somewhere that you haven't thought of. So can I say that we are a four? So, I mean, without a shadow of doubt, where I think we are strong is anywhere that is patient facing. That is always going to be number one priority. So the effective elements, activities, achievements. I think it's a major achievement that we have started off in a bad place. We have very high *Legionella* counts. Extremely high *Legionella* counts. So we took it on the chin. We've decided all in to control instructors where we needed to, to actually do our testing. So we started it. Shock holler, it came in bad. We took it on the chin. We then tested weekly, week after week after week after week, doing remedial actions in between, logging it, being fundamental in thought process where this didn't work, we'll try this. And it made you stop and think that you have to go all the way back to the beginning before you can get to the end. So the achievements were that we got the guys on board. The activity in water management increased. I'm going backwards on your list because it's actually very good. Within the activities, the elements, well, we may have had some flexible hoses. We may have had some taps that were incorrect. We had to change our thought process in the type of taps that we purchased to future proof. To also make sure that we only maintained one product on	PEn, PT PEn PP PL, PEn PT, PEn

	the site rather than have multiple different parts so that maintenance was easy. And the biggest factors were how can we improve this? What can we do? And how do we make that safe? So where you put factors, it may sound a bit silly but we use - are you familiar with a point-of-use filter? Okay, so we got a filter but we need to attach that to the tap. So, therefore, in our thought buying - purchasing - of our products, the first fundamental factor was can we fit one of those filters to that tap in the event of something going wrong. So it was a backward process from what you can see. But all of those I can fundamentally see that they fit absolutely spot on. The factor was that we failed. The elements were why did we fail. The activities were to correct, which is our remedial action. And the achievements were we are now clear of *Legionella*.	PP
08	So for me, it's patient safety first. That's our primary driver, is to manage patient safety. We've got a lot of ill people in our hospitals. We've got lots of immunosuppressed people in our hospitals. So the first question that will come out of-- the first driver will always be, are we impacting on patient safety? And then, the second one is general health and safety. Are we compliant with UK law, UK guidance, UK approved codes of practice, in terms of managing water. And then from there, it's really down to about due diligence. So are we doing what we should be doing and are we following best practices?	PP PEn PL
09	Currently, we are continuously testing for *Legionella* all across the hospital. So we have a constant programme in place of testing every part of the hospital to detect whether or not we've got an increase in the *Legionella* levels within the water supply. We've got a constant water temperature monitoring and flushing programme. So then every day, we've got a team of engineers that make their way around every part of the hospital so that we cover the whole hospital every month, sort of, key points within each floor. Sentinel points. So we measure the temperature at those points and monitor it, keeping records of that and monitoring it. This allows us to detect increases in *Legionella* levels within the water, as well as problems with water temperature very early on, which means that we can either isolate those areas until we can identify why we've suddenly had this increase or this drop in temperature, or we can go and install [redacted] filters to the taps in order to deal with the potential of *Legionella* or the potential of an increase in *Legionella* levels above what is acceptable.	PL PEn, PT PS PT, PEn PL

10	I'm having the authorising engineer reviewing the form of the risk assessments to make sure that they fully comply with the requirements in L8, HTM 04-01. And they meet the needs of the level of compliance and quality that we're looking for. I know that the risk assessments that we received, we've got nearly over 200 premises. Some of our premises are, our assets are third-party managed. But for the ones that we manage, I know that some of the risk assessments given by the company that we're using at the moment, is our water hygiene contractor. They've also been producing the risk assessments. I don't think that the risk assessments are of a great quality. And I've also reviewed the water hygiene company that we're using at the moment, and the first-- I've just got today a new procurement person, a procurement resource, and I'm going to be carrying out the top 10 tenders that I require. And then the first one I'm going to tender is the water hygiene services because the contractor hasn't flowed me full of confidence. I am not impressed with the risk assessments, and I'm not impressed with the work that they have done just due to the holes in the information that they have given me. And I've reviewed many risk assessment documents before, and these are not of the quality that I require, so. And I'll be appointing a new water safety contractor, but through one of the NHS frameworks, so that before we even speak, I know that they've met the particular quality standards that I require. And well, so they are an incompetent team, or the incompetent contractor, I don't think they're very good. Well, I think that conversations are hearsay and they can't be proved. So within any kind of works, what you're looking for is, the written part, the training documentation of the team that are doing the work. You're looking for method statements. You're looking for risk assessments, and you're looking for a permit as well. And so I have been here for about four months, and I've encountered contractors working without a permit, without the right documentation. And going forward from about the first week that I was here, nobody is now doing anything on any contractors at all. Nobody is doing anything without a permit now under my direction.	PL PS PP PS PP, PL PS, PL PP
11	We have daily checks by the internal staff, hospital staff, by temperature checks, and flushings, and checks on the system. We also have, three or four times, daily checks on the building management system, where we monitor hot water temperatures, cold water temperatures, end-of-line temperatures, tank temperatures. And then we also have, every month, the water management contractor comes and does all the specifics, like thermostatic mixing valve maintenance and inspection, and checking tanks for are they clean, checking sentinels, *Legionella* samples, the whole raft of what we do on that. And then we also have the continuous	PEn PT

	chlorine dioxide on the system. So that is to prevent any bacterial growth in the system. It's not foolproof because if you're not flushing your water through, your chlorine dioxide does have an expiry date of maybe a week. But what it does, it kills the biocides if you can get your water flowing. We obviously have the water management group, where we meet every month to discuss any issues, and finally we have an annual water systems audit by an external auditor, who will come and inspect everything I've said that we have documentation for.	PS

Common understanding of a process

Table Appendix B-7: Extracted and condensed answers on question 16, phase I b

ID hospi-tal	Extract of specific answer	PESTLE and CTAAPM category codes
01	The way which task needs to be fulfilled. So a process step would be one part of the process, so within a process there will be multiple parts. There is also a hierarchy. A process step is an element to fulfil a certain major process. The person with a vested interest in ensuring the proper process is followed. The owner.	PS, PEn
02	Simply an effort of doing something. I think a process step is an item within that process, almost a gateway. Someone who ought to have responsibility for that process. From a water safety perspective, the process owner is of the group, more than an individual.	PS, PEn
03	All out of processes are designed around the HTM04, so the NHS which has all to do with water systems. So when we find anything wrong we look to that to say we’ve got capturing this, heating or we need to do pasteurisation or whatever. So it’s very prescripted around what the HTM says. Well it’ll the hard FM provider then will have to inter-provide to our model to allocate whose responsibility is that.	PS, PEn
04	Well, a process is a set of [inaudible] that moves about [above ground?] that you can understand. They're clear, and they match a scenario. So they can approach you for-- they help in certain scenarios. And so they're put [in?] reference. And in water management, there are various processes. Some of them are reactive processes that help you respond to a	PS, PEn

	set of problematic situations, like on the high elevated counts of *Legionella* bacteria in water and sort of what you do about that. So we've got processes for those eventualities and then other processes of what to do for day to day management, so the monitoring of temperatures of water systems, etc. So all of which should be documented and whether that's in a policy or a standard operating procedure. Each estates team that works on any of our hospitals, they are the approved person, and they are the responsible person for tackling this. There shouldn't be any ambiguity about that. Of course, sometimes, there is ambiguity in certain functions. So, to provide another example, not policy, it's just the nurses should be responsible for flushing water outlets to not be stagnant in public. But of course, that's not a primary function for a nurse, and sometimes it isn't always widely understood. So that sometimes creates a problem. So it's not perfect for every single aspect of all of our processes are perfectly understood. I think the central ones are.	
05	[proces] Taking you from the start to a defined end point. [process step] Individual progress points in the process. [process owner] The person in overall charge of the process. Let's say the HTM says that you need to identify then little-used outlets. So that's a statement, okay? So that the way in which we then prove that we've achieved that requirement, I would deem is a process. So let's look at that example. So if it' flush little-used outlets, there'd be what we call a standard operating procedure, which would define the process of flushing an outlet. So effectively, the process is step-by-step doing necessary works to get to an endpoint to which would then either prove or disprove that you've achieved the goal that you set out in the first place. So that's my understanding of the process. Let's say we'd given that process to a domestic to undertake the work. So he doesn't actually own the process, he's just undertaking that process. He's just doing what he's being told effectively. The process owner is the person who said, "Okay, so the HTM says I need to do this, and this is how I think we can achieve it from starting point to the endpoint." Now, that process might just sit with that individual. And that will be something like a manager within the estate departments or it might be my compliance manager. Somebody who has the knowledge and the authority to understand the document and interpret it, so somebody that can follow those instructions. So that will be the process owner. He would own that. And then if the HTM has changed, he said, "Well, you don't flush now for two minutes. You flush for four minutes." He will change that process as the process owner and reissue it to the person who was then implementing it. Well, I suppose, there's sort of the three documents that we just mentioned that deal with water safety. It would all-	PS, PEn

	- we'd look at them all as best practice, and some may be stronger than others in certain areas about how to deal with it. So we would look across the suite of the documents - the HTM, the HSG, and the ACoP - then look and decide which is, I suppose, probably the most thorough and try to pick the best from each and then use that to then define what process we're going to follow. And again, it comes back to somebody says-- usually, something goes wrong. Somebody will say to you, "So why did you do that?" And what I always like to say is, "Well, the reason we did that is because this is the document that says what we need to do. We took that document, turned it into a process," which then hopefully would prove that what we said we'd have to do, we've done by this method. And hospital systems all differ, hospital site to site, so sometimes a process might have to be adapted to suit the actual installed-- so the goal you're trying to achieve is always the same. The methods by which you achieve it will vary depending on the systems and the way that you can work.	
06	We've got processes through policy and procedure. A standard operating procedure. Sentinel taps are all recorded so they're a process. They know on six months where they're going to go, what sample they're going to take. So all of the system is built on standard operating type processes.	PS, PEn
07	This is where I was starting to struggling a little bit with our terminology. So a process is, okay, let's go backwards then. That would be me. I'm the process owner because I've got the knowledge as in I've gathered the information because I've got the water results. So I've got the results, know the site as the responsible person, I know where that water's fed from. So I sort of own that responsibility. So stepping back up, a process step is me talking to either the actual plumber or his supervisor and-- or even the water safety group is another process step. So the water safety group, I would suggest that these are my recommendations for the process step. The process would be my maintenance staff actively carrying out those remedial actions. So you have to assure certain steps that you can repeat at any time, or improve at any time, or develop further to check things-- We fall repeating the process. We test for [inaudible] on a weekly basis. So here's the process. We test for four weeks the same outlet. And if it passes every week for four weeks, we then move our testing to monthly. If it passes every month for three months, we then move our testing to quarterly. And we maintain our testing at quarterly now forever. Now should, for any reason, that outlet fail on a quarterly test, we will revert all the way back to weekly	PS, PEn

	again. And we will reprocess four weeks, then three months, then quarters. So it's always the same process. And they are the steps that we take.	
08	A process, it's a system by which you follow. A process step is an element within the process. And a process owner is the person responsible for overseeing the process. So it's essentially HTM that we’re following. This is the guiding document. And then we're about to go through the appointment of authorized person, responsible person, approved person, competent person. Those persons are defined but not the process steps. So the process steps are more clear for those in the water safety plan. It's after, who does what? So that's where they’re defined, what they follow, the guide. So it comes from HTM. Okay. And then it's implemented to the organisation situation, and this is described in the water safety plan.	PS, PEn
09	For me a process is almost a set of steps that you define that forms part of a wider plan or strategy. It's something that enables you. It may be part of something that enables you to achieve a strategy that you're looking for. It's normally made up of at least two or more steps. You would normally have a process owner. Not necessarily at every step, though, no. There is a document that outlines who the process owners are not only in terms of the individuals or the roles, but in terms of the functions and the departments. And the water safety team will own the processes. But it's not schematic, it's written.	PS, PEn
10	A process is beginning in certain stage and then resulting in a particular outcome. A process consists of different process steps. Depending on what it is and what you're doing. It's much like drawing a flow chart or a decision-making process. And the process owner is then the person who's responsible for carrying out the respective process or process element. That's like doing some analysis and having an action plan from the analysis, and then there would be an owner for each action in that line. So a description of what it is, date and time, a description of what it is, then the action owner, and then the, "Yes/no, have you completed this action?"	PS, PEn
11	Process is the term. We have a maintenance process, where we have what we call job cards that come out to tell you to do all this work, which I've just gone through. So we then have another way of checking. So if a man has to go and check a temperature in a clarifier, he records that on the job card and signs it off, dated. And it's recorded both on the paper system and on the computer, so you can see that all this work has been done. On the other side also, the water management company have their own portal to where I can go on and see everything they've done, what	PS, PEn

	they've picked up, which then prints me an email for me to action anything that's non-compliant. There is an action point that comes up because of not meeting the required temperatures. So there's a full process that you can see from if there was a fail to how we rectified the issue. Well, a process is the way you do something. Your process tells you how to do it and the step is how you do it. Your owner, well, that's the person who is, possibly, the person who writes the process. Not always though. It might be the person who is the manager to the process but hasn't written it. So I've got processes here that I've not written but I manage it. There is common processes across the board in the Trust here and how we do things. It's the same as all the hospitals. So there is common, shared processes between various hospitals within the Trust. And this is defined in the water safety policy and in the water safety plans so that everyone who is a process owner, or who is serving for a certain process, has the same access to knowledge.	

A common process *Legionella* prevention and water safety

Table Appendix B-8: Extracted and condensed answers on question 18, phase I b

ID hospital	Extract of specific answer	PESTLE and CTAAPM category codes
01	At the moment I putting a way for a water safety plan, and procedures. We’re still discovering quite a lot of what we need to do. I’m quite clear on what HSG and the HTM requires. But it’s put a nose into a plan, which is a challenge. "It’s quite a sort of dynamic. And according to the individual circumstances. Then people available, budgets available. So, there is a lot to balance. And the HTM, some parts of it can be a little bit big. You find yourself opening the document and searching for an individual word, to find exactly what you need to know. Sometimes is, no pleased really got time to read the whole thing from front to back. I still haven’t got read the whole thing from front to back. So I find myself reading parts of it. But you know, it’s a waste there for me.	PS, CM PL PP, PEc PL CAw

	So it could be sleepy misinterpreted because I can't imagine everybody does the same thing, you know, reading the parts at that particular moment in time which turns into a long process of putting things in place, then reviewing and then fine-tuning and continually fine-tuning."	
02	In our organisation, talking about 'the process' of *Legionella* prevention. Well, we use the term 'management'. But in essence this is process. It's just a terminology thing. We use the word process. So it uses management, you know, so it might be a management step rather than a process step, the essence is the same thing.	CM
03	The HTM, you said it's our guiding document, when looking on processes and responsibilities and there is also the ACoP. It's also a kind of bible and forcing instrument for organisation. The problem is that because we outsource the technical services part, they keep their own backdoors. And then, so that's kept on a software system called ZetaSafe. Well, they've got a separate package for the schematic drawings that we've got, and they have got a third system when we flush the water system. So we've got almost a desperate record-keeping approach.	PL PT
04	I don't know if it's an end-to-end process. So what I mean by that is what if it's explicitly documented is an end-to-end process. So, for example, if we have a building adaptation or we build a new construction, new building, or new wing to a hospital or something like that, you would expect that the designers, being engineers, would understand the healthcare technical memorandum concerning design of domestic water systems and would sufficiently understand to be able to design and construct a safe system. So this all starts with good engineering. And so if you've got bad engineering, then you're always going to be struggling to keep *Legionella* and other bacteria under control because you wouldn't have designed out some of the problems. So that's not highly explicit in the process in any of our documents, or very explicit. It's just assumed. So there's an assumption. But if you ask me about what we would do if we took a water sample and it had more than 1,000 CFU, *Legionella* might tip that. We would say that we know what do to because there's a very prescriptive document [talking us through that?]. And so the different steps and the different scenarios, most of them are documented.	CM CAw CT
05	As we only have on site it is relatively easy. So those documents (HTM, HSG, ACoP) give a kind of starting point how to find access to generalise a process, but generalisation is not a good option for each site or ward. So there are building specific requirements, so it has to be looked closely what has to be modified. But I think there might be a kind of basic process	PL, CC PEn

	element for your organisation. And that's what the HTM documents say. They say they're guidance. They're not mandatory. They're not law. They say in the front piece they're guidance documents, and that's the way we use them. We use them as guidance. The way I see it - well, the way both myself and my compliance manager look at these documents, say, "Right, these are guidance. These are very strong steps to the direction we would be expected to take." But, like I said, if for some reason we have to move away from that guidance, then that's fine. Provided if we move away from it, we've looked it and said, "Okay. So if we do something different, are we still covering our risk? Are we still able to show that we have taken appropriate steps to effectively get to the same endpoint?" Because, as you say, one size doesn't fit all and you can't try and you shouldn't try and force a process into a system. Because you'll waste your time, you'll waste your effort, you probably won't get the right answer, and ultimately, you won't end up with assurance that you were trying to get in the first place. You've got to be an informed client. You've got to understand what you're trying to prove in the first instance and test your process to make sure you get to that point. You need people to know what they're doing when you give these documents out. You can't just give them to anybody because they're not an ABC guide. They're a "This is the answer, this is a good way of getting there, but it's kind of up to you."	PP, CAw, CP CP CAw CAc
06	Well, that would be within the water safety plan.	PS, CM
07	n/a	
08	So it's essentially HTM that we're following. This is the guiding document. And then we're about to go through the appointment of authorised person, responsible person, approved person, competent person. Those persons are defined but not the process steps because each organisation may be of defined different process steps. So the process steps are more clear for those in the water safety plan. It's after, who does what? So that's where they are defined, what they follow, the guide. So it comes from HTM. And then it's implemented to the organisation situation, and this is described in the water safety plan. I guess there's no common process of Legionnaires prevention and water safety in our organisation in place.	PL PS PS, CM CM
09	It's a hybrid. So it's both. There's a common process which, because it works, we've carried it on. So that would be the temperature monitoring and the *Legionella* monitoring process. That process already works. Whilst it doesn't stop all cases, it probably stops sort of 95 percent of cases or allows us to detect 95 percent of cases. So that's already a very efficient process. So those processes already exist and we continue to	PEn, CP, CM

	use them but some of the other processes in terms of looking at gaining all of the information about the systems and then trying to tackle the problems that we identify within those systems, that's a new process and that is still under development.	CP, CM
10	We do have a process in place. The water safety policy dictates what we do and how we do it, so that would be the process. It's a controlled document, and it's all budged with the trust's bits and pieces. I think that what it is is that, it's not one process. There's lots of different parts of that, so it's not just one simple thing. It's a complex structure also. There will be a water safety plan document. That's not been built yet. So there will be a water safety plan, water safety policy.	PS, CP, CM PEc CM
11	The process, that's all probably pretty well set in stone. Something you won't be changing. I don't think there's anything to change unless the rules are changing, in terms of changing the way that we're supposed to do things. And there is common processes across the board in the trust here at how we do things. It's the same for all the hospitals. There is common, shared processes between various hospitals within the trust. And this is defined in the water safety policy and in the water safety plans so that everyone who is a process owner, or who is serving for a certain process, has the same access to knowledge.	PS, CM CAc CAw

Top three arguments hitting strongest a common process

Table Appendix B-9: Extracted and condensed answers on question 19, phase I b, explaining context

ID hospital	Extract of specific answer	PESTLE and CTAAPM category codes
01	Communication is the major thing. The biggest issue we have at the moment is understanding what the water hygiene contractor is actually doing on our site. This because at the moment they are working on a paper process which makes it very difficult to interrogate exactly where we are. How complying are we? And so, communicating precisely what they are doing, that they’ve got a planned workload. That we are knowing exactly on the day. So that basis is a key, but also the outcomes of what they are finding, rather than things, you know, being brushed under the carpet or	PS, CT CAc CAw CM

	forgotten about. It's important that we have electronic record keeping system or web system where information is freely available to the water safety group. So that we can establish our audit trails and that's the most vital thing that we've got to get right. Which we stayed on got right yet. So, I don't know what else to say about that.	
02	Patient safety is probably my number one, because I think that was against across the board, no matter what department you're in. I think the need to flush used outlets is probably the next one. And the third one, I think, is around defect reporting. That could be improved. It's not that strong as it could. But it's a common, it's a common process that everybody in the trust understands. It's all things of re-action or to be re-active to find out what's the current situation and do things to improve that for future times.	PP PEn PT
03	I think there is a tendency, that I mean water safety is not often a lot on top of everybody's priority, unless there is an issue. And what we consistently do about, we always have references from Estates, the authorising engineer. He is got a good quick, if you like, I believe, the group has.	CAw, CM
04	n/a	
05	I think that is proving that you've got return water temperatures at every part of the system. That is very, very difficult and very complicated to do. I think the identification of little-used outlets, which then would fall into a flushing regime. That's quite difficult because that relies on clinical staff or the wards saying, "Well, actually, we don't use this toilet very often, or we don't use that washroom, or this bathroom is not in use too much." We rely on them to sort of start that process because if they don't say that, then we don't know if it's a little-used outlet and we won't put a flushing regime in place. And then we've got stagnant water. So that was probably quite difficult. And then I suppose maybe the third one is something like biannual inspection. So we bring a third party in every couple of years to review our process and our systems on-site. Getting them to do a proper and thorough job sometimes can be quite difficult, and getting it to be consistent. Even though we use the same company, each year they manage to find the same things. I always talk to my compliance manager and say, "It was like that last year and they never raised it. Why are they not being consistent?" So I think that can be quite difficult and challenging sometimes. It shouldn't be, but, funny enough, it is.	PT, PEn CP, CM CC; CP, CM

06	Well, I think in terms of the way in which we control *Legionella* is by having a temperature regime that meets the approved code of practice and HSG. But it's not only there that you have to have the temperature. You have to have the water circulating. You can't have just one thing. So it's temperature, it's movement, and monitoring to make sure what we have to and we use either planned preventative maintenance or *Legionella* sampling to ensure that the other two are keeping *Legionella* under control. Sometimes it takes a longer journey to take those that are not in the first instance the most obvious ones.	PL, PT PEn CC, CP, CM
07	Okay. So obviously there, I think one of the biggest instrumental things was the setting up of the Water Safety Group because that gave us a common process for *Legionella*, because, within the Water Safety Group, we have got a water action tech plan. So that's a standard set of procedures that all of the staff within the estate department can use as a reference for the process of water safety. So that was a major, major step forward in our organisation, moving forward for the Water Safety Group, without shadow. So we've got the Water Safety Group. We've got the testing regime and the documentation. And one of the other strongest is when we've had feedback from the organisation coming down from the chief executive to say, "Well done." We had a newsletter go out, an internal newsletter, that congratulated the estate staff for removing *Legionella* from [redacted] Hospital. So that was a major thing for us.	 PS, CAc CP, CM CM
08	Flushing, temperature monitoring, and positive camp reporting. This also means monitoring a lot. And a lot of initial costs because water samples, sampling is not the cheapest thing. So under my stewardship, it's safety first and cost second. [after explaining a longer example] Well, I don't care how costly it is. If we've got a robust plan that says we need to do 10 samples a week, then we do. Technically, you could just be doing resamples of those positive samples made in previous weeks of your sampling plan. It's terrible. You don't get a clue about what the contamination level in the whole organisation will be, so. What I'll share with you, which I think is absolutely bizarre is the gentleman that was in charge of running operational estates for [redacted], who left two years ago, he actually left to become an authorised engineer within another organisation for water. And this was his approach to water safety management.	CC, CP, CM PEc

09	I think currently the thing that creates the most common process is the acknowledgement obviously at a senior level. The how they ignored the fact that we've had a couple of deaths related to *Legionella*. To go back a little bit, [redacted] Hospital 09 is very special when it comes to *Legionella* and the reason being is because we actually have our own strain, our own biologically identifiable strain of *Legionella* within the hospital. So if someone died from *Legionella* they can actually pinpoint it to our hospital. They can specifically state that this person didn't just die from *Legionella* because they got it at their own home or at their hotel or anything like that. They can actually turn around and say, "This strain of *Legionella* is specific to [redacted] Hospital 09". So because we know that and we have had deaths that has been proven, directly linked to the hospital, that drives obviously a very strong determination and requirement from the senior management level to respond to that and to ensure that it doesn't occur again. So that drives probably the most common heart of our process establishment. And then because of the processes like the temperature testing and the *Legionella* testing, that element gives us the information to respond reactively to something that's already occurring. It doesn't help us to actually deal with the problem before it's occurred. It's not proactive, it's reactive. So the next strongest driver would be understanding the distribution system and the generation system. Which actually helps us to explain, from an engineering perspective, why we have a *Legionella* that is able to grow within the system or why we have areas that do not achieve the temperatures that they need to in order to kill the *Legionella* bacteria. So that is the next strongest driver because that basically allows us to drive the process in terms of to understand what works need to be completed, what we are trying to do, and the strategy. And then, further allow us to understand what financial assistance we need in order to achieve that, which we then filter through to the board level, who are, like I said, very much driven by those debts.	PP, PM CAw CC, CP CM PT, PEn PEc
10	That should be risk assessments, scheme of control, and temperature testing because temperature testing is part of our scheme of control. All cold water should be below 20 C and hot water above 55°C of all parts of the system.	CP, CC, CM
11	Top three will be testing, monitoring, and third will be recording.	CP, CC, CM

Application of management instruments, tools, software

Table Appendix B-10: Management instruments or tools / software in use

Hospital ID	**Management instrument, tool, software**
ID 01	ZetaSafe®
ID 02	• Asset management system with planned maintenance tasks and reactive maintenance tasks • L8 guard (flushing software system)
ID 03	ZetaSafe®
ID 04	Process-led Datix & wide risk register
ID 05	Estates Management Computer System (maintenance tasks PPM)
ID 06	Helpdesk, CFM, CMMS
ID 07	ZetaSafe®
ID 08	Assignment matrix (Clearwater)
ID 09	Software management systems since two years looking at sentinel points, temperature monitoring, laboratory results (*Legionella* testing)
ID 10	CAFM, i.e. Micad Property Management Software
ID 11	Maintenance portal system dor delivery and maintenance work inPPM

Table Appendix B-11: Extracted and condensed answers on questions 21 and 23, phase I b, explaining context

ID hospital	Extract of specific answer	PESTLE and CTAAPM category codes
01	Because it's paper-based it's quite difficult. For what I'm open is, that our contractor, they're developing a web-based electronic record keeping system. Previously I've used system such as ZetaSafe® (From the web site: "use it as a tool in their provision of compliance and/or facilities management services as well as to client organisations for their own compliance). ZetaSafe® allowed me to keep taps and everything that was happening which is important when I've 200 buildings across the city have been focus on what we had problems rather then, you know, don't receive a building find there is nothing to look up. We are moving in that direction but it's just taking a long time to go there.	

	I've on the site spoken to infection control team and they did more or less a desktop exercise to assign a ward A, high, medium, or low patient risk, A-level. So I've got a clinical risk rating and the information I can extract out of the risk assessments, I can determine an engineering risk and between the two then I compare that to how many defects have been reported on that risk assessment.	PEn CP
02	We have an asset management system, which links into our helpdesk. So, within that asset management system there are planned maintenance tasks and reactive maintenance tasks. Which all then obviously become jobs that are issued to the treatment. They do the job and then updated it on the system, so we basically have that asset management system. In addition to that, we have a flushing software system, which is called 'L8 guard'. So, basically what that is, is an enter-based system. Each of the departments and wards have a responsible person for flushing alerts, and they have to physically go onto the system and find to say they are flushing those areas outwards. But the system analysis is then to have, a report on a daily basis, of what's been flushed and what's not. And importantly, there is an escalation process in there. So, for instance, if nurse on ward one doesn't flush for two days running, her boss, the matron, receives an email to say that's not occurred. Escalation level. So it gives us some clarity if you like. Sensors were electronically linked. Talking about proactive management, in terms of water safety and a proactive approach, I would you refer to TMV checks, temperature checks, that could be tank cleaning. I think this about 270 tasks that were allocated in a proactive way. We're quite a big site, so we're always could duplicate us. So we probably got 30 water tanks across the two sites.	
03	Zeta safe®. This is a tool, it's a software. They then bring so to the water safety an assurance, we then print off temperatures and the flushing results and cases on which we actually see in that meeting what's been important or what's happening.	
04	It is process-led, e.g. for planned preventative maintenance, PPM, we have systems that prescribe tasks to be done. So there's a database of some of the activities available from the software. We have a system, which isn't similar to the PFI company, the service provider. So the in-house estates teams that we have their own software, and it prescribes tasks. From a different sort of risk management perspective, we've got a trust-wide risk register, and we also use a reporting software system for health and safety risks known as 'Datix'. That's quite common in all	

	of the trusts. So in that, it describes the risk, what the mitigation is, and so on. And there should be a risk assessment in that document.	
05	The way it works is you load it onto the systems or assets that we have within hospital, the engineering systems or assets that we have within the hospital. There's a number of maintenance tasks assigned to them. So there will be a task in the system. And let's say that task comes up every six months. That job gets printed off onto a piece of paper, given to that person, and that's one of his tasks to go and do that during the day. From start to finish, it could probably take two or three weeks. The ability of going from electronic to paper and then paper back to electronic isn't great. Pieces of paper get lost. People don't fill them in properly. It's not a great system, but that's not in itself a wholly water safety problem. But as with everything, there's a cost expense in it, and that cost can be quite considerable. And the question then is, well, what's the benefit to spending, I don't know, £100,000 on a system?	PEc
06	Helpdesk is ineffective for corrective maintenance or breakdown activities. We have fundamentally for *Legionella* controlling a planned preventative state. So you'd be relying on what we term as CFM, which is a computerised facility management system or a CMMS, computerized maintenance management system. Everybody's got different acronyms for those. So when you do your *Legionella* risk assessment, for example, you find out where your risks are. And then, you would build your planned preventative maintenance around what your risks are. So if you had said, long dead legs, it might be more beneficial for you to take more regular temperature checks. So that would determine how you set up your planned preventative maintenance system, and that would generate a docket for the plumbers here to go and take temperatures on whatever frequency based on the risk that the water safety group feel that has been identified within the assessment. It's really a CMMS but it doesn't work without your risk assessment an understanding of risk that they pose to the occupant of that building because as you know, a long-dead leg and in an admin unit does not pose the same risk as a long-dead leg in a critical care unit.	
07	Yes, I do use some software. It's basically it's a web-based portal. And basically when Biochemica come in the ZetaSafe®. And it's basically Biochemica coming they input all the data, all the temperatures into that piece of software, and then I can then interrogate via the barcoded outlet number from the report to see what the temperatures have been on that month.	

08	But we will be moving into an assignment matrix. So we've just moved. We've just moved Salford onto a system with a company called Clear Water. The reason why it's gone to Clear Water is simply because there was an interim operational estates manager who was brought into [redacted] whilst that gentleman who had left was replaced. He saw the weakness, but was not part of the [redacted] at the time. So he just went to market and got, and it's literally, just been switched on. In the last four months, it was switched on.	
09	We have software management systems that look at our sentinel points, look at our temperature monitoring and our results that come back from the laboratory in terms of each *Legionella* testing. So we are able to generate charts and matrices off of that system.	
10	We use something called a CAFM system, Computer-Aided Facilities Management tool. And in this case, at this hospital, it's Micad.	
11	We have the maintenance portal system, which is for delivery and maintenance work in PPM. Our water management contractor, as part of the contract we have with them, we get access to our own water management portal. So on there is everything that they do. It shows when they came to site, what they did, their compliance sheets. It will show *Legionella* samples. It shows method statements, risk assessments. So that's really our best software for workflow.	

Six critical areas for water safety management

Table Appendix B-12: Extracted and condensed answers on questions 25 and 26, phase I b, explaining context

ID hospital	Extract of specific answer	PESTLE and CTAAPM category codes
01	A: Recently roles have been changing there’s uncertainty B: Training is readily available C: ‘Control measures’ have improved over the last 12 months but still there’s a long way to go to meet ACoP compliance. D: No comment	PS, CAc CAw CC

	E: The risk assessment changed, but the schemes of control did not change. So there is breakdown in the procedures. The information is not been relayed. It was a one of this 'the more I've looked the more I've found'. Record keeping is inadequate. F: The water hygiene contractor do this risk assessing for us and monitoring for us. So they're not reviewing their own monitoring. They are assuming everything is fine. And even we now identify assets, excentional points. You know, It be a be common sense to adjust your scheme of control. If you're an expert in that field, it's not happening. Full review complete and estimated 60% compliance (doing what we should be doing to meet ACoP).	CC, CAw CAw, CP
02	All those need to be done to ensure that water safety is managed. If you lose one of those, you haven't got a water safety management plan. They are all critical to be able to managing. I don't think there is anything in there, that I could log down. I just think, they are all, they are the keys. They are the keys to being successful. A: One of the main bits about the allocation of responsibilities is in the balance of the Chief Executive. So he is detailed as of the own role responsibility for water safety within the trust. I think the fact that that's dictating within the policy helps us get some character at that level. In fact, that his name within the policy is as the responsible person gives us that clarity.	PS, CM, CC, CAc, CAw PS, CAc
03	I think that given where we are, working in a PFI hospital, the allocation of responsibilities are vague, because it's understanding which part is responsible for what.	PS, CAc
04	A: That's one of the most critical areas. If you don't know what you're responsible for, then there's a high risk that. There would be an inaction, no action because people didn't feel they were responsible for that particular matter. So, we've got a person is at each site, and they know what they're responsible for. If they don't know what they are responsible for, then that would get more critical quite quickly. B: n/a C: Control measures are important, but that would be variable to the situation.Patients who are very weak or immuno-suppressed, it'll be obviously absolutely critical that we've dealt with a control measure, in engineering terms, for an area that was accommodating those type of people, that type of risk profile. But if it was in an area where there wasn't	PS, CAc CC

	going to be sleeping in the building, it was more like a domestic premises. But patients visited daily but they weren't really particularly, acutely ill, then maybe it's, of course, important to comply with the law, but the criticality of control measures may be less severe. D: From an organisational governance perspective, it's very important. People would seek assurance They would want to see evidence of processing and evidence of good management. Like your controlled measures. When you're in a situation that's just become problematic, it becomes increasingly critical if you have a problem. So I may not speak to the chief nurse about water safety system for 10 months. But when there's a problem, then that conversation must happen, and it must happen with the right level of urgency and good articulation. So it is important, but the variability, the importance is determined by the situation. All organisations and all processes rely on communication. You must have good communication, but that's all I could say. E&F: I mean, record keeping is important. Reviews and the engineering views, we have our own water management plans, buildings or safety plan. The risk assessments are reviewed periodically. We still maintain an annual review, although that was changed recently because document L8 said that you could risk assess the situation to determine your own periodic review period. We kept to the prescriptive annual risk assessment. And in an exception report from the group, I would expect to see the date the review for the risk assessment documented. So it's very explicit. It's extremely important if things change, buildings get adapted, patient cohorts change. So the risk profile can change. And in that sense runs a problem that creeps in routinely. So, for example, we had an issue recently where we converted part of a wing of a hospital into short-term accommodation for patients and their families coming to [redacted] Hospital 04 to have treatments for cancer. And what was understood was that some of those people stay in these accommodation for quite long periods of time. And that does shift the risk dynamic of the situation. That inter-department or lack of precision in communication can create problems. And so you need to be on your guard again.	CC, CM CC, CAw, CP
05	I see C is a four as being the one that's sort of led by all of the rest of them really. So as far as I'm concerned, they're all equally important. Really, really, really important.	PS, CAc, CC

06	In my view, water systems is an element of critical infrastructure in a hospital. So all of these are either fours or fives. We always lag behind a little bit on records, so we never quite hit a five. And you always have to review your practices to ensure that, and you would think of even *Legionella* sampling as a review to make sure your control measures are successful.	CC, CAw CAw, CP CC
07	Allocation responsibility, yeah, that's quite straightforward. That's highlighted in our water safety group and also in the HTM and in our water safety plan. All the responsibilities are noted. Training and competency of personnel is also noted and documented on the agenda of our water safety group. Control measures, depends how we're looking at this but if we've got to look at control measures for *Legionella* prevention, we will take guidance from the HSG and also from our tech plan. It will show quite clearly that we have got control measures in place should this happen, what happens, what do we do. Communication and management is solely and purely in the reporting from the water safety group. So we communicate within the group. The group is then managed via responsible person, authorised person, infection control. So, again, the water safety group has got that one completely covered in the different directions of communication going up and down the chain. Record-keeping as already discussed, we have our water safety group monthly and full reports are given on action plans and outlets that have failed and also outlets that haven't failed. Because you also have to have good ones. And, obviously, they are reviewed on every month. The whole of that is covered by the water safety group. I'm responsible for the results coming in from the samples. The staff, the tradesmen, are responsible for writing an action log per outlet, handwritten. I take that documentation and then put it into a Word document that is a rolling. The Word document which goes in our water safety folder on the full shared drive. So it's there for all members of the water safety group to see. It's available to all of them. And we review that, as I say, on a monthly basis.	PS, CAc CAw CC CC, CM CC, CAw CAw, CP
08	If you've got all that in place, then by definition, you'll have a process whereby it will be a constant review. You'll have processes in place. Among reviews is moderation, right, because a five are what you need in place anyway. A: Is: So for allocation responsibilities, management scheme put there were well defined but poorly managed. B: Is: Training and competence of personnel, I've put poor to average. C: Is: Control measure, I've put poor to average. D: Is: Communication and management, poor. E: Is: Record keeping, average.	PS, CAc CAw CC CC, CM

	F: Is: And reviews, poor.	CC, CAw CAw, CP
09	A: If you're not sure within the organisation, so for instance, how confused I was when I first joined to this trust, if there was a doubt about who was specifically responsible for what parts of the water safety, then there's a grey area, a chance for people to create confusion. With that confusion, there comes people start missing things, people start not doing what they need to do, which means that your chances of becoming unsafe increase quite dramatically. And so your responsibilities, it's not just the allocation, it's making sure that it's been very clearly defined and clearly outlined for everyone to understand. There's no opportunity for confusion there.	PS, CAc
	B: I think it's very easy for not just our organisation, but a lot of organisations to rely on people's previous training or assumed competence from the point of employment rather than spending the money to make sure that they're constantly, continuously training, and ensuring that competence. Again, if you're relying on an assumed competence then that assumption means you could have people doing work or being involved in water safety who don't necessarily understand all part of it. And you get into this situation where there's a saying about a little bit of knowledge is more dangerous than no knowledge at all. So it's very very kind of important, again, from that point of view.	CAw
	C: Without the correct control measures, you're leaving yourself open to incidents, you're leaving yourself open to that risk actually someone who may have a low-- an unstable immune system. We have a lot of patients within our hospitals who have to be kept in special rooms to make sure that they don't come into contact with the outside world because they have weak immune system. If they get infected or they get exposed to pathogen bacteria they die immediately. They have no way of fighting it. So the control measures without those you can't deal with the incidents that are going to arise. It is impossible to completely eradicate all risks. It's always going to be present in the environment. But you have to be able to reduce the risk to the point where it's no longer an issue.	CC
	D: If your responsibility is clearly defined and there's no scope for confusion, your staff and personnel are adequately trained and on a good level competent and your control measures are secure, then whilst your communication it's necessary to have communication and it's necessary to have management, but if your first three elements are correct then your management becomes less critical because it becomes more of a case of just ensuring that documentation and information is being	CC, CM

	passed around correctly, which is important but not critical. It's not going to save somebody's life or kill somebody. E: Again, your record keeping, this is moderate. It's important to have history and knowledge of what happened on the site before, it's important to have knowledge and history of the processes that are being involved, incidents that have occurred, monitoring that's taken place, and any work that has been done. These incidents go on to form part of making sure that your strategy remains solid, but your records again aren't going to kill someone or save someone. So you can still be safe, you can go do your water safety management with no records, you just make it harder for yourself. So it's moderate. And it's harder for you to show in terms of an audit, an external audit, to demonstrate compliance. F: I would say if I'm understanding your definition of reviews correctly in terms of what is written coming back from what people are saying about how they feel or what they think, this sort of thing would only impact your management, it wouldn't necessarily impact anything else. It would impact your communication, it would impact your management considering that those are only moderate. Your reviews would only slightly impact how you're communicating or managing things, it would even impact it that greatly, it really becomes something that's nice to have.	 CC, CAw CAw, CP
10	Especially with the reviews, reflection is an integral part of that learning mechanism. And so to see what we did, how we did it, and did it lower the risk, did we have any out-of-spec returns. It's very quite key to seeing whether we're being successful or not. Look past and look at the present situation, and go forward to what will come.	CAw, CP
11	A: Responsibilities are very well defined. And they have been allocated professionally to the various people. B: So it's imperative that all the nominated competent personnel are trained and trained at the correct intervals of refreshers. And anybody leaving or coming is trained quickly. C: Control measures, they're in place. And anything that falls out of the parameters of control measures is dealt with efficiently, and corrected, and brought to the attention of senior managers if it cannot be repaired or the control measure has not been brought into control. D: Communication and management, again with the various meetings we have, having a management structure where if something goes wrong you can sometimes jump a couple of levels so a higher person knows straight away if decision-making has got to be made for actions to	PS, CAc CAw CC CC, CM

	prevent any issues that may happen after out of any control measure that's gone out of sync.	
	E: Record keeping, most important. Usually done by administration people. Most important for the person responsible for *Legionella* water systems is that they're ensuring that all the record keeping is up-to-date, properly filed, properly documented on PC, not just conserved for somebody to do and never checking up on them.	CC, CAw
	F: And finally reviews, most important. Always should be done by himself and a third person who doesn't work at the site, as a fresh pair of eyes.	CAw, CP

Biggest challenges in water safety risk management

Table Appendix B-13: Extracted and condensed answers on question 33, phase I b

ID hospital	Extract of specific answer	PESTLE and CTAAPM category codes
01	Improve compliance. Because of the budget restrictions.	PEc, CP
02	My biggest challenges is all the fact, that my hospitals are 40 to 60 years old. They are old systems, they are to be added all the time. I think they are at the end of their life cycle. And we're not replacing as quickly as we should be doing. I think that's my biggest concern and my biggest challenge.	PT, PEn
03	Actually, again, I think it's about availability of capital moneys to do some of the remedial work that we need to do. And it's obviously a scarcity of that at the moment.	PEc
04	So I think one of the biggest challenges is the lack of sufficient backlog investment. So you've got some old engineering systems and they're quite difficult to maintain and safe. I think there's kind of a challenge in managing the kind of proportionality in response for some people because when people hear about bacteria in water, they immediately jump to the conclusion that it's not safe. And so, in a sense, managing people's kind of concerns, and the communication with contamination. Normally, these things just happen behind the scenes, but as soon as somebody who doesn't have any understanding of the topic suddenly hears that there's *Legionella* contaminated water, it's just making sure that there's no hysteria around that. And if you're managing along the process and	PEc CT CAw

	that will be responded to. And the reason we have these samples taken is to control the problem. There is certainly a problem, proportionality, I guess, in terms of response and communication with others.	
05	I think the biggest challenges are the little-used outlets and flushing. They're the biggest challenges. Temperature controls, not a problem. But finding the outlets and then flushing them and evidencing that we're properly flushing are the biggest issues.	PT, PEn CAw, CP
06	Flushing is a huge thing given that we are relying on the temperature regime, and we're very concerned about dead legs. Flushing. Microbiological sampling results. *Legionella* risk assessments because they are fundamental to understanding your risk and putting in the planned preventative maintenance regime that will manage that. Audit reports that I just mentioned they are very, very useful and always have been by an independent.	PT, PEn CAw, CP CM CT
07	Oh, they can be huge. I mean, if you're looking at, say, a major reconstruction, the Capital project could only have X amounts of pounds, so to speak. And we as a group-- take as an example, I have a preference on a type of tap that I wanted fitted. It took me two years, Thomas, but they finally agreed that as standard now, this particular tap is fitted and its now been fitted on every single Capital project. So it took the weight and the strength of the Steering Group, the Water Safety Group, to push that forward. If I'd have fought that fight on my own as just a head of planned preventative maintenance, I wouldn't have gone anywhere with it. It wouldn't have happened. However, with that strength of the group behind me, it was successful.	PEc PS, CAc
08	The biggest challenge is in the ability of the Water Safety Group. I would say it's taken the last eight weeks to form an opinion, to smooth people, to massage egos, to get people to understand why we need to do what we need to do in terms of the Water Safety Group. So for example, we've had some very senior people sitting on these two Water Safety Groups, and the example I'll give you is they've been meeting quarterly. So you've got to be very careful when you say to people, "You meet every 12 weeks. So you wait 12 weeks to look if an action's been completed, and if the action's not been completed, you're going to wait another 12 weeks before you get any feedback on it." So you could be taking some of the actions from one of the Water Safety Groups. I've chaired four Water Safety Groups. And what's clear to me is it's all eyes on me because no one's spoke this language before. So the challenge is about the ability of the Water Safety Group to really	PS, CM CAw CAw

	understand what they're doing there, all these members to understand. And then to convert their understanding into educating and supporting the trust itself. So we've got 20 people on the new Water Safety Group, but we've 18,000 people in our organisation. So that was the challenge. But the first challenge is get the WSG to understand what it's there for. […longer example with mobile units, vehicle trailers, APBM rubber hoses in the water systems in these units…] So it's that framework, understanding these to expand. Not just to water safety type groups but what I call imported risks from manufacturers and suppliers.	CP
09	The biggest problem you have with *Legionella* prevention in hospitals, it's not just hospitals. There's any large site. But specifically in hospitals, because they undergo so much change over the years. You got to think when these hospitals were originally built, [redacted] Hospital was built in 1960, 1970, etc. Now, when they were originally built, the technology available to us was a lot more limited. The understanding that we possessed was a lot more limited. The compliance requirement a lot more limited. We experienced less deaths and less problems from *Legionella*. And the main reason for this is because the systems were designed to work or to be used in that hospital for exactly the amount that they required. You have a distribution system, you have a general system that will produce hot water, sufficient quantity to a sufficient temperature to supply that hospital. You have only the exact number of taps, or outlets, or showers, that you actually need it. So, you would have, on a ward, you would maybe have two or three sinks, maybe two showers. And their system was designed for this. Now, we have less problems I think, but what has happened since then is that as time is going on, as time is moving forwards, we are constantly changing the way that our hospitals are designed, the way that our hospitals are used. So we are refurbishing or upgrading wards and theatres and public areas. And as we are doing this we are installing more wash-hand basins and wash showers. Now, one of the reasons why we are doing this is because of infection control are driving that process because more areas for people to wash their hands, because if your hands are cleaner, there's less chance of you spreading potential bugs like MRSA or these other bacteria, which come in through contact. So you're now starting to put more sinks in, you're starting to put more taps in, you're starting to pay a lot more attention to disability regulations, to people who have weak bladders, to the older generation. People are living longer, so you are having to account for people needed to have closer access to toilets, so you're putting new toilets in. You're increasing the size of the population that	PT PEn CAw

	you have to deal with so you're putting more showers in, but all of this is going on constantly, all the time and they're adding more and more. But everybody's still using the same distribution system that was designed for a load in 1970, which was designed for 1 or 2 taps in a ward, not 10 or 15. Decentralisation, I would say, is a good thing, because if you can keep your outlet closer to the source of where you are heating your water or where you are storing your cold water, then there is less distribution system for it to either cool down or heat up. And so you are reducing your risk. So it will be best to have your point of generation or your point of storage as close to your point of use as possible.	
10	Allocating the correct resource to resolve risk issues.	PEc, CAc, CAw, CM
11	The biggest challenges are *Legionella* control, *Pseudomonas* control, compliance with PAM (premises assurance model), which is the NHS control methods for water systems, and ensuring that training and auditing is being carried out.	PL CC, CP CAw

Success stories

Table Appendix B-14: Extracted and condensed answers on question 34, phase I b

ID hospital	Extract of specific answer	PESTLE and CTAAPM category codes
01	So, basically influencing our water hygiene contractor. So, originally we were a large site. We’ve got about 340 different wards and departments in our building stock. And, before I came here, the risk assessments, which just, they had 30 or 40 risk assessment covering massive areas. Which didn’t help. And so I set up a monitor strategy of basically, or basically walked around the hospital, wrote down every single ward and department, and then I said I want a risk assessment for each one of those small areas. But the same time, the infection control team were able to do a desktop exercise of giving each area a clinical risk. So it gave me a starting point. The clinical risk, basically, influenced the engineering risk assessment program, so I’ve seeked in with the high patient risk areas first and then down to the car park right at the end. So that was a massive lead forward. Suddenly organising things having some sort of strategy	PS CAw CM

	and then I've been putting the database together to capture all of this information, and then trying to use it, you know. Trying to organise it. I knew we've got from the risk assessment information, we had about 1,500 water system defects, which is probably nowhere in there what we really have got. That's the old information, that I've had. But now we are able to, I'll see, put some sort of strategy striving for a five year plan to address all of these defects and request the budget, because of then split into risk rating and prioritised it. So I've broken it down into manageable chunks where I could say 'work over £ 5,000 pounds' I've worked out this budget. And then £ 5,000 pound the next month. And then we can slowly improve our water system designs and, hopefully, water quality results, all sample results, as a consequence. So that was quite a big step forward. Just getting things organised and electronic folders, you know, an explorer, one folder for each ward with all of the records together, and each the risk assessment in that folder. Just organising everything, the defects that have been identified. The sampling results.	
02	Without a doubt. Water safety group. Coming issues in drive. That's generated through that group. This is, by far, the biggest success.	CM
03	Well, we got congratulations when we got a 100% push in return rate. And so all the clinical.	CAw
04	We did have a problem at [redacted] Hospital with *Pseudomonas* contamination and we couldn't really understand why that was. But as the topic became better understood, we sort of became quite experts ourselves in dealing with the problem. We found that components of taps were actually propagating the growth of the bacteria. And so we made adaptations, especially temperature control at tap head and we actually removed some of the components of the taps fitting and the diffuser head. And so, in a sense, that was a successful piece of work. So whilst it was a live issue we were managing, controlling, the risk, and eventually, we managed to some extent to eradicate the risk.	CC PEn CAw CP
05	We didn't use to test, we didn't use to take water samples and test for *Legionella* when I started. It was the heritage from the previous director of infection and prevention control. That person retired, and we got a new one. And she came in with very, very different attitude and couldn't believe we didn't test it. And she was wanting to do-- I don't know. It would have been about 300 samples every year, would have cost us a lot of money. And I was at the other end of the spectrum saying, "Well, look, we can prove temperature, we can prove this, that, and the other. And also, what are you going to do if you find it? It's all very well said you want to test it,	CC CC

	but you have to have a plan if you find it because you cannot shut the hospital and decontaminate. You have to work an operation plan." So we kicked that around for about 6 months with some different opinions, and we finally settled on testing and the pre-consumer numbers. And we got down to about 30 samples, once a quarter. And we did all the testing and been doing testing for 12 months and we've not had a positive result at all, anywhere. So in terms of what I said, that I was comfortable with our systems and processes. Okay, they weren't perfect. They were reasonably good. Then that's borne out. That's been borne out by independent testing. So I've got a director and infection prevention control who's happy. I'm happy because what I said would happen has happened. So I take that as a win. I've got to say, I take it as a win.	CAw CM
06	What I think I'm pleased about is the governance structure, which you will see. There was quite a few risk reports forms by external order does highlight a number of deficiencies, I think you would call them. Managerial deficiencies more than technical ones. If you think about an independent report on medical gases, which could be quite damaging, was not seen by the organisation. And it was left in an engineer's office. You're not set up with the right government structures if engineers can keep reports and not share them with the organisation to understand the risks. So I've completely renewed all of the working groups with their terms of reference. And I've got these reporting structures, as you will see, *Legionella* being one of them. But it covers a lot, all the critical infrastructure: pressure systems, medical gasses, electrics, lifts to a certain extent, food management systems. So that's probably a key success to managing risk. Reporting and documentation is an essential part of it. I think during that time, maybe not everything was our best, not everyone was your best friend. But it's the best way for organising things. The collaboration. The idea is you've got to be professional. And you've got to do what you think is right and stick to your convictions.	CM PS, CT, CAc PS CM
07	I have to say very proudly, well, two. Can I squeeze a little bit of *Pseudomonas* into this? I was instrumental with a company called Horne Engineering. They developed a new product. It's called in-line thermal disinfection unit. So this product came to me. I installed this product. Was very, very successful, so much so that I wrote a case study which was published. And it fell on the internet, and it's the whole success story of how we beat *Pseudomonas* in a particular ward using that particular process. If you wish me to send that to you I certainly can. That was a success. But also the success of the team which obviously is the letter that we got in	CAw CP CM

	our staff news, which was to congratulate everybody for removing Legionellae from this site. We beat it. We've achieved all the things that we're after in the water safety group. We followed the procedure that's in the water safety action plan. We followed the trend. We've excelled the pain for want of a better way of putting it because it has been hard work, and keeping on it, remembering to do the testing, waiting for the results. If that hadn't worked what do we do next? And everybody on board, everyone being proactive, and to finally beat it. And not only beat it but now we have all quarterly testing continue to beat it, if that makes sense? I think the last 12 months have been major, major improvements. And it also about giving the people more awareness about certain things, Lord, yes. Yeah. At the hospital, we have a thing called Theme of the Week. So in our newsletter - it's the same every week - we actually put one out for underused outlets. So we basically said 'use it or lose it'. So if you've got a washer and basin in the cupboard that you just don't use day after day after day after day, ask the estates department and we'll actually remove it. We'll take it out because you don't need it. It's just another blind end, and people did. They contacted us, said, "Can you remove this washer and basin? We don't use it.", "Can you remove this sink?" "This old cleaner's cupboard, we don't use it anymore.". And I think that was another great instrument of everybody working together.	CP CM CAw PT, PEn CM
08	I'd say it's getting the restructure. Getting the restructure and people. So people now in staff to understand.	PS, CAc CAw
09	So greatest success is, where I started the journey of the worst wing of the hospital, of the distribution systems, regeneration system that comes with the hot water and cold water. This has now been completed. There was two very big things that came out of this whole process one was the identification of considerable quantities of dead legs all around the site where projects have been undertaken, and they happen to cut the old pipework out. So you are left with all of this pipework that's now no longer being used but still connected to the system. So we are now slowly getting rid of all of those and cutting all of that old pipework out. And, obviously, as we are doing this, we are reducing the amount of areas where *Legionella* can grow. The second biggest part is that we've identified areas within the hospital or of this wing where we do not have enough capacity in the pipework for the hot water to be, for enough volume to flow to these areas. And so we have now secured a £ 2-million budget to put in a new riser, a new hot water and cold water riser, to split the system a little bit more so that we can get a larger volume flow to these areas.	PL, CC CAc CAw PT, PEn PEc

10	I think appointing and authorising engineer of water.	PS, CAc
11	We installed automatic cold water flushing on the tanks. We were getting tanks go well over at nighttime in little-used areas of the hospital, and we were getting temperatures up to 26°C or 27°C, which was getting a bit dangerous. So utilising the building management system, it monitors the tank temperature, and there's a adjustable set point where I think I've got it set at this moment with such warm weather, at 23°C. It opens a dump valve, lets fresh water in, which brings your temperature down. So that means that we're supplying water into the site more or less within the remit of HTM. So we did that in the last 12 months.	PT CAw CP CM

Money annually spent for water safety

Table Appendix B-15: Extracted and condensed answers on question 36, phase I b, explained context

ID hospi-tal	Extract of specific answer	PESTLE and CTAAPM category codes
01	Round about £400,000 a year.	PEc
02	It was interesting as an exercise just to (practically) understand where we think we are. About £ 350,000.	PEc
03	That's a difficult one to answer, actually, because the costs for that aren't ours, really. They're the FM provider's costs. I wouldn't even like to tell you what that is. I know we're just gearing up now to do a new risk assessment. And that'll be quite sizeable cost, I think.	PEc
04	That's a difficult question because some of the activities that we carried out were done by in-house staff. So it's trying to estimate how many man-hours contribute to that. And some of it is subcontracted. So it's difficult for me to say with any accuracy. I would say in the hundreds of thousands. I couldn't be more specific about that.	PEc
05	I've written the figure down, but when I think about it's probably a bit light because I've wrote down £30,000, because I was thinking for domestics time and estates time and then there's contractors and *Legionella* sampling. So probably if I included people's time and what that actually means in terms of their salary, it's probably more like 50,000, I would think. Which	PEc PEc

	sounds a lot, but effectively you're paying two or three domestics to do a lot.	
06	I think water safety is better funded than electrical safety, than medical gas safety and ventilation safety. But I wouldn't complain about the budget that we have for water safety. I think it's on a very good track. I'm slightly changing it (the budget) in a restructure because it was actually managed by Environmental Services. The head of Environmental Services, he's got a master's degree in Environmental and Sustainability. Environmental Services comes under my directorate anyways. So I put it back on the chartered engineers and I want to make sure that goes smoothly with it. It should fit there. It does fit there. I just want to make sure that it's still given the priority that it's had and the tender loving care by the head of Environmental Services.	PEc
07	I'd like more money. But if you imagine you've got an existing building, you've got an existing infrastructure, you have an existing hot water plant that generates that hot water, and that hot water's distributed all the way from top to bottom of the building, that's what you've got. Now, when they do a refurbishment of a board, of the floor, they might put all new brand new pipework and new basins, and so forth. But they tend to always build onto the existing infrastructure. So if your infrastructure's wrong and old and antiquated, it doesn't matter how good and robust the front-end is, or that new part is. If we could look at some of the future proofing, about finding better ways of storing the water using clay heat exchangers. Everything changes. So what I would like to improve in regional risk management is for the people to understand that to achieve compliance and to maintain mandatory inspections meeting requirements doesn't come for nothing. It is always going to cost. And we always need to look at future proofing at the end of the day.	PEc PEc
08	First there must be an understanding of the processes and the problem in total and then you can count figures so.	PEc
09	There aren't exact figures. I mean, the figures vary very greatly because we've got a water safety problem. I mean, currently, we spent probably - last year we maybe spent three-quarters of a million (£ 750,000). This year, we will probably spend near on two million (£ 2,000,000); maybe even more than this because we are going to start undertaking projects to improve our water safety. So it varies very much but that's because we've identified where our risks are and then where our failings have	PEc

	been, and we're putting into phases of actions. So what we would normally spend is I couldn't answer.	
10	150,000 and above, we're a big outfit. Probably 200,000 to be honest.	PEc
11	We spend with the water management company and our own labour. I've not put in things like tank cleaning because that's not every year. So you're looking at about 30K. UK £30,000. It's not my time either. It's just what comes out through our budget.	PEc

Budget sufficiency

Table Appendix B-16: The sufficiency of the budged in relation to cost

ID hospital	Sufficient	Cost : Budget (£)	Comment
01	N	400,000 : 275,000(250,000)	
02	N	350,000 : n/a	
03	U (N)	n/a : n/a	I wouldn't even like to tell you what that is. I know we're just gearing up now to do a new risk assessment. And that'll be quite sizeable cost, I think.
04	N	n/a : n/a	
05	Y	30,000 (50,000) : n/a	
06	Y	n/a : n/a	
07	N	n/a : 45,000	Focus on regional management
08	U	n/a : 200,000 (revenue) n/a : 250,000 (capital)	
09	(Y), see comment	n/a : n/a	Budget is enough for the basic solution, but it doesn't give you the best
10	N	150,000 (200,000) : n/a	
11	(Y), see comment	30,000 : n/a	For day to day running. More cash for unplanned major investments needed (on demand) to assure compliance with the water systems.

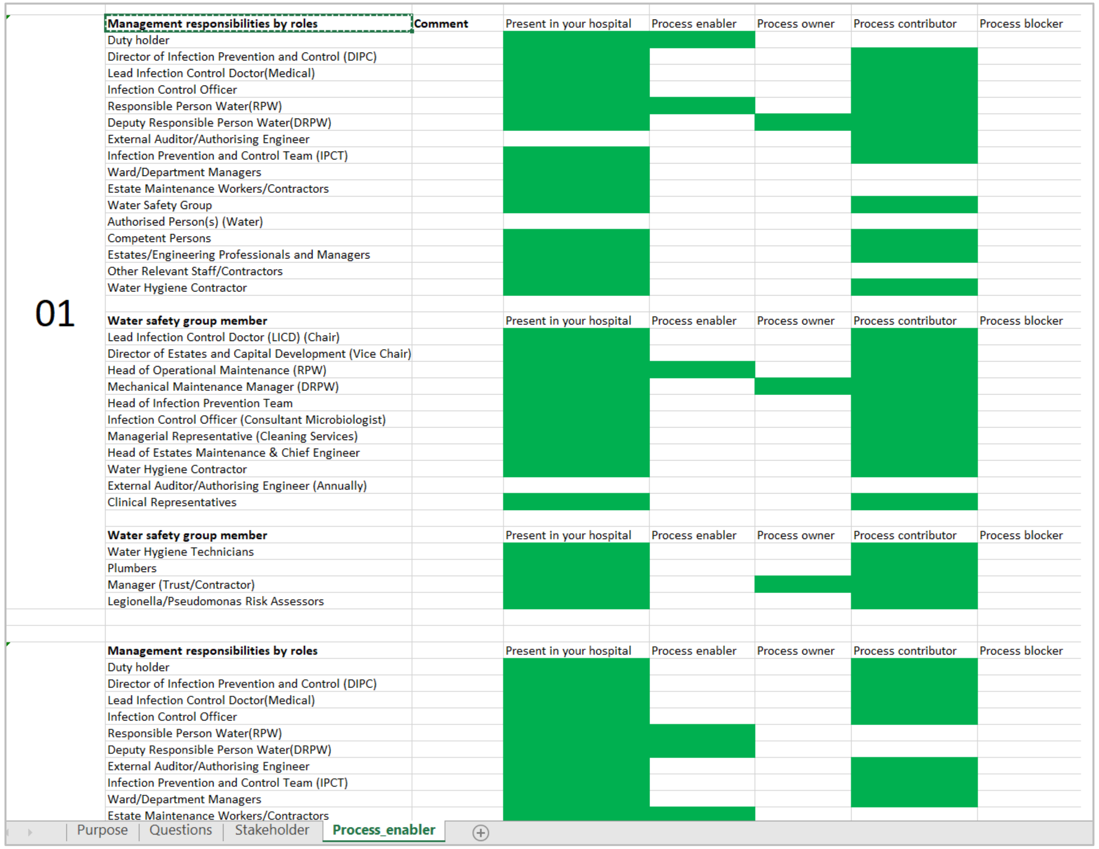
(qualitfying options: y=yes; n=no; u=unclear)

Table Appendix B-17: Extracted and condensed answers on question 37, phase I b, explained context

ID hospital	Extract of specific answer	PESTLE and CTAAPM category codes
01	Obviously not. The budget is around about 275,000, I think, or 250,000. But, I mean on priority I’ve overspent. But, I’m trying to do things the right way.	PEc
02	Not really.	PEc
03	n/a	PEc
04	I would have to say probably not. But certainly not in capital investments terms. Just about adequate to keep it legally safe. But in terms of the ongoing, is it getting worse.	PEc
05	I'd say yeah. We're getting the evidence, we don't have any significant gaps or anything that's really causing me lots of concern that I just have no idea what's happening. I'll probably better say it is about right.	PEc
06	n/a	PEc
07	If we focused on regional management, I'm going to say there are £45,000 and is the budget, and that's to meet the requirement? No.	PEc
08	For revenue, the number is around about £200,000 at the moment. And for capital, it's going to be in the order of £250,000 at the moment. But that's until we start to discover how far off North we are. That number will probably change.	PEc
09	The budget is what you make of a debit. There's always multiple options within everything in life, right? You've got the solution, which is the best solution, through to the solution which will achieve what you need, but it's a basic solution. But it will do what it's needed to do.	PEc

	Is that budget enough? The budget is only enough for the basic solution. Achieves what you need to achieve, but it doesn't give you the best.	
10	What it should be is, as they're not delivering a compliant water safety service at the moment, then more budget is needed than has been previously allocated to allow a compliant system. To get the clue about the present situation, and get an order, and to move it forward. We're going to get the right governance in place, lower the risk to the organisation, and improve compliance massively.	PEc
11	Yeah. Because, obviously, the day-to-day running of it is within budget. Obviously, if we need to clean the tank or there's a fault on a clarifier - obviously, replacing thermostatic mixing valves isn't a massive cost because we only do it as and when. But if something major cropped up, we would go and request that money for any method that we needed to find the money. So I don't have a problem here trying to find the cash to ensure compliance with the water systems.	PEc

Table Appendix B-18: Process enabler, owner, contributor, blocker



01

Management responsibilities by roles	Comment	Present in your hospital	Process enabler	Process owner	Process contributor	Process blocker
Duty holder						
Director of Infection Prevention and Control (DIPC)						
Lead Infection Control Doctor(Medical)						
Infection Control Officer						
Responsible Person Water(RPW)						
Deputy Responsible Person Water(DRPW)						
External Auditor/Authorising Engineer						
Infection Prevention and Control Team (IPCT)						
Ward/Department Managers						
Estate Maintenance Workers/Contractors						
Water Safety Group						
Authorised Person(s) (Water)						
Competent Persons						
Estates/Engineering Professionals and Managers						
Other Relevant Staff/Contractors						
Water Hygiene Contractor						

Water safety group member	Comment	Present in your hospital	Process enabler	Process owner	Process contributor	Process blocker
Lead Infection Control Doctor (LICD) (Chair)						
Director of Estates and Capital Development (Vice Chair)						
Head of Operational Maintenance (RPW)						
Mechanical Maintenance Manager (DRPW)						
Head of Infection Prevention Team						
Infection Control Officer (Consultant Microbiologist)						
Managerial Representative (Cleaning Services)						
Head of Estates Maintenance & Chief Engineer						
Water Hygiene Contractor						
External Auditor/Authorising Engineer (Annually)						
Clinical Representatives						

Water safety group member	Comment	Present in your hospital	Process enabler	Process owner	Process contributor	Process blocker
Water Hygiene Technicians						
Plumbers						
Manager (Trust/Contractor)						
Legionella/Pseudomonas Risk Assessors						

Management responsibilities by roles	Comment	Present in your hospital	Process enabler	Process owner	Process contributor	Process blocker
Duty holder						
Director of Infection Prevention and Control (DIPC)						
Lead Infection Control Doctor(Medical)						
Infection Control Officer						
Responsible Person Water(RPW)						
Deputy Responsible Person Water(DRPW)						
External Auditor/Authorising Engineer						
Infection Prevention and Control Team (IPCT)						
Ward/Department Managers						
Estate Maintenance Workers/Contractors						

Purpose | Questions | Stakeholder | Process_enabler

Appendix C

Online survey ‘ Water Safety Management’

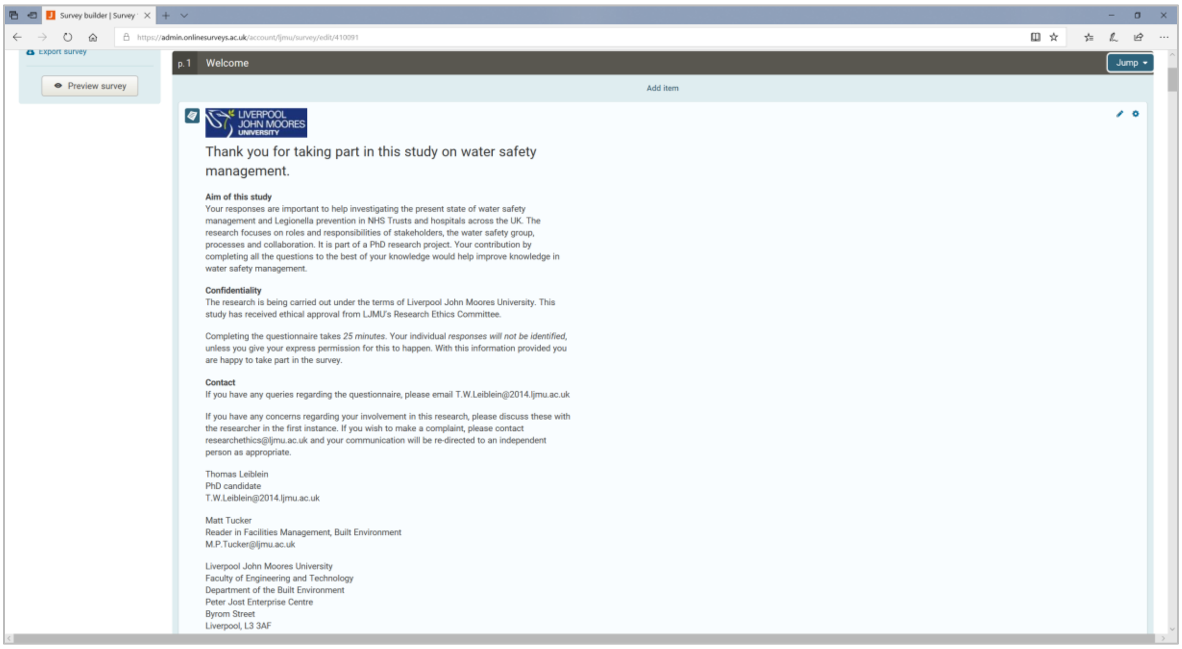


Figure Appendix C-1: Opening page of the online - administrator’s view

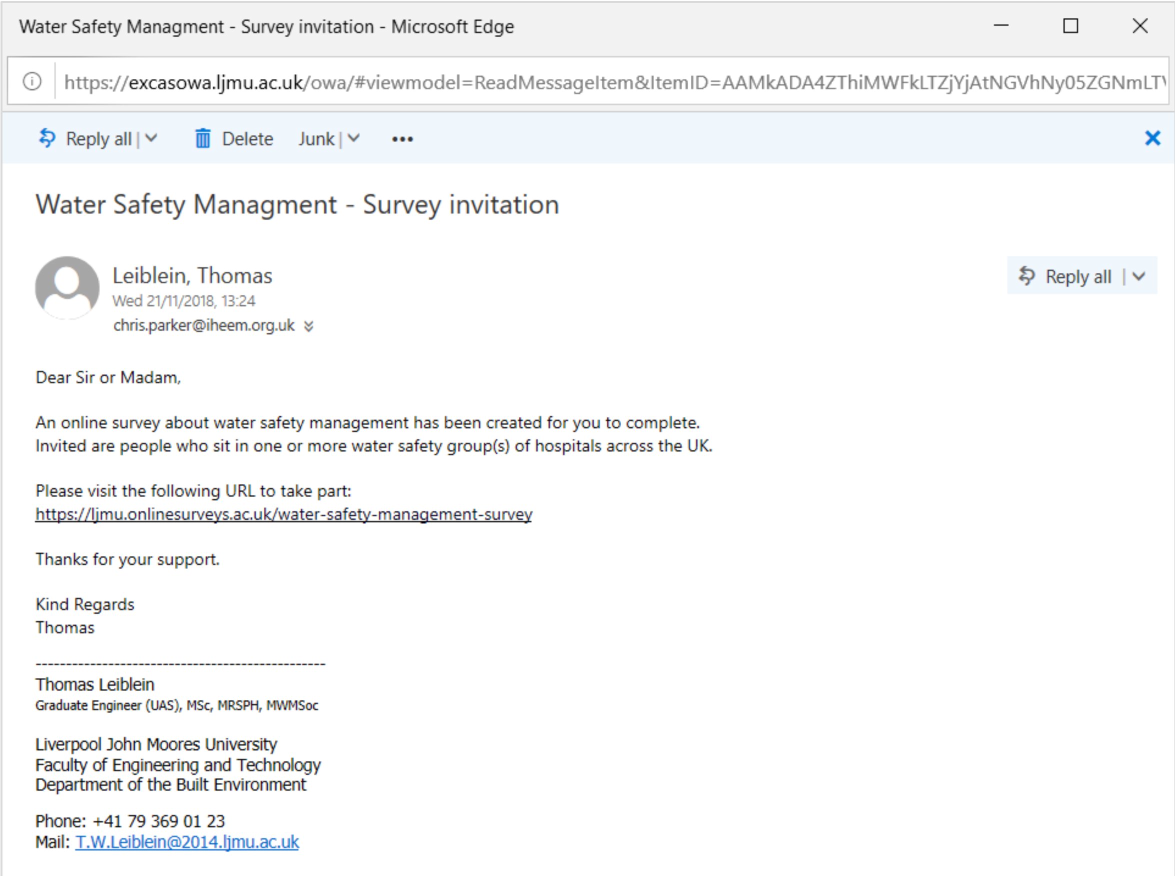


Figure Appendix C-2: Water safety management survey invitation

Thomas Wolfgang Leiblein hat in der Gruppe Legionella & Water Borne Diseases einen Beitrag veröffentlicht

Thomas Wolfgang Leiblein
Leiter Infektionsprävention bei Hirslanden AndreasKlinik Cham
1 Jahr • Bearbeitet •

Water Safety Group Members - watch out!

Dear Colleagues

Please see below link and details to support my survey on water safety management in hospitals. Invited are people who sit in one or more water safety group(s) of hospitals across the UK.
Please visit the following URL to take part:

https://lnkd.in/ezTCaNF

My Name is Thomas Leiblein and I'm a PhD candidate at Liverpool John Moores University.
In my research my interest lies in water safety management, Legionella prevention and facilities management.
I wish to better understand the processes, the roles/responsibilities and the management of the processes around water safety management.

In a final stage I want to sum up my findings and compile a framework for facilities management on the process of Legionella prevention in health care facilities in the UK.

My research has progressed to the next step which is this online survey.
I need to address people who sit in water safety groups or who collaborate with them.

The survey has gained ethical approval from the Research Ethics Committee of the University.
Content is treated confidentially.

Thank you for supporting my research and help gaining knowledge in the field of water safety management, risk management and facilities management.

Kind Regards,
Thomas

Water Safety Management
ljmu.onlinesurveys.ac.uk

Figure Appendix C-3: Screenshot of advertising post in LinkedIn professional groups

Feedback person no. 1	Feedback person no. 2
My overall impression of the survey is that it is too long and many NHS workers will not have the time to complete it. My specific observations are below: Q1 Organogram not organigram Q3 You may have to ask AEs to complete for just one of their sites as they usually work on multiple. Q4 no 6 - its not ist Q5 P. aeruginosa not Pseudomonas. What about other waterborne organisms? Approved by Capital Projects. 17 - Microbiology may depend on the other controls working - these are not mentioned. 18 - very long and complicated 20 - can't see questions and diagram on same screen, have to scroll down, so not easy to complete 21 - headings roll out of view 8f - POU filters as microbiological filters could include POE and hydrotherapy for example Also - you may get inaccurate answers as they may feel they are incriminating themselves!! 25 - I don't understand the term perceive? I hope that this is useful? Best Wishes,	Firstly, I'd say that 20 minutes to complete the questionnaire is probably optimistic - I think it'll take most people around half an hour to do it properly. There are one or two typos which will also need to be corrected, e.g., organogram is misspelled in Q1, final bullet in Q4 - should this say 'delivering'? More specifically, Q1 Suggest including Authorising Engineer (Water) here. No doubt you've looked at HTM 00 (https://hes32-ctp.trendmicro.com:443/wis/clicktime/v1/query?url=https%3a%2f%2fassets.publishing.service.gov.uk%2fgovernment%2fuploads%2fsystem%2fuploads%2fattachment%5fdata%2ffile%2f299276%2fHTM%5f00.pdf%29 c69e-4e31-a601-09b398bafddf&auth=f90b0c85f895db27b33fe67efe705fc71df6644c-3602daa84ea3e9d40486b821410be4691f90ff62 but it would be worth just checking the positions listed in this guidance and ensuring that they're reflected in the questionnaire and that this is consistent throughout. Q4 Suggest including 'Sufficient time and/or resource' Q5b Suggest explaining the term 'Capital' Q8 Why restrict questions to Legionella - suggest 'waterborne pathogens' Q13 Suggest using the term 'Infection prevention and control' Q13 Suggest avoiding use of the term duty holder - it almost always causes confusion Q13 'Doctor of Nursing' should be Director of Infection Prevention and Control Q13 Suggest including the WSG somewhere here - maybe above Director of Facilities and Engineering Q19 Suggest explaining 'professionalising' Q24-26 Suggest explaining 'FM'. This is usually an abbreviation for Facilities Management. Some Trusts utilise external companies for this service, particularly in hospitals built under PFI. I was a bit confused because this could have been referring to Estates and Facilities, which is often the case in non-PFI hospitals So, just a couple of minor things to think about, but in general I think this has the potential to be a useful tool for Trusts to benchmark their water safety management arrangements and I'm grateful for the opportunity to have seen it. Kind regards,

Figure Appendix C-4: Exemplified survey pilot test feedback

LIVERPOOL JOHN MOORES UNIVERSITY

Water Safety Management - Training needs for management and practitioners in hospitals

Thomas W. Leiblein
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Byrom Street, Liverpool, L3 3AF, UK
Elise Maynard
Technical Committee, The Water Management Society

ABSTRACT

Every water safety management group (WSMG) in a hospital or Trust is composed of different members, who are responsible for either clinical or non-clinical processes. According to their roles within the hospital organisation they should be members of professional organisations to maintain their own continuing professional development (CPD) and to keep them up-to-date in specialist knowledge and training. Each professional discipline and role has its particular interest in water safety management (WSM) and Legionella prevention. This poster summarises selected data of a web-based survey on WSM. Presented are characteristics of participants and their responses with regard to training needs in WSM. Memberships to different professional organisations are presented who are more relevant to WSM. The findings underline the need for continuous training and up-to-date specialist knowledge. Furthermore it reflects what percentage of working time professionals spend on water hygiene, varying widely. Findings highlight common topics of interest with respect to training needs towards Legionella and water hygiene. Regulatory uncertainty or poor understanding of best practice can potentially inhibit an accurate process definition of WSM and Legionella prevention in hospitals. Results suggest that compliance and awareness about regulations, risk and responsibilities are present issues in WSM and Legionella prevention in hospitals.

BACKGROUND

This work is part of an ongoing PhD research project, which systematically reveals the present situation of *Legionella* risk management and prevention in water systems in hospitals. It aims to provide a framework for estates and facilities management (FM) with focus on the process of *Legionella* WSM and prevention in hospitals in the United Kingdom. The objective of this poster is to present answers to questions of the web-based survey specifically on training and training needs. Furthermore it attempts to characterise different stakeholders in WSM and *Legionella* prevention in hospitals across the United Kingdom.

Table 1: List of requested organisations for distributing the survey-link

Organisation abbreviation	Organisation full name
IHEEM	Institute of Healthcare Engineering and Estate Management
WMSoc	Water Management Society
HEFMA	Health Estates and Facilities Management Association
BIFM	British Institute of Facilities Management
SoPHE	Society for Public Health Engineers
CIBSE	Chartered Institution of Building Services Engineers
CIPHE	Chartered Institute of Plumbing and Heating Engineering
LCA	Legionella Control Association
BSRIA	Building Services Research and Information Association
RSPH	Royal Society for Public Health
BIA	British Infection Association
FIS	Federation of Infection Societies
HIS	Healthcare Infection Society
NHS	National Health Service
CIOB	Chartered Institute of Building
IET	Institution of Engineering and Technology

METHODOLOGY

In a business research context (Saunders et al., 2016), a web-based survey (Aldridge and Levine, 2001) with open and closed ended questions was compiled (Maree and Pietersen, 2012, p.161) in the LJMU browser application 'Online surveys'. For the remainder of the questions, a Likert scale response system was used. It is a type of multiple-choice question (Delport, 2007, p.177). The link for participating was provided to be spread by different organisations (Table 1), which hold members sitting in *WSMGs*. A total of 169 people being a member of at least one WSMG have accessed the survey. In total, 17 respondents completed the survey, which gives a response rate of 10%, which is typical for on-line surveys of this nature.

FINDINGS

With respect to training needs most participants seem to be up to date, yet they wish further involvement in the design stage of water systems (figure 15). However, figures 1-6 and figures 8-11 underpin the gaps, demands and the need for CPD. In figure 7 it becomes evident, that the role of FM is very present and collaboration of WSMG members with FM is rated with a span between intense to moderate. With respect to training needs for both *Legionella* and water hygiene, one participant highlights a common phenomenon, which has already been evidenced in an interview study, at an earlier stage of the research project (Leiblein *et al.*, 2019). They say "I think I get by and there is no requirement for me to do more. I think I could progress the next level and offer more to the Trust and to colleagues but there is no clear route laid down for me to follow". They continue that they "will press for funding if I identify something which might be fit for purpose - I'm just not sure if this even exists".

Figure 1: Q-1

Figure 2: Q-4.1, Q-4.2, Q-4.3

Figure 3: Q-18.26a, Q-18.26b

Figure 4: Q-19.12F

Figure 5: Q-21

Figure 6: Q-23

CONCLUSION

According to the results of this survey, which is designed for **people with duties in WSM and *Legionella* prevention in hospitals** across the **United Kingdom**, management personnel and other practitioners in hospitals and Trusts may require:

- specific **training**
- more sense of **awareness about processes**, **regulations** and **risks**, and **responsibilities**

to meet their specific training needs.

Figure 7: Q-24

Figure 8: Q-30

Figure 9: Q-27

Figure 10: Q-28

Figure 11: Q-29.1, Q-29.2

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DELPORT, C. S. L. 2007. Quantitative data collection methods. In: DE VOS, A. S. (ed.) Research at grass roots: for the social sciences and human services professions. Pretoria: Van Schaik.
LEIBLEIN, T. W., TUCKER, M. & HOFER, S. 2019. Water Safety Management in hospitals - Pilot test and case definition for an interview study (submitted).
MAREE, K. & PIETERSEN, J. 2012. The quantitative research process. In: AL., C. E. (ed.) First steps in research. Pretoria: Van Schaik.
SAUNDERS, M., LEWIS, P. & THORNHILL, A. 2016. Research Methods for Business Students, Pearson Education Limited, Harlow.

NOTE: *Results presented here are insights on selected data of an ongoing PhD research project. The content is context-specific, tailored to the overall research project design and has not been published anywhere else.*

Figure Appendix C-5: WSM – training needs for management and practitioners in hospitals

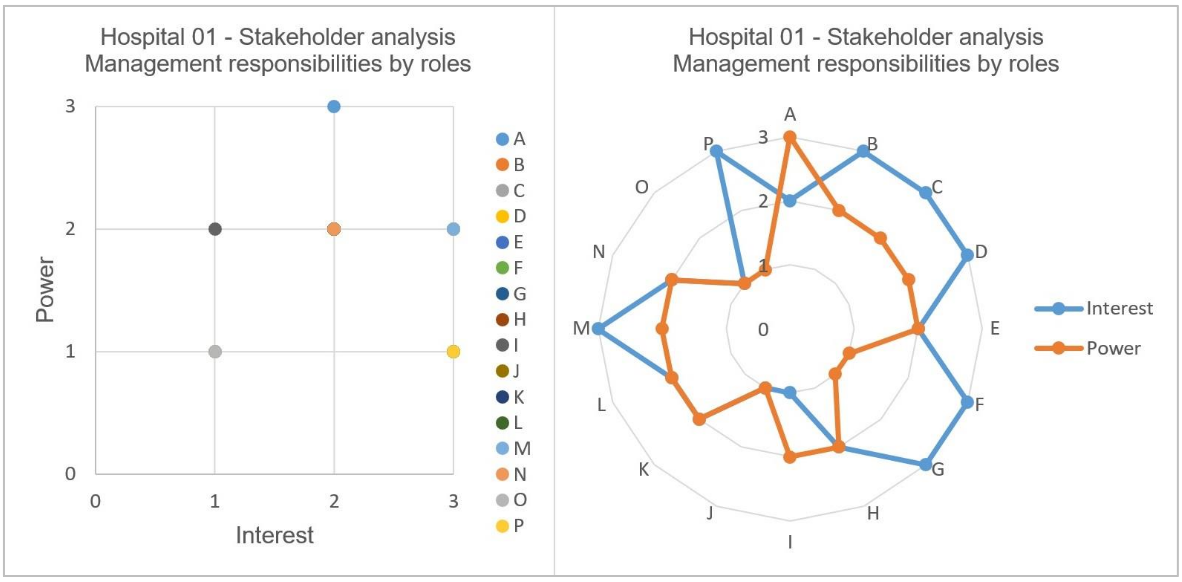

Figure Appendix C-6: Stakeholder analysis hospital ID01: Management responsibilities by roles

One on top of the other are (3;2)=B, C, D, M; (2;2)=E, H, K, L; (3;1)=F, G, P; (1;1)=J, O.

Table Appendix C-1: Stakeholder analysis hospital ID01: Management responsibilities by roles

Group 'low'	I, J, O
Group 'high'	A, B, C, D, M
Group 'check role'	F, G, P

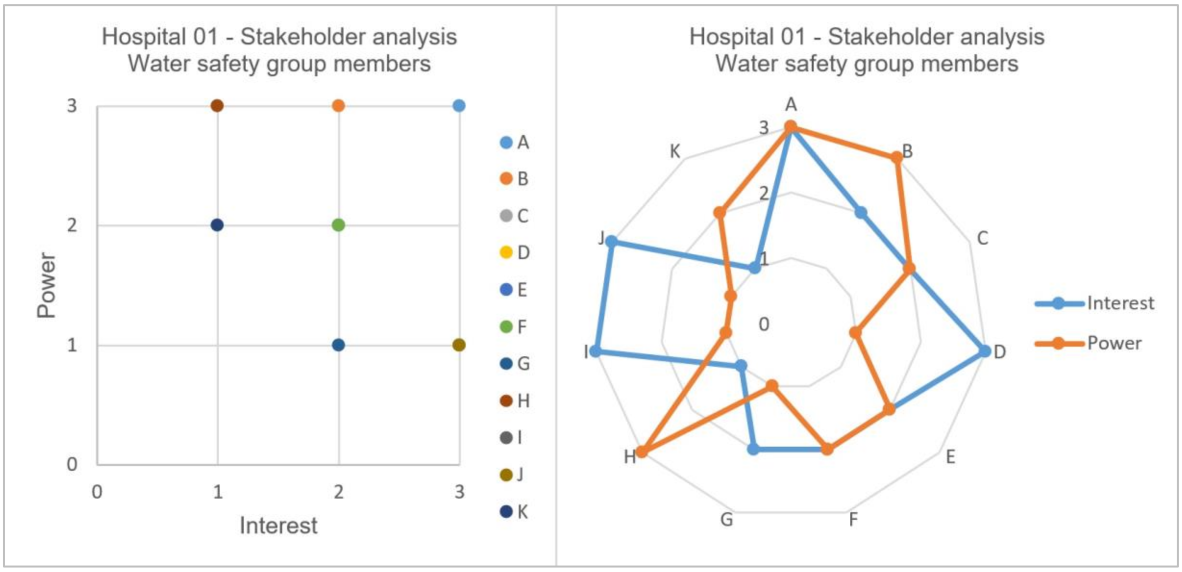

Figure Appendix C-7: Stakeholder analysis hospital ID01: WSG members

One on top of the other are (2;2)=C, E, F; (3;1)=D, I, J

Table Appendix C-2: Stakeholder analysis hospital ID01: WSG members

Group 'low'	G, K
Group 'high'	A, B
Group 'check role'	D, H, I, J

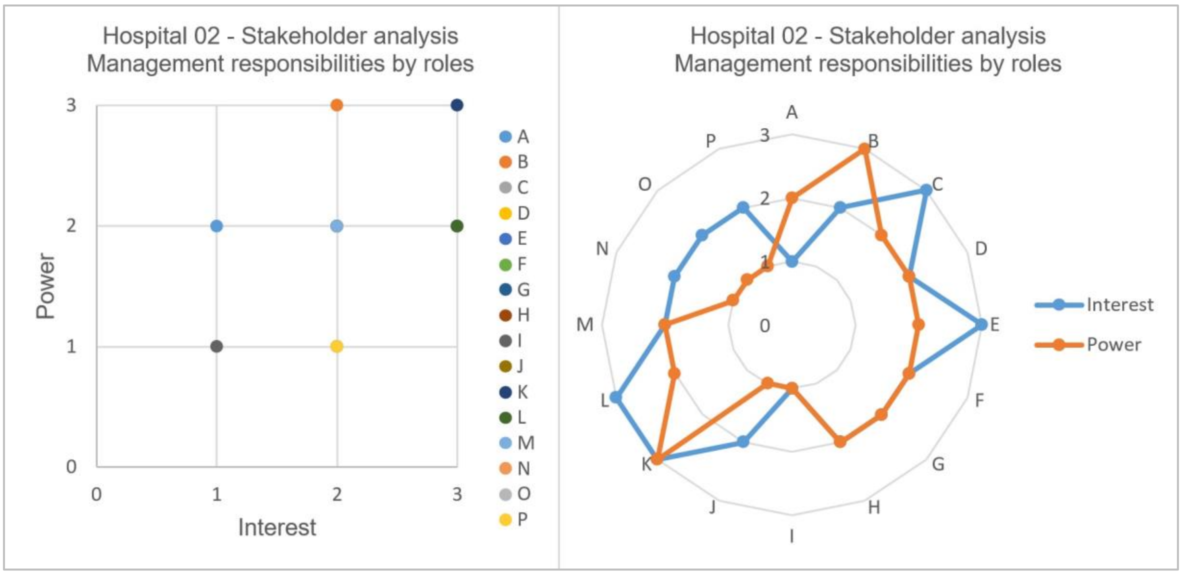

Figure Appendix C-8: Stakeholder analysis hospital ID02: Management responsibilities by roles

One on top of the other are (3;2)=C, E, L; (2;2)=D, F, G, H, M; (2;1)=J, N, O, P.

Table Appendix C-3: Stakeholder analysis hospital ID02: Management responsibilities by roles

Group 'low'	A, I, J, N, O, P
Group 'high'	B, C, E, K, L
Group 'check role'	n/a

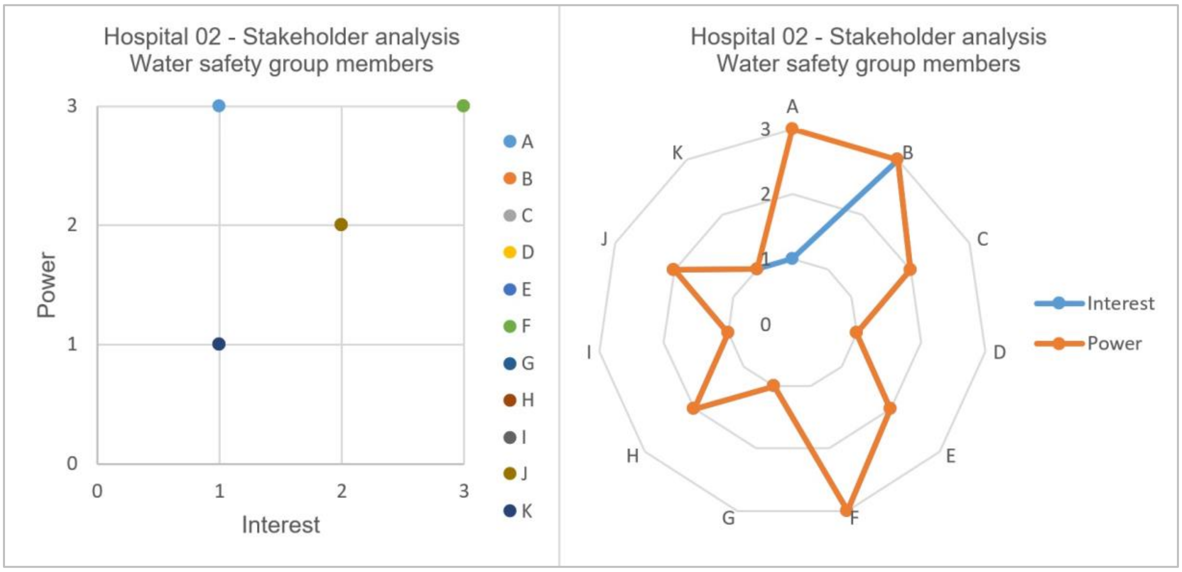

Figure Appendix C-9: Stakeholder analysis hospital ID02: WSG members

One on top of the other are (3;3)=B, F; (2;2)=C, E, H, J; (1; 1)=D, G, I, K.

Table Appendix C-4: Stakeholder analysis hospital ID02: WSG members

Group 'low'	D, G, I, K
Group 'high'	B, F
Group 'check role'	A

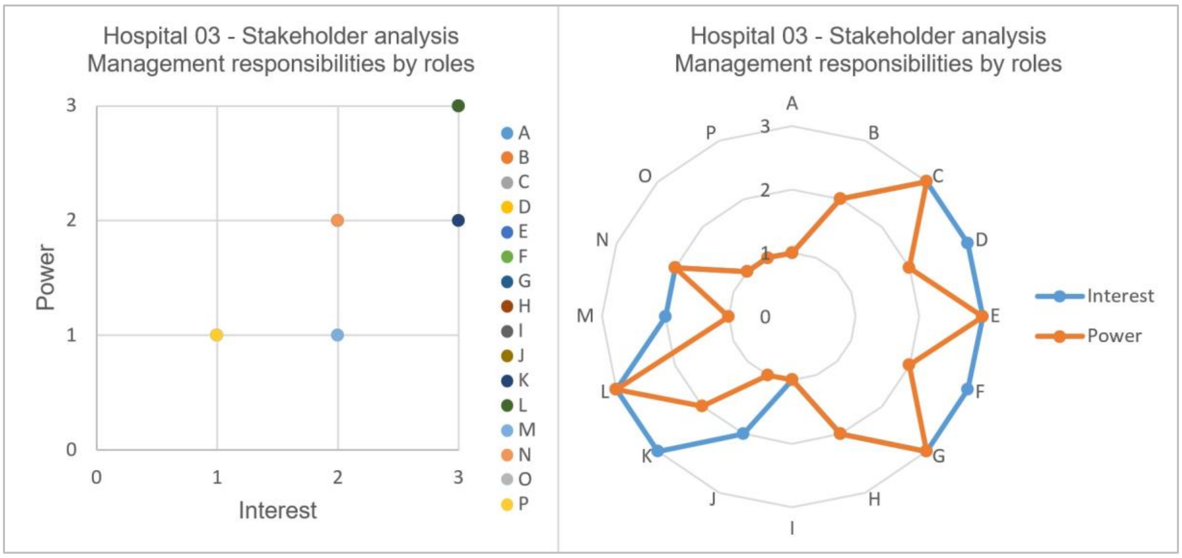

Figure Appendix C-10: Stakeholder analysis hospital ID03: Management responsibilities by roles

One on top of the other are (1;1)=A, I, P; (2;2)=B, H, N; (3;3)=C, E, G, L; (3;2)=D, F, K; (2;1)=J, M.

Table Appendix C-5: Stakeholder analysis hospital ID03: Management responsibilities by roles

Group 'low'	A, I, J, M, O, P
Group 'high'	C, D, E, F, G, K, L
Group 'check role'	n/a

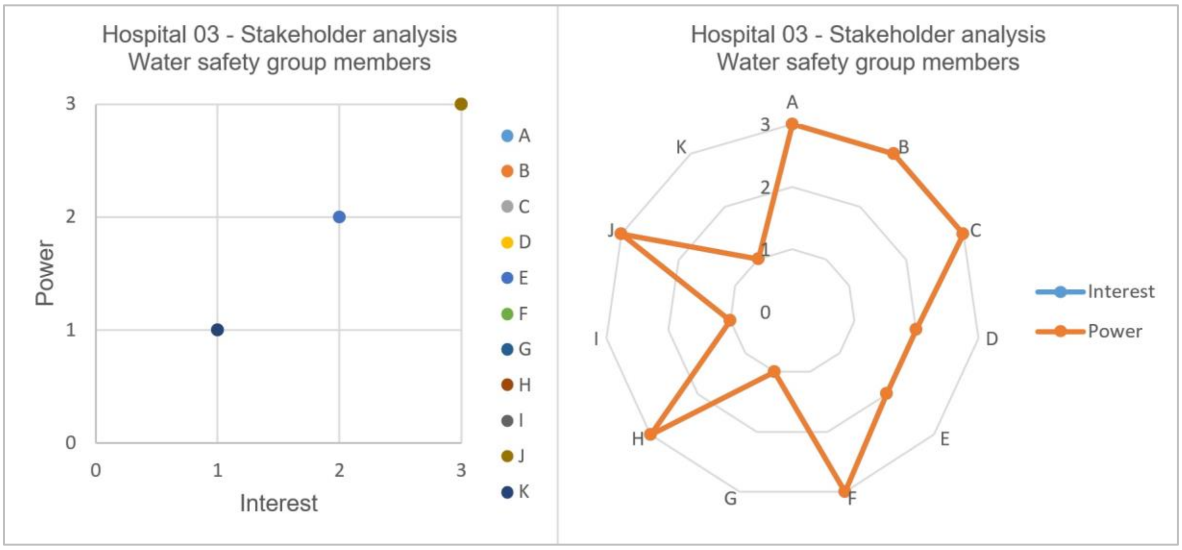

Figure Appendix C-11: Stakeholder analysis hospital ID03: WSG members

One on top of the other are (3;3)=A, B, C, F, H, J; (2;2)=D, E; (1;1)=G, I, K.

Table Appendix C-6: Stakeholder analysis hospital ID03: WSG members

Group 'low'	G, I, K
Group 'high'	A, B, C, F, H, J
Group 'check role'	n/a

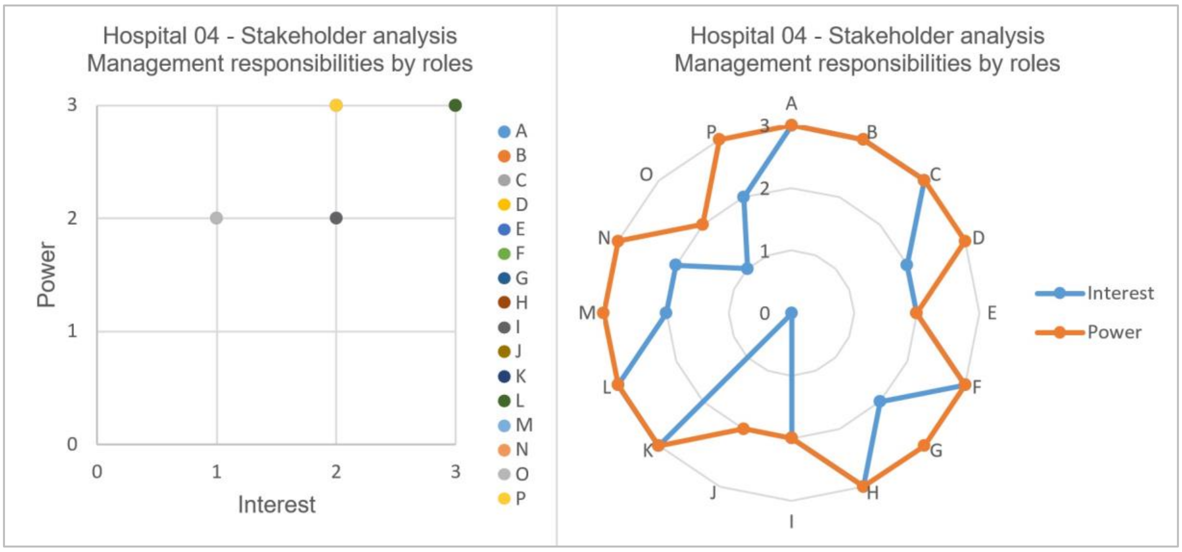

Figure Appendix C-12: Stakeholder analysis hospital ID04: Management responsibilities by roles

One on top of the other are (3;3)=A, B, C, F, H, K, L; (2;3)=D, G, M, N, P; (2;2)=E, I.

Table Appendix C-7: Stakeholder analysis hospital ID04: Management responsibilities by roles

Group 'low'	O
Group 'high'	A, B, C, D, F, G, H, K, L, M, N, P
Group 'check role'	n/a

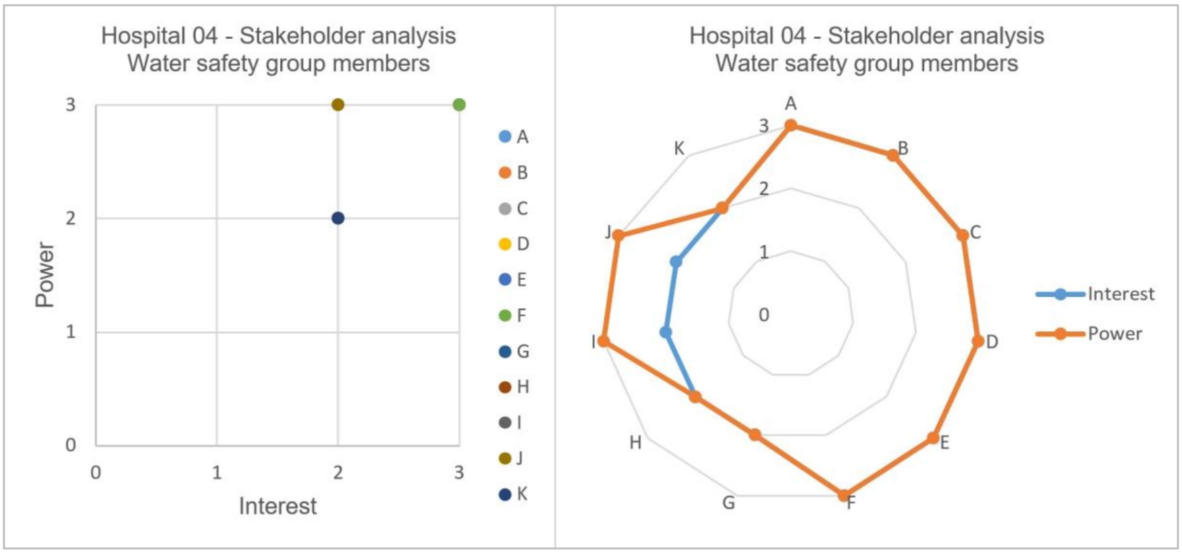

Figure Appendix C-13: Stakeholder analysis hospital ID04: WSG members

One on top of the other are (3;3)=A, B, C, D, E, F; (2;2)=G, H, K; (2;3)=I, J.

Table Appendix C-8: Stakeholder analysis hospital ID04: WSG members

Group 'low'	n/a
Group 'high'	A, B, C, D, E, F, I, J
Group 'check role'	n/a

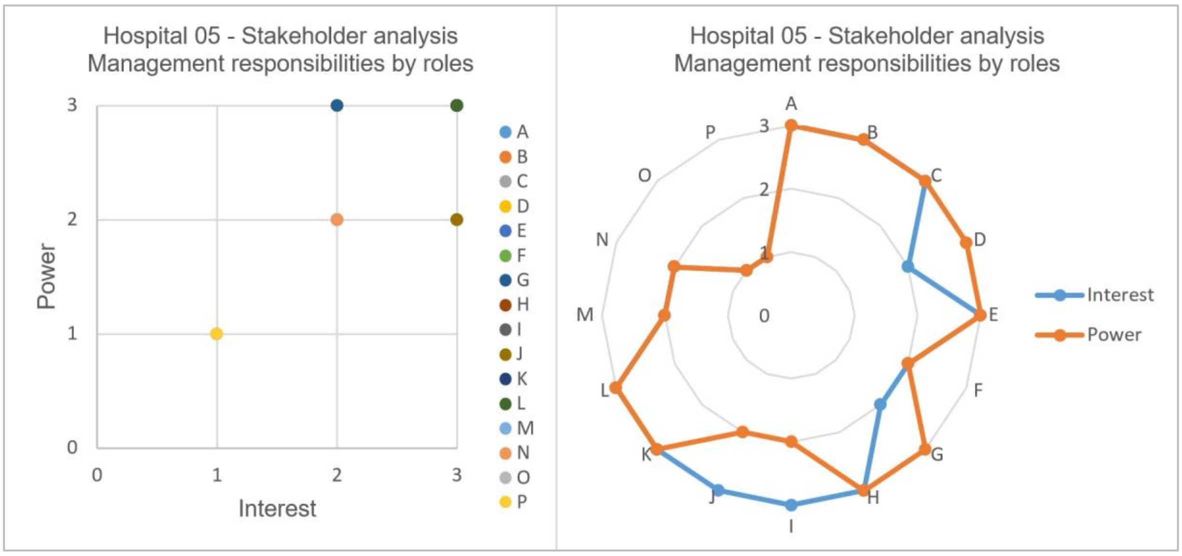

Figure Appendix C-14: Stakeholder analysis hospital ID05: Management responsibilities by roles

One on top of the other are (3;3)=A, B, C, E, H, K, L; (2;3)=D, G; (2;2)=F, M, N; (1;1)= O, P.

Table Appendix C-9: Stakeholder analysis hospital ID05: Management responsibilities by roles

Group 'low'	O, P
Group 'high'	A, B, C, D, E, G, H, I, J, K, L
Group 'check role'	n/a

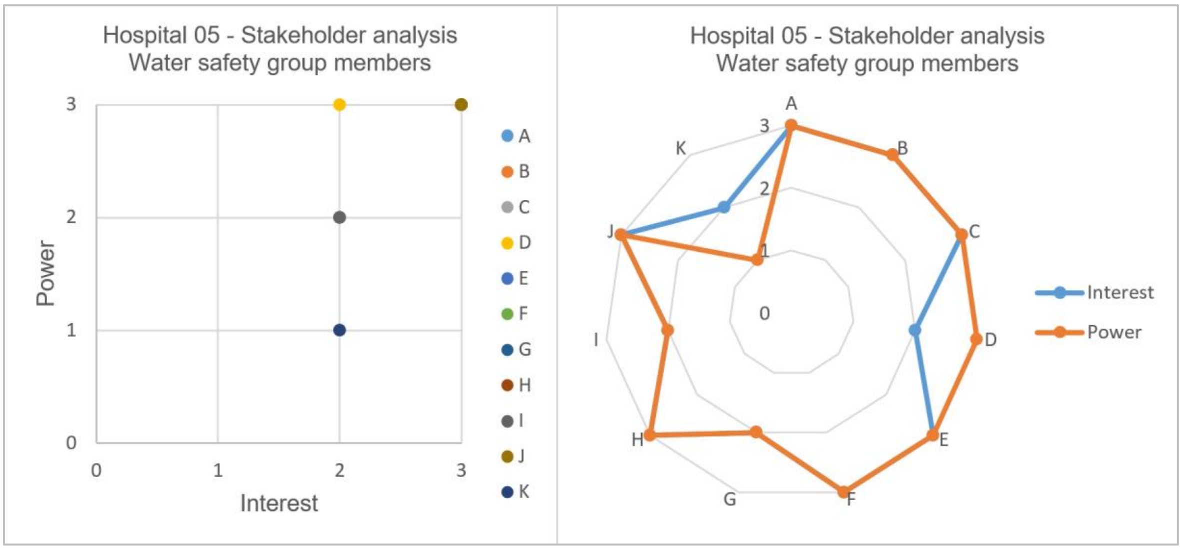

Figure Appendix C-15: Stakeholder analysis hospital ID05: WSG members

One on top of the other are (3;3)=A, B, C, E, F, H, J; (2; 2)= G, I.

Table Appendix C-10: Stakeholder analysis hospital ID05: WSG members

Group 'low'	K
Group 'high'	A, B, C, D, E, F, H, J
Group 'check role'	n/a

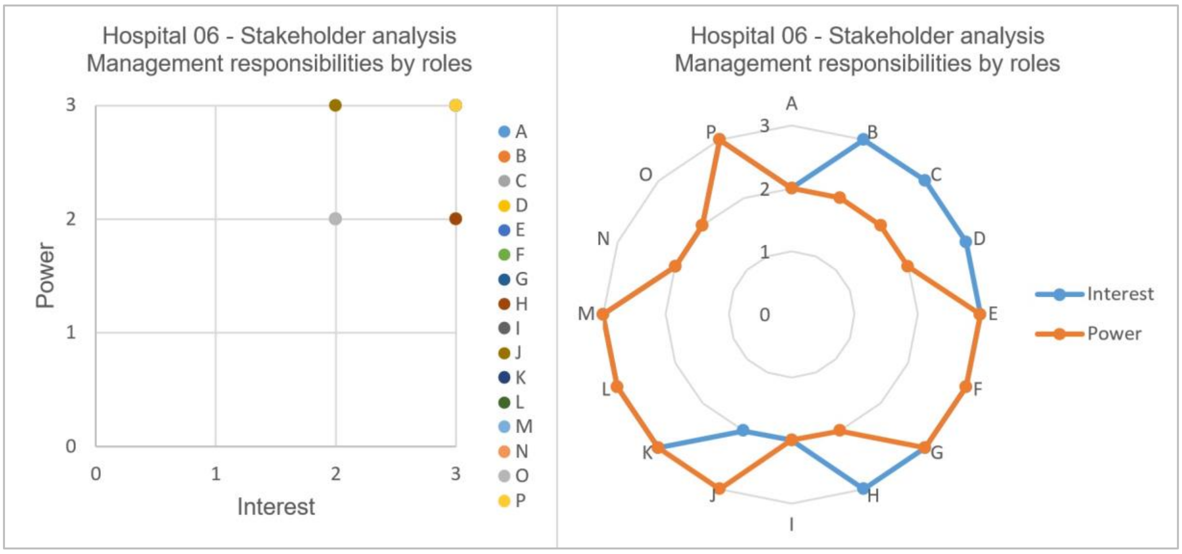

Figure Appendix C-16: Stakeholder analysis hospital ID06: Management responsibilities by roles

One on top of the other are (2;2)=A, I, N, O; (3;2)=B, C, D, H; (3;3)=E, F, G, K, L, M, P.

Table Appendix C-11: Stakeholder analysis hospital ID06: Management responsibilities by roles

Group 'low'	n/a
Group 'high'	B, C, D, E, F, G, H, J, K, L, M, P
Group 'check role'	n/a

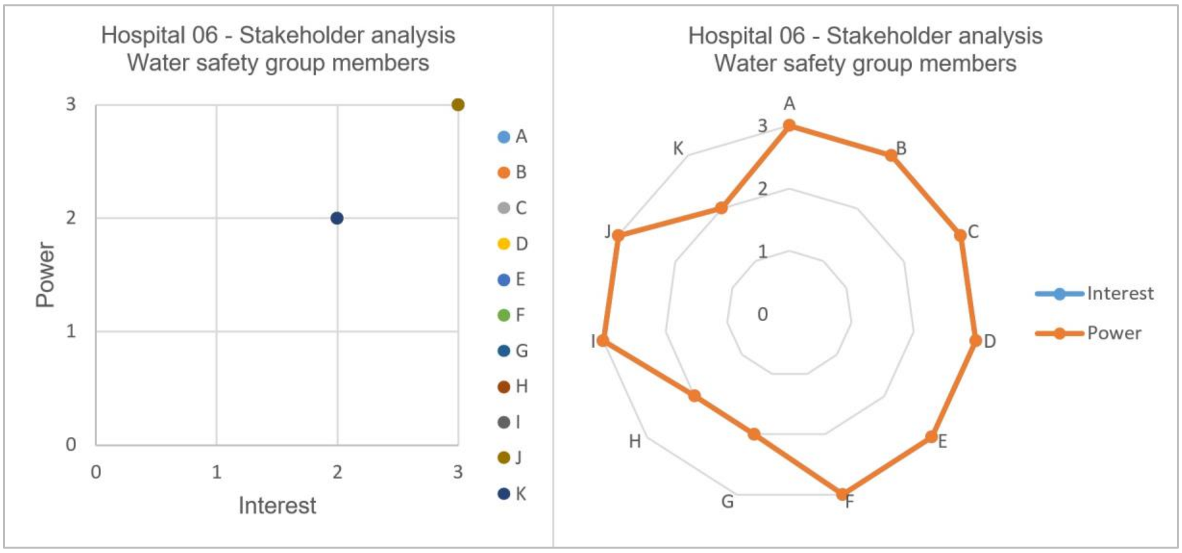

Figure Appendix C-17: Stakeholder analysis hospital ID06: WSG members

One on top of the other are (3;3)=A, B, C, D, E, F, I, J; (2;2)=G, H, K.

Table Appendix C-12: Stakeholder analysis hospital ID06: WSG members

Group 'low'	n/a
Group 'high'	A, B, D, E, F, I, J
Group 'check role'	n/a

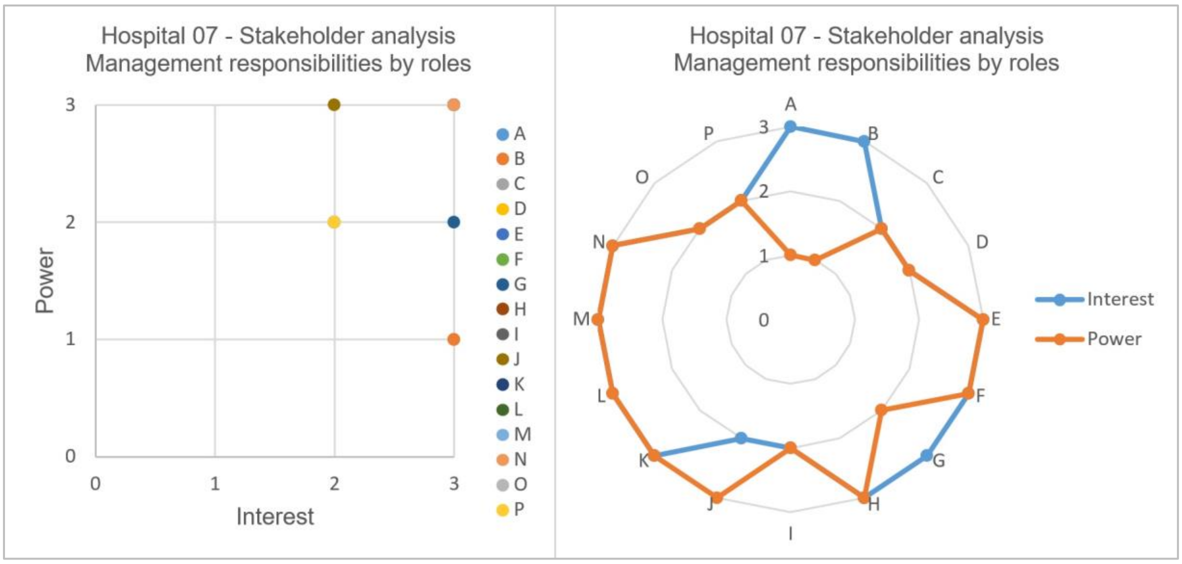

Figure Appendix C-18: Stakeholder analysis hospital ID07: Management responsibilities by roles

One on top of the other are (3;1)=A, B; (2;2)=C, D, I, O, P; (3;3)=E, F, H, K, L, M, N.

Table Appendix C-13: Stakeholder analysis hospital ID07: Management responsibilities by roles

Group 'low'	n/a
Group 'high'	E, F, G, H, J, K, L, M, N
Group 'check role'	A, B

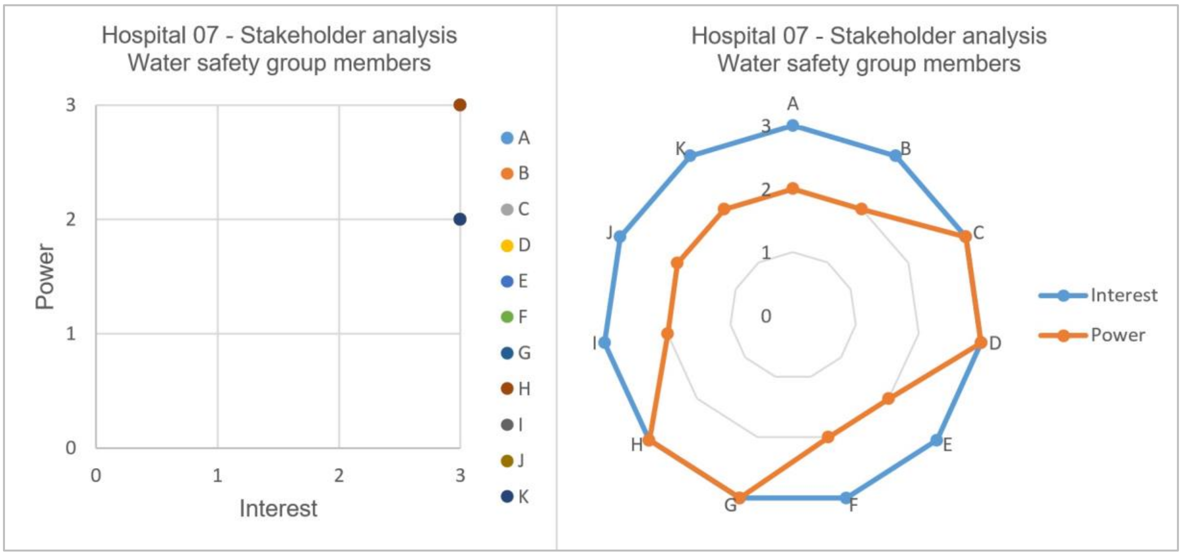

Figure Appendix C-19: Stakeholder analysis hospital ID07: WSG members

One on top of the other are (3;2)=A,B,E,F,I,J,K; (3;3)=C,D,G,H.

Table Appendix C-14: Stakeholder analysis hospital ID07: WSG members

Group 'low'	n/a
Group 'high'	A, B, C, D, E, F, G, H, I, J, K
Group 'check role'	n/a

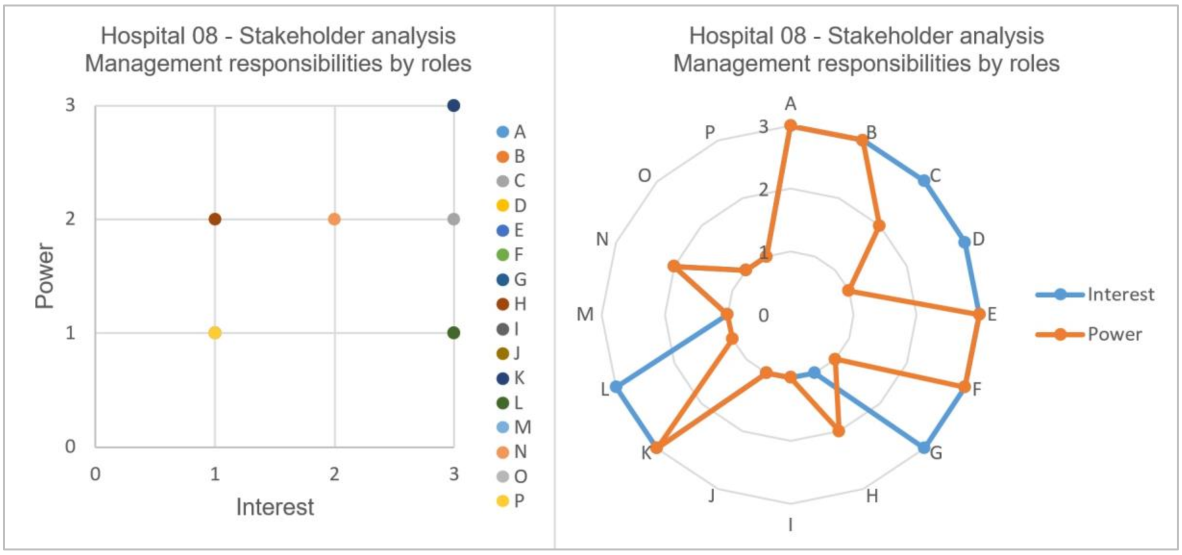

Figure Appendix C-20: Stakeholder analysis hospital ID08: Management responsibilities by roles

One on top of the other are (3;3)=A, B, E, F, K; (3;1)=D, G, L; (1;1)=I, J, M, O, P.

Table Appendix C-15: Stakeholder analysis hospital ID08: Management responsibilities by roles

Group 'low'	H, I, J, M, O, P
Group 'high'	A, B, C, E, F, K
Group 'check role'	D, G, L

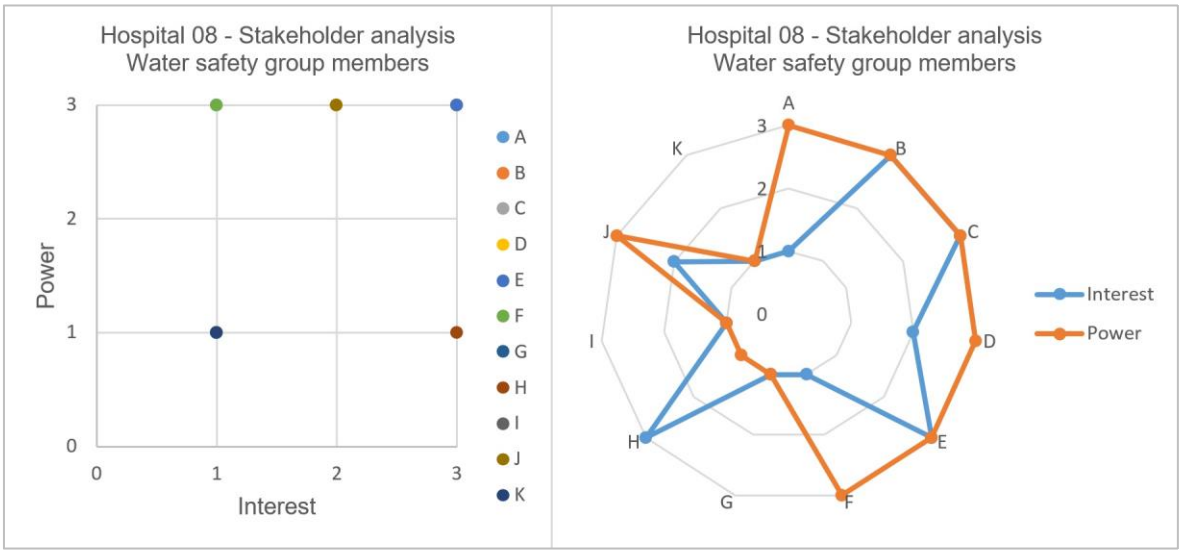

Figure Appendix C-21: Stakeholder analysis hospital ID08: WSG members

One on top of the other are (1;3)=A, F; (3;3)=B, C, E; (2;3)=D, J; (1;1)=G, I, K.

Table Appendix C-16: Stakeholder analysis hospital ID08: WSG members

Group 'low'	G, I, K
Group 'high'	B, C, D, E, J
Group 'check role'	A, F, H

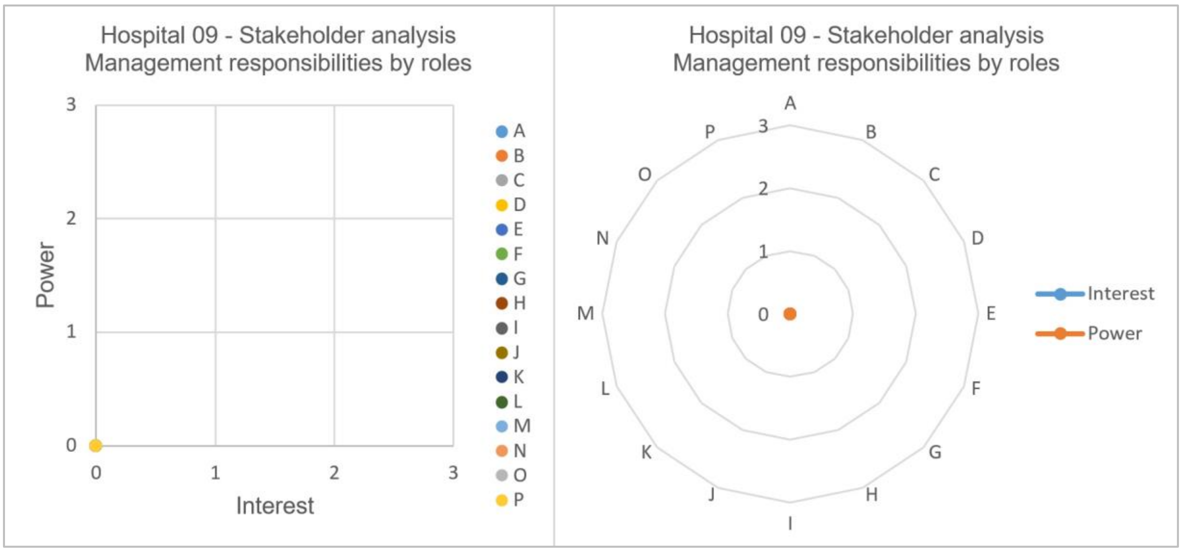

Figure Appendix C-22: Stakeholder analysis hospital ID09: Management responsibilities by roles

One on top of the other: n/a.

Table Appendix C-17: Stakeholder analysis hospital ID09: Management responsibilities by roles

Group 'low'	n/a
Group 'high'	n/a
Group 'check role'	n/a

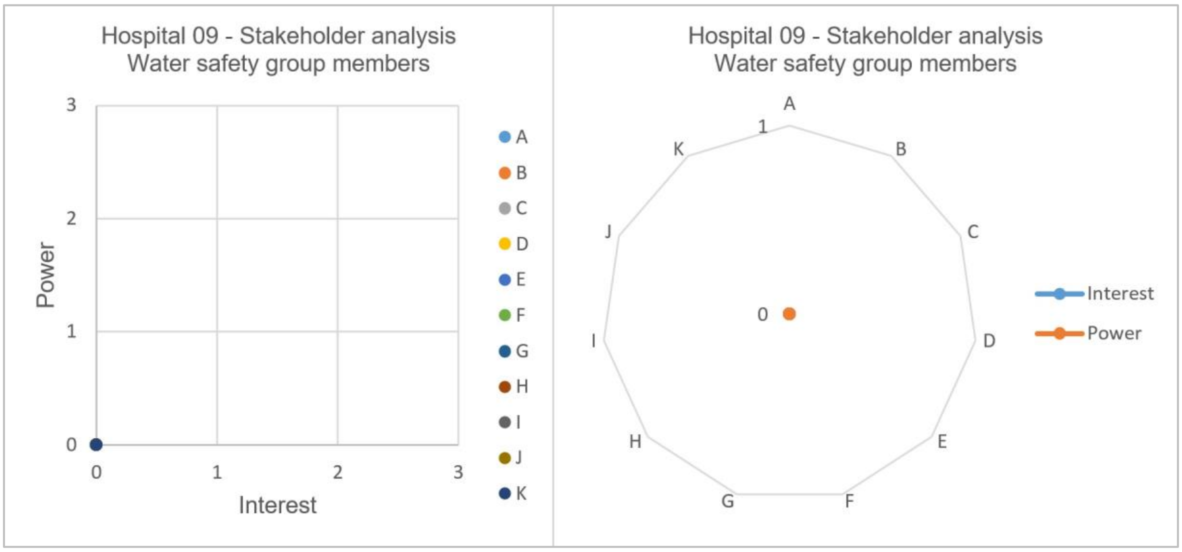

Figure Appendix C-23: Stakeholder analysis hospital ID09: WSG members

One on top of the other: n/a.

Table Appendix C-18: Stakeholder analysis hospital ID09: WSG members

Group 'low'	n/a
Group 'high'	n/a
Group 'check role'	n/a

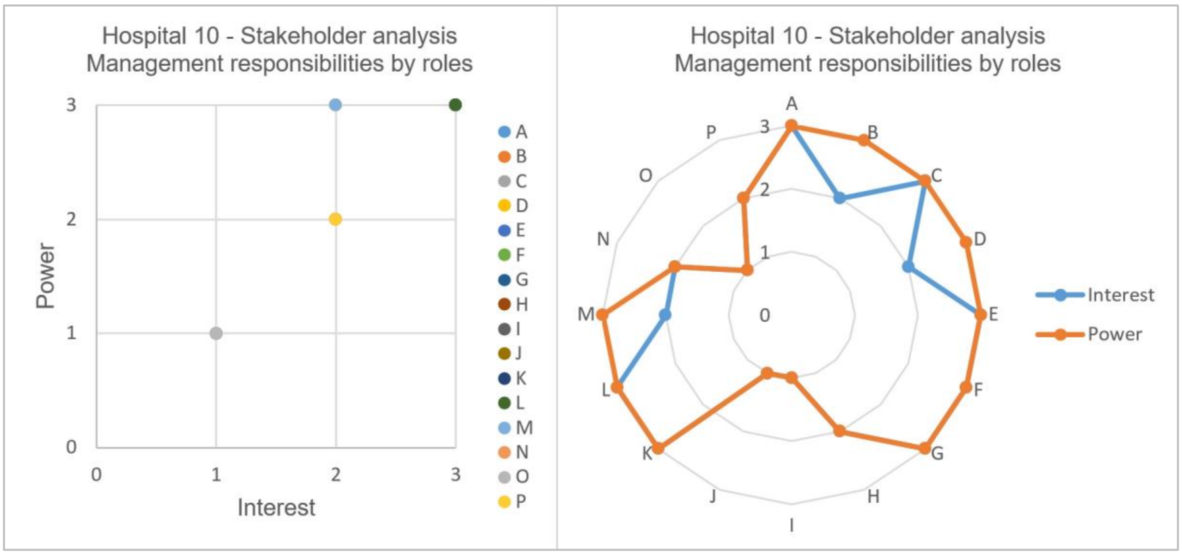

Figure Appendix C-24: Stakeholder analysis hospital ID10: Management responsibilities by roles

One on top of the other are (3;3)=A, C, E, F, G, K, L; (2;3)=B, D, M; (2;2)=H, N, P; (1;1)=I, J, O.

Table Appendix C-19: Stakeholder analysis hospital ID10: Management responsibilities by roles

Group 'low'	I, J, O
Group 'high'	A, B, C, D, E, F, G, K, L, M
Group 'check role'	n/a

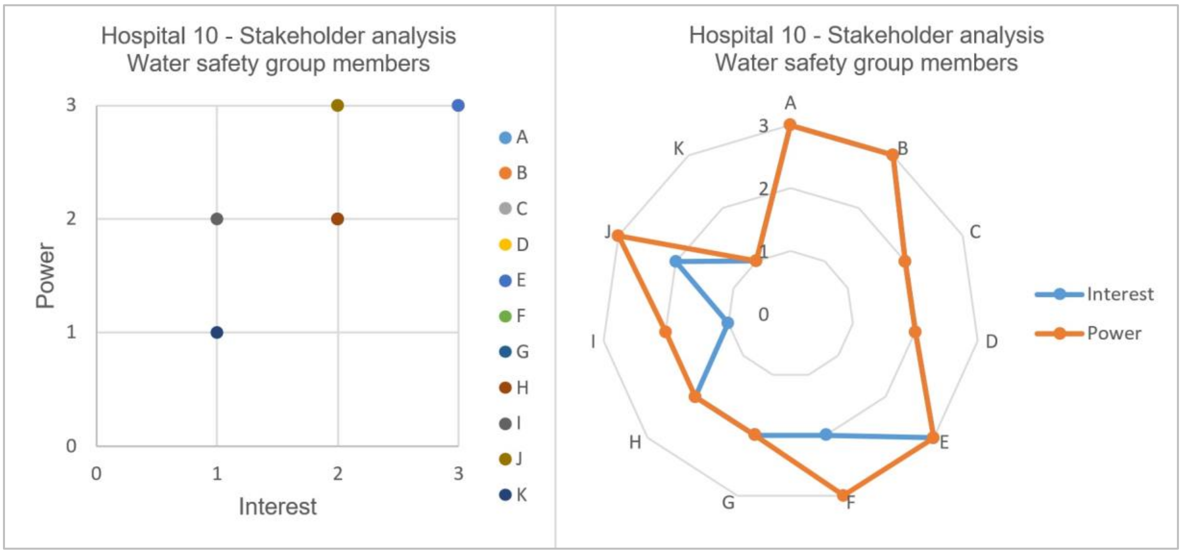

Figure Appendix C-25: Stakeholder analysis hospital ID10: WSG members

One on top of the other are (3;3)=A, B, E; (2;2)=C, D, G, H; (2;3)=F, J; (1;2)=I; (1;1)=K.

Table Appendix C-20: Stakeholder analysis hospital ID10: WSG members

Group 'low'	I, K
Group 'high'	A, B, E, F, J
Group 'check role'	n/a

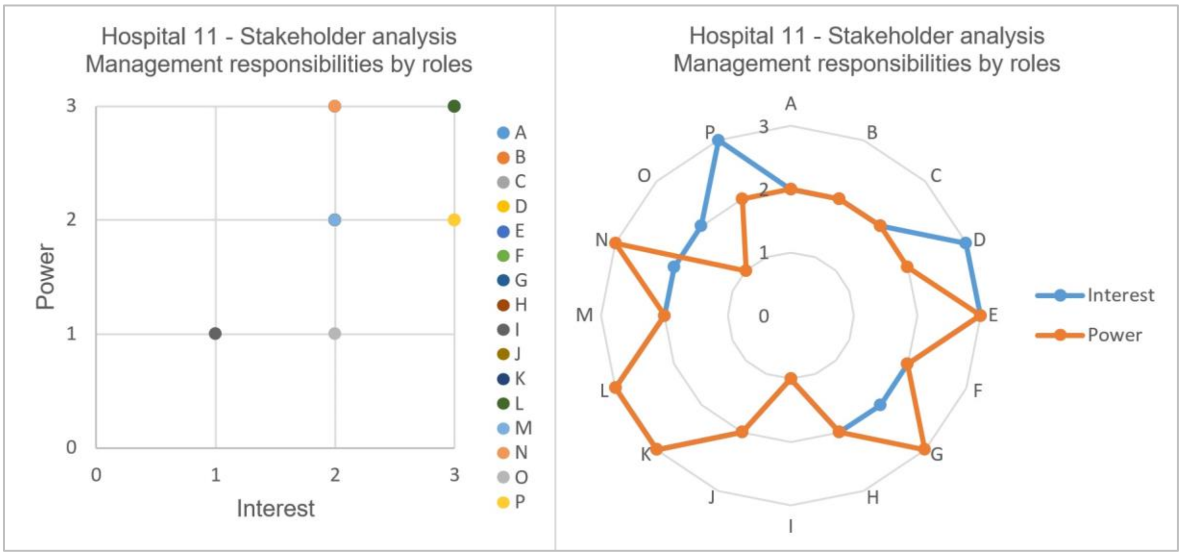

Figure Appendix C-26: Stakeholder analysis hospital ID11: Management responsibilities by roles

One on top of the other are (2;2)=A, B, C, F, H, J, M; (3;2)=D, P; (3;3)=E, K, L; (2;3)=G, N; (1;1)=I; (2;1)=O.

Table Appendix C-21: Stakeholder analysis hospital ID11: Management responsibilities by roles

Group 'low'	I, O
Group 'high'	D, E, G, K, L, N, P
Group 'check role'	n/a

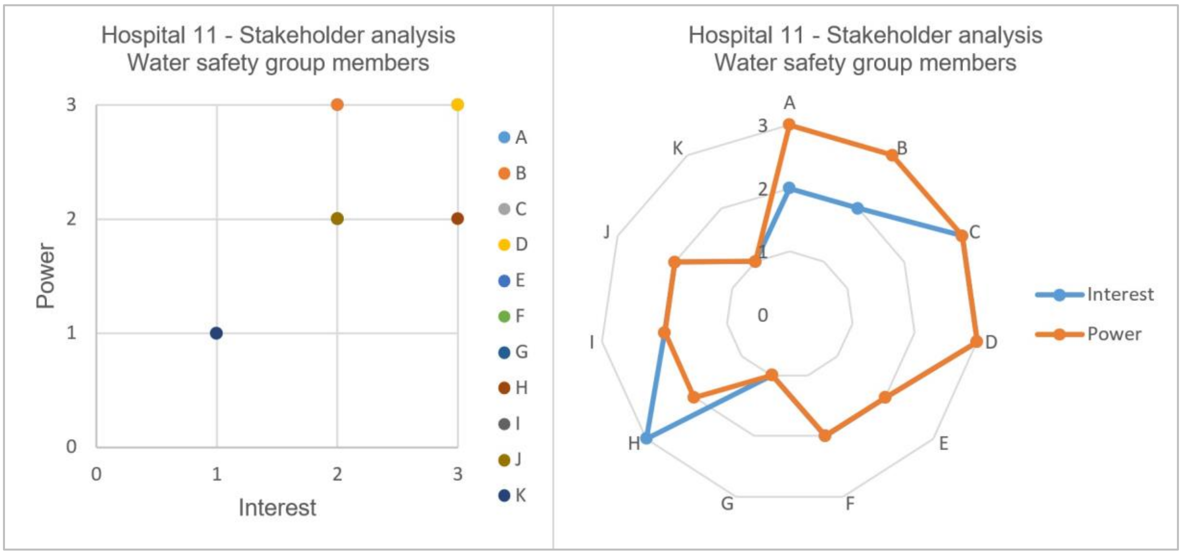

Figure Appendix C-27: Stakeholder analysis hospital ID11: WSG members

One on top of the other are (2;3)=A, B; (3;3)=C, D; (2;2)=E, F, I, J; (1;1)=G, K; (3;2)=H

Table Appendix C-22: Stakeholder analysis hospital ID11: WSG members

Group 'low'	G, K
Group 'high'	A, B, C, D, H
Group 'check role'	n/a

Table Appendix C-23: Type of active role in processes. Management responsibilities by roles.

	Occurence	**Type of active role in process**			
Role		Enabler	Owner	Contributor	Blocker
A - Duty holder	9/9 (100%)	3/9 (33.3%)	4/9 (44.4%)	1/9 (11.1%)	0/9 (0.0%)
B - Director of Infection Prevention and Control (DIPC)	9/9 (100%)	3/9 (33.3%)	1/9 (11.1%)	5/9 (55.5%)	0/9 (0.0%)
C - Lead Infection Control Doctor(Medical)	9/9 (100%)	2/9 (22.2%)	1/9 (11.1%)	6/9 (66.6%)	0/9 (0.0%)
D - Infection Control Officer	9/9 (100%)	2/9 (22.2%)	0/9 (0.0%)	7/9 (77.7%)	0/9 (0.0%)
E - Responsible Person Water (RPW)	8/9 (88.8%)	6/9 (66.6%)	3/9 (33.3%)	2/9 (22.2%)	0/9 (0.0%)
F - Deputy Responsible Person Water (DRPW)	8/9 (88.8%)	6/9 (66.6%)	3/9 (33.3%)	3/9 (33.3%)	0/9 (0.0%)
G - External Auditor/Authorising Engineer	6/9 (66.6%)	3/9 (33.3%)	0/9 (0.0%)	6/9 (66.6%)	0/9 (0.0%)
H - Infection Prevention and Control Team (IPCT)	9/9 (100%)	1/9 (11.1%)	1/9 (11.1%)	7/9 (77.7%)	0/9 (0.0%)
I - Ward/Department Managers	9/9 (100%)	0/9 (0.0%)	1/9 (11.1%)	6/9 (66.6%)	1/9 (11.1%)
J - Estate Maintenance Workers/Contractors	9/9 (100%)	2/9 (22.2%)	0/9 (0.0%)	6/9 (66.6%)	0/9 (0.0%)
K - Water Safety Group	8/9 (88.8%)	2/9 (22.2%)	4/9 (44.4%)	4/9 (44.4%)	1/9 (11.1%)
L - Authorised Person(s) (Water)	7/9 (77.7%)	3/9 (33.3%)	2/9 (22.2%)	3/9 (33.3%)	0/9 (0.0%)
M - Competent Persons (Water Hygiene Technicians, Plumbers, Manager (Trust/Contractor), *Legionella* Risk Assessor	7/9 (77.7%)	1/9 (11.1%)	0/9 (0.0%)	6/9 (66.6%)	0/9 (0.0%)
N - Estates/Engineering Professionals and Managers	9/9 (100%)	0/9 (0.0%)	1/9 (11.1%)	5/9 (55.5%)	2/9 (22.2%)
O - Other Relevant Staff/Contractors	7/9 (77.7%)	0/9 (0.0%)	0/9 (0.0%)	5/9 (55.5%)	1/9 (11.1%)
P - Water Hygiene Contractor	8/9 (88.8%)	0/9 (0.0%)	0/9 (0.0%)	8/9 (88.8%)	0/9 (0.0%)

11 interviews held. 2 did not reply at all, 9 replied complete.

Table Appendix C-24: Type of active role in processes. WSG members.

	Occurence	Type of active role in processes			
Role		Enabler	Owner	Contributor	Blocker
A - Lead Infection Control Doctor (LICD) (Chair)	7/8 (87.5%)	1/7 (14.3%)	0/7 (0.0%)	6/7 (85.7%)	0/7 (0.0%)
B - Director of Estates and Capital Development (Vice Chair)	7/8 (87.5%)	1/7 (14.3%)	5/7 (71.4%)	2/7 (28.6%)	0/7 (0.0%)
C - Head of Operational Maintenance (RPW)	8/8 (100%)	6/7 (85.7%)	0/7 (0.0%)	3/7 (42.9%)	0/7 (0.0%)
D - Mechanical Maintenance Manager (DRPW)	8/8 (100%)	4/7 (57.1%)	2/7 (28.6%)	2/7 (28.6%)	1/7 (14.3%)
E - Head of Infection Prevention Team	8/8 (100%)	1/7 (14.3%)	0/7 (0.0%)	7/7 (100%)	1/7 (14.3%)
F - Infection Control Officer (Consultant Microbiologist)	8/8 (100%)	1/7 (14.3%)	0/7 (0.0%)	7/7 (100%)	0/7 (0.0%)
G - Managerial Representative (Cleaning Services)	7/8 (87.5%)	0/7 (0.0%)	0/7 (0.0%)	6/7 (85.7%)	0/7 (0.0%)
H - Head of Estates Maintenance & Chief Engineer	6/8 (75.0%)	1/7 (14.3%)	2/7 (28.6%)	2/7 (28.6%)	0/7 (0.0%)
I - Water Hygiene Contractor	6/8 (75.0%)	1/7 (14.3%)	0/7 (0.0%)	5/7 (71.4%)	0/7 (0.0%)
J - External Auditor/Authorising Engineer (annually)	6/8 (75.0%)	2/7 (28.6%)	0/7 (0.0%)	5/7 (71.4%)	0/7 (0.0%)
K - Clinical Representatives	6/8 (75.0%)	0/7 (0.0%)	0/7 (0.0%)	5/7 (71.4%)	1/7 (14.3%)

11 interviews held. 2 did not reply at all, 8 replied complete on ‘occurrence’, 2 replied incomplete on the type of active role in processes with answers not available (n/a).

Table Appendix C-25: Type of active role in processes: Competent persons.

	Occurence	Type of active role in processes			
Role		Enabler	Owner	Contributor	Blocker
Water Hygiene Technicians	5/8 (62.5%)	1/7 (14.3%)	1/7 (14.3%)	4/7 (57.1%)	0/7 (0.0%)
Plumbers	8/8 (100%)	2/7 (28.6%)	1/7 (14.3%)	4/7 (57.1%)	0/7 (0.0%)
Manager (Trust/Contractor)	7/8 (87.5%)	2/7 (28.6%)	2/7 (28.6%)	4/7 (57.1%)	0/7 (0.0%)
Legionella/*Pseudomonas* Risk Assessors	7/8 (87.5%)	1/7 (14.3%)	0/7 (0.0%)	7/7 (100%)	0/7 (0.0%)

11 interviews held. 3 did not reply at all, 8 replied complete on ‘occurrence’, 1 replied incomplete on the type of active role in processes with answers not available (n/a).

Appendix D

Focus group validation

Figure Appendix D-1: Invitation correspondence for focus group formation

Figure Appendix D-2: Focus group presentation “framework”

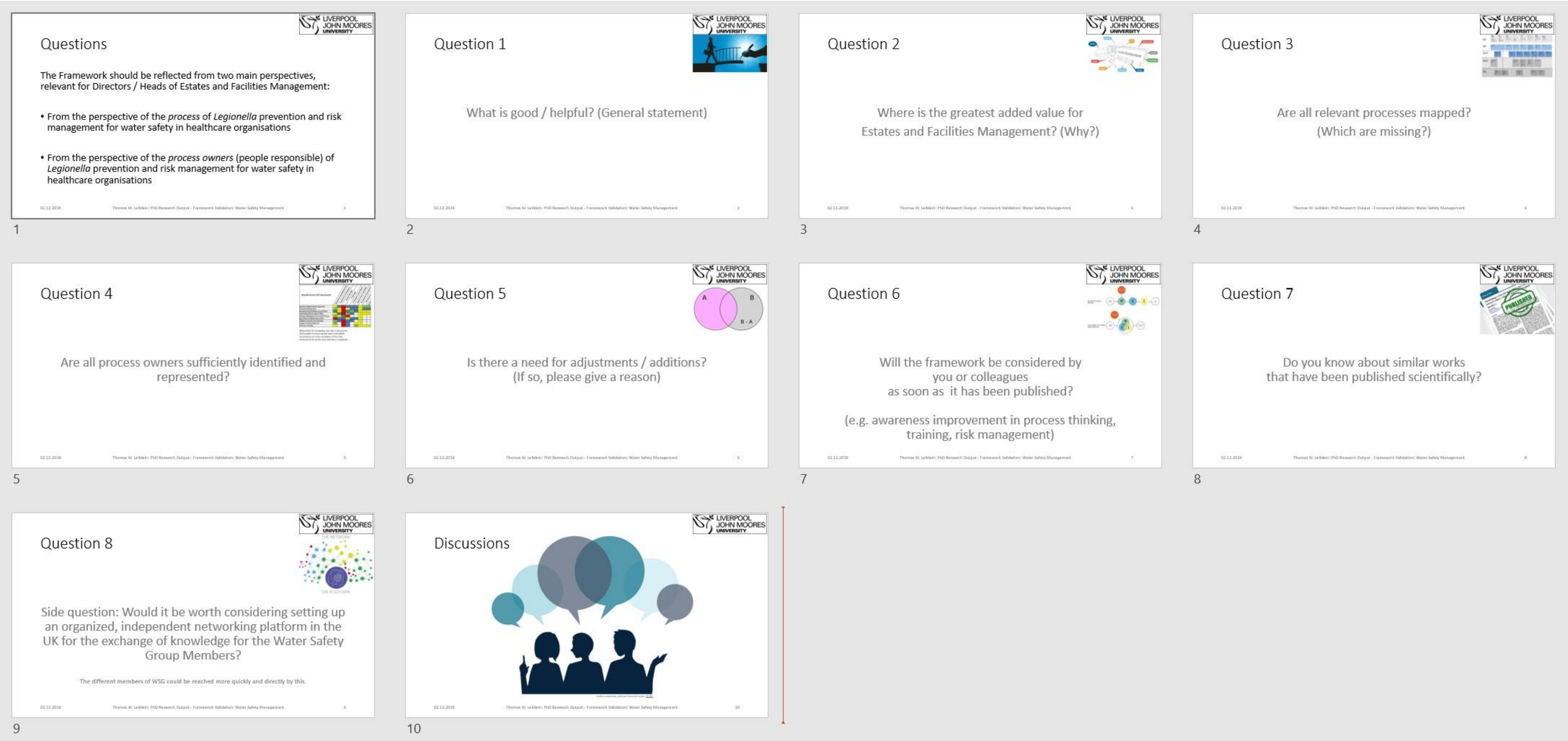

Figure Appendix D-3: Focus group presentation of questions

Appendix E

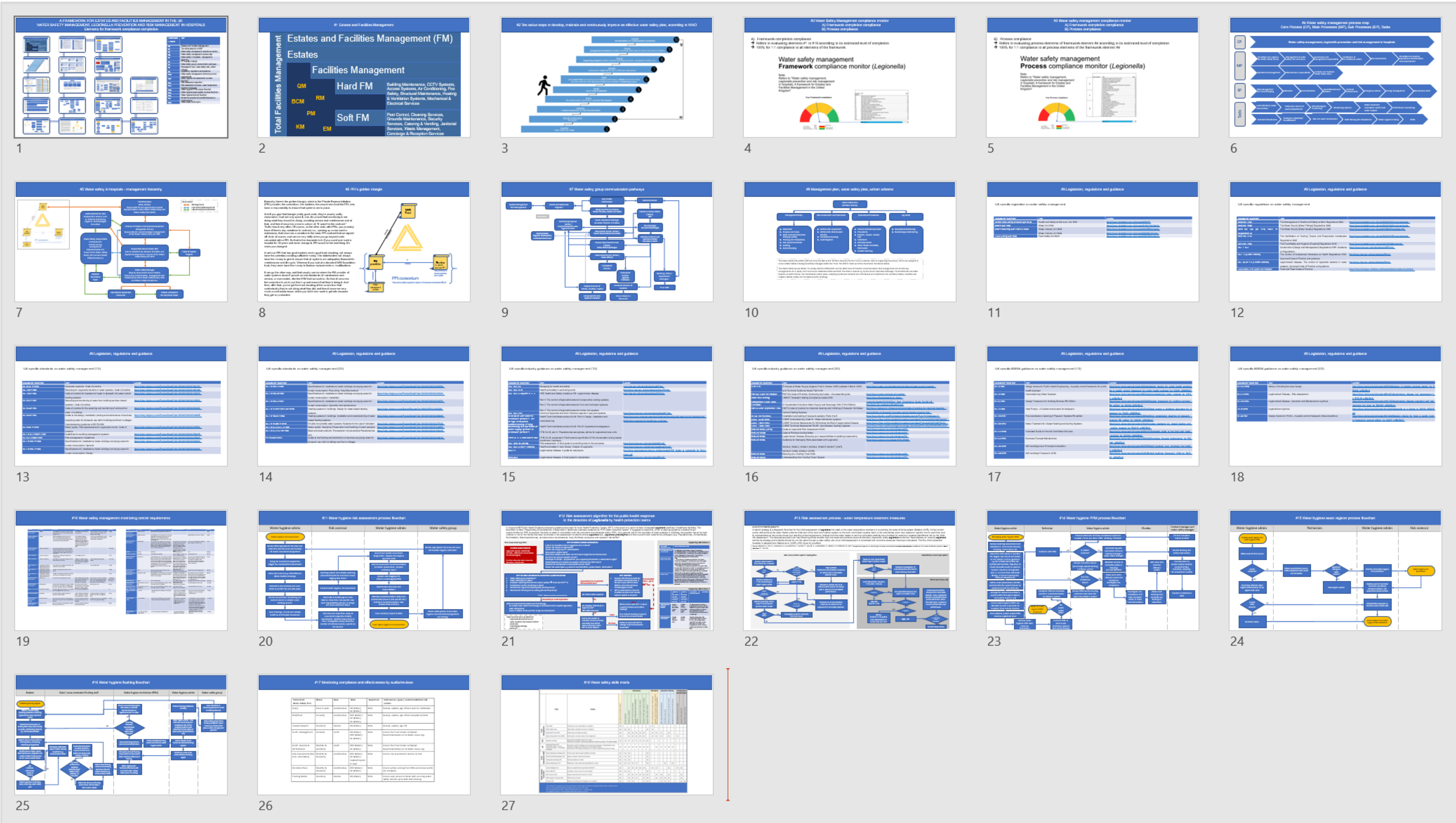

Figure Appendix E-1: Summary of final famework output “Water safety management, *Legionella* prevention and risk management in hospitals: a framework for Estates and Facilities Management in England”

Appendix F

PhD Research Project 15/BUE/014 Water-related risks in hospitals 7

IP: Okay, so made a note of that. And then last one there is Head of Capital Estates Projects. So we in the UK, there has been a revision to our HTM, HTM-04. Not sure if you're familiar with that?

I: Yes, it was released in July.

IP: Yes, yeah. So one of the changes of HTM04 was it now stipulates – and we follow HTM pretty much to the letter at LTHT – HTM04 nastycally, the Head of Capital Projects or the manager in charge of Capital Projects is mandated now to attend the water safety group meetings. So Head of Capital Estates Projects, he's the guy that does official assessing who does all the capital projects. Previously it was not required for that person to attending these meetings, and we did struggle as a Trust to get the capital team on board to understand what their responsibilities was. So with this revision of HTM earlier this year that just gave us absolutely power to our elbow and allowed us to insist that that person now attends. So, that's the key model to the group, and he is to have to learn quick. And what he does do he gives us greater assurance now that we have a voice in the capital project's team that understands the principles of the WSG and what the kinds to achieve. Okay. In terms of the culture and the hierarchies and collaboration (#1-collaboration), that group of people I would say is a very strong group of people who have a very good understanding of what the common goal is at the water safety group. There is at least one that sits there on the table who doesn't understand why we do this every month – we meet every month, sorry, by the way – and we go the agenda and there is active debate each month on water safety and water safety management. And there is a group, that group reports to the Trust's Infection Prevention Control Committee, which is chaired by the what is called 'dipsy' - DIPC – that's the director responsible for the Infection Prevention Control, and this instance, that is our Chief Medical Officer who chairs that. So it's our Chief Medical Officer who is the DIPC (Director of Infection Prevention and Control). The link is well with the water safety group is, because of its – if you like – of its membership and its credence. If the water safety group finds it does have a problem or it needs some support, then it gets its support from the IPCC – so the Infection Prevention Control Committee. So if there something was struggling to get through we go to IPCC because that's the highest group in our organisation, and then IPCC will then endorse or not – I've never had a 'not' – but endorse any recommendations that the WSG put forward. I could send you an example – although we stopped doing so – I send you an example of the reports we were sending to the IPCC. We as a water safety group meet every month; the IPCC meets every two months. So we have to send the assurance report to the IPCC, now then, that was my last one. Last one is pending to be assured, so I'll send you the February one. I'll send you a couple of the ICCP reports now. Because we've got quite good control now of water safety, these reports –as you'll see shortly – became a little bit repetitive. As a result of that repetitiveness the DIPC gave us dispensation to recall by exception only. What we're saying, We don't provide this anymore because of the control we've gone. But what we have to do is we have to send, or I have to send, minutes of the monthly meetings to the IPCC. So it just went to me, but I sent you a copy.

I: To keep them updated, yes, I went through, last mail came through.

IP: I've just sent it out. There on the list is 'minutes of the water safety group meetings'. Oh, Water safety, I just pick a couple of sample plans for you. I'm picking up it random, so, there we go.

I: I need to need, a couple of hours to get through on all things again – so. I'm really happy when you can provide or share things. Just to make the picture better.

Phase I, Interview study 1 Transcript interview, Object ID 02-I1, 28th Feb 2018

Legend: I=Interviewer/Researcher; IP=Interview partner

Figure Appendix F-1: Structured example of a transcript document of phase Ia

IP: I suppose, like a lot of things in hospitals, it falls under the sort of patient safety banner. So it's discussed at water safety group. That report falls into an overarching sort of compliance group for all things estates and facilities. And then that feeds into the senior management team of the trust, and that group's chaired by the chief executive. So it's looked at from the point of view of myself giving the organization assurance that, with respect to Legionella, we are managing the risk of-- we're not putting either patients, visitors, service users, staff at risk due to, well, basically, not doing what we should be doing. So it's a safety matter.

I: It's a safety matter, yeah. [12] And are there examples or other points that you can mention how you actively manage the hospital's water systems? Is it you're responsible in the-- yeah. Not the responsible person?

IP: Yeah. Well, I suppose from the way we manage it or how I expect it to be managed, obviously we've got the HTM 04-01, which is the base document. And that's where we take our guidance from. And then we've got the HSE guidance document on Legionella. We use those as our base documents, as our good-practice documents. And if it says in there that we flush taps that are used on an infrequently basis for 2 minutes, then that's what we'll do. If it says we store water at above 60, and we need it back at 55, that's what we'll do. So it's very much-- water safety management is one of those things where, if you-- well, the way we look at it is if we follow the published guidance and whatever those documents say, then we try to achieve. If we can't, first of all, we need to know that we can't. Secondly, we need to know what we can do about it. Thirdly, if there's a cost, we need to make people aware of that cost. But it's basically proving to the organization that we follow what we would consider to be best practice because that's what it is. It's best practice for a reason, and we should be following it. Like I said, thing is, if there's mainly a cost issue around something, well, we never say, "Well, we're not do it. We don't have the money." That then becomes my job to say, "Don't have enough money? This is the risk. This is the cost. Let's make an informed decision about what we do do," So in this hospital, it's a very open discussion around risk management then because you've got to have it. You've got to have that discussion.

I: [13] And how robust do you assess is the water safety risk management and prevention process at present, in terms of, for example, Legionella risk management, when you have a scale from one to five; and one is not even complying, and five is everything seems to be under control? Three would be on average. Where do you think--?

IP: Well, I think we're about a four.

I: A four. Yeah.

IP: [14] And the reason I'm saying-- and the reason I'm saying a four rather than a five is because I know there are things that we struggle with. I suppose the biggest thing that we struggle with is guaranteeing that we've got return water temperatures at all points around the site. It's very easy to get a return water [inaudible] at 55 or above. That is not difficult. But to absolutely guarantee it at every point in your system is very, very difficult, and to prove on a regular basis. Hospitals naturally grow with services, come into the organisation on a contract, and getting systems commissioned and recommissioned, that is difficult. So that's why I say a four rather than a five. Everything else in terms of risk assessment, and identifying little-used outlets, and flushing regimes, and biannual wash inspections, and tank cleaning, and Legionella tests, all that kind of stuff, it's in there. It's done. And evidence done, evidence that it's all working and doing properly. So I'll say a four.

I: Yeah. And you mentioned some steps or activities, for example, the temperature measurements, the microbiological testing, and you also referred it to the HTM and the HSG274, and the ACOP, I think?

Figure Appendix F-2: Structured example of a transcript document of phase Ib

Appendix G

The following additional MS Word documents are stored on the memory stick added to the thesis. They comprise:

- “Template_8_3_2_Risk_assessment_form_template_8pages”
- “Template_8_3_3_Corrective_and_remedial_actions_4pages”
- “Template_8_3_4_Compliance_report_2pages”

The following additional MS Excel documents are stored on the memory stick added to the thesis. They comprise:

- “3a_LoC_Framework”
- “3b_LoC_Process”

The following additional MS Power Point document isstored on the memory stick added to the thesis. It comprises:

- “Framework_Overall”