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Risk management of water systems in residential homes: The ‘process’ of *Legionella* prevention

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ABSTRACT

In the present study data was collect and analysed to gain evidence for the present situation of *Legionella* risk management and prevention of water systems in different buildings in the Canton of Zurich, Switzerland. These buildings comprise retirement homes, care homes and dwellings for people with a disability. According to given legislation, standards and technical rules, duty holders are liable for the quality of drinking water distributed by the water system in a building. Showers represent a frequently used, aerosol-generating device in the domestic setting and have been proposed as a source of Legionnaires’ disease, caused by *Legionella* bacteria. This study investigated the prevalence of *Legionella* in showers which are recognised as a potential source of risk of contamination for users. During a field campaign, data from ten buildings were collected. Water was sampled from showers and analysed with reproducible sampling procedures. As a second source of data, information concerning technical specifications and operating parameters of the (hot) water systems and shower facilities was collected from the operating manager through a semi-structured questionnaire. Based on the microbiological results provided by the classical culture method, a *Legionella* contamination was detected in two objects. Three additional care facilities showed raised results according to a different method applied. Evaluation of the responses given in the questionnaire revealed that control functions and documentation seem to be either unsatisfactory within the institutions, or are missing completely. Although the small size of the sample in this study does not permit generalizable statements, the results provide a solid foundation upon which further investigations can be based.

Keywords: Risk management, process, prevention, water system, *Legionella*

1 INTRODUCTION

1.1 Facility management in healthcare

In this article, risk management and *Legionella* prevention is discussed and reflected from a practice-oriented point of view. It can be assigned to facility management in healthcare (FM in HC). The topic of *Legionella* in water systems in HC settings has a clear link to FM and prevention, which can be regarded as part of an active risk management (Shohet & Lavy, 2004; Leiblein *et al.*, 2016).

Legionellae are causative agents of Legionnaires' disease (LD) and can cause a potentially fatal pneumonia (Phin *et al.*, 2014). Species of *Legionella* (*Legionella* spp.) are ubiquitous in aqueous environments but favour growth in man-made water systems operating between 20°C and 45°C (Fields *et al.*, 2002). One species of *Legionella*, *L. pneumophila*, seems to cause approximately 90% of all reported cases of legionellosis (R.E. Besser cited in Fields *et al.*, 2002: 507). Among 15 serogroups (Sg) of *L. pneumophila* almost 80% of all culture-confirmed cases are caused by *L. pneumophila* Sg1 (Marston *et al.*, 1994).

1.2 Duty holder

Water systems in facilities contaminated with *Legionella* is just one example but a serious and a topical issue of hygienic risks which needs to be addressed. Besides the threat of economic or image loss to the facility, the risk to people is undeniable. Potentially affected are people being exposed to open water systems or the apertures of water systems, e.g. showers (Collins *et al.*, 2016). Hazards arise from contaminated small-size water droplets, termed aerosols. Awareness of the potential contamination risks from environmental sources is relevant in FM contexts where managers (e.g. operators or any other duty holders) may be responsible for building-associated facilities such as water systems (*"Legionella* - stay vigilant*"*, 2015). Understanding the context and the environment is the first step towards precisely defining actions against hazards such as *Legionella* (Arvand *et al*., 2011).

When talking about the management of processes, we must not forget about the key personnel responsible. On closer examination, however, who are those who are responsible?

In their 'Guide to *Legionella* Risk Assessment' the Water Management Society (WMSoc, n. d., p. 11) differs between four types of key personnel with respect to the responsibility for processes of water safety. These are 'duty holder', 'responsible person', 'deputy responsible person' and 'other key persons'. Each represents a different level of hierarchy. The 'duty holder' characterises as follows: *"Described in L8 (the Approved Code of Practice, 4th edition 2013) as the employer, the self-employed person or the person in control of the premises. […] in cases of shared accommodation, there may well be a shared responsibility. The duty holder cannot delegate his duty, but he can delegate managerial responsibility to the responsible person […]"*

The responsible person for the building is liable for maintaining the hygienic quality of drinking water throughout the building.

1.3 Protective goals

According to legislation and to generally accepted engineering standards (norms, recommendations, technical and guidance documents) there can be undeniable aspects of water hygiene that enforce criminal and civil law obligations (Gollnisch & Gollnisch, 2016). The maxim of the operating manager should therefore also be aligned according to defined "protective goals" of his own organization, which go beyond the liabilities created by law. This is to ensure the highest possible contribution to the protection of drinking water hygiene for the building users. Where health or even human life is endangered at the end of a process chain, there is no tolerance for gross deficits, e.g. seen in the lack of objective control mechanisms.

1.4 Norms, legislation, recommendations

WHO

Drinking water distribution networks harbour the risk of *Legionella* formation. Due to the optimal temperatures, the proliferation of *Legionella* occurs mainly in DHW (drinking hot water) distribution networks. Based on the WHO (2007, p. 32), certain components have to be examined for safe drinking water distribution, of which were taken into account in the present paper. In addition, the WHO (2007, p. 62) has published a list of risk factors that could lead to legionellosis associated with water systems. The list mentions stagnation, pipe materials, water temperature between 25 and 50°C, and the presence of biofilms or the potential of outlets generating aerosols.

Food Legislation

In Switzerland, the 2016 VQWmK regulation of the Federal Office for Food Safety and Veterinary Affairs on the quality of water, "intended for human consumption and contact with the human body" regulates the use, treatment and disinfection of drinking water as an object of use or as food. This regulation applies only to non-private installations. Until now, there has been no legal basis for hygiene standards of shower and bathing water (related to *Legionella*) in Switzerland. This will change with the revision of the Food Act in mid-2017. From there *Legionella* spp. (all species of the genus *Legionella*) in shower water should not exceed 1000 CFU/l (unit: Colony forming units per litre) in the warm water cycle.

Recommendations of the Federal Office of Public Health

In a step-by-step list of measures, a publication by the Federal Office of Public Health (from here onwards 'FOPH recommendations') describes the measures to be taken in case of presence of *Legionella* in the water pipeline system (FOPH, 2009). Contamination with *Legionella pneumophila* is differentiated into three levels. If a value of 1000 CFU/l is not exceeded, there is only a low risk of legionellosis according to the FOPH. The FOPH also assigned three different risk categories to various building types. Residential / nursing homes are assigned to the medium risk level. Corresponding measures for exceeding concentrations include flushing with hot water. Sanitary installation must be designed in such a way that the temperature in the heated part of the distribution network is always above 55°C. If the temperature recommendations are not adhered to or cannot be adhered to bacteriological checks must be carried out.

1.5 Risk management

For the future, it is important to define effective and, in practice, viable self-control of drinking water systems and water systems in buildings. Various national guidelines and standards can be used for guidance. Merely complying with existing legislation and guidance, however, does not necessarily mean that a system is safe or operates reliably. Particularly for buildings with water systems serving third parties (Dyck *et al*., 2007), and a variation in water consumption, water-associated hazards and associated measures are to be considered carefully and closely scrutinised ("Facility-borne illness", 2013).

As part of self-control it is necessary to limit appropriately, and to establish appropriate control and intervention measures, according to hazard potentials (Freije, 2005). At the beginning of preventive measures (as regards *Legionella*), an individual risk assessment of the building's water systems should be performed (Kruse *et al.*, 2016; Völker *et al.*, 2016).

1.6 Hygiene and water safety

The discipline of FM is confronted with issues which differ in their complexity regarding hygiene in healthcare settings (Freije, 2005; Gamage *et al*., 2016; Liyanage & Egbu, 2005). Thus, hygiene-related issues must be understood as an interdisciplinary task. However, the responsibility for the effectiveness of the quality management, to which the rate of hygiene makes an essential contribution, is also assigned to the management level. Top management is obliged to take managerial responsibility. In the present article, one of the various possible areas of responsibility will be scrutinised, in which special demands on hygiene, water safety and risk management arise. These are not solely important to the FM (Hübner *et al.*, 2012). In terms of hygiene for water systems in buildings, there is a risk of contamination of drinking water in the final meters before reaching the consumers (WHO, 2011). *Legionella* and *Pseudomonas* are the most prominent pathogens which can become a problem in water systems (Völker *et al.*, 2010). This study focuses on *Legionella*.

Temperature of drinking water

According to the WHO (2007), the DHW water should leave the hot water reservoir with a temperature of at least 60°C. Furthermore, the WHO states that the return temperature should not be less than 50°C for a circulating line. According to the Swiss Association of Gas and Water, the hot water temperature in distribution and riser ducts in residential / nursing homes should be at least 50°C.

Hydrodynamic conditions

Kistemann (2014) argues the dynamics of the water movement in the drinking water installation is of great importance from the point of view of drinking water hygiene. So-called "dead lines", in which the water stagnates, must be avoided.

1.7 Legionnaires' Disease and showers

Worldwide, the occurrence of LD is increasing, with the highest number of cases ever reported in Europe in 2014 (ECDC, 2016). *Legionella* infections are particularly dangerous for immobile and elderly persons. According to BAG statistics, the number of reported cases of legionellosis has increased considerably in recent years. Household potable water systems have been shown to be a potential source of sporadic LD (Straus *et al*., 1996). Exposure to *Legionella* contaminated showers is a recognised risk factor for legionellosis (Muhlenberg, 1993) and previous exposure assessment has ranked showers second in a relative ranking of *Legionella* exposure pathways from common household water uses (Hines *et al*., 2014). However, there is limited information on the prevalence of *Legionella* in household showers and the associated risk to users. With aging and increasingly immunocompromised populations (Chan *et al*., 2016), a better understanding of opportunistic pathogens, including *Legionella* in household water systems, will become more important.

1.8 Research-driven field campaign

Based on the theoretical framework described above, a field campaign was conducted to explore the current state of residential homes and their present situation with respect to FM, risk management, water safety and *Legionella* prevention.

2 MATERIALS AND METHODS

2.1 Mixed methods design

The aim of the study is to associate microbiological results with building-specific parameters. This requires a mixed-method research design, since there are quantitative and qualitative instruments of data collection. In principle, the research complies with knowledge-oriented research methodology. Due to the non-representative sample size of ten organisations, no generalised statements can be made about the total population of all the residential homes of the Canton of Zurich. Results are discussed with reference to current research on this topic.

2.2 Instruments for data collection

Different microbiological analysis methods represent one of the two data sources. Overall-data collection is carried out using two different instruments. A questionnaire differentiates the results in their content quality and is therefore a qualitative survey instrument. A questionnaire from the United Kingdom, which is used as part of risk assessments for drinking water installations (WMSoc, n.d.) was used as a basis. For the purposes of this project, the questionnaire was translated, abridged, and adapted to Swiss water system standards and terms, and supplemented where considered necessary.

2.3 Sampling sites

According to the Federal Statistical Office there exist 1552 residential/care homes in Switzerland. Of a total amount of 238 such homes in the Canton of Zurich, 10 were randomly selected for this study.

2.4 Water sampling

Samples were collected by experienced water sampling stuff from the local health authority according to a defined sampling scheme, transported to the laboratories and processed within 24 hours. Places for sampling had been defined prior to sampling. Sampling included points furthest from and nearest to the rising pipe.

2.5 Microbiology: Detection of *Legionella*

In this study, the classical cultural method and a novel one were applied for microbiological analysis of water samples. Different measurement methods yield different data on *Legionella*. This can be related to different sensitivity and specificity. There may also be non-culturable cells of *Legionella*, so-called VBNC state, which means 'viable but not culturable'. Inaccuracies such as this may represent a potential hazard for 'water-consumers' and are unsatisfactory for decision makers. Thus, it is essential to employ a reliable, specific analytical method for the detection (Keserue *et al*., 2013).

Classical culture method

The classical cultivation method carried out by the Official Food Control Authority of the Canton of Zurich within this field campaign is based on ISO standard 11731. This method represents the currently recognized valid reference method.

Immunomagnetic separation with FCM-detection (FCM-IS)

According to Hammes and Steinberg (2012), single cells suspended in aqueous solution are passed through a laser beam during flow cytometry in a flow chamber. Keserue *et al*. (2013) state that a large proportion of the *Legionella* cannot be detected with the classical cultivation method, and might lead to inaccurate results. The advantages of the immunomagnetic separation are described in Füchslin *et al*. (2010) as a shortened examination period (1h), as well as the differentiation into living and dead cells.

2.6 Questionnaire to duty holders

A total of 10 questionnaires were filled and returned by operating managers with a 100% response rate. The questionnaire consisted of a larger set of questions (items) of which we present a selection.

2.7 Data analysis

Microbiology

Results are presented with descriptive statistical analysis, where characters A – J indicate the ten different institutions. Within each institution, 6 water samples were collected. Water samples indicated with odd numbers mean 'direct sampling without water forerun', even numbers 'with water forerun'. This is relevant for the interpretation of the results (Figure 1). Thus, a sampling location is characterised by two samples of water.

Classical culture method

Water sample analysis was carried out by the Official Food Control Authority of the Canton of Zurich. The detection limit of a sample is 1000 CFU/l. The samples were tested for *Legionella* spp. (species), which comprises all species of the generic group *Legionella*.

Immunomagnetic separation with FCM-detection (FCM-IS)

Water sample analysis by means of FCM-IS method was carried out by an independent laboratory. The FCM-IS method provides the total number of *L. pneumophila* Sg1 detected in the water samples. One of two analyses includes viable but not culturable cells (total *L. pneumophila* Sg1). The second analysis contains only the number of *L. pneumophila* Sg1 (viable cells). The detection limit of the FCM-IS up to the level "single cell" of a sample.

Questionnaire

A semi-structured questionnaire was used, containing scaled and open questions. The questions were answered by the operating manager or the person who fulfils the jobs of an operating manager. For reasons of clarity, the results were grouped into five main groups: 'general questions', 'system properties', 'hygiene / maintenance', 'monitoring / recording', and 'showers'. The results are tabulated for these groups (Tables 1-5). The ten residential homes are each designated a letter (columns A-J).

2.8 Objectivity, validity, reliability

In this study, the three scientific quality criteria 'objectivity', 'validity', 'reliability' are taken into account. Objectivity is ensured by an objective, non-interpretive but descriptive evaluation of the data. The microbiological analysis methods are scientifically common methods, which are carried out by specialist departments, ensuring the reliability of the findings. The reliability of the questionnaire is ensured by the fact that a verified questionnaire of the Water Management Society has been used as a basis in practice. All presented survey instruments are used in practice in the examination of *Legionella*. Therefore, the validity can be considered fulfilled.

3 RESULTS

The results of microbiological detection and temperature of water samples are illustrated in figure 1. Threshold values are taken from the FOPH recommendations.

3.1 Microbiological detection of *Legionella*

Classical culture method

Of 60 analysed water samples, 52 are below the detection limit. In all water samples of homes B, C, G, H and J, less than 1000 CFU/l were determined by the classical method. The largest value is from home A. The second sample of the same shower shows 2000 CFU/l. The water sample from the third shower in this home (sample A5) also shows an increased value with 5000 CFU/l. In home I, a high *Legionella* spp. concentration was also detected at the last two sampling sites, I5 and I6. The result of the analysis of water without water forerun is 50,000 CFU/l, and those of water with water forerun 40,000 CFU/l. Further values, which are above the limit value, were observed for water samples D1, 4000 CFU/l, E4 and F1, 2000 CFU/l each.

Immunomagnetic separation with FCM-detection (FCM-IS)

The results of 47 water samples were below the threshold level of 1000 CFU/l. In 13 water samples, total *L. pneumophila* Sg1 detected succeeded the threshold level. More than 10,000 CFU/l had been detected in samples C1, C4, C6, D5, E1, E6. In seven water samples total viable *L. pneumophila* Sg1 detected succeeded the threshold level of 1000 CFU/l.

3.2 Temperature of water samples

No values were recorded for A1, A3 and A5.

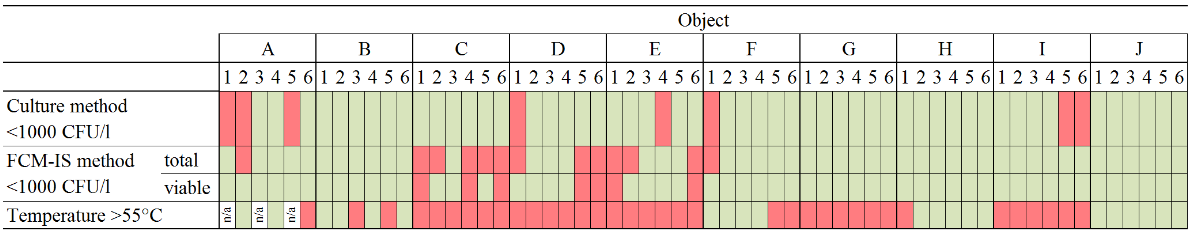

Figure 3 Microbiological results. Samples indicated succeeding the threshold level of 1000 CFU/l (red boxes for rows ‘culture method’ and ‘FCM-IS method’). The threshold level is relevant for *Legionella* spp. FCM-IS method yielded results for *L. pneumophila* Sg1. Therefore the interpretation must be considered carefully. Temperature of water samples smaller than 55°C indicated by red box (row ‘Temperature’).

3.3 Questionnaire

General questions

Table 2 Results questionnaire: Items of category ‘general questions’ (FOPH=FOPH recommendations; QMS=Quality Management System; PHI=experienced plumbing and heating installer; n=no; y=yes; n/a=not available; a.=annually; m.=monthly; w.=weekly; *= Building A+O: 2008, Building B+C: 2009; **= Main building: 1997, new building: 2013)

Question	Object									
	A	B	C	D	E	F	G	H	I	J
Guidance for keeping the water system hygienic quality?	FOPH	QMS	n/a	FOPH	n/a	n/a	n/a	n/a	n/a	PHI
Controls and frequencies conducted on the water system?	*[This question was answered with a very wide variation of control measures and frequencies. It requires a separate, in-depth discussion from an operative perspective.]*									
Installation date of the drinking water system in the building?	1974	2013	n/a	2010	2004	1993	1993	2011	*	**
Parts of the water system that have been replaced or reconstructed?	y	y	n/a	n/a	y	y	y	n	y	n/a
Problems of water quality in past?	y	n	y	n	y	n/a	n	n	n	n/a
Dead lines in water system?	y	n	n/a	n	y	n/a	n/a	n	n/a	n

System properties

System characteristics are the technical characteristics and their condition characteristics in connection with the water systems of the objects.

Table 3 Results questionnaire: Items of category ‘system properties’ (*=groundwater 61%, surfaces waters, spring water 21%, others: lake water 11%; ci=cast iron; c=copper; p=plastic; ss=stainless steel; gs=galvanized steel n=no; y=yes; n/a=not available; y**=yes, for selected lines; r=recirculating; nr=non-recirculating; ***=combined system of recirculating, non-recirculating and point of use; mp=mains pressure)

Question	Object									
	A	B	C	D	E	F	G	H	I	J
Sources of the water?	mains	mains	mains	mains	*	n/a	mains	mains	mains	mains
Materials of construction?	ci	ss	n/a	ci	gs, ss	ss	ci, c, p	n/a	gs, ss, p	ss, p
Does the mains supply serve a water softener?	y	y	y	y	y	y	n	y	y	y**
Is water softener system maintained periodically?	y	y	y	y	y	y	n	y	y	y
Calorifier / hot water storage outlet temperature?	92°C	60-65°C	n/a	n/a	45°C	70-80°C	72°C	n/a	65°C	54°C
Return temperature?	62°C	58-60°C	n/a	n/a	42°C	40-50°C	70°C	n/a	20-45°C	48°C
Type of system?	r	r	n/a	r	r	r	r	nr	***	mp

Hygiene / maintenance

In this category, answers are presented which refer to procedures supporting the maintenance of hygienic level of the DHW distribution system.

Table 4 Results questionnaire: Items of category ‘hygiene / maintenance’ (n=no; y=yes; n/a=not available)

Question	Object									
	A	B	C	D	E	F	G	H	I	J
System regularly cleaned and disinfected?	n	n	n/a	y	n/a	n/a	n	y	n/a	n
Is there a weekly flushing regime in place?	n	n	n/a	n	n/a	n	n/a	n	n	n

Monitoring / Recording

The 'monitoring / recording' cluster contains questions relating to internal routine monitoring and recording of the drinking water system. Answers can provide information about the organisation or quality standards of the institutions.

Table 5 Results questionnaire: Items of category ‘monitoring / recording’ (n=no; y=yes; n/a=not available; *=partly)

Question	Object									
	A	B	C	D	E	F	G	H	I	J
Is there a site logbook?	n	y	n	y	y	y	n	n	y	n
Evidence of regular audits/reviews by management?	n	y	n	n/a	n	n	y	n	n/a	n
Are incoming temperatures checked regularly?	n	n	y	y	n	n/a	n/a	n	n	n
Are calorifier / hot water storage outlet and return temperatures checked & recorded monthly?	y	y	n/a	n/a	y	*	y	n/a	y	n
Are supply water temperatures of furthest/nearest tap from incoming supply checked & recorded monthly?	n	n	n/a	n	n	n	n	n	y	n
A representative number of taps checked annually?	y	n	n/a	n	n	y	n	n	y	n

Showers

Table 6 Results questionnaire: Items of category 'showers' (n=no; y=yes; n/a=not available; *=partly)

Question	Object									
	A	B	C	D	E	F	G	H	I	J
Number of shower outlets?	38	n/a	n/a	n/a	32	>60	15	n/a	~50	4
Is scale evident on shower head?	y	n	n/a	*	n	n	y	y	y	y
How often is shower used?	n/a	n/a	n/a	daily	daily	daily	daily	daily	n/a	daily
If the shower is used less than weekly, is there a flushing regime in place?	n	n	n/a	y	n/a	y	n/a	n/a	y	n/a
Shower head fitted to a flexible hose?	y	n	n/a	y	y	y	y	y	y	y

3.4 Limitations

A number of limitations have been identified for this study. This work focuses on the presence of *Legionella* spp. in drinking water systems, which includes shower installations. The questionnaire used required a relatively large amount of expertise. Not all questions were completed by the participants. The classical cultivation method was used as a reference in the evaluations since it is currently the legal reference method. The small sample of ten homes does not allow any generalizable conclusions on the totality of all homes in Switzerland.

4 DISCUSSION

4.1 Microbiological detection methods

Within this field campaign, the results of the classical cultivation method were used as a reference. On the basis of the available results, it can be said that the *Legionella* concentrations are significantly above the limit value for at least two care homes.

4.2 Questionnaire

From 26 preselected items, the most striking are discussed briefly. Implications to operations and thus, risk management procedures and demands for duty holders are pointed out.

General questions

Two of the ten residential homes are concerned with drinking water hygiene, referring to relevant documents (FOPH recommendations). Three homes indicated past problems with water quality. Two respondents affirmed the presence of dead lines. However, in one home, supplementary information provided that these lines were disconnected from the pipe work. This would defuse the problem from a hygienic point of view.

System properties

Nine of the ten care homes operate a water softening system which is serviced regularly. A water softening system bears the advantage that the pipes and fittings do not calcify so quickly. However, as an additional technical device, this system must also be serviced regularly and faultless function must be ensured. The flow and return temperatures of the hot water storage vary greatly between the homes. A circulating DHW distribution system is installed in seven care centres. In non-circulating installations, such exist in homes H and I, the water stagnates. It can cool down and thus fall into the critical temperature range where *Legionella* grow.

Hygiene / maintenance
None of the ten homes are running a weekly flushing regime applied on the DHW system. In the case of consumption points, which are not used or are irregularly used, a weekly flushing may be recommended to prevent stagnation. Other technical solutions may be conceivable.

Monitoring / recording
Half of the residential care homes indicated the existence of a building logbook. Plant components of the drinking water supply network should also be considered. Inspections indicate the existence of an internal quality control, even if this does not allow any statement on its contemporary quality. Regular audits are carried out by the management at two homes. For the other institutions this suggests that the quality of drinking water is subject to the operating managers, and that higher management is not concerned with this issue, although it serves with responsibility for it. In half of the institutions the flow and return temperatures in the DHW distribution system are measured monthly. Only one home checks the hot water temperature at the point of consumption. Three institutions carry out annual checks of water taps (points of consumption).

Showers
50% answered the question of regular flushing of showers used less than once a week. Regular flushing is considered an important preventive measure when the shower is not used or not used regularly.

4.3 Linking results from microbiological analysis and questionnaires

After assessing the results of the classical cultivation method, a high *Legionella* infestation was found for two institutions. The institutions C, D and E also showed high numbers according to the FCM-IS method. This should be given further attention, due to building-specific indices (e.g. water temperatures in the system). The FCM-IS method is an interesting, specific, rapid detection method (analysis result after 1 h) which can differentiate between living and inactive cells. It may be useful for decision-makers who have to act quickly and cannot wait up to 10-14 days for results (as required by the cultivation method).

The control function and documentation in homes might require optimisation. The orientation towards recommendations for drinking water hygiene, such as those of the FOPH recommendations, would contribute to a greater awareness of the operating managers.

Although the FOPH recommendations provide valuable information, it does not appear to be a suitable medium for operating managers. Two of the ten institutions refer to this recommendation. It suggests that not enough is known about the recommendation. Preference is probably given to a different way of available information, holding the most important principles for safeguarding drinking water hygiene and procedures in cases of contamination.

5 CONCLUSION

To counteract potential threats caused by *Legionella* contamination, organisations should consider a mandatory scope statement as part of their risk management. However, the legal framework or potential threats are not always sufficiently identified. Duty holders may fail to determine appropriate strategies to counteract *Legionella* (Gollnisch *et al*., 2003). Considering parameters specific to the organisation must be an inclusive part of the risk assessment. An infected water system is something which is lacking in a building and reduces the value of a facility. Foremost the hazard to people and the liability of duty holders may be two even stronger arguments. Professionals with operator duties must bear this in mind.

Apart from the challenges of historically grown building structures and changing infrastructure, hygiene-related issues are perceived and discussed from different perspectives. According to the de-facto existing requirement of an organisation, the scope of action aligns itself in the competitive tension of those who are responsible. Not only classic microbiological topics play a role in the prevention process, but also activities serving the building which are specific to the building and which are people-related. The subject of functioning (water-) hygiene is often dependent on and influenced by a variety of protagonists (Gamage *et al.*, 2016; Spagnolo *et al.*, 2013).

FM can synergistically support where there is a perceived and recognized need by decision-makers. Building age, materials, proper handling, compliance and consistency along defined process chains with conjunct objectives and their implementation are just as authoritative as an appropriate, forward-looking (re)view and adjustment of protective goals. These need to be incorporated strategically. Demands must be 'translated' into process logic according to existing requirements A common and mutual understanding at the operational and strategic levels between different disciplines is essential to achieve mandatory objectives.

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REFERENCES

Arvand, M., Jungkind, K., & Hack, A. (2011), "Contamination of the cold water distribution system of health care facilities by *Legionella pneumophila*: Do we know the true dimension?", *Euro Surveill.*, 16(16), pii=19844.

Bentham, R. (2002), "Routine sampling and the temporal variation of *Legionella* spp.concentrations in cooling tower water systems", in Marre, R. et al. (Ed.), *Legionella: proceedings of the 5th conference on Legionella.*, American Society for Microbiology, Washington DC.

FOPH / Federal Office of Public Health (2009), „Legionellen und Legionellose", available at: https://www.bag.admin.ch/bag/de/home/themen/mensch-gesundheit/uebertragbare-krankheiten/infektionskrankheiten-a-z/legionellose.html (15.12. 2016).

Chan, A., Saito, Y., Robine, J.M. (2016), "International Perspectives on Summary Measures of Population Health in an Aging World", *J. Aging Health,* 28, 1119-1123.

Collins, S., Stevenson, D., Bennett, A., & Walker, J. (2016), "Occurrence of Legionella in UK household showers". *Int. J. Hyg. Environ. Health,* http://dx.doi.org/10.1016/j.ijheh.2016.12.001

Dyck, A., Exner, M., & Kramer, A. (2007), "Experimental based experiences with the introduction of a water safety plan for a multi-located university clinic and its efficacy according to WHO recommendations", *BMC Public Health, 7*(1), 1-14.

ECDC - European Centre for Disease Control and Prevention, 2016, "Legionnaires' disease in Europe 2014", *ECDC*, Stockholm.

"Facility-borne illness poses environmental risk in hospital construction" (2013), *Healthcare Financial Management*, 67(12), 126.

Fields, B.S., Benson, R.F., Besser, R.E. (2002), "*Legionella* and Legionnaires' disease: 25 years of investigation", *Clin. Microbiol. Rev,.* 15, 506-526.
Freije M.R. (2005), "Formulating a risk reduction strategy for waterborne pathogens in hospital water systems", *American Journal of Infection Control*, 33(5), 50-53.
Füchslin, H., Kötzsch, S., Keserue, H.-A., & Egli, T. (2010), "Rapid and Quantitative Detection of *Legionella* pneumophila Applying Immunomagnetic Separation and Flow Cytometry. Cytometry Part A", *Journal of the International Society for Advancement of Cytometry*, 77A(3), 264-274.
Gamage S.D., Ambrose M., Kralovic S.M., & Roselle, G.A. (2016), "Water Safety and *Legionella* in Health Care: Priorities, Policy, and Practice", *Infectious Disease Clinics of North America*, 30(3), 689-712.
Gollnisch, A., Gollnisch, C., & Klühspies, K. (2003), "Diskussion des Einsatzes von Desinfektions-verfahren zur Inaktivierung von Legionellen unter Beachtung rechtlicher Vorgaben", *Der Hygieneinspektor - Zeitschrift des Bundesverbandes der Hygieneinspektoren*, 12, 1-9.
Gollnisch, L.-P., & Gollnisch, C. (2016), "Praktische und juristische Aspekte der TrinkwV mit dem Schwerpunkt Legionellen an den Beispielen Festlegung Probenahmestellen, Probenentnahme und Gefährdungsanalyse", *Der Hygieneinspektor - Zeitschrift des Bundesverbandes der Hygieneinspektoren*, 06/2016.
Hammes , F., & Steinberg, M. (2012), „Analysemethoden; Durchflusszytometrie in der Trinkwasseranalytik", *BIOspektrum*, 18(3), 300-302.
Hines, S.A., Chappie, D.J., Lordo, R.A., et al., (2014), "Assessment of relative potential for *Legionella* species or surrogates inhalation exposure from common water uses", *Water Res*, 56(1), 203-213.
Hübner, N.-O., Fleßa, S., Jakisch, R., Assadian, O., & Kramer, A. (2012), "Review of indicators for cross-sectoral optimization of nosocomial infection prophylaxis – a perspective from structurally- and process-oriented hygiene", *GMS Krankenhaushygiene interdisziplinär*, 7(1), Doc15.
Keserue , H.-A., Bertsch, D., & Schaffhauser, D. (2013), „Schnelldetektion von Legionellen", *Aqua & Gas*, 11, 36-39.
Kistemann, T. (2014), "Erhalt der Trinkwassergüte in Trinkwasser-Installationen", in A. Heidemann, T. Kistemann, M. Stolbrink, F. Kasperkowiak, & K. Heikrodt, *Integrale Planung der Gebäudetechnik* (pp. 105-150). Berlin Heidelberg: Springer-Verlag.
Kruse, E.-B., Wehner, A., & Wisplinghoff, H. (2016), "Prevalence and distribution of *Legionella* spp. in potable water systems in Germany, risk factors associated with contamination, and effectiveness of thermal disinfection", *American Journal of Infection Control,* 44(4), 470-474.
Leiblein, T.W., Tucker, M., Ashall, M., Lee, S., Gollnisch, C., & S. Hofer, S. (2016), "*Legionella* and risk management in hospitals - A bibliographic research methodology for people responsible for built environments and facility management", *Int. J. Hyg. Environ. Health*, 219(8), 890-897.
Liyanage, C., & Egbu, C. (2005), "Controlling healthcare associated infections (HAI) and the role of facilities management in achieving *quality*" in healthcare: a three-dimensional view. *Facilities*, 23(5/6), 194-215.
Marston, B. J., Lipman H. B., & Breiman R. F. (1994). „Surveillance for legionnaires' disease. Risk factors for morbidity and mortality". *Arch. Intern. Med*. 154:2417–2422.
Muhlenberg, W., (1993), "Fatal travel-associated legionella infection caused by shower aerosols in a German hotel", *Gesundheitswesen*, 55, 653-656.

Phin, N., Parry-Ford, F., Harrison, T., Stagg, H. R., Zhang, N., Kumar, K., . . . Abubakar, I. (2014). “Epidemiology and clinical management of Legionnaires' disease”. *The Lancet Infectious Diseases*, 14(10), 1011-1021.

Shohet, I.M., & Lavy, S. (2004), “Healthcare facilities management: state of the art review”, *Facilities*, 22(7/8), 210-220.

Spagnolo, A.M., Cristina, M.L., Casini, B., & Perdelli, F. (2013), “*Legionella pneumophila* in healthcare facilities”, *Reviews in Medical Microbiology*, 24, 70-80.

Straus, W.L., Plouffe, J.F., File, T.M., Jr., et al. (1996), “Risk factors for domestic acquisition of legionnaires disease”, Ohio legionnaires Disease Group”, *Arch. Intern. Med.* 156(15), 1685-1692.

Völker, S., Schreiber, C., & Kistemann, T. (2010), “Drinking water quality in household supply infrastructure - A survey of the current situation in Germany”, *Int. J. Hyg. Environ. Health*, 213(3), 204-209.

Völker, S., Schreiber, C., & Kistemann, T. (2016), “Modelling characteristics to predict *Legionella* contamination risk – Surveillance of drinking water plumbing systems and identification of risk areas”, *Int. J. Hyg. Environ. Health*, 219(1), 101-109.

Water Management Society (WMSoc). (no date), “W043 - A guide to *Legionella* Risk Assessment”. *The Water Management Society (WMSoc)*, Fazeley, UK.

WHO / World Health Organisation (2011), “Water safety in buildings”, D. Cunliffe, J. Bartram, E. Briand, Y. Chartier, J. Colbourne, D. Drury, J. Lee, B. Schaefer, & Susanne Surman-Lee (Ed.), WHO Press, Geneva.

WHO / World Health Organisation (2007), “*Legionella* and the prevention of legionellosis”, WHO Press, Geneva.