ACCURATE MEASUREMENT OF BLOOD PRESSURE IN PREGNANCY

JACQUELINE KERRY GIBSON

A thesis submitted in partial fulfilment of the requirements of Liverpool John Moores University for the degree of Master of Philosophy

July 2014

The completion of this thesis would not have been possible without the ongoing support I have received from several people. I would like to thank my Supervisors especially Carol Hughes, Ruth Khatari, Penny Cook and the late Dr Charles Crosby for their support encouragement and invaluable constructive advice. In addition the continued love and support and patience from my husband and family that has enabled me to spend the time to complete the work required for the thesis. I would also like to thank my midwifery work colleagues for their listening ears, encouragement and unfailing confidence in my ability to complete the work has been invaluable. I would also like to thank the midwives and doctors who kindly participated in the study as without them there would be no thesis. Last but not least I would like to dedicate this thesis to my parents as they brought me into the world and enabled me to achieve many things.

Abstract

Hypertensive disorders are the most common medical complication of pregnancy and a major cause of neonatal and maternal morbidity and mortality in the UK and worldwide. Accurate recording of blood pressure measurement (BPM) is critical to ensure hypertension in pregnancy is correctly diagnosed and managed. Defective equipment and a failure to follow the correct BPM technique can lead to inaccurate readings. Studies have found this to be the case in both primary care and hospital settings. However, there is limited research evidence regards the condition of BPM equipment and BPM practice of health professionals working in maternity services.

This study is unique in that it encompasses an audit of BPM equipment, an assessment of BPM practice among health professionals and the impact of continuing education within three U.K. maternity units. This was a descriptive evaluation study that included a baseline audit of 165 blood pressure devices and a practice survey questionnaire distributed to 436 health professionals. In addition, 57 observations of staff conducting BPMs were undertaken. This was followed by an intervention in the form of an education programme delivered to 163 members of staff. The impact of the intervention upon equipment and matched pairs of health professionals was evaluated by a follow up equipment audit of 119 blood pressure devices and practice survey of 46 members of staff who completed the education programme and 32 who did not. Data were analysed using non-parametric statistic tools that included Chi-Square, McNemar, Spearman, Mann-Whitney-U and Wilcoxon tests.

The baseline survey found that out of 165 BP devices, 89% (148) had no indication of ever being serviced, 21% (28) failed calibration testing and that only 3% (5) devices were found to have no component faults. Out of the 22 automated devices surveyed, none had been independently validated as suitable for use on pregnant women. There was a lack of availability of large cuffs located across all three maternity

units of the recommended size. The observed practice of 57 staff taking BPM did not comply with current BPM guidelines. The baseline practice survey findings revealed that 156 (63%) of the 246 respondents did not use the correct rate of deflation, 103 (42%) incorrectly used Korotkoff 4 for diastolic pressure and 188 (76%) could not correctly identify the effect of arm position on BP readings. Evaluation of the impact of the education programme upon the working condition of BP equipment and practice of BPM revealed some positive effects with a significant changes in overall practice questionnaire scores (before vs. after P=<0.001) in participants who attended the education programme compared to those who did not attend the education programme (P=0.982). Of the 119 BPM devices examined in the follow up survey there was a 13% increase in the number of devices that had evidence of servicing and a 6% increase in the number that passed calibration testing.

Thus, the study identified that the accuracy of BP measuring equipment was questionable. Also, there were variances with the method of BPM technique and a lack of compliance with recommended guidelines on how BP should be measured. Updating staff on how to conduct an accurate BPM and raising awareness of the factors that affect accurate BPM has the potential to reduce the risk of obtaining an inaccurate BPM due to faulty equipment or incorrect technique. Quality improvement initiatives around the care of women with hypertensive disorders in pregnancy need to incorporate performance assessment of staff BPM technique and BP equipment accuracy assessment. Equipment should be in full working order, regularly serviced and maintained and defective equipment removed. Health professionals conducting BPM on pregnant women need to ensure that they access regular and appropriate updating on the recommended technique for BPM and have knowledge around servicing, calibration requirements, and validation requirements of BP devices. Perhaps most important of all is not to take for granted their competency in this basic but essential clinical skill.

CONTENTS **Page**

ACKNOWLEDMENTS 2

ABSTRACT **3**

CHAPTER 1 – STRUCTURE OF THESIS 15
1.0 Introduction 15
1.2 Overview of Chapters 20

CHAPTER TWO -CONTEXT AND BACKGROUND TO THE MEASUREMENT OF BLOOD PRESSURE IN PREGNANCY
2.0 Introduction 23
2.1 Maternal and Neonatal Mortality and Morbidity 23
2.2 Definition and Classification of Hypertensive Disorders of Pregnancy 27
2.2.2 Hypertension 28
2.2.3 Pre-existing hypertension 28
2.2.4 Pregnancy induced or Gestational Hypertension 29
2.2.5 Pre-eclampsia 30
2.2.6 Eclampsia 30
2.2.7 Pre-eclampsia superimposed upon pre-existing hypertension 31
2.3 Blood pressure and the effect of pregnancy on blood pressure 33
2.4 Antenatal care and guidelines for hypertensive disorders 37
2.5 Impact of hypertensive disorders on maternity services in England 39

CHAPTER 3 – LITERATURE REVIEW OF FACTORS THAT IMPACT ON ACCURATE BLOOD PRESSURE MEASUREMENT
3.0 Introduction 45
3.1 Equipment 46
3.1.1 Standardization of equipment 46
3.1.2 Automated BP devices and independent validation 48
3.2 Accuracy of automated BP devices for use in pregnancy 52
3.3 Manual BP devices
3.3.1 Mercury manometers 55
3.3.2 Aneroid manometers 57
3.4 Servicing and calibration checks of blood pressure devices 58
3.4.1 Servicing and calibration of BP equipment in maternity settings 64
3.5 Working condition of manual BP devices 65
3.6 Stethoscopes 70
3.7 Observer and client factors that affect accurate BP measurement 70
3.7.1 Posture blood pressure and pregnancy 74
3.7.2 Arm Position 75
3.7.3 Cuff size 75
3.7.4 Guidelines for the clinical measurement of blood pressure 80
3.7.5 Initial education and adherence with guidelines for BPM 80
3.7.6 Continuing education 89
3.8 Summary and rationale for proposed study 92
3.8.1 Automated BP equipment 92
3.8.2 Manual BP equipment 93
3.8.3 General factors that affect accurate BPM 93
3.8.4 Observer application of knowledge to BPM practice 94
3.9 Rationale for study 95

CHAPTER FOUR- METHODOLOGICAL CONSIDERATIONS OF THE STUDY
4.1 Aim 97
4.2 Research questions 97
4.2.1 Objectives of the study 98
4.3 Philosophical perspective 99
4.4 Research design 100
4.4.1 Evaluation research 100
4.4.2 Summary of current study's research design 104

4.5 Research methods 105
4.6. Setting 105
4.7 Triangulation 106
4.8 Methodological consideration of the survey approach 107
4.9 Equipment surveys 109
4.9.1 Tools for the equipment survey 110
4.9.2 Equipment sample 111
4.9.3 Equipment Survey 1 - Sample 111
4.9.4 Data collection for Equipment Survey 1 112
4.9.5 Equipment Survey 2 - Sample 113
4.9.6 Data collection for Equipment Survey 2 113
4.10 Practice Survey 114
4.10.1 Methodological considerations of the use of questionnaires 115
4.10.2 Consideration of methods of administration for questionnaires 115
4.10.3 Disadvantages of self-administered questionnaires 116
4.10.4 Methodological considerations in the construction of a questionnaire 116
4.10.5 Development of the Practice Questionnaire 119
4.10.6 Pilot study 122
4.11 Sample of health professionals for Practice Survey 125
4.12 Preparation for Practice Survey 1 126
4.12.1 Sample for Practice Survey 1 127
4.12.2 Administration of the Practice Questionnaire 127
4.12.3 Follow up of non-respondents of Practice Survey 1 128
4.12.4 Sample for Practice Survey 2 128
4.12.5 Administration of questionnaire – Practice Survey 2 129
4.13 Observations 129
4.13.1 Methodological considerations of observations 130
4.13.2 Tool used for observations 131
4.13.3 Sample for observations 132
4.13.4 Observations of staff conduction BPMs 133
4.14 Data input and analysis 134
4.15 Dissemination of Baseline survey results 135
4.16 Ethical issues of the study 135
4.16.1 Participants 136
4.16.2 Consent 136
4.16.3 Confidentiality and anonymity 137
14.17 Summary 138

CHAPTER 5 – EDUCATION PROGRAME
5.0 Introduction 140
5.1 The effectiveness of education as a means to change practice 140
5.2 Methodological considerations in the development of an education programme 142
5.2.1 Adult learning theory 144
5.2.2 Domains of learning and the education programme 147
5.3 Aim and learning outcomes for the education programme 149
5.4 Content of the education programme 151
5.4.1 Teaching and learning strategies for the education programme 153
5.4.2 Ensuring consistency of delivery of the education programme 157
5.5 Pilot delivery of the education programme 158
5.6 Sample 161
5.7 Delivery of the education programme 161
5.8 Evaluation 162
5.8.1 Evaluation of learning 164
5.8.2 Administration of Knowledge Questionnaires 1 & 2 166
5.8.3 Data input and analysis 167
5.8.4 Participant evaluation of the session 167
5.8.5 Administration of participant evaluation questionnaire 168
5.8.6 Data input and analysis 168
5.9 Wider evaluation of impact of the study 169

CHAPTER 6 – RESULTS 171
6.1 Baseline Survey - Equipment Survey 1 171
6.1.1 Servicing of BP equipment 173
6.1.2 Calibration testing of BP equipment 173
6.1.3 The working condition of BP equipment 174
6.1.4 Size, type, labelling and availability of blood pressure cuffs 177
6.1.5 Number, type, location and validation of automated BP devices 177
6.2 Number, type and working condition of stethoscopes surveyed in Equipment Survey 1 179
6.3 Results from Equipment Survey 2 180
6.3.1 Servicing of BP equipment 182
6.3.2 Calibration testing of BP equipment 183
6.3.3 The working condition of BP equipment 183
6.3.4 Size, type, labelling and availability of blood pressure cuffs 185
6.3.5 Number, location and validation of automated BP devices 185
6.4 Number, type and working condition of stethoscopes 186
6.5 Results of the observations on staff undertaking BPM 187
6.6 Results from Practice Survey 1 190
6.6.1 Demographic data of respondents 190
6.6.2 Practice Survey 1 questionnaire responses 191
6.6.3 Results of respondents scores for Practice Survey 1 193
6.7 Evaluation of the Education Programme 193
6.8.1 Initial evaluation of the Education Programme 194
6.8.2 Longer term evaluation of the Education Programme 196
6.8.3 Participant evaluation of the Education Programme 199
6.8 Practice Survey 2 results evidence of changes 200

CHAPTER 7 DISCUSSION 204
7.1 Equipment Survey 1 204
7.1.1 Servicing and calibration of BP devices 205
7.1.2 Working condition of the BP devices 206
7.1.3 Size, labelling and availability of blood pressure cuffs 208
7.1.4Number, type and validation of automated BP devices 209
7.2 Number, type and working condition of stethoscopes 209
7.3 Equipment Survey 2 210
7.3.1 Type and module of BP devices found in Equipment Survey 2 210
7.3.2 Equipment Survey 2 results for the working condition, servicing and calibration of BP devices 211
7.3.3 The size, type, labelling and availability of blood pressue Equipment Survey 2 213
7.3.4 Automated BP devices 214
7.3.5 Equipment Survey 2 results for the number, type and working condition of the stethoscopes 215
7.4 Practice implication of the results of the equipment surveys 215
7.5 Observations 223
7.6 Practice Survey 1 224
7.6.1 Demographic data of respondents 224
7.6.2 Type of devices used by respondents to measure BP 224
7.6.3 Practice Survey 1 Questionnaire responses 225
7.7 Practice Survey 2 226
7.7.1 Demographic data and response rates 226
7.8 Clinical implications of questionnaire response to Practice Surveys 227
7.8.1 Sound used to determine diastolic pressure 227
7.8.2 Rate of deflation 229
7.8.3 Resting period prior to BPM 230
7.8.4 Arm circumference 230
7.8.5 Increasing the resting period prior to BPM 231
7.8.6 The effect of arm position on BPM 232
7.9 Evaluation of the Education Programme 233
7.10 Impact of the Education Programme 235
7.10.1 Development of the Education Programme 236

7.11 Study limitations 241
7.11.1 Sample limitations 242
7.11.2 Limitations of using survey questionnaire method 244
7.12 General discussion of the study BP Practice, Equipment and continuing education 246
7.13 Recommendations for clinical practice 259
7.13.1 Recommendations for actions to be taken by individual health Professionals 259
7.13.2 Recommendations for actions to be taken by ward managers 260
7.13.3 Recommendations for actions to be taken by Medical Engineers 261
7.13.4 Recommendations for actions to be taken by Risk managers, research/audit teams 262
7.13.5 Otherl recommendations 263
7.14 Conclusion 264

List of appendices 9

List of tables 10

List of figures 11

Glossary 12

Reference list 269

Bibliography 298

Appendices 312

APPENDICIES **Page**

Appendix 1 Proformas for assessment of BP devices 313
Appendix 2 Practice Questionnaire and covering letter for pilot study 322
Appendix 3 Revised Practice Questionnaire and covering letter 328
Appendix 4 Example of Study Flyer for display in units 334
Appendix 5 Follow up letters for non-respondents Practice Survey 1 336
Appendix 6 Covering letter for Practice Survey 2 338
Appendix 7 Follow up letter to non-respondents Practice Survey 2 341
Appendix 8 List of BP observation factors 343
Appendix 9 Proforma for BP observations 345
Appendix 10 Observation consent form 347
Appendix 11 Ethical approval letters 349
Appendix 12 Original lesson Plan 364
Appendix 13 PowerPoint presentation for education programme 366
Appendix 14 Revised lesson plan 370
Appendix 15 Flyer to advertise education programme to staff 372
Appendix 16 Knowledge Questionnaire 1 374
Appendix 17 Knowledge Questionnaire 2 and covering letter 377
Appendix 18 Follow up letter for non-respondents KQ2 382
Appendix 19 Participant feedback questionnaire and covering letter 384
Appendix 20 Proforma for assessing competency in Blood pressure measurement with a manual device 388
Appendix 21 Proform for assessing competency in Blood pressure Measurement with an automated device 391

List of tables

	Page
Table 2.1 Classification of Hypertensive disorders	24
Table 2.2 Maternal Deaths by cause in the UK.	25
Table 2.3 Terms used for hypertensive disorders of pregnancy	28
Table 2.4 Eclampsia in the UK	31
Table 2.5 Effects of activities of daily living on blood pressure	35
Table 2.6 Hospital episodes in England for Hypertensive disorders	40
Table 2.7 Timing of Blood pressure measurements for pregnant women with hypertension as recommended by NICE Hypertension Guidelines 2010	41
Table 3.1 Summary of studies that have involved calibration testing of manual sphygmomanometers	60
Table 3.2 Common equipment factors that affect accurate BPM	66
Table 3.3 Comparison of Equipment study results	67
Table 3.4 Summary of factors affecting accurate measurement of blood pressure due to observer and technique	72
Table 3.5 Summary of factors affecting accurate measurement of blood pressure due to client preparation and environment	73
Table 3.6 Recommended cuff sizes	77
Table 3.7 Summary of studies conducted on observer knowledge and /or technique of BPM	87/88
Table 4.1 Performance testing of Sphygmomanometers	111
Table 4.2 Summary of Questionnaire topics used in previous studies	121
Table 4.3 Category of topics used in the Practice Questionnaire	124
Table 5.1 Observer factors affecting accurate measurement of blood pressure	152
Table 5.2 Client factors affecting accurate measurement of blood pressure	153
Table 5.3 Evaluation of the educational outcomes of education programme	163
Table 5.4 Category of topics used in Knowledge Questionnaire 1	165
Table 5.5 Category of topics used in Knowledge Questionnaire 2	166
Table 6.1 Type and number of blood pressure devices in Equipment Survey 1	171
Table 6.2 Summary of the working condition of the BP equipment assessed in Equipment Survey 1	172
Table 6.3 Servicing data of mercury, aneroid and automated BP devices assessed in Equipment Survey 1	173
Table 6.4 Calibration testing results for manual BP devices Equipment Survey 1	174
Table 6.5 Proportion of mercury and aneroid devices that failed to meet assessed component standards in Equipment Survey 1	175
Table 6.6 Number of BP devise by type and model in Equipment Survey 1	176
Table 6.7 Number and clinical location of automated BP devices in Equipment Survey 1	178
Table 6.8 Number model and validation evidence of automated devices	178
Table 6.9 Working condition of sethoscopes in Equipment Survey	179
Table 6.10 Comparison of the type and number of blood pressure devices in Equipment Surveys 1 and 2	180
Table 6.11 Comparison of servicing data by type of device between Equipment Surveys 1 & 2	182
Table 6.12 Comparison of aneroid devices between Equipment Surveys 1 & 2 that failed to meet assessed component standard to measure BP	184
Table 6.13 Summary of automated devices by manufacturer, model and independent validation evidence	186
Table 6.14 Comparison of the condition of the stethoscopes	187
Table 6.15 Summary of observations of staff undertaking BPM	189
Table 6.16 Summary of Practice Survey 1 response rates by hospital site	190
Table 6.17 Summary of age groupings for Practice Survey 1 respondents	190
Table 6.18 Practice Survey 1 questionnaire responses	192
Table 6.19 Question category results for Knowledge Questionnaire 1	194
Table 6.20 Question category results for Knowledge Questionnaire 2	197
Table 6.21Comparison of respondents'scores for Practice Surveys 1 & 2	202
Table 6.22 McNemar test results of individual question responses for Practice Surveys	203

LIST OF FIGURES PAGE

Figure 1.1 Flow Chart -Overview of Hypertensive Disorders in Pregnancy and factors that affect accurate BPM 19
Figure 4.1 Flow chart for Equipment Surveys 114
Figure 4.2 Age grouping of Midwives for England 2004-2010 126
Figure 4.3 Stages of the research study 139
Figure 5.1 Sources of information used to determine the content of the Education Programme 152
Figure 6.1 Comparison of Equipment Survey data for BP devices that did meet component quality standards 181
Figure 6.2 Respondents age group summarised per hospital site 191
Figure 6.3 Summary of respondents scores for Practice Survey 1 193
Figure 6.4 Respondents scores for Knowledge Questionnaire 1 195
Figure 6.5 Participant identification of factors that affect accuracy of BPM 195
Figure 6.6 Summary of Scores for Knowledge Questionnaire 2 196
Figure 6.7 Identification of factors that affect accurate BPM 198
Figure 6.8 Comparison of overall scores for Practice Surveys (attenders) 201
Figure 6.9 Comparison of overall scores for Practice Survey (non-attenders) 202

GLOSSARY

AAMI	Association for Advancement of medical instruments
ACOG	American College Obstetricians and Gynaecologists
AHA	American Heart Association
APEC	Action on Pre-eclampsia
BHS	British Hypertensive Society
BP	Blood pressure
BPM	Blood pressure measurement
CEMD	Confidential enquiry into maternal deaths
CEMACH	Confidential enquiry maternal and child health
CESDI	Confidential enquiry stillbirths and death in infancy
CPD	Continuing Professional Development
ESH	European Society Hypertension
ES1	Equipment Survey 1
ES2	Equipment Survey 2
GMC	General Medical Council
HDU	High Dependency unit
HES	Hospital Episode Statistics
HSE	Health and Safety Executive
ICU	Intensive Care Unit
ISSHP	International Society for the Study of Hypertension in Pregnancy
MDU	Maternity Day Unit
MHRA	Medicines and Healthcare Regulatory Agency
NHLBI	National Heart Lung Blood Institute
NICE	National Institute Clinical Excellence
NMC	Nursing and Midwifery Council

NOO	National Obesity Observatory
PRECOG	Pre-eclampsia community guidelines
PIH	Pregnancy Induced Hypertension
PS1	Practice Survey 1
PS2	Practice Survey 2
RCM	Royal College Midwives
RCOG	Royal College Obstetricians and Gynaecologists
SOGC	The Society of Obstetricians and Gynaecologists of Canada
UKOSS	United Kingdom Obstetric Surveillance System
WHO	World Health Organisation
Booking Interview	First official antenatal appointment normally takes place by 10 weeks gestation and books woman in for maternity care from a particular service care provider i.e. NHS Trust Maternity Unit
Chronic hypertension	The presence of hypertension in a woman prior to 20 weeks gestation or hypertension that is diagnosed for the first time at booking prior to 20weeks gestation
Diastolic	Diastolic pressure is the when the blood pressure reaches its lowest level as the heart relaxes between beats and is the second or bottom number of a blood pressure reading Diastolic pressure is the pressure exerted on the arterial walls during ventricular relaxation and is the stage when the vessels contain the least amount of blood and hence the pressure is at its lowest.
Eclampsia	The occurrence of life threatening convulsions during pregnancy or within 10 days postpartum
Gestational hypertension	The occurrence of hypertension at or after 20 weeks gestation
Hypertension	A systolic reading equal to or more than 140mmHg and or a diastolic reading equal to or more than 90mmHg
Maternal death	"The death of a woman while pregnant or within 42 days of termination of pregnancy, irrespective of the duration and the site of the pregnancy, from any cause related to or aggravated by the pregnancy or its management, but not from accidental or incidental causes." http://www.maternalmortalitydata.org/Definitions.html

Maternal morbidity	A serious disease, disability or physical damage to a woman caused by pregnancy related complications.
Maternal mortality rate(ratio)	The number of women who die during pregnancy and childbirth, per 100,000 live births.
Neonate	A newborn child of less than 4 weeks old
Neonatal mortality	Death following a live birth before the age of 28 completed days
Neonatal mortality rate	The number of neonates dying before reaching 28 days of age, per 1,000 live births in a given year.
Perinatal mortality	Death of a fetus after 24 weeks gestation or neonate before seven completed days
Pre-eclampsia	Hypertension and significant proteinuria occurring at or after 20 weeks gestation (significant proteinuria = urine protein excretion of >300mg /24hours)
Pre-eclampsia Superimposed on Chronic hypertension	The occurrence of the features of pre-eclampsia in a woman with pre-existing hypertension
Pre-existing Hypertension	The presence of hypertension in a woman prior to 20 weeks
Pregnancy induced Hypertension	The occurrence of hypertension at or after 20 weeks gestation with no proteinuria
Systolic	Systolic pressure is when your blood pressure reaches its highest level as the heart is beating and is the first or top number of a reading. Systolic pressure is the measurement taken when the arteries contain the maximum amount of blood during contraction of the left ventricle the time of the highest pressure.

CHAPTER ONE - STRUCTURE OF THE THESIS
1.0 Introduction

The focus of this study is accurate blood pressure measurement (BPM) in pregnancy. The competent performance of a clinical psychomotor skill is dependent upon the acquisition and retention of theoretical knowledge and how it is transferred into clinical practice by the health professional (O'Neil & Addrizzo-Harris, 2009; Bordage, Carlin & Mazmaniam, 2009). The failure of health professionals to apply theory to practice leads to a gulf between evidence and practice and can impact upon clinical care and health outcomes for clients. Measures to reduce the theory practice gap include the continued professional development (CPD) of qualified health professionals (Davis, et al. 2003). Continuing professional education beyond the point of initial qualification would include activities such as attendance at conferences, journal clubs, workshops, seminars, case study discussions as well as self-directed learning activities. The intention of this study is to audit blood pressure measuring equipment, appraise the application of theory to practice in the method of BPM and evaluate the impact of the introduction of continuing education on accurate BPM within maternity settings.

Application of theoretical medical knowledge in clinical practice demonstrates deeper learning and clinical proficiency requiring the use of cognitive skills such as comprehension and analysis. If a health professional cannot apply what they know to their clinical practice, the knowledge is not useful (Bordage, Carlin & Mazmanian, 2009).

According to Miller (1990), clinical competence can be assessed by the utilisation of the factual knowledge through the performance of a practice skill (knowing how and showing how). Therefore, the basis of the thesis includes the assessment of theoretical knowledge of factors that affect accurate measurement of BP, what health professionals working in maternity units know about BPM; to the method of BPM within the clinical practice of BPM and how BPMs are conducted.

The measurement of blood pressure is an essential screening test of modern medicine, one of the oldest and most common observations undertaken by health care professionals worldwide. The development of the technology for the measurement of blood pressure spans a long time in medical history. It began in 2500BCE with several ancient civilizations measuring the pulse through to the development of instruments in 1896 (Naqvi & Blaufox, 1998). The procedure used to measure blood pressure in clinical practice has changed very little over the last century. The method first described by Korotkoff in1905 with the sphygmomanometer invented by Riva Rocci in 1896 is similar to that currently used. Aside from some technological refinements with the introduction of electronics and computer technology, no major discoveries or advancements have occurred within the area of sphygmomanometry (Naqvi & Blaufox, 1998).

When blood pressure is raised this is known as hypertension and untreated hypertension can lead to negative health outcomes and a shortened life expectancy. A significant point for the history of blood

pressure measurement was the introduction of guidelines for clinicians, researchers and manufacturers. These were first proposed in 1939 by joint recommendations of the American Heart Association and the Cardiac Society of Great Britain and Ireland (Jones, 2003). Today hypertension guidelines produced by the British Hypertensive Society, World Health Organisation, European Society of Hypertension and the American Heart Association are recognised and cited worldwide and have significantly influenced the treatment and prevention of hypertension (Naqvi & Blaufox, 1998; Jones, et al. 2003).

Ever since its inception the measurement of blood pressure by sphygmomanometry has resulted in controversy. Hill and Barnard in 1897 emphasized that in order to avoid inaccurate readings the arm needs to be kept at the same level with the heart (Naqvi &. Blaufox, 1998). Over a century later the position of the arm is still a factor that leads to an inaccurate measurement. In 1901, Von Recklinhausen demonstrated that a narrow tube such as the one used in the Riva-Rocci instrument, i.e. 5cm gave erroneous higher systolic measurements, which could be corrected if a larger cuff of at least 12cm in width was used. Von Recklinhausen was the first person to show that bladder dimension could influence the accuracy of blood pressure measurement and subsequently over the following 100 years there has been much discussion and disagreement as to what is the optimum dimension of the bladder that is used to obtain an accurate blood pressure measurement (O'Brien, 1996; Naqvi & Blaufox, 1998;

Shennan & Halligan, 1999). Subsequent research has identified other factors that impact on the accuracy of BPM.

Health professionals who conduct BPM on pregnant women need to be up to date with their knowledge and BPM skills, regarding factors that affect accuracy, because care provided to clients should be evidenced based and not compromised by the misdiagnosis of hypertension or failure to diagnose a hypertensive disorder in pregnancy or inappropriate management due to the inaccurate measurement of blood pressure. Accurate and timely diagnosis and management of the condition can improve maternal and neonatal mortality and morbidity. The following flow chart provides an overview of the importance of blood pressure measurement during pregnancy and identifies the factors that lead to inaccurate measurement.

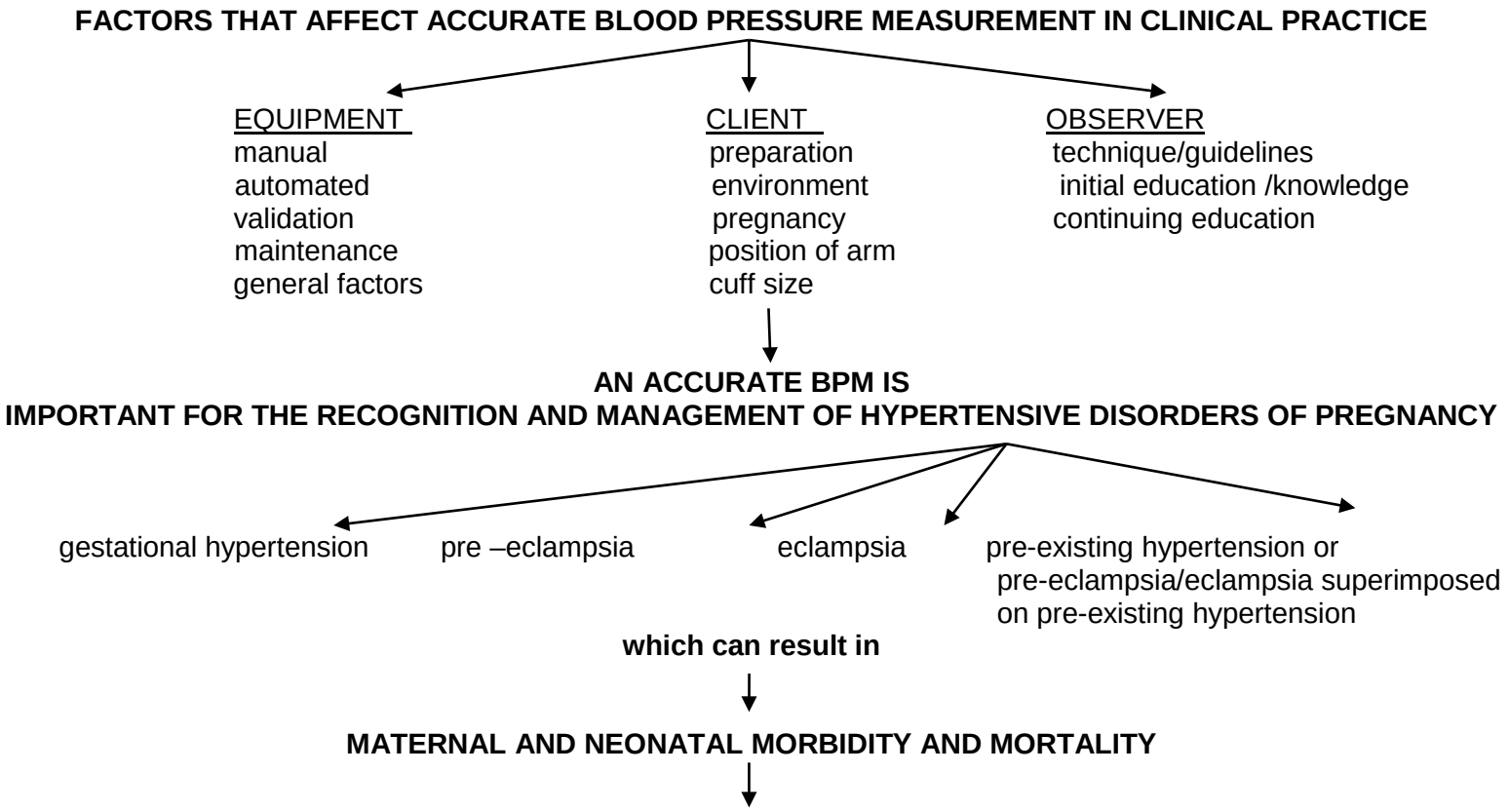


Figure 1.1 Overview of Hypertensive Disorders in Pregnancy and factors that affect accurate BPM

1.2 Overview of Chapters

Chapter one provides a general introduction to the topic chosen for the study, including a brief history of BPM and why it is important for health professionals to apply evidenced-based theory to practice. The discussion outlines the basis of the thesis and identifies the factors that can impinge upon accurate BPM.

Chapter two provides the context and background to BPM in pregnancy. The discussion focuses on the impact hypertensive disorders in pregnancy have upon maternal and neonatal mortality and morbidity. A definition of hypertensive disorders and how they are classified is provided. The discussion then leads on to the effect pregnancy has on blood pressure, how hypertensive disorders are recognised during pregnancy and the impact this has upon maternity services in England. The chapter concludes with identification and responsibilities of the health professionals who conduct BPMs.

The purpose of Chapter three is to examine the literature to identify these factors and as shown in the previous flow chart 1.1, they have been separated into equipment, observer and client factors. The content of chapter three includes a discussion on the research literature regarding application of knowledge to practice, issues around BPM education for health professionals and the lack of continuing education on the topic. The chapter concludes with a summary of the issues

identified during the literature review and provides the rationale of why the study was required.

Chapter four outlines the aim and identifies the objectives of this study and defines the research questions that will lead to an increase in the knowledge and understanding of the professional activity around BPM within maternity settings. This is followed by a discussion of the methodological considerations of the study's philosophy, research design, study sample and setting. The research design provides the outline to enable the collection and analysis of study data to answer the questions proposed by a research study. In addition, the content will detail how the instruments of data collection were selected and designed, how the data will be analysed and the ethical considerations in the study. As the study had several phases and utilised various tools, the chapter concludes with a diagram that outlines the phases of the study.

A key element to the study involved the design and delivery of an education programme on accurate measurement of BP. The education programme formed the basis of the intervention was not in itself a data collection tool and therefore, was excluded from the Chapter 4 discussions. The, discussions about the education programme are presented separately in Chapter five where the context of the education programme, is outlined, starting from the methodological considerations in regard to its development, through to the selection of content,

teaching and learning strategies. This discussion continues with how consistency of delivery will be achieved, on how the programme was piloted and concluding with the alterations required before the final product could be delivered. The final section within the chapter covers how the education programme was delivered and evaluated.

Chapter six presents the results from the equipment surveys, observations, practice surveys and evaluation of the impact of the education programme. Chapter seven is a discussion and evaluation of the results, incorporating the implications and recommendations for the future clinical practice of BPM. The limitations to the study are identified and discussed along with aspects for future research.

CHAPTER 2

CONTEXT AND BACKGROUND TO THE MEASUREMENT OF BLOOD PRESSURE IN PREGNANCY.

2.0 Introduction

The purpose of this chapter is to provide context and background to the study. The content of the chapter includes the identification of hypertension in pregnancy as a major cause of maternal and neonatal mortality and morbidity. The classification of hypertensive disorders in pregnancy and the effects that pregnancy has upon blood pressure are discussed. This is followed by a discussion on the importance of antenatal care and guidelines for hypertensive disorders and the impact of hypertensive disorders on maternity services in England along with the identification and responsibilities of the health professionals who conduct BPMs in maternity settings.

2.1 Maternal and neonatal mortality and morbidity

The commonest medical conditions to arise during pregnancy stem from hypertension, affecting around 8%-10% of all pregnancies (Meher & Duley, 2005). Table 2.1 provides a brief definition of the different types of hypertensive disorders; a more detailed discussion is provided later in this chapter at 2.2. These hypertensive disorders of pregnancy are major causes of maternal and neonatal mortality and morbidity worldwide (NHLBI, 2003). It is estimated that hypertensive disorders internationally contribute to 50,000 to 76,000 maternal deaths a year (WHO, 2004; Pre-eclampsia Foundation, 2008).

Table 2.1 Classification of Hypertensive disorders

HYPERTENSIVE DISORDER	DEFINTION
HYPERTENSION	A systolic reading equal to or more than 140mmHg and or a diastolic reading equal to or more than 90mmHg
PRE-EXISTING HYPERTENSION (CHRONIC HYPERTENSION)	The presence of hypertension in a woman prior to 20 weeks gestation or hypertension that is diagnosed for the first time at booking
GESTATIONAL HYPERTENSION OR PREGNANCY INDUCED HYPERTENSION	The occurrence of hypertension at or after 20 weeks gestation
PRE- ECLAMPSIA	Hypertension and significant proteinuria occurring at or after 20 weeks gestation (significant proteinuria = urine protein excretion of >300mg /24hours)
ECLAMPSIA	The occurrence of life threatening convulsions during pregnancy or within 10 days postpartum
PRE-ECLAMPSIA SUPERIMPOSED ON CHRONIC HYPERTENSION	The occurrence of the features of pre-eclampsia in a woman with pre-existing hypertension

Of the 130 million babies born worldwide each year around 7- 8 million will die before one year of age (WHO, 2006). Four million babies die during the neonatal period (from birth to four weeks of age). Of these deaths 31% worldwide and 34% in Europe are due to prematurity and low birth weight (WHO, 2006; CEMACH, 2009; WHO, 2009). The risks of preterm birth, (born before 37 weeks gestation) in pre-eclampsia are substantial with 8-10% of all preterm births being due to hypertensive disorders (Slattery, Geary & Morrison, 2008). Preterm births occur in 50% of pregnancies complicated by severe pre-eclampsia. One in every two hundred and fifty primigravida women with pre-eclampsia will deliver before thirty four weeks gestation (Hernadez,-Diz, Toh & Cnattingius, 2009). In relation to low birth weight, 20- 25% of preterm births and 14-19% of term births due to pre-eclampsia are small for

gestational age, that is less than the 10th centile of birthweight for gestational age (Slattery, Geary & Morrison, 2008).

Hypertensive disorders of pregnancy remain the second leading cause of direct maternal deaths in the UK with thromboembolic complications being the first cause. In the UK Confidential Enquiries into Maternal deaths (CEMD) and Confidential Enquiry into Maternal and Child Health (CEMACH) and Centre for Maternal and Child Enquires (CMACE) have reported deaths from pre-eclampsia and eclampsia in successive reports since the 1950's (Yentis, 2011). Table 2.2 summarises the main causes of maternal deaths in the UK from 1985-2008.

Table 2.2 Maternal Deaths by cause in the UK

Number of Maternal Deaths per 100,000 maternities in the UK 1985-2008 (maternities = live birth at any gestation or stillbirth after 24weeks gestation)								
Cause of direct death	1985-87	1988-90	1991-93	1994-96	1997-99	2000-02	2003-05	2006-08
Thrombosis/ Thromboembolism	32	33	35	48	35	30	41	18
PRE-ECLAMPSIA/ ECLAMPSIA	27	27	20	20	16	14	18	19
Haemorrhage	10	22	15	12	7	17	14	9

Other maternal complications of hypertensive disorders of pregnancy are convulsions, cerebral haemorrhage, placental abruption, myocardial infarction, renal failure, pulmonary oedema, liver haemorrhage and clotting dysfunction such as disseminated intravascular coagulation (Bergal, Carroli & Althabe, 2002). Tuffnell, et al. (2005) estimated one in fifty women with complications resulting from severe pre-eclampsia required admission to an Intensive care (ICU) or high dependency units

(HDU). Knight (2007) found out of 295 women in the UK with eclampsia 119 (56%) required admission to ICU or HDU. Waterstone, Bewley & Wolfe (2001) suggests hypertensive disorders were responsible for just over 33% of severe obstetric morbidity problems. In addition, hypertension in pregnancy may result in long term consequences such as chronic hypertension and increased cardiovascular risk and cerebrovascular disease (Bellamy, et al. 2007).

Hypertensive disorders in pregnancy are a cause of perinatal mortality (neonatal death within 1st week of life) and increase the risk of neonatal mortality and morbidity (Greer, 2005). Hypertension with or without proteinuria is the single identifiable risk associated with stillbirths (Maternal and Child Health Research Consortium, 1999). The 5th Perinatal mortality report by CEMACH (2009) reported that Pre-eclampsia was present in one in twenty (4.9%) of women who had a stillbirth in an infant with no congenital abnormality. Pre-eclampsia is generally associated with fetal growth restriction, low birth weight in term and preterm neonates, prematurity, respiratory problems, which inevitably result in admissions to neonatal units (The Magpie Trial Collaborative Group, 2002). Long term consequences of survival can lead to an increased risk of developmental delay and chronic childhood illnesses (Annath, Savitz & Bowes, 1995; Meher & Duley, 2005). It is important that health professionals caring for women with hypertensive disorders during pregnancy can identify the different disorders and

comprehend the significant risks to maternal and neonatal mortality and morbidity.

2.2 Definitions and Classification of Hypertensive Disorders of Pregnancy

As shown in table 2.1, hypertension in pregnancy can include a spectrum of disorders ranging from pre-existing hypertension (or chronic hypertension), pregnancy induced (gestational) hypertension, pre-eclampsia, eclampsia and superimposed pre-eclampsia on pre-existing hypertension. However, within the literature, there is a lack of uniformity in the terms used for hypertensive disorders (Chappell, et al. 1999; Harlow & Brown, 2001). For health professionals in clinical practice this can lead to confusion, misinterpretation or misunderstanding and variation of management of hypertensive disorders between maternity units. To provide an example of this table 2.3 depicts the equivalent terms used by different organisations and those that will be used in the purpose of this study. The terms utilised by this study were chosen because they are the most common and they encompass terminology that enables differentiation between the types of hypertensive disorders. An explanation of each term follows the table.

Table 2.3 Terms used for hypertensive disorders of pregnancy

	Terms used for hypertensive disorders of pregnancy by different organisations				
Current study	NHLBI NATIONAL HEART LUNG Blood Institute	PRECOG & PRECOG2DAU Pre-eclampsia community guidelines and day unit guidelines	HES Hospital Episode Statistics	ISSHP International Society for the Study of Hypertension in Pregnancy	ACOG American College Obstetricians Gynaecologists
PRE-EXISTING HYPERTENSION or CHRONIC HYPERTENSION	Chronic Hypertension	Pre-existing hypertension	Pre-existing hypertension	Chronic hypertension	Chronic hypertension
GESTATIONAL HYPERTENSION or PREGNANCY INDUCED HYPERTENSION	Gestational hypertension	New hypertension	Gestational (Pregnancy Induced) hypertension Without significant proteinuria	Gestational hypertension	Gestational hypertension
PRE-ECLAMPSIA	Pre-eclampsia	Pre-eclampsia	Gestational (pregnancy induced) hypertension with significant proteinuria (pre –eclampsia)	Pre-eclampsia	Pre-eclampsia
ECLAMPSIA	Eclampsia	Eclampsia	Eclampsia	Eclampsia	Eclampsia
PRE-ECLAMPSIA SUPERIMPOSED UPON CHRONIC HYPERTENSION	Pre-eclampsia superimposed upon Chronic hypertension	superimposed pre-eclampsia	Pre-existing hypertensive disorder with superimposed proteinuria	Pre-eclampsia superimposed on chronic hypertension	Pre-eclampsia superimposed on chronic hypertension

2.2.2 Hypertension

A systolic reading of ≥140mmHg and/or a diastolic of ≥90mmHg is classed as hypertension (Shennan & Halligan, 1999; NHLBI, 2003; BHS, 2004; AHA, 2005).

2.2.3 Pre-existing hypertension

The recording of or known presence of hypertension prior to conception or before 20 weeks gestation is classed as pre-existing hypertension (or chronic hypertension). Thus, some pregnant women have a pre-existing hypertensive disorder diagnosed and managed with antihypertensive

medication prior to pregnancy or hypertension is recorded for the first time during pregnancy prior to 20 weeks gestation (Shennan & Halligan, 1999; Meher & Duley, 2005). The incidence of pre-existing hypertension in pregnancy has been reported as between 0.6- 2.7% (Roberts, et al. 2008).

2.2.4 Pregnancy induced or Gestational Hypertension

Pregnancy induced hypertension or gestational hypertension is when hypertension is detected for the first time after 20 weeks gestation in the absence of proteinuria (Brown, et al. 2001; Lowe, et al. 2009; Lindheimer, Talylor & Cunningham, 2009; NICE, 2010). Pregnancy induced hypertension has been found in 4.2-7.9% of pregnancies, (Roberts, et al. 2008) or up to 15% of pregnancies, (Anumba, Lincoln & Robson, 2009). This would include hypertension occurring during labour or within 48 hours of delivery (WHO, 2008) in a woman whose blood pressure had remained within normal limits throughout pregnancy. With gestational hypertension the maternal and fetal outcomes are usually normal, as long as there is an absence of pre-eclampsia (Gibson & Carson, 2009). However, careful surveillance and monitoring are required as gestational hypertension can lead to pre-eclampsia. Anumba, Lincoln & Robson (2009) suggested that between 15-30% of women with gestational hypertension develop pre-eclampsia.

2.2.5 Pre-eclampsia

Hypertension and proteinuria detected for the first time after 20 weeks gestation is pre-eclampsia. The incidence of pre-eclampsia has a reported range 2% to 8% of pregnancies depending upon the definition used and the population studied (WHO, 1988; Dawson, et al. 2002; Jacobs, et al. 2003; Lee, O'Connell & Baskett, 2004; Roberts, et al. 2005; Lawler, et.al. 2007). Pre-eclampsia is a pregnancy specific multisystem disorder and is more common in primigravida, 4.1% as opposed to 1.7% in subsequent pregnancies (Hernandez-Diaz, Toh & Cnattingius, 2009). The pathogenesis of the disorder is not fully understood but is associated with abnormal vasoregulation, hyperaggregabiltiy of platelets, with activation of the coagulation system and endothelial cell dysfunction that results in hypoperfusion of multiple organs (Roberts & Cooper, 2001). Therefore, it is possible for the disorder to affect the maternal kidneys, liver, brain and placental blood flow. This means that some women will present with predominately renal features whereas others could have hepatic and thrombocytopenic or neurological features (Brown & de Sweit, 1999).

2.2.6 Eclampsia

Eclampsia is an acute and life threatening complication of pregnancy. It is characterised by the occurrence tonic-clonic convulsions usually in a woman who has been suffering from severe pre-eclampsia (Roberts & Cooper, 2001; Meher & Duley, 2005). The convulsions cannot be attributed to other causes such as epilepsy or a brain tumour. The

convulsions normally occur after 22 weeks gestation or during delivery but up to one third of women have eclamptic convulsions in the first 48hours following delivery of the infant (Roberts, et al. 2003). Katz, Farmer & Kuller (2000) identified that in some cases a headache was the only warning sign of severe pre-eclampsia or eclampsia. Hypertension occurred during or after eclamptic seizures with results from previous blood tests for liver function and platelet levels within normal limits. Table 2.4 complied from data provided by two studies conducted to determine the incidence of eclampsia in the UK provides some indication as to the number of women who do not present with the classical symptoms of hypertension prior to a convulsion. This appears to be around 12%. It also identifies the number of women who suffered from eclampsia in 2005 in the UK and when the convulsions occurred.

Table 2.4 Eclampsia in the UK

Year	Cases	Timing of eclamptic fit			Maternal Mortality rate	Presence of classical signs and symptoms		
		A/N	I/N	P/N		Hypertension Only	Hypertension & proteinuria	Hypertension absent
** 1992	383	38 %	18 %	44 %	4.9/ 10 000	22%	57%	11%
* 2005	295	45 %	19 %	36 %	2.7 / 10 000	48%	38%	12%

Key A/N = antenatal period I/N = intranatal P/N = Postnatal
*Compiled from Knight * (2007) and Douglas & Redman ** (1994)*

2.2.7 Pre-eclampsia superimposed upon pre-existing hypertension

A pregnancy for a woman with a pre-existing hypertension can be further complicated by pre-eclampsia. This is known as pre-existing hypertension with superimposed pre-eclampsia. It is recommended that the differentiation between chronic hypertension and pre-eclampsia

should be identified (NHLBI, 2003; BHS, 2004; SOGC, 2008; Lindheimer, Taylor & Cunningham, 2009). Pre-existing hypertension superimposed with pre-eclampsia occurs in 20-25% of women with chronic hypertension (Gibson & Carson, 2009). Several studies (Davies, et al. 1970; Reiss, et al. 1987; Sibai, et al. 1995; McCowen, et al. 1996; Odegard, et al. 2000; Stamilio, et al. 2000), identified hypertension as a risk factor for pre-eclampsia. A systematic literature review by Duckitt & Harrington (2005) found a diastolic blood pressure above 80mmHg at the first antenatal visit is predictive of pre-eclampsia. It has been identified that chronic hypertension in general is a cause of heart failure, cerebral vascular accidents, renal and eye problems (WHO, 2003; WHO, 2005a). In pregnancy chronic hypertension particularly when superimposed with pre-eclampsia is associated for the mother with higher incidences of placental abruption, acute renal failure, cerebral accident. For the fetus, the incidence of growth retardation and unexplained mid trimester fetal demise is higher.

The age of the mother, duration and control of the hypertension, obesity and the presence of end organ damage correlate to the degree of risk for the above-mentioned complications (Lindheimer, Taylor & Cunningham, 2009). Thus, appropriate surveillance and management of the hypertension in pregnancy are vital. However, the approach to treatment has been controversial as opinions vary particularly whether or not mild to moderate pre-existing hypertension should be treated or not (Lindheimer, Taylor & Cunningham, 2009). The NHBPEP (2002);

ACOG (2002); Lowe, et al. (2009) recommend that antihypertensive treatment is not given unless the diastolic pressure is ≥100 or systolic pressure is ≥150 unless there is evidence of end organ damage or other risk factors such as underlying renal disease. This is because there has been no proven reduction in the risk of superimposed pre-eclampsia, preterm delivery, placental abruption or perinatal death or stroke, (Abalos, et al. 2007) and the antihypertensive treatment may result in an increased incidence of fetal growth restriction (von Dadelszen & Magee, 2002).

Crucial to the detection, monitoring and management of hypertensive disorders in pregnancy is an accurate blood pressure measurement. Appropriate monitoring informs management decisions aimed to reduce maternal and neonatal mortality and morbidity.

2.3 Blood pressure and the effect of pregnancy on blood pressure

A BPM involves measurement of systolic and diastolic pressure and readings are measured in millimetres of mercury and reflect arterial blood pressure. Arterial blood pressure facilitates blood flow around the body providing an adequate blood supply to the tissues. This ensures that oxygenation of cells, organs and tissues occurs thus guarantees their survival. Systolic pressure is the measurement taken when the arteries contain the maximum amount of blood during contraction of the left ventricle the time of the highest pressure. Diastolic pressure is the pressure exerted on the arterial walls during ventricular relaxation and

is the stage when the vessels contain the least amount of blood and hence the pressure is at its lowest (Johnson & Taylor, 2000; Tortora & Grabowski, 2002). Increased blood volume leads to increased pressure and vice versa if there is a decrease in volume. Friction between the blood and walls of the vessels leads to resistance to blood flow and has an impact on blood pressure known as vascular resistance. The lumen of the blood vessel, blood viscosity and total blood vessel length are factors that can impact on vascular resistance. Increases in resistance raises blood pressure and decreases leads to the opposite effect (Johnson & Taylor, 2000; Tortora & Grabowski, 2002).

Pregnancy requires physiological adaptation of the maternal cardiovascular system. The changes are made to accommodate the increase in oxygen requirements due to the growing fetus, placenta and hypertrophy of maternal tissues. The physiological changes to the cardiovascular system start in early pregnancy, the majority completed by the end of the first trimester. The most important of these haemodynamic changes in a normal pregnancy are, an increase in blood volume by 50%, increase in cardiac output by 40% and a decrease in peripheral vascular resistance (Stables & Rankin, 2005). Blood pressure as a general pattern in a normal pregnancy is reduced by 5 – 10mmHg. There is usually a slight decrease in systolic blood pressure accompanied by a greater decrease in diastolic pressure. This decrease is at its lowest at mid-pregnancy and then returns to around non-pregnant levels at term. Due to this normal physiological response

to pregnancy, in some instances, it leads to the masking of a hypertensive disorder in a woman with undiagnosed pre-existing hypertension. When the blood pressure rises during later pregnancy and then becomes abnormal a misdiagnosis of gestational hypertension can occur (Lindheimer, Talylor & Cunningham, 2009). During labour, blood pressure will rise, (especially during a contraction), in conjunction with the increase in cardiac output at this time (Blackburn & Loper, 1992; Stables & Rankin, 2005).

Apart from the gestation of pregnancy blood pressure is affected by many factors, including, age, parity, ethnicity, time of day, (morning, evening or night), posture, (sitting, standing, lying), smoking, obesity, levels of activity, (awake, asleep, exercising resting), environment (hot, noisy, cold). The effects that the activities of daily living have upon BPM are shown in table 2.5.

Table 2.5 Effects of activities of daily living on blood pressure

	INCREASE IN BLOOD PRESSURE (mmHg)	
ACTIIVTY	**SYSTOLIC PRESSURE**	**DIASTOLIC PRESSURE**
Getting dressed	↑ 12	↑ 10
Eating	↑ 9	↑ 10
Talking	↑ 7 -17	↑ 7 -13
Working	↑ 16	↑ 13
Travelling to work	↑ 14 -16	↑ 9 -13
Reading	↑ 2	↑ 2
Watching television	↑ 0.3	↑ 1
Talking on the telephone	↑ 10	↑ 7
Doing everyday tasks	↑ 11	↑ 7
Acute exposure to cold	↑ 11	↑ 8
Acute ingestion of alcohol	↑ 8 for ≤ 3hrs	↑7 for ≤ 3hrs

(adapted from Campbell and McKay 1994; McAlister and Straus 2001)

Blood pressure is dependent on heart rate, stroke volume and peripheral resistance, which constantly fluctuate due to the physical and

emotional state of the individual at any one time (Shennan & Halligan, 1999). These fluctuations are normal and health professionals need to consider how these variables impact upon readings in order to obtain an accurate BPM. As a key diagnostic test for the detection of hypertension in pregnancy BPM for the clinician is an inexpensive, convenient and a relative easy to use non-intrusive screening procedure. With chronic hypertension, an elevated blood pressure is a pathophysiological feature. Whereas in gestation hypertension or pre-eclampsia, it is a surrogate marker or sign of the underlying disorder. The degree of hypertension can be an indication of the severity of the maternal condition. Systolic BP levels of 160mmHg increase the risk of cerebral haemorrhage a leading cause of maternal death in pre-eclampsia. In addition, the risk of perinatal morbidity is increased once diastolic pressures reach 90mmHg and intermittent elevations of systolic pressures have been identified at risk markers for the development of gestational hypertension (SOGC, 2008). Thus, increases in BP levels should act as a trigger that ongoing follow up will be required. The identification of hypertension should alert the clinicians to be vigilant to the possibility of eclamptic convulsions and indicates the woman and her fetus are at an increased risk of maternal and neonatal mortality and morbidity and require careful surveillance.

*2.*4 Antenatal care and guidelines for hypertensive disorders

One of the aims of antenatal care is to recognise any deviations from the normal such as gestational hypertension, pre-eclampsia or fetal growth restriction. Blood pressure measurement is an integral part of care throughout the whole of the childbirth continuum. Antenatal guidelines from National Institute for Clinical Excellence (NICE, 2003, & 2008) and the Action on Pre-eclampsia group (APEC, 2009) recommend that blood pressure should be checked at each antenatal visit. In normal pregnancies, for example, routine antenatal care should consist of ten antenatal appointments for nulliparous women and seven for parous women (NICE, 2008).

Unlike the inconsistency in the terms used to classify hypertensive disorders, there is consistency within published guidelines and literature with regards to the threshold levels of blood pressure to indicate when actions should be initiated (Shennan & Halligan, 1999; NHLBI, 2003; AHA, 2005; PRECOG, 2004; BHS, 2004; WHO, 2008; APEC, 2009; NICE, 2010). This threshold is a BP of a systolic or diastolic of ≥140/90 for hypertension and the severe hypertension threshold of systolic ≥160mmHg or a diastolic of ≥110mmHg.

Despite the existence of published guidelines this does not guarantee their implementation into clinical practice. In relation to how guidelines are utilised in clinical practice it appears that there could be a dichotomy between the narrative, (meaning advice from guidelines) and clinical

practice. Bateman-Webb (2006) found that an NHS Trust's hypertension guidelines were not utilised by maternity staff despite being widely available. In addition, the participants commented on the need for more comprehensive guidelines, better education and the importance of uniformity and standardisation of practice. Furthermore very few respondents identified the importance of accurate BPM despite highlighting the value of using the clinical evidence in diagnosis. These results have to be interpreted with caution and cannot be generalised to all maternity units as this was a small research study of 28 participants (18 midwives and 10 doctors).

.

The failure to implement and utilise guidelines for hypertension can have significant consequences. In the UK, substandard care of pre-eclampsia contributes to 80% of maternal and 65% of fetal deaths (CESDI, 1999; & 2000; DOH,1998; Drife & Lewis, 2001; DH, 2004; Lewis, 2007). When substandard care has been identified within these reports, it is related to the failure of health professionals to identify and act upon known antenatal risk factors at the beginning of a pregnancy, not recognising signs and symptoms and thus the appropriate management was not initiated. In relation to identified aspects of inferior care and BPM, the reports refer to inaccurate measurements, omission of blood pressure measurements or failure to act appropriately on readings (Drife & Lewis, 2001; DH, 2004; Lewis 2007). Whilst it is acknowledged that maternal deaths from hypertensive disorders are not always attributable to substandard care health professionals cannot

ignore the implications that inaccurate measurements and failure to act appropriately contributed to substandard care that resulted in maternal deaths. In addition neither will all women who receive substandard care for a hypertensive disorder in pregnancy die but as discussed at 2.1, there are other consequences in terms of maternal morbidity and neonatal mortality and morbidity.

2.5 Impact of hypertensive disorders on maternity services in England

There are 152 NHS Trusts providing midwifery care in England (Health Care Commission, 2008). In 1989-90, there were 633,500 babies delivered in England; in 2002/3, it was 548,000 and in 2007/08, it had increased to 649,837 (HES, 2009). All these women undergo routine BPMs conducted throughout the childbearing continuum. However, if 8 - 10% of all gestations are affected by hypertension (as identified in 2.1), this suggests yearly up to 64,983 women would be at risk and hence require extra blood pressure measurements, additional care and surveillance. This ongoing increase in the birth rate places increasing pressure on UK maternity services and workforce. In particular, the trend of women over 40 giving birth has increased by over 50% contributing to more complex births (RCM, 2011). This has financial and service implications for the planning and delivery of maternity care.

It has been estimated that in the UK two thirds of referrals to maternal and fetal assessment day units (Anthony, 1992) and a fifth of antenatal admissions (Rosenburg &Twaddle, 1990; Twaddle, 1995) are due to

gestational hypertension and or pre-eclampsia. More recent estimations suggest that 15% (Scott, et al. 1997) or up to a quarter (James & Nelson Piercy, 2004) of antenatal admissions are due to hypertensive disorders. Data collated from information provided to the Hospital Episode Statistics (HES) in England from NHS maternity units provides some additional insight into the impact of hypertension. Table 2.5 summarises these data in relation to maternity admissions during pregnancy and the delivery period for 2008/9 in relation to hypertensive disorders. However, as a woman could have more than one episode of admission, the data does not provide detail on the number of individual cases of women with hypertensive complications.

Table 2.6 Hospital episodes in England for Hypertensive disorders

Classification according to ICD 10 – codes	Non-delivery episodes 2009-10	Non-delivery episodes 2010-11	Delivery episode 2009-10	Delivery episode 2010-11
Pre-existing hypertension complicating pregnancy childbirth and puerperium	2,701	2,654	2,325	2,542
Pregnancy induced Gestational oedema with proteinuria without hypertension	6,354	6,020	2,406	2,282
Pregnancy induced Gestational hypertension without significant proteinuria	13,515	12,971	14,390	14,493
Pre-eclampsia Gestational hypertension with significant proteinuria	7,215	6,514	2,778	13,017
Pre-existing hypertensive disorder with superimposed proteinuria	239	253	333	322
Eclampsia	148	147	476	387
Unspecified maternal hypertension	21,696	19,202	12,128	11,923
Total	*51,868*	*47,761*	*34,836*	*44,966*

However, the statistics do not include pregnant women with hypertension being seen by community midwives in the primary care sector, (the estimation of the number of non-hospital episodes related to hypertension), as this information is not collected at the present time. When hypertension is identified an increase in the frequency of BPM is required, which has been summarised in table 2.6 (NICE, 2010). The accuracy of BPMs from community staff are thus crucial in the initial diagnosis of hypertension and how if these measurements are not accurate impact upon service provision in terms of increased surveillance within day units or hospital admission has not been studied.

Table 2.7 Timing of Blood pressure measurements for pregnant women with hypertension as recommended by NICE Hypertension guidelines 2010

Timing of BPMs	Mild hypertension 140/90 -149/99	Moderate hypertension 150/100 t0 159/109	Severe hypertension 160/110 or higher
Gestational hypertension	Not more than once a week	Twice a week minimum	4 times a day minimum
Pre –eclampsia	4 times a day minimum	4 times a day minimum	More than 4 times a day – clinical circumstances will dictate
Intrapartum BP measurements	Hourly BP	Hourly BP	Continuous measurement
Postnatal regime for women with antenatal Gestational hypertension	Daily for first 2 days Once during days 3 -5 Or as clinically indicated		
Postnatal regime for women with antenatal/ intrapartum Pre-eclampsia	4 times a day while inpatient At least once 3 -5 days after birth On alternate days if BP abnormal for up to 2 weeks after transfer to community care until antihypertensive treatment discontinued and no hypertension present		
Postnatal regime for women with pre-existing hypertension	Daily for first 2 days At least once 3 – 5 days after birth As clinically indicated if hypertensive treatment changed		

To provide a further example of the scope of the impact upon maternity services and health professionals data obtained from HES (2009) for Cumbria and Lancashire Strategic Health Authority, identifies 1675 days of hospital bed use were related to Gestational hypertension

without significant proteinuria and 1563 days of bed use for gestational hypertension with significant proteinuria during the year of 2005/2006. No data beyond 2006 can be accessed from HES about hospital bed use by the Strategic Health Authority. However general data on hospital admission and number or days of bed use for England in 2010/11, shows 16,726 days for women with gestational hypertension without significant proteinuria and 20,365 days for women with significant proteinuria. In addition in this period 20,365 days of bed use are attributed to unspecified maternal hypertension during pregnancy thus accounting for potentially a significant use of health care resources. According to the DH (2010) payment by results tariffs each hospital antenatal admission for a client to be observed costs £787 and an admission that includes investigations costs £892. The tariff for an outpatient consultation with a midwife is £141 and for admission to a day unit the tariff is £324 for observations, increasing to £460 if investigations are conducted. A hospital admission can disrupt the lives of the woman and her family and can be associated with a need to take time off work or incur childcare costs for other children and travel costs.

Women accessing maternity services are cared for by midwives, student midwives, obstetricians, doctors and health care assistants. In some maternity units, a small minority of women may be cared for by medical students. The majority of BPMs for maternity clients would be conducted by midwives or student midwives. In some NHS Trusts, nursing assistants complete a National Vocational Qualification (NVQ)

level 3 or an assistant nurse practitioner course that enables them to measure blood pressure. Their role would be to obtain and record a BPM not to initiate action. The responsibility for clinical interpretation of the measurement remains with the trained health professional.

Midwives are regulated by the Nursing and Midwifery Council (NMC). According to the NMC code (2008a), they are required to provide a high standard of practice and care at all times, being personally accountable for actions and omissions in practice. Student midwives under supervision of their mentor abide by the NMC code. All clinical decisions should be based upon current research or best practice evidence. Obstetricians and doctors are regulated by the General Medical Council (GMC). Registered Midwives and Obstetricians and doctors are required to ensure their knowledge and skills are kept up to date through undertaking continuing professional development activities to maintain clinical competency and be fit to practise (NMC, Prep handbook 2008b; GMC, 2009a). Thus as clinical decisions are made based upon BPMs it is imperative and a professional requirement that the knowledge and skills required to conduct measurements are up to date. Obtaining a BPM initially appears to be a straightforward procedure. However, if certain principles (will be discussed in detail in chapter 3) are not adhered to during the process, the accuracy of the measurement will be subjected to factors that can lead to errors and possible significant consequences such as inappropriate management

of a hypertensive disorder or failure to identify hypertension (O'Brien, et al. 2003; Veiga, et al. 2003).

Blood pressure measurement is one of the most commonly performed observations in clinical practice. It can be regarded as a basic or core skill for health professionals. Anecdotal evidence would suggest that once the technique has been mastered a person's ability to conduct the skill accurately appears to be taken for granted and never questioned. Mandatory continuing education for maternity staff usually includes topics such as, adult life support, fetal cardiotocograph monitoring and emergency drills for obstetric emergencies. These sessions may include the importance of obtaining a blood pressure measurement and the clinical significance of the reading obtained but do not address aspects that impact upon accuracy of measurement. Despite blood pressure being an important diagnostic measurement at present there are no formal requirements for the updating of core skills such as BPM. It is up to individual health professionals to update their knowledge and skills to ensure they obtain an accurate BPM measurement. However, as will be discussed in the next chapter the evidence suggests that there are some controversies with the reliability and quality of current clinical practice in regard to BPM. Evidence indicates that readings are prone to observer and device error and health professionals are failing to take basic precautions that would prevent errors (Perry, et al. 1991; Brown & Simpson, 1992; Guidotti & Jobson, 2005).

CHAPTER THREE

LITERATURE REVIEW OF FACTORS THAT IMPACT ON ACCURATE BLOOD PRESSURE MEASUREMENT

3.0 Introduction

The focus of this chapter is to examine the literature regarding factors that affect accurate measurement of blood pressure. This is followed by a discussion on how this review of the literature informed the aims and objectives of the study.

Blood pressure is a variable haemodynamic phenomenon influenced by many factors as discussed in chapter 2 (section 2.3). Obtaining an accurate BPM can be a time consuming process. It requires a relaxed client and competent operator with the requisite skills and patience. Careless handling of equipment can lead to damage of the tubing, cuff or inflator and the lack of equipment maintenance augments the observer errors (Watson & Lip, 2006). Measurements obtained are dependent upon the accurate transmission of a signal, (Korotkoff sounds or pulse wave), from the client, via a device (sphygmomanometer) to an observer who interprets the results. Errors can occur at any of these interaction points resulting in the recording of an inaccurate measurement, although it has been identified that the observer is the most fallible component with most errors being operator dependant and correctable (Beevers, Lip, & O'Brien, 2001; Stryker, 2004; AHA, 2005). The following sections will discuss the aspects that

affect accuracy of measurement in related to the equipment, observer and client.

3.1 Equipment.

Observers have the option of using manual or automated devices to obtain a BPM. Both methods require the observer to place an inflatable cuff that is connected to a sphygmomanometer on the client's arm. This cuff is inflated and deflated by the observer manually or electronically by the automated device. If using a manual device the observer is required to auscultate Korotkoff sounds via the stethoscope to determine the measurement. The automated device measures oscillations, the variations in the amplitude of pulsations of the arterial wall producing a digital display of the BPM.

A fundamental requirement for blood pressure measurement is an accurate device (Beevers, Lip, & O'Brien, 2001). With any device manufactured for a particular purpose, there is an expectation that it is fit for purpose. Thus, in this instance observers would expect that if used correctly, a BPM device would produce an accurate measurement. In addition, devices available for clinical use would comply with any requirements for regulatory validation or certification.

3.1.1 Standardization of equipment

Standardization protocols for instruments that measure blood pressure were first introduced in 1917 by the USA Bureau of Standards. Today certification of medical devices in the United States comes under the

responsibility of the Food and Drug Administration working through the Association for the Advancement of Medical Instrumentation (AAMI). Many of the automated devices available for purchase in the U.K. are manufactured by American Companies. Safety and basic accuracy requirements for U.K. blood pressure devices are governed by European Directives (EN1060 1-4). There is a legal requirement for devices to obtain EU certification through the CE mark (European Conformity Mark) that certifies the device conforms to medical device directives. However, manufacturers can choose various methods to demonstrate compliance with the essential requirements of the directives and do not have to comply with a recognised validation protocol (MHRA, 2005a). Therefore, whilst an oscillometric (automated) device may have a CE mark it should not be assumed that it is automatically suitable for use in diagnosis of hypertension (MHRA, 2005; MHRA, 2008). Sims, et al. (2005) found that out of fifty seven automated devices available on the European Union market that had a CE mark only 40% had evidence of some form of clinical validation. Thus, whilst it could be argued that the use of an automated device could eliminate operator error there are issues about their clinical suitability for use in pregnancy.

Prior to 2005 the EU standards did not specify the size or composition of the population group on which accuracy tests had to be conducted. Amendments that determine the minimum criteria for the size and composition of population groups were made in 2005 to EN-1060-3.

The importance of population groups for accuracy testing of BPM devices is discussed in section 3.1.2. Scrutiny of the accuracy validation results is at the discretion of the notified body and there is no requirement for validation results to be placed in the public domain (NHS, 2008). The Medical Device Agency (2005) states, that NHS and other healthcare sectors should only purchase devices that meet acceptable performance criteria.

3.1.2 Automated BP devices and independent validation

To ensure BPM equipment meets minimum standards of accuracy and performance the British Hypertension Society (BHS) and the AAMI publish validation protocols for BPM equipment (0'Brien, et al. 1993; ANSI/AAMI, 2002). These two protocols have been widely utilised for the independent evaluation of accuracy of blood pressure measuring devices (O'Brien, et al. 2001). In 2002 the European Society of Hypertension (ESH) produced an updated protocol called the International protocol (IP) and this has since been utilised for newer devices (O'Brien, et al. 2002). However, whilst the AAMI and BHS validation protocols meet the minimum criteria of the EN-1060-3 (2005) amendments, the ESH IP does not (NHS, 2008). The ESH International Protocol was revised in 2010 (O'Brien, et al. 2010) and the criteria required to achieve a pass standard has been raised to ensure only the most accurate devices are recommended for clinical use. However, it is not mandatory for a device to comply with these independent validation standards (MHRA, 2006a) and the absence of a successful

independent validation does not preclude the device being available for purchase.

To achieve a pass standard through independent validation tests the BHS protocol requires 80% of measurements (systolic and diastolic) to be within 5mmHg and 90% within 10mmHg (Reinders, et al. 2003). The AAMI pass standard is a mean difference of 5mmHg with a standard deviation of 8mmHg or less (White, et al. 1993). The IP from the ESH requires 65, 80 and 95 out of the 99 measurements taken to be accurate at 5, 10 and 15mmHg respectively (O'Brien, et al. 2002). Thus even with an independently validated device awarded a pass grade 20-34% of measurements could be inaccurate by 5mmHG and 10 -20% inaccurate by 10mmHg. The WHO (2005b) advises that users should be aware that device validation does not guarantee that a reliable measurement will be obtained for all patients. Wan, et al. (2010) concluded from a systematic review of validated automated BP devices, that there was no guarantee of their accuracy in clinical practice following validation by current protocols. When the same device was tested by each of the current different protocols (AAMI, BHS, ESH-IP) the results varied significantly. Devices could pass the rigorous protocols with a few as 60% of readings within 5mmHg of the observed value. Wan, et al.(2010) recommend that it is essential that clinicians undertake multiple readings, to ensure diagnostic and treatment decisions are based on accurate information.

The process used by automated devices to determine measurement affects their accuracy. The oscillometric method of BPM relies upon the detection of variations in pressure oscillations which are caused by movement of the arterial wall (MHRA, 2001). This provides an accurate value for mean arterial pressure. Systolic and diastolic pressure can only be estimated because the oscillations begin above systolic and there is no indication for the instant when cuff pressure passes diastolic pressures. Thus, an algorithm is needed to estimate systolic and diastolic pressures which is normally based upon a specific population group, (in general adults over the age of 30). Manufacturers devise their own chosen end points for the machines and the algorithms are zealously guarded. Therefore, differences in blood pressure measurements occur between different products depending on the specific population group chosen for the algorithm (Geddes, 1991; NHS, 2008). There can be a systematic difference of 10mmHg between devices due to algorithm differences (Sims, et al. 2005b). The European Society of Hypertension recommends that the accuracy of all blood pressure measuring devices should be validated through independent evaluation and not based on the claims of manufacturers (O'Brien, et al. 2003; Tholl, et al. 2004). Only those devices which achieve a high grade of accuracy for both systolic and diastolic blood pressure are recommended for clinical use.

Several authors (O'Brien, et al. 2001; Thomas, Radford & Dasgupta, 2001; Markandu, et al. 2002; Sims, et al. 2005b; WHO, 2005b)

confirmed that very few automated devices being used in clinical practice have been validated according to the BHS protocol or American Standards. O'Brien, et al. (2001) identified two out of hundreds of commercially available automated devices that could be recommended for clinical use. The WHO (2005b) suggested that out of 500 blood pressure measuring devices available on the market, only 10% had been independently validated. There are inconsistencies between the manufacturer's claims of diagnostic suitability and clinical validation (Simms, et al. 2005b). Some of the claims were related to earlier or similar products and not the specific product being offered for sale. Pickering, et al. (2005) stated that sometimes manufacturers make alterations to models after validation with alterations to the measurement algorithm not identified and thus the original validation tests may no longer be relevant. Clinicians can access up to date information about blood pressure measuring devices from two websites, the BHS (2009, 2012) and an independent site established by Dabl Educational Trust DABL (2011). These sites provide details of BPM devices in particular their suitability for clinical use, the results of any independent validation tests performed and the identification of discontinued devices. If the people responsible for the purchase of BPM equipment are not aware of the above issues the implication is that inappropriate equipment will be purchased and utilised. Thus, increasing the risk of obtaining inaccurate readings from maternity clients and could lead to incorrect management. It is not possible to determine how many clinicians are aware of the issues around the

accuracy of automated devices or consult these sites prior to purchasing equipment.

3.2 Accuracy of automated BP devices for use in pregnancy

As stated, algorithms devised for automated devices are based on specific populations that normally exclude pregnant women. Validation studies assessing the suitability of an automated device using a population of pregnant women are scarce and those using population groups of women with hypertension disorders in pregnancy even rarer. Due to the physiological changes associated with pregnancy, (as discussed at 2.3), generally automated devices produce inaccurate measurements when used on pregnant and hypertensive pregnant women. The vast majority underestimate blood pressure by a mean of more than 5mmHg (Franx, et al. 1994; Quinn, 1994; Gupta, et al. 1997; Reinders, et al. 2005). Manufacturers do not clearly identify that a device is unsuitable for use in pregnancy. Product information leaflets fail to specify which population groups the validation tests have been conducted upon or confirm if the device has passed, failed or undergone independent validation testing (Gupta, et al. 1997).

A lack of awareness of these validation issues by health professionals identifies the potential for confusion and misuse of devices within clinical settings. The 'Welch Allyn Vital Signs' monitor was the first automated device validated as suitable for robust clinical use in pregnancy but was found to be inaccurate for women with pre-

eclampsia. The device significantly under-recorded readings and thus for women with severe hypertensive disorders it was recommended that BPM should be taken using a mercury sphygmomanometer (Reinders, et al. 2003). This Welch Allyn Vital Signs device is no longer recommended for clinical use and failed the ESH IP tests (BHS, 2009).

In 2003 Reinders et al. found that of 400 automated devices on sale in the UK only ten had been validated for use in pregnancy. Of the 10 five met the criteria of the BHS validation protocol. Two of the devices were ambulatory, two made for self-measurement and one a wrist device. Thus in 2003 no suitable automated validated device for routine clinical use in pregnancy was available. Furthermore only one of the devices was shown to be accurate in pre-eclampsia. According to the BHS (2009) device list there were two devices validated for use in pregnancy and pre-eclampsia.

The accuracy of a measurement obtained from an automated device is reliant upon the accurate interpretation of the amplitude of the oscillations. This depends upon several factors not just blood pressure. Shivering, coughing, seizures, movement, muscle tremors or talking can produce an inaccurate measurement. Extremes of pulse rate and blood pressure can affect the readings. For example, someone in a state of shock with corresponding vasoconstriction means the pulse oscillations will be small and difficult for the monitor to detect (Burton, 2000). Pregnancy itself causes haemodynamic changes as discussed

in chapter two (2.3). Pre-eclampsia is associated with increased vasospasm and reduced circulatory volume resulting in reduced oscillations of the arterial wall. This can result in possible underestimation of the blood pressure measurement if it is obtained through an unvalidated automated device (Quinn, 1994; Gupta, et al. 1997). The MHRA (2005) stated that in clinical conditions where oscillometric BPM is inadequate, such as in pre-eclampsia, an alternative method of auscultation or arterial cannulation should be used for BPM. Skirton, et al. (2011) conducted a systematic review of the variability and reliability of auscultatory and oscillometric devices for BPM. The review determined that when the client was hypertensive or hypotensive use of an oscillometric device could have serious repercussions. Thus, in these situations auscultatory devices were more accurate.

The 2001 and 2004 maternal mortality reports (Drife & Lewis, 2001; DH, 2004) raised concerns regarding automated blood pressure measuring devices: - in particular warning of the significant underestimation of blood pressure in women with pre-eclampsia. To avoid inaccurate readings the reports recommended that measurements obtained from an automated device are compared to those obtained by conventional sphygmomanometry at the beginning of treatment (Drife & Lewis, 2001; DH, 2004). The 2007 CEMACH report highlighted for the first time the importance of clinicians ensuring the use of a pregnancy evaluated automated device for BPM (Lewis, 2007).

The original use of the oscillometry technique was for the self measurement of blood pressure in the home and not for clinical use. It was used to provide monitoring of changes to systolic and diastolic measurements; not for the diagnosis of hypertension which requires greater accuracy and precision of measurement. Thus many of the automated devices introduced into the clinical area have been adapted to be used for a purpose for which they were not designed. The eventual phasing out of mercury devices could see an increase in the number of automated devices in the clinical environment (WHO, 2005b). There is a lack of research evidence to ascertain if and which automated devices are being used in maternity services. The lack of available pregnancy evaluated automated devices for purchase and the recommendations from the maternal mortality reports suggest that inappropriate devices are being used clinically.

3.3 Manual BP Devices

3.3.1 Mercury manometers

The mercury device is classed as the 'gold standard' device against which all other devices (manual or automated) are compared for accuracy (Pickering, et al. 2005). The simplicity in the design of the mercury device ensures that there are few parts to malfunction and there are negligible differences in the accuracy of different brands. The absence of mechanical moving parts such as levers or springs means accuracy of measurement is maintained. The device is robust and able to withstand constant use in a clinical environment. Thus, errors

associated with mercury devices unlike automated or aneroid devices are related to the working condition of the manometer and technique of the user. Table 3.2 lists the factors related to errors of the working condition of the mercury manometer.

Due to the known toxic danger of mercury to the environment and individuals regulations regarding its use have been implemented since 1988 (The Health and Safety Executive (HSE) 1988). This has resulted in moves to eliminate the mercury sphygmomanometer from clinical practice (Langford & Ferner, 1999). Since 2007 there has been a restriction in the marketing of products containing mercury and from April 2009 the sale of mercury sphygmomanometers has been restricted to the healthcare sector (Smith, 2008). A total clinical ban is not possible as there is still an ongoing review to identify the availability of an accurate alternative to the gold standard mercury device. However, as will be discussed next there is some evidence that mercury devices are no longer being used in the clinical environment.

Canzanello, Jenson & Schwartz (2001) in the USA reported that due to increasing pressure from the state regulatory and licensing agencies between 1993 and 1998 the Mayo clinic in Rochester replaced the majority of its mercury sphygmomanometers with aneroid devices. Sweden and Finland banned mercury in 1996 and France in 1997 and which resulted in the elimination of mercury sphygmomanometers. There is no research evidence on what instruments have taken the

place of mercury sphygmomanometers in these countries (Aylett, 1999). Neither is there any research evidence as to whether hospitals in the UK have replaced mercury sphygmomanometers. Studies conducted within primary care settings on servicing and calibration check of devices provide some indication in regards to this. Table 3.1 indicates that in 2001/2002 mercury devices were more prevalent that aneroid devices.

3.3.2 Aneroid manometers

Accurate measurement of BP can be obtained from a calibrated aneroid device. However, due to its construction the aneroid device is not as robust as the mercury manometer. It is prone to mechanical alterations that affect accuracy (O'Brien, & O'Malley, 1981; Perloff, et al. 1993; Beevers, Lip & O'Brien, 2001). The mechanics of the aneroid manometer are more intricate than the basic hydrostatic mechanics of the mercury manometer. Accuracy is affected as the system of bellows and levers are affected by the jolts and bumps encountered during normal use, which then restricts movement. A fixed wall mounted aneroid device could be less susceptible to trauma and thus more accurate than a mobile device. Loss of accuracy over time and or a lack of regular calibration testing leads to aneroid manometers tending to underestimate BP (Bailey & Bauer, 1993; O'Brien, et al. 2005). Re-calibration is required when the readings from an aneroid manometer differs from the standard mercury manometer by 4mmHg (AHA, 2001; O'Brien, et al. 2003). It is recommended thatt yearly servicing for

mercury and automated devices and aneroid devices twice a year is undertaken (MHRA, 2006a).

3.4 Servicing and calibration checks of blood pressure devices

The prevention of erroneous measurement through regular maintenance calibration and servicing checks for blood pressure devices has been recommended for many years (Burke, et al. 1982; AHA, 2001; NHLBI, 2003; O'Brien, et al. 2003; Pickering, et al. 2003; BHS, 2004; MHRA, 2005a; NHS, 2008).

In the UK within General Practice (GP) settings routine servicing and calibration testing of blood pressure devices has been found to be substandard. Hussain & Cox (1996) found 23% out of 1223 GP's never had their instruments serviced. Maskrey, et al. (1999) found 40% of practices could not recall when their sphygmomanometers were last tested. Knight, et al. (2001) found that out of 472 sphygmomanometers 91% had no service history. Rouse & Marshall (2001) found formal arrangements for regular servicing and calibration testing were not in place for 217 GP practices in Birmingham and 53 out of 54 GP practices from England and Wales The results indicated sphygmomanometers had not been serviced or calibrated for years.

This lack of servicing and calibration testing is not just confined to primary care areas, as studies conducted in hospital settings concur with these findings, (Carney, et al. 1999), in Australia and from the UK (Burke, et al. 1982; Markandu, et al. 2000; Thompson, Gillespie &

Curzio, 2002). The study by Markandu, et al. (2000) varies from others through the inclusion of ascertaining staff awareness of the requirement for BPM devices to be regularly serviced and maintained. The authors stated that 'most of the staff' (p33) were unaware that sphygmomanometers needed regular servicing; but no data is provided to quantify the statement or clarify how the information was obtained and recorded. A recent study by de-Greeff, et al. (2010) found a quarter of 127 BP devices including a selection of mercury, aneroid and automated devices at a tertiary care teaching hospital in London with unacceptable calibration errors.

Results of studies conducted in the UK and Ireland that have included calibration testing to determine the accuracy of sphygmomanometers being used in clinical practice have been summarised in the following table 3.1.

Table 3.1 Summary of studies that have involved calibration testing of manual sphygmomanometers

Study	Setting Country	Number/type of Devices Total in brackets	Mercury number failed accuracy test	Aneroid Number failed accuracy test	Total number failed accuracy test	Number failed by >5 mmHg
Burke et al. 1982	88 GP practices and 2 hospitals including 1 maternity unit Ireland	160 mercury, 50 aneroid (210)	3	15	18 8%	10 Aneroid
De Greeff et al. 2010	Various clinical area in a large London teaching hospital -Including maternity, surgical, medical, orthopaedics, gynaecology, outpatients, ophthalmology, trauma, neurology, geriatrics	18 mercury 62 aneroid 47 automated (127)	1	19	32 (25%) includes 12 (automated devices)	1 mercury 4 aneroid 6 automated
Thompson et al. 2002 *	6 Medical wards from 1 hospital in Glasgow in 1997	22 mercury (22)	5 18%	None included in study	5 18%	Information not provided
Thomson et al. 2002 *	7 Medical wards from 1 hospital in Glasgow in 2000	24 mercury & 1 aneroid (25)	9 32%	No information provided	9 32%	Information not provided
Rouse & Marshall 2001*	231 GP practices in England	949 mercury 513 aneroid (1462)	Not differentiated	Not differentiated	277 19%	134
Knight et al. 2001	86 GP practices In England	246 mercury 111 aneroid (472)	45	66	111 23.5%	Information not provided
Ashworth et al. 2001	32 GP practices in London	130 mercury 61 aneroid (191)	3	9	12 6%	Information not provided
Waugh et al. 2002	Maternity hospital in England	31 mercury 36 aneroid (67)	4	25	29 43%	21
Ali & Rouse 2002*	15 GP Practices in England	92 mercury 39 aneroid (131)	Not differentiated	Not differentiated	22 17%	5

***Indicates studies that used a tolerance of within 2mmHg**

Some studies (Markandu, et al. 2001; Thompson, Gillespie & Curzio, 2002), lack details of how calibration testing was conducted. Therefore, it cannot be determined if the testing was completed according to set protocols related to established guidelines and standards. Neither is there a consistent utilisation of the standard definition of tolerance for accuracy. The studies highlighted by a star used a tolerance of “within 2mmHg” for calibration assessment, the others used “within 3mmHg” (de Greeff et al. 2010) or “4mmHg”.

As can be determined from table 3.1 between 6% and 43% of BPM devices would have provided erroneous readings due to inaccuracy of calibration. The clinical implications of this is the under or over estimation of a BPM and possible subsequent mismanagement. With the increasing pressures on the NHS services concerns around the health cost of mismanagement in terms of staff time as well as financial costs will become more of an issue. The funding of NHS services from 2003 was by payment being received for every episode of care provided to a client, such as each inpatient episode, scan or hospital visit. So in essence the more clinical interventions the more the hospital was paid. However from 2013 a new payment by results pathway system came into force, one standard payment is received for each of the three stages, antenatal, intranatal or postnatal care. The women are categorised onto one of three levels, standard, intermediate or intensive. Thus, women with hypertension or at risk of pre-eclampsia who require extra monitoring come under the intermediate category and

the provider of care receives £1,803 for the client instead of £1,126 for standard antenatal care, regardless of the number of additional visits, tests or hospital admissions. The previous system led to wide variations in the amount NHS Trusts received for providing maternity care and it was felt that the payment system did not act as a sufficient lever for quality review and thus existing patterns of referral and care have not being challenged (NHS, 2012). Thus, with the new system the emphasis for providers of NHS maternity care will be to deliver a high quality proactive maternity service that prevents the onset of avoidable conditions or complications (DH, 2012). The intention is to improve the quality of referrals and primary care provision and reduce unnecessary interventions (NHS, 2012). Inaccurate high BP readings due to faulty device and or measurement technique could lead to the woman requiring follow up BP surveillance. Thus, unnecessary additional visits by the community midwife or attendance at the maternity day unit for BPM and or blood tests or ultrasound scans, plus referral to an obstetrician, need to be avoided as additional payments will not be received. In addition, for the pregnant woman unnecessary anxiety could be caused if a woman is incorrectly informed she has developed hypertension in pregnancy and superfluous ongoing surveillance could have implications in terms of travel costs such as child care issues and having to arrange unnecessary time off work.

The studies summarised in table 3.1 highlight the importance of regular maintenance and calibration checks to ensure the accuracy of devices.

The results also identify that when differentiated into mercury and aneroid it would appear that aneroid devices are more likely to be inaccurate due to the lack of robustness of the hydrostatc mechamsim as discussed at 3.3.2.

Several authors (Perlman, et al. 1970; Fisher, 1978; Bowman, 1981; Burke, et al. 1982; Jones, et al. 1987; Mckay, et al. 1990; Bailey, Knaus & Bauer,1991) have conducted investigations specifically into the accuracy of aneroid sphygmomanometers thorough calibration testing. The studies included devices used in hospital practice and primary care settings. The results show the percentage of intolerance for devices ranges from 22%, to as high as 69.9%. A manometer would be classed as intolerant when there is a deviation of a set level of mmHg in readings obtained between the test device and control device during calibration testing. Ranges for levels of intolerance vary from ± 2mmHg to ±5mmHg. As these studies all used different criteria for their definition of level of intolerance an accurate estimation of instruments producing erroneous measurements is not possible from the data. There is also variation of methodology used to gauge accuracy and in addition a failure to exclude observer bias, the use of static calibration testing and failure to test accuracy across the whole pressure range.

In the USA Canzanello Jenson & Schwartz (2001) conducted a survey to appraise the impact of the introduction of servicing and maintenance on ensuring the accuracy of aneroid devices. Out of two hundred and

eighty three aneroid devices tested four failed, of the four, three were from an area not covered by the policy. This sample represented 17% of a possible 1500 aneroid devices. As there does not appear to be any evidence available to verify whether portable BP devices are more common than wall mounted devices in UK hospital settings, personal experience would suggest that fixed wall mounted devices are not typically found in the majority of UK general hospitals areas. They tend to be located in areas such as ICU, Labour/delivery rooms or antenatal clinics.

3.4.1 Servicing and calibration of BP equipment in maternity settings

There is a lack of evidence from within maternity settings within the UK or worldwide in regards the regularity of servicing and calibration checking of BPM equipment. The Burke, et al. (1982) study included 110 mercury manometers from a general hospital and a maternity unit. However, the results do not differentiate the accuracy of devices for each setting. A weakness of this study's methodology was that the accuracy of the gauge was tested at two pressures 90mmHg and 150mmHg rather than over the entire pressure range. Contradictory to the methodology utilised the authors recommend that calibration testing should be over the entire pressure range, testing against an accurate mercury device (Burke, et al. 1982). Similarly the study by de-Greeff et al. (2010) included devices located within a maternity unit but again the results do not differentiate the accuracy of devices for each setting. The small study by Waugh, et al. (2002) conducted in a maternity unit,

concluded that compared to a mercury device aneroid sphygmomanometers are inaccurate. The authors recommended that aneroid devices required six monthly accuracy checks using dynamic calibration testing across the whole pressure range. A routine servicing or maintenance check of equipment in clinical use should include an inspection for signs of wear and tear or damage that would render the device unsuitable for use. Thus the next section will discuss these factors.

3.5 Working condition of manual BP devices

Manual blood pressure devices have common features and components that can lead to mechanical faults and predispose to pfoducing an inaccurate BPM. These factors have been summarised in the table 3.2 using information from the AHA, 1993; BHS, 1997; AHA, 2001; ESH, 2005.

There are limitations in the previous studies that have assessed the general condition of BP devices. Despite stated objectives in several studies (Carney, et al. 1999; Canzanello, Jenson & Schwartz, 2001; Knight, et al. 2001; Rouse & Marshall, 2001) to indicate that devices were checked for faults such as defects with tubing, bulb, cuff, bladder, connections, legibility of markings, mounts, no specific data is provided in regards to the findings. Rouse & Marshall (2001) stated, that due to their poor physical condition it was suggested that almost 100 devices should be withdrawn from clinical use. Other studies do identify

common defects such as faulty control valves, perished rubber of the tubing or bulb, oxidation of the mercury, markings illegible, incorrect cuffs and bladder size (Burke, et al. 1982; Markandu, et al. 2000; Thompson, Gillespie & Curzio, 2002). Table 3.3 presents a comparison of the number and components that were found to be unsatisfactory.

Table 3.2 Common equipment factors that affect accurate BPM

FACTOR	RESULT	REMEDY
EQUIPMENT		
Date of last service clearly visible on device	Possible inaccurate reading if calibration out or defective parts not replaced	Service and calibration check
MERCURY MANOMETER		
Meniscus not at zero at rest	Inaccurate reading	Replace or top up mercury
Column not vertical	Inaccurate reading	Place manometer on a level surface/ service may be required
Bouncing of mercury with inflation or deflation	Inaccurate reading	Clean tubing and air vent replace mercury/service required
Visibility of meniscus	Inaccurate reading	Clean or replace
Air vent clogged	Inaccurate reading	Clean
Legibility of gauge	Inaccurate reading	Replace
ANEROID MANOMETER		
Needle not at 0 at rest	Inaccurate reading	Recalibrate
Legibility of gauge	Inaccurate reading	Replace
BLADDER /CUFF		
Too narrow for arm	Blood pressure too high	Use cuff length 80% of circumference
Too wide for arm	Unable to fit arm	Use regular but longer cuff
General condition –worn Velcro, clean, etc.,	Wear, unable to secure properly	Replace
Tubing – length	Incorrect placement of manometer if tubing too short – kinking of tubing if too long	Replace
Markings, cuff size, bladder size, arm range, artery centre line	Incorrect placement of cuff, incorrect size of cuff used – inaccurate reading	Replace or mark cuff in indelible ink
Bladder condition rubber not perished or holes	Inaccurate reading Leaks, difficulty with inflation	Replace
INFLATION SYSTEM		
Faulty control valves	Inaccurate reading Difficulty inflating and deflating bladder	Replace
Leaky tubing or bulb	Inaccurate reading	Replace
Incorrect, badly fitting or missing connectors	Leaks in system	Replace
STETHOSCOPE		
Stethoscope ear pieces plugged	Poor sound transmission	Clean ear pieces
Ear pieces fit poorly	Distorted sounds	Angle ear pieces forward
Bell or diaphragm cracked	Distorted sounds	Replace
Tubing too long	Distorted sounds	Length from ear piece to bell should be 12 – 15 inches (30 -38cm)

Table 3.3 Comparison of Equipment study results (N/R = not reported)

Study ( ) = total number of devices	Pump Bulb	Control valve	Cuff dirty	Cuff missing	Wrong bladder size	Worn cuff	Cuff and bladder worn and incorrect bladder dimensions	Tubing perished	Connectors missing or faulty	Markings illegible	Pointer or mercury not at zero	Oxidation of Hg or dirty columns
Burke et al. 1982 160 mercury, 50 aneroid (210)	15	141	N/R	N/R	N/R	N/R	15	30	N/R	93	N/R	135
Thompson et al. 2002 (1997 survey) 22 mercury (22)	2	6	N/R	2	N/R	11	N/R	5 cuff tubing 4 manometer tubing	N/R	3	4	8
Thomson et al. 2002 (2000 survey) 24 mercury & 1 aneroid (25)	6	4	N/R	2	N/R	2	N/R	2 cuff tubing 2 manometer tubing	N/R	12	8	3
Markandu et al. 2000 444 mercury 688 cuffs	252	109	177	N/R	7	54	N/R	212 cuff tubing 168 manometer tubing	268	95	244	147

Common defects among aneroid sphygmomanometers include gauges not zeroed, cracked face plates and defective rubber tubing, badly fitting or missing connections and faulty inflation deflation system (Bailey & Bauer, 1993). A common missing factor of these studies (Burke, et al. 1992; Bailey & Bauer, 1993; Markandu, et al. 2000) is what criteria was used to check the equipment and that there is no differentiation between number of faults for each model type that is fixed, portable or hand held. Carney, et al. (1999) does differentiate between wall mounted and portable devices and found portable devices in a better state or repair. However, there is no differentiation between mercury or aneroid devices and specifics of the faults is not provided.

Carney, et al. (1999), Markandu, et al. (2000) and Thompson, Gillespie & Curzio (2002) differ from the other studies in that they included automated devices. Markandu, et.al. (2000), identifies the lack of independent validation of devices and unlike other studies includes a survey of the equipment, observations of staff and administration of a questionnaire. However methodological details of tools or instruments utilised and how the questionnaire was administered, sample selection and ethical approval are not provided. The survey did not include maternity settings.

Thompson, Gillespie & Curzio (2002), compared a repeat assessment of the manual sphygmomanometers located on Medical wards at the

Victoria Infirmary in Glasgow in 2000 with a previous survey that had been conducted in 1997. The 2000 results identified an increase in the number of automated devices available from one to twenty three and a move away from the use of manual devices. Staff indicated the mercury sphygmomanometers whilst still available were rarely used. In addition despite the full servicing of manual devices after the first survey no follow up servicing or calibration checks had been undertaken thus new defects were not identified or rectified. Faults identified were the same as found previously. None of the automated devices in use had been independently validated for clinical use.

O'Brien, et al. (2003) stated that, an accurate device is a fundamental requirement when conducting a BPM and if one uses an inaccurate device attention to methodological detail is of little relevance. The repeated findings of common defects in sphygmomanometers in general clinical use cast doubt on the validity of the BPM obtained by these devices. Visible defects due to wear and tear with use and deterioration of rubber components over time are to be expected. It would appear health professionals using the equipment are unlikely to have the parts or devices replaced promptly as defective equipment were found in every study conducted. The equipment studies identified were all conducted upon BPM equipment being used by the staff. The awareness of staff of the implications of these defects upon accurate measurement or the need for regular servicing has not been determined.

3.6 Stethoscopes

The stethoscope is essential equipment for the manual measurement of blood pressure. It can influence the quality of the sounds that require interpretation by the observer and therefore the reading itself. O'Brien, et al. (1993) state that the quality of the stethoscope is crucial and stethoscopes with badly fitting ear pieces or poor quality diaphragms preclude precise auscultation of the Korotkoff sounds. The stethoscope has not been included in any of the equipment studies discussed in the previous section.

As identified a human operator is required to obtain blood pressure measurements thus the next section will move on to factors affecting accuracy in relation to the client and observer.

3.7 Observer and client factors that affect accurate BP measurement.

In relation to the observer and client there are many factors that can lead to errors within the measurment process which can lead to inaccurate readings. Inadequate preparation of the individual combined with defective equipment and deviation from the recommended technique of blood pressure measurement can result in measurement errors of 10mmHg or more (Campbell & McKay, 1994). Observer error is the major limitation of the auscultatory method of BPM the but the observer is the most critical component in acquiring an accurate BPM (Perloff, et al. 1993; O'Brien, 2003; Pickering, et al. 2005). Petrie, et al. (1986) stated that false readings are prevented if only those observers,

who are fully aware of factors that can impact on measurements measure blood pressure. These factors have been summarized in tables 3.4 factors related to observer and technique and table 3.5; factors related to client preparation, activity and environment.

Table 3.4 Summary of factors affecting accurate measurement of blood pressure due to observer and technique

Factor	Result	Magnitude of increase or decrease of SBP/DBP in mmHg	Literature sources	Recommendation
Digit Preference	Inaccurate reading	Rounding to nearest 5 or 10mmHg	AHA, 2001; AHA, 2005; Campbell et al. 1994(b); Campbell et al. 1994(b); ESH , 2003; McAlister & Straus 2001 O'Brien et al. 1997; Perloff et al. 1993	Record to the nearest 2mmHg
Cut off Bias	Inaccurate reading	Records BP either above or below working threshold	AHA 2001; AHA, 2005; Perloff et al. 1993	Record to the nearest 2mmHg
Fatigue or poor memory	Inaccurate reading	Under or over estimation	AHA 2001, Perloff et al. 1993	Write down reading immediately
Cuff too narrow	Inaccurate reading	↓8mmHg/↑8mmHg (average) studies range from 3.2 2.4 - 12/8 mmHg 30mmHg in obese clients	Campbell & Mckay 1999; ESH , 2003; Lyriboz, Hearon, & Edwards 1994; O,Brien 1996	Use appropriate sized cuff – bladder size length 80% of arm circumference width 40% of arm circumference
Cuff too large	Inaccurate reading	Underestimation 12.7/7.7 average	AHA 2001, AHA 2003; ESH , 2003; Perloff et al. 1993; O,Brien 1996	Use appropriate sized cuff
Cuff not centred	Inaccurate reading	↑4mmHg/↑3mmHg	AHA 2001; AHA, 2005; ESH , 2003;	Use artery centre line marked on cuff
Cuff over clothing	Inaccurate reading	↑ 5 – 50mmHg	AHA 2001; AHA, 2005; Campbell et al 1994(b); ESH , 2003; O'Brien et al.1997; Perloff et al. 1993	Remove arm from sleeve
Cuff too loose	Inaccurate reading	Overestimation	AHA 2001; AHA, 2005, ESH , 2003; Perloff et al. 1993	Rewrap more snugly
Manometer below eye level	Inaccurate reading	Underestimation	AHA 2001; AHA, 2005, Perloff et al. 1993	Place manometer at eye level
Manometer above eye level	Inaccurate reading	Overestimation	AHA 2001; AHA, 2005; Perloff et al. 1993	Place manometer at eye level
Using phase IV (Korotkoff)	Inaccurate reading	Overestimation DBP Phase IV average of 5 – 10mmHg ↑ than Phase V 15mmHg in pregnancy	Campbell et al. 1994(b); ESH , 2003; Duggan 1997	Use Korotkoff Phase V for diastolic reading
Stethoscope head not in contact with skin	Extraneous noise	Misreading of sounds that could lead to under or overestimation	AHA 2001; AHA, 2005; ESH , 2003; Perloff et al. 1993	Place head correctly
Stethoscope head applied to firmly	Inaccurate reading	Underestimation of diastolic	AHA 2001; AHA, 2005; Campbell et al. 1994(b); ESH , 2003; O'Brien et al. 1997; Perloff et al. 1993	Place head correctly
Stethoscope head not over artery	Sounds not well heard	Misreading of sounds that could lead to under or overestimation	AHA 2001; AHA, 2005; ESH , 2003; O'Brien et al. 1997; Perloff et al. 1993	Place head over palpated artery
Stethoscope head touching tubing or cuff	Extraneous noise	Misreading of sounds that could lead to under or overestimation	AHA 2001; AHA, 2005; O'Brien et al. 1997; Perloff et al. 1993	Place below edge of cuff
Inflation level to high	Client discomfort	Causes pain and anxiety could lead to an increase in systolic BP	AHA 2001; AHA, 2005, O'Brien et al. 1997; Perloff et al. 1993	Inflate to 30mmHg above palpatory estimate of systolic pressure
Inflation level too low	Inaccurate reading	Underestimation of systolic	AHA 2001; AHA, 2005; O'Brien et al. 1997; Perloff et al. 1993	Inflate to 30mmHg above palpatory estimate of systolic
Inflation rate too slow	Client discomfort Inaccurate reading	Diastolic pressure overestimated	AHA 2001; AHA, 2005; O'Brien et al. 1997; Perloff et al. 1993	Inflate at an even rate
Deflation rate too fast	Inaccurate reading	Systolic underestimated Diastolic overestimated	AHA 2001; AHA, 2005; Campbell et al. 1994(b); Perloff et al. 1993, Reinders et al. 2006	Deflate at 2 – 3mmHg per second or 2mmHg per beat
Deflation rate too slow	Forearm congestion Inaccurate reading	Overestimation of diastolic pressure -1 to +2/5 to 6	AHA 2001; AHA, 2005; Campbell et al. 1994(b); O'Brien et al.1997; Perloff et al 1993	Deflate at 2 – 3mmHg per second or 2mmHg per beat Completely deflate at end of measurement
Palpatory pressure omitted in BPM procedure	Danger of missing auscultatory gap	underestimation systolic pressure 55/80mm/Hg	AHA 2001; AHA, 2005; Campbell et al. 1994(b); O'Brien et al.1997; Perloff et al. 1993	Follow recommended guidelines for BPM and include and estimation of systolic pressure in procedure

Table 3.5 Summary of factors affecting accurate measurement of blood pressure due to client preparation and environment

Factor	Result	Magnitude of increase or decrease in SBP/DBP in mmHg	Literature source	Recommendation
No resting prior to measurement	Inaccurate reading	Overestimation of blood pressure Varied estimates	AHA, 2001; AHA, 2005; Campbell et al. 1994(a); ESH , 2003; Perloff et al. 1993	Rest quietly for 5 minutes before blood pressure reading
Position of client supine or sitting	Increases from the lying to sitting to standing	2 to 4 mmHg Pregnant women larger differences 10mmHg	AHA, 2001; AHA, 2005; Bhalla et al. 2005Campbell et al. 1994(b) Neeta et al. 1998; Perloff et al. 1993; Whichman, Ryder & Whichman 1994,	Record posture BPM is taken and standardize for an individual
Arm position above or below heart	Inaccurate reading	Average of 8mmHg for every 10cm that arm is above or below heart Arm above –underestimation Arm below – overestimation	AHA, 2001; AHA, 2005; Mourad et al. 2003 Webster et al. 1984, Campbell et al. 1994(b); ESH , 2003; McAlister & Straus 2001: Perloff et al. 1993; Poole 2003: Webster et al. 1984	Midpoint of upper arm should be at heart level
Arm unsupported	Inaccurate reading Causes isometric muscle activity	Overestimation on average of 4mmHg 1 to 7 / 5 to 11	AHA, 2001; AHA, 2005; Campbell et al. 1994(b) ESH , 2003; McAlister & Straus 2001; Neeta et al. 1998; Perloff et al. 1993	Support arm at heart level Avoid isometric exercise
Back unsupported	Inaccurate reading isometric exercise	Overestimation 6 to 10mmHg	AHA, 2001; AHA, 2005; Perloff et al. 1993	Avoid client being seated with no back support Avoid isometric exercise
Legs dangling	Inaccurate reading isometric exercise	Overestimation	AHA, 2001; AHA, 2005; Perloff et al. 1993	Avoid isometric exercise Feet should be flat on floor
Legs crossed	Inaccurate reading isometric exercise	Overestimation 2 to 8 / 2.97	AHA, 2001; AHA, 2005; Perloff et al. 1993	Legs uncrossed feet flat on floor Avoid isometric exercise
Large or muscular arms	Inaccurate reading if correct cuff not used	Overestimation	AHA, 2001; AHA, 2005; Perloff et al. 1993	Use appropriate sized cuff
Talking or signing	Inaccurate reading	Overestimation 7 to 17 / 7 to 13	AHA 2001; AHA 2005; Campbell et al. 1994(a); Campbell & Mckay 1999; McAlister & Straus 2001; Perloff et al. 1993	Avoid any talking by client or observer during measurement
Pain anxiety	Inaccurate reading	Overestimation Can be large	AHA, 2001; AHA, 2005; ESH , 2003; Perloff et al.1993	Ascertain if client in pain or particularly anxious prior to reading
Smoking	Inaccurate reading	Overestimation 6 to 10 /5 to 8	AHA, 2001; AHA, 2005; Campbell et al. 1994(a); ESH , 2003;	Avoid nicotine within 30 mins of BPM
Caffeine ingestion	Inaccurate reading	Overestimation 11/ 5 to 14	AHA, 2001; AHA, 2005; Campbell et al. 1994(a); Perloff et al. 1993	Avoid ingestion of caffeine within 30 mins of BPM
Recent meal	Inaccurate reading	Overestimation 10 to 33 mmHg	AHA, 2001; AHA, 2005; Campbell et al. 1994(a)	Avoid taking a BPM within 30 mins of ingesting a meal
Distended bladder	Inaccurate reading	Overestimation 15 to 50 / 10 to 40	AHA, 2001; AHA, 2005; Campbell et al. 1994(a); ESH , 2003;	Recommend bladder be emptied prior to BPM
Exercise	Inaccurate reading Exertion	Overestimation of up to 30mmHg Underestimation due to post exercise decreases by 18 to 20 / 7 to 9 mmHg	AHA, 2001; AHA, 2005; Campbell et al. 1994(a); ESH , 2003; Perloff et al. 1993	Avoid exertion for 30mins prior to BPM
Cold environment	Inaccurate reading	Overestimation 3 to 6 / 2 to 6 on average Acute cold exposure response 11 to 23 / 8 to 24	AHA, 2001; AHA, 2005; Bhalla et al. 2005; Campbell et al. 1994(a); McAlister & Straus 2001	Allow 30 mins for client to adjust to indoor room temperature before taking blood pressure during cold periods
White coat hypertension	Misdiagnosis	Overestimation 1 to 28 / 2 to 15	AHA, 2001; AHA, 2005; Bhalla et al. 2005; Campbell et al. 1994(a) ESH , 2003; Le Pailleur et al. 1998; McAlister & Straus 2001	More than one reading taken before diagnosing hypertension May need ambulatory monitoring

Observers should be aware that activities of daily living also cause blood pressure to alter as shown in table 2.5 (chapter 2). It is not possible to predict the degree to which stressors increase blood pressure as individuals vary in how they respond to a stressor. Generally the response is related to the type and severity of the stimulus (Campbell, et al. 1994a). Of the aspects summarised in tables 3.4 and 3.5 posture, arm position and cuff size have particular significance for BPM in pregnancy and thus further explanation is provided on these aspects in 3.71 -3.7.3.

3.7.1 Posture, blood pressure and pregnancy

The gravid uterus affects arterial and venous circulation particularly if the woman is in the supine position. The risk of supine hypotensive syndrome is known to midwives and obstetricians. Whilst this syndrome affects 10% of pregnant women, research indicates for all pregnant women the supine position leads to some degree of compression of the vena cava and the aorta (Kelly, 1982). Therefore, BPM for pregnant women should be obtained with the woman in a sitting or left lateral position not supine as this could lead to an underestimation of blood pressure measurement (AHA, 2001; Perloff, et al. 2001; Pickering, et al. 2005).

Overall the research is limited, in regards to health professionals' awareness of the effect of position on BPM or if the recommended positions for measurement are utilised in practice. Perry, et al. (1991)

in the UK found a low level of awareness regarding the effect of position of blood pressure measurement and Duggan & Miller (1998) in Australia report a lack of standardisation for positioning of the pregnant woman for blood pressure measurement.

3.7.2 Arm position

BPM should be taken with the arm at the level of the heart. As can be seen from table 3.4 the arm position affects accuracy of measurement on average by 8mmHg for every 10cm that the arm is above or below heart. If the arm is above the heart this leads to an underestimation and below heart level overestimation of blood pressure. It is important observers know that when the woman is in left lateral position as is often used in labour the inferior arm should be used for measurement as the superior arm will be above heart level (Poole, 2003). There appears to be a lack of research regarding ascertaining if maternity staff are aware of the impact of the arm position upon BP reading. Neither of the studies by Perry, et al. (1991) or Duggan & Miller (1998) asked questions on the effect of arm position.

3 7.3 Cuff size

The use of an inappropriate cuff size is another factor that can lead to under or over estimation of BP. O'Brien (1996) identified a weakness that emerges from the literature with regards to cuff size, that virtually no attention has been directed towards the individual characteristics of the arms in which blood pressure is measured. Demographic features

suggest that recommended optimum bladder dimensions should be based upon the arm circumference of the particular population in which the BPM is undertaken. Conceicao, Ward & Kerr (1976) in the UK found that out of 500 hospital patients 75% of arm circumferences were between 24 and 31.5cm long yet the cuffs in general use in this setting were too small for the arms of more than half of the patients. As the prevalence of obesity in England has tripled over the last 25 years the average diameter of arm circumferences of clients and cuff size becomes more pertinent and it is anticipated by 2050 that 50% of women over the age of 16 in England will be obese (NOO 2012).

National bodies such as the BHS (1997) and AHA (2005), recommend a range of cuffs to cater for all eventualities. However, these two national bodies differ on their recommendations for cuff sizes with regards to bladder width and length (table 3.6). The bladder width and length determines the maximum arm circumference the cuff can encircle properly. Manufacturers classify cuffs by the width of the bladder rather than the length labelling them as ‘newborn’, small adult, adult, large adult or ‘thigh’. Thus, whilst a cuff label may state it is an adult or large adult size as there are no universally agreed national standards of cuff size the actual dimensions can vary. There is no mandatory requirement to produce cuffs based upon recommended sizes of the national bodies. Ideally the size of the bladder should be labelled on the cuff and a line should mark the centre of the bladder with two lines to indicate the range of arm circumferences for which that

particular bladder is suitable. O'Brien (2003) states that users need to label cuffs being used in a clinical setting if they have not been labelled by the manufacturer.

Table 3.6 Recommended cuff sizes

Cuff labelling	Bladder width and length (cm) BHS	Arm circumference (cm) BHS	Bladder width and length (cm) AHA	Arm circumference (cm) AHA
Small Adult/ Child	*12 x 18*	*<23*	10 x 24	22 – 26
Standard Adult	*12 x 26*	*<33*	16 x 30	27 – 34
Large Adult	*12 x 40*	*<50*	16 x 36	35 – 44
Adult Thigh cuff	*20 x 42*	*<53*	16 x 42	45 – 52

Key Blue = BHS Guidelines Red = AHA Guidelines

In the UK Thomas, Radford & Dasgupta (2001) found that out of 48 devices, 17 had an attached cuff of a bladder length of 26cm or more, 31 had cuffs with a bladder length of 22 – 23cm. This was smaller than the recommended standard adult length and would likely undercuff most of the population for which the devices were being used upon. Out of the 48 devices 17 had more than one cuff size available there were only three cuffs with a bladder size suitable for arms with a circumference of > 38cm. Burke, et al. (1982) found cuffs with bladder widths ranging from 11- 13.5cm and lengths of 22cm to 28.5cm. When these cuff dimensions were compared to the AHA recommendations for a standard adult cuff, it was found that the bladder widths for 85% of the cuffs and 94% of bladder lengths were too small.

The increased prevalence of obesity in the USA has led to a larger mean arm circumference (Graves, Bailey & Sheps, 2003; Ostchega, et al. 2006). Jones, et al. (2003) stated that due to increasing obesity in the US population the recommended standard adult cuff is too small for the arm of many adults and larger cuffs should be more widely available. Jones, et al. (2003) suggested the possibility of some negative connotations to the labelling of cuffs as a 'thigh cuff' or even 'extra large' with the potential to prevent or inhibit use on clients for whom it would be the most appropriate size. The increasing body size of populations is not just limited to the United States. In the UK the number of obese adults has doubled since the mid 1980's (National Obesity Observatory (NOO), 2010). The UK Obstetric Survey System (UKOSS) estimated that in 2008 one in every thousand pregnant women was obese (NOO 2010) and an overall incidence rate of between 16-19% of pregnant women being obese is suggested by CEMACH (2010a). Thus, the availability within the clinical environment of a range of cuffs with various bladder sizes is an important issue.

The issue of the lack of availability of large cuffs has been raised in the literature (Conceicao, Ward & Kerr, 1975; Burke, et al. 1982; Perry, et al. 1991; Markandu, et al. 2000; Thompson, Gillespie & Curzio, 2002). The studies by Burke, et al. 1982 and Perry, et al. 1991 reported that staff had no access to large cuffs at all. In the study by Perry, et al. (1991) although staff were questioned regarding access to larger cuffs, there was no requirement forthem to produce the said cuff, to verify

they did have access to it when needed. However, it should be noted that these studies are dated and perhaps do not reflect the current trends in obesity and overweight as significant health concerns. Thompson, Gillespie & Curzio (2002) reported that in only one out of seven medical wards were staff able to produce a large BP cuff upon request. This was despite all the wards being supplied with large cuffs following the results of a similar study conducted in 1997 when it was found that a large BP cuff could only be produced by staff from one out of six medical wards. Markandu, et al. (2000) reported that only nineteen out of eighty two hospital areas which included wards, operating theatres and out-patient departments did staff had access to a choice of cuff sizes. However, no detail is provided regarding how many of these were large cuffs or in which areas they were located.

The literature identifies some difficulties with the availability of different sized cuffs in the clinical arena. There is some indication of a disparity between the recommended cuff size from guidelines and what manufacturers produce. In studies that have included an assessment of cuff size and condition, the results have not always been compared to the BHS recommended cuff sizes. In addition, data regarding appropriate labelling of size and arm range has not been obtained. Whilst the evidence is limited it implies that BPM are being conducted with inappropriate sized cuffs. Only one of the studies is based in a maternity setting (Perry, et.al. 1991). The CEMACH report (Lewis, 2007) found that for some obese women a lack of a suitably sized cuff

led to a delayed diagnosis of pre-eclampsia. This would suggest that the problem of the lack of alternative cuff sizes is not an isolated issue but research evidence is required to confirm this..

3.7.4 Guidelines for the clinical measurement of blood pressure

Published guidelines show general uniformity on how to measure blood pressure clinically (Reeves, 1995; McAlister & Straus, 2001). Guidelines to standardise the technique for blood pressure measurement were proposed in 1939 by joint recommendations of the American Heart Association and the Cardiac Society of Great Britain and Ireland. These guidelines provided guidance to clinicians, researchers and manufacturers. The recommendations have been revised and updated in line with research findings and are recognised and cited worldwide (Naqvi & Blaufox, 1998; Jones, et al. 2003).

3.7.5 Initial education and adherence with guidelines for BPM

Blood pressure measurement is a core competency that all student nurses, midwives and doctors have to achieve as part of the requirements to enter onto their respective professional registers as a qualified practitioner (UKCC, 1999; Fox, Clarke & Dacre, 2000; NMC, 2002; NMC 2004(a); NMC, 2004(b); GMC, 2009b; NMC, 2009; Jones, 2010; NMC, 2010). For health professionals in maternity services as a core assessment skill BPM is essential in the provision of effective care and to meet national guidelines such as NICE antenatal care or hypertension in pregnancy. It is a skill that is performed on a daily basis

by these health professionals and as such there is a standard procedure that should be followed.

Roach (1992) suggests that competence is having the knowledge and skills required to meet the demands of one's professional responsibilities. Thus, competence is something that a person working within an occupational area is able to do. This can be identified through the description of specific actions that a person demonstrates in their performance of their work, through actions, behaviours or outcomes (The Manpower Services Commission, 1988; Mansfield & Mitchell, 1996; McMullan et al. 2003). Therefore, at the point of registration the expectation is that all midwives or doctors practicing in the maternity environment will have achieved competence in BPM. It is not an extended or enhanced skill obtained once qualified.

The skill of conducting a blood pressure measurement is taught early in the education programme of health professionals. Once the skill is mastered formal testing of competency is rare. Retraining, updating and retesting for competency is not a clinical practice requirement. The complex skill requires extensive background knowledge for the procedure to be performed correctly and an accurate measurement obtained.

O'Brien, et al. (2003) suggested that the training of observers in the technique of auscultatory BPM is often taken for granted and

comprehensive instructions are not always provided to nursing and medical students.

The AHA (2001) stated that despite several excellent training programs providing standardized instruction, training and testing for observers, participation of health care professionals to improve and reassess skills is limited. Grim (2002) argued that as yet there has been comparatively little effort made into correcting the deficit in basic professional education with regards to factors that affect accurate BPM. This is despite the considerable research that has been conducted over the last seventy years on human blood pressure measurement. The majority of these identified errors being linked to lack of awareness of standard technique and recognised guidelines.

Grim (2002) found in a survey conducted with Physicians in America that 50% of respondents were not familiar with the AHA recommendations for the measurement of blood pressure. Whilst 45% were aware of these recommendations only 5% had read them from cover to cover. However, an awareness of guidelines does not ensure the reduction in errors of measurement. The recommendations of the guidelines need to be put into practice in the conduction of a BPM. Campbell & McKay (1999) comparing a recommended standard technique with a casual technique of BPM found 42% of the sample population that had been classified as hypertensive using a casual non standard BPM technique were actually normotensive. In addition 15%

of the population that had been classified as normotensive through the casual BPM technique were found to be hypertensive when BP was measured through the recommended standardized technique.

Bogan, et al. (1993) in the USA and Torrance and Serginson (1996) in the UK found that senior nursing students lacked knowledge and skills to perform an accurate blood pressure measurement. Clinical educators rarely or never reinforced the national recommended standards (AHA or BHS) of BPM. The studies were conducted with small samples of students forty two in the USA and fifty one in the UK; therefore, the generalisation of the results to the total student nurse population is not possible. But the results do raise the issue of the competency of students and newly qualified nurses' ability in recording blood pressure measurement. However, one cannot consider the competence of student nurses/midwives obtaining clinical skills without examining the influences and competence of the clinical staff in particular those who mentor those students.

To facilitate a student to acquire competence in accurate BPM the mentor/qualified health professional needs to have the requisite skills and underpinning knowledge demonstrating the application of theory to practice in their BPM technique. There is limited evidenced based literature on the impact that the students' mentor/mentors have on the mastering of the skill. A study by Baillie & Curzio (2009) on student nurse experiences of learning blood pressure measurement found

variations in opportunities to practice, equipment used, level of supervision and self confidence. A sample of 447 first year pre-registration nursing students completed questionnaires following two six week clinical placements. Exposure to using both automated and manual equipment during both placements was only experienced by 158 (36%) of the students. The skill of BPM was not practiced by 27(6%) of students in either placement. Supervision of students by mentors when conducting BPMs was more likely to occur when measuring BP manually. Only 8 (2%) of students were always supervised when conducting BPMs during both placements with 85 (27%) sometimes being supervised and 52 (17%) of students were never supervised conducting BPMs in either placement. Students made comments about how the mentor's technique of BPM varied from what they had been taught prior to placement. This resulted in students being incorrectly advised about the correct technique of BPM by their mentors. This study highlights the importance of evaluating the need for trained staff to be updated and has implications for healthcare education.

It is not uncommon for health professionals to be assessed as a group rather than as individuals to determine a practice competency of core clinical skills. For example studies have assessed communication skills in physicians (Tamblyn, et al. 2007), the inability of nursing students and nurses to perform basic life support (Wynne, et al. 1987; Badger & Rawstorne, 1998), the clinical performance of newly qualified nurses

(O'Conner, et al. 2001) and the competence of technical clinical skills of general practitioners, (Jansen, et al. 1995). Further studies include communication skills in obstetricians and midwives in providing screening advice and interpretation of serum screening (Smith, et al. 1994; Sadler, 1997), midwives clinical practice improvement of four clinical skills (Engels, et al. 2003), and the basic skills of final year medical students (Remmen, et al. 1999). Many studies have used questionnaires as the assessment method to test performance of clinical skills (Wynne, et al. 1987; Smith, et al. 1994; Jansen, et al. 1995; Sadler, 1997; Badger & Rawstorne, 1998; Remmen, et al. 1999; O'Conner, et al. 2001; Bird & Wallace, 2002; Payne, et al. 2002; Engels, et al. 2003; Kemper, et al. 2003; Bartelt et al. 2011). The assessment of how health professionals practice the skill of BPM by using a questionnaire is common in previous studies (Perry, et al. 1991; Brown & Simpson, 1992; Nolan & Nolan, 1993; Villegas, et al. 1995; Ahmed, 1997; Duggan & Miller, 1998; Markandu, et al. 2000).

Therefore, previous research provides some evidence relating to errors of technique, failure to follow recommended guidelines and lack of knowledge in regards to BPM by a number of different health professionals and this is summarised in table 3.7. The research studies identified in table 3.7 focus on some or all of the aspects highlighted as sources of errors by the AHA or BHS guidelines (summarised in tables 3.4 and 3.5). All the studies found that the practice of BPM varied and/or staff knowledge was inadequate about factors critical to accurate

blood pressure measurement. Thus overall the application of knowledge to BP practice was not adequate to prevent the introduction of errors into the measurement.

Table 3.7 Summary of studies conducted on observer knowledge and /or technique of BPM

Study Reference	Sample characteristics	Study design	General Findings	Topics poorly answered or poor technique observered
Armstrong 2001 Australia	78 nurses	Questionnaire	Participants current level of knowledge is not adequate to prevent the introduction of error into BPM	Lacked knowledge on how to assess accurately if cuff was appropriate for arm Incorrect rate of deflation used in practice Arm position Estimation of systolic pressure
Ahmed 1997 Saudia Arabia	195 hospital bases staff 28 consultants 40 doctors 127 nurses	Questionnaire	Poor knowledge of basic BPM techniques Insufficient knowledge was found for 60% of the respondents	Knowledge of correct cuff size Incorrect Korotkoff sound for diastolic Position of the arm Incorrect rate of deflation Rounding off readings
Bhalla et al. 2005 India	80 doctors tertiary care centre India	Prospective observational study	Practice of recording BP varies from standard BHS guidelines	Pre-measurement resting Incorrect inflation pressure No estimation of systolic pressure Incorrect rate of deflation Rounding of reading
Brown & Simpson 1992 *Australia*	*85 Obstetricians* *173 Midwives*	*Questionnaire - 8 questions*	*Considerable variation in way BP is recorded Hypertension in pregnancy being under or over diagnosed consensus needed on how to measure BP*	*6 different methods identified for recording BP* *Position of client* *Cuff selection*
Carney et al. 1999 Australia	37 nurses	Structured interview and assessment through use of a videotape of 12 adult BP	Staff knowledge about manual devices adequate 42% accurate in 9 or more of the 12 videotape BP measurements	Knowledge of cuff size Stethoscope placement
Duggan & Miller 1998 *Australia*	*213 medical and midwifery staff no differentiation in results*	*10 point multiple choice questionnaire*	*Failure of standardisation of method of BPM producing errors of 10-15mmHg*	*Incorrect Korotkoff sound for diastolic* *Positioning of client* *Rounding off reading* *Cuff selection* *Pre measurement resting*
Feher et al. 1992 UK	80 hospital doctors	Questionnaire	Lack of understanding of principles of BPM 1/3rd no formal education in BPM	incorrect deflation rate Rounding off readings incorrect Korotkoff sound for diastolic
Gilespie & Curzio 1998 UK	60 nurses	31 questionnaires 29 individual interviews 11 questions	Poor knowledge and technique of BPM	Incorrect rate of deflation Rounding off readings incorrect Korotkoff sound for diastolic Arm circumference
Kemp et al. 1994 UK	129 hospital based staff 18 doctors 100 nurses 11 unknown	Questionnaire	Lack of clarity among practitioners on how BPM should be performed	Incorrect rate of deflation Rounding off readings incorrect Korotkoff sound for diastolic

Study Reference	Sample characteristics	Study design	General Findings	Topics poorly answered or poor technique observered
Kennedy and Curzio 1986 UK	54 Practice Nurses	Questionnaire	92 % acknowledge a need for revision	Incorrect rate of deflation Rounding off reading incorrect Korotkoff sound for diastolic
McKay et al. 1990 Canada	114 GP'S	Observation study Comparing practice with AHA guidelines / standards for BPM	Not one GP complied with all recommended requirements accuracy in meeting any aspect ranged from 3% -98%	Inappropriate cuff size Incorrect inflation pressure No estimation of systolic Incorrect deflation rate
McVicker J 2001 UK	37 health professionals (doctors and nurses)	Questionnaire	Considerable variation in individual measurement technique Staff needed updating	Incorrect rate of deflation Incorrect Korotkoff sound for diastolic Rounding of reading Unaware of significance of auscultatory gap
Nolan and Nolan 1993 UK	65 qualified nurses	20 item questionnaire	Range of scores 4 – 15 out of 20 Majority scored less than half Mean scores 7-9 Overall limited knowledge of sources of error in BPM	No resting before measurement Importance of placing centre of bladder over artery incorrect speed for deflation Rounding off readings incorrect Korotkoff sound for diastolic
Perry et al. 1991 *UK*	*91 respondents from 116 midwives and 11 obstetricians*	*Questionnaire*	*Compliance with recommended technique for BPM in pregnancy is poor*	*Incorrect Korotkoff sound for diastolic* *Minimal use of large cuff* *Rounding off readings* *Position for measurement*
Veiga et al. 2003 Brazil	105 health professionals 13 medical lecturers 11 nursing lecturers 11 assisting nurses 26 nurses aides 29 doctors 15 nursing students	Observation and Semi structured interview	Nurses and nurses aides abided 6 out of 16 steps for the recommended procedure of BPM The other professionals abided by 11 of the 16 steps Lack of availability of adequate cuffs Need to improve observance of the steps of BPM Need for continuing education - updating for qualified staff and more attention given to factors that lead to errors in undergraduate and postgraduate education	Inadequate selection of a cuff with adequate width Rounding off reading No estimation of systolic pressure Incorrect rate of deflation Only a single measurement taken
Villegas et al. 1995 Columbia	172 Health care workers 63 GP's 59 nurses 25 clinical specialists 25 surgical specialists	Observation and Questionnaire	Health care workers took Blood pressure inaccurately and incorrectly from both a practical and theoretical basis	Inadequate use of sphygmomanometer Lack of knowledge of basic principles of BPM Rounding off reading Incorrect Korotkoff sound for diastolic Lack of awareness of effect of arm position
Wingfield et al. 1996 UK	831 550 GP's 281 Practice nurses	Postal survey	Nurses had a statistically significant greater knowledge base than the doctors Gaps in the knowledge of community practitioners	Rounding off readings Failure to use a large cuff Unable to name source of national guidelines on BPM

Bold italic font indicates the studies that were conducted within maternity settings

The majority of the research has been conducted within primary care or with doctors and nurses in general hospital settings. There is a limited amount of research conducted solely with midwives and obstetricians. The findings of the three studies that have been conducted in maternity settings are as follows. Perry, et al. (1991) concluded that compliance with current recommendations on blood pressure measurement technique in pregnancy was poor. Agreement among midwives and obstetricians as to how blood pressure should be recorded in pregnancy was also poor. Brown & Simpson (1992) reported similar findings of a marked variability in the way BP was recorded and suggested that hypertension in pregnancy was being under or over diagnosed due to the lack of accuracy with the methods utilised. Similarly the results from Duggan & Miller (1998) found differences in the measurement technique. The authors concluded that these differences may result in substantial random errors in blood pressure measurement and called into question the reliability of the measurements.

3.7.6 Continuing education

Most studies conducted on knowledge of factors leading to inaccuracy of BPM in clinical practice suggest that an educational intervention is required (Curb, et al. 1982; Perry, et al. 1991; Bogan, et al. 1993; Perloff, et al. 1993; Kemp, et al. 1994; Grim & Grim, 1995; Duggan & Miller, 1998; Gillespie & Curzio, 1998; Kay, 1998; Veiga, et al. 2003), but this does not appear to have been offered or

evaluated to any extent. In relation to research studies on diagnosing and management of hypertension there is extensive literature on the need for repeated training for researchers to achieve competency and maintain quality of measurement. In addition ways to identify research staff who measure inaccurately are discussed (Bruce, et al. 1988; O'Brien, et al. 1991; O'Brien, et al. 1993; Mee, Atkins & O'Brien, 1994; Atkins, et al. 1997; O'Brien, et al. 2002; Pickering, et al. 2005). However, there are no such recommendations for clinical staff, and whilst the BHS recommends annual training and re-testing for research, suggests that this is not possible in clinical practice. This is despite the research evidence from the last twenty or more years indicating that ongoing educational input is required for health professionals to try and reduce errors of measurement caused by lack of clinical application of knowledge to practice that leads to an incorrect measurement technique.

Alderman (2002) identified that fifty three out of fifty four outpatient staff had never had any formal updating on the procedure of BPM. Kemp, et al. (1994) found that forty out of one hundred nurses and eighteen out of eighteen doctors claimed never to have received any formal training in BPM. Regarding education on BPM following qualification, 75% of the nurses and 89% of the doctors had never received any. Despite one hundred and eight respondents described

their ability to perform BPM as accurate, the majority failed to correctly answer simple questions related to the BHS BPM protocol.

Armstrong (2002) found that thirty out of seventy eight nurses had received some form of clinical updating since their initial instruction. A questionnaire was administered and for every correct answer respondents scored one point with a maximum score of fifteen. The nurses who had received some form of clinical update scored higher than those who had not received updating with a mean of 8.5 out of 15 as opposed to 5.96 for those not updated. In particular eight of the thirty participants had received practical tutorials and competency assessment, as they worked on the hypertension unit and the average score for these participants was 12.1. The need for clinical updating and assessment of accuracy of blood pressure technique was acknowledged by fifty eight of the seventy eight participants. The results show that there is a need for continuing education and that updating could impact on knowledge of factors that affect accuracy. However, the number of participants these findings are based upon is small and there are limited details regarding the format of the clinical updating undertaken by the eight participants. An aspect addressed by this study that has not been included in other studies was the identification of factors that influenced the participant's measurement technique. Forty seven of the participants stated that their current technique was most influenced by what they had been taught in their basic training.

Whereas, nineteen participants were most influenced by observing the actions of other health professionals and ten participants were most influenced by BPM guidelines. Twenty three participants stated that they measured blood pressure in some way differently from how they had been taught (Armstrong, 2002).

3.8 Summary and rationale for proposed study

The above review has presented the research evidence regarding factors that can affect accuracy of blood pressure measurement. It has identified how the current body of evidence is limited in relation to maternity settings. In particular the review has identified the following aspects:

3.8.1 Automated BP equipment

The current evidence would indicate that clinical use of automated devices in pregnancy is questionable. There is a limited number of pregnancy assessed automated devices available to purchase suitable for use in pregnancy or pregnancies complicated by hypertension. This suggests that unsuitable devices are being utilised in the clinical area. However, there is no research evidence regarding the number, type, location of automated devices currently being used in maternity settings.

3.8.2 Manual BP equipment

Inaccurate measurements can be caused by faults with the equipment (table 3.2). Aneroid manometers are more likely to underestimate blood pressure particularly if regular calibration checks and servicing are not undertaken. Studies conducted in primary care and general hospital settings show that BP equipment is unlikely to have been serviced or maintained and are generally in a poor condition. Only two small studies have been conducted on equipment within maternity settings (Burke et al. 1982; Waugh, 2002). The data obtained from the Waugh study provides information on sixty seven BPM devices. Whilst the Burke et al. study included equipment from a maternity setting the data obtained is combined with the equipment from GP and general hospital settings. Therefore, there is limited evidence in regards as to the general condition of BPM equipment in maternity units.

3.8.3 General factors that affect accurate BPM

It cannot be ascertained from the literature if there has been a move away from mercury devices and if that is the case, what devices have they been replaced with. Neither is it clear if there is a difference in the number and type of defects due to wear and tear between portable or fixed devices. The increase in prevalence of obesity in pregnancy impacts upon average arm circumference and the size of cuff required to obtain an accurate measurement. CMACE (2010a) guidelines of management of women with obesity

in pregnancy, state that an appropriate size arm cuff should be used for all BPM undertaken during pregnancy and the size of cuff utilised should be recorded in the client's medical records. The current evidence indicates that the availability of cuff other than a standard adult size could be limited. There is no research evidence that provides details regarding type, size and markings on cuffs available in maternity settings. Neither is it clear if the sizes of cuffs available conform to BHS recommendations. None of the studies have included stethoscopes in the survey of BPM equipment in any setting.

3.8.4 Observer application of knowledge to BPM practice

Observer faults in BPM are often due to a failure to apply knowledge to practice resulting in non-compliance with published guidelines on how a BPM should be conducted. Studies have shown that the failure to apply knowledge to practice is linked to staff having limited knowledge and understanding of factors that influence blood pressure readings and of published BPM guidelines on how to measure BP, (O'Brien, O'Malley & Sheridan, 1979; Feher, et al. 1992; Nolan & Nolan, 1993; Villegas, et al. 1995; Torrance & Serginson, 1996; Ahmed, 1997; Gillespie & Curzio, 1998; Markandu, et al. 2000; Meert, 2000).

The literature review highlighted the need for the implementation of procedures to improve the teaching of health professionals in the

measurement of blood pressure. This should start in their training period and progress through into continuing education sessions. However, there is a lack of research studies that have determined what method of BPM is utilised by Maternity care health professionals and if there is a failure of staff to comply with the published guidelines on how to measure BP. Limited evidence exists with regards to the implementation and evaluation of continuing education programmes specifically focused on accurate BPM.

3.9 Rationale for study

Many research studies related to errors associated with blood pressure measurement are limited to a comprehensive survey of one factor or a brief survey of all the factors that lead to inaccurate measurements. Thus the focus has either been on equipment or staff knowledge or measuring technique or observer bias. Studies have individually shown that equipment is faulty but the application of knowledge to practice of the staff using that equipment has not always been evaluated or vice versa. If the equipment is faulty and method of BPM does not comply with current guidelines then the combination of the two will augment the degree of inaccuracy that can be introduced into the measurement.

Another aspect that has not been fully addressed in previous studies is whether the number of years that someone has performed blood pressure measurements impacts on their knowledge or application

of theory to BPM practice. Much of the research has been conducted in America and Australia and in some instances the studies undertaken more than 15 years ago. Practice and guidelines have changed over the years and whilst there is an abundance of literature relating to nurses and medical staff in hospital and primary care, the research conducted in maternity care is limited. The proposed study therefore intends to add to the body of knowledge by examining the following areas:-

1. The working condition and type of blood pressure measuring equipment available in maternity settings.

2. The method of BPM utilised by health professionals working in maternity services to determine if theory is being applied to practice.

3. The implementation and evaluation of a continuing education teaching session on obtaining an accurate measurement of blood pressure in pregnancy.

CHAPTER FOUR

METHODOLOGICAL CONSIDERATIONS OF THE STUDY

This chapter will present the aim of the study, identify the research questions and outline the study's objectives. This will be followed by a discussion of the philosophical perspective and the methodological considerations of the research design, setting, methods, sample and tools and include discussion on how the study was conducted.

4.1 Aim

Chapter three summarised the limitations in the body of knowledge around accurate BPM in pregnancy and led to the development of the aim of the study which is to***: -*** conduct an audit of the equipment, evaluate practice and the impact of continuing education in regards to BPM in maternity settings. This aim will be addressed by the current study developed to answer the following research questions:-

4.2 Research Questions

1. What is the working condition and type of blood pressure measuring equipment available within U.K. maternity settings?

2. What is the current practice of BPM of health professionals working in maternity services?

3. What is the impact upon the clinical practice of BPM following the introduction of an education programme?

4. Does the provision of an education programme result in changes to the working condition of the blood pressure measuring equipment?

4.2.1 Objectives of the study

To answer the research questions the following objectives were set;

1. Equipment

To audit and compare the type and working condition of blood pressure equipment available in the clinical area against the standards set by the European Committee for standardization (1995), BHS and AHA.

2. Practice

To evaluate the clinical practice of health professionals conducting BPM ‘s on pregnant women.

3. Continuing education.

To examine the effects upon the clinical practice of BPM following the introduction of an education programme on factors that may affect accurate blood pressure measurement

4. Equipment Changes

To re-evaluate and compare the type and working condition of the blood pressure measuring equipment available in the clinical areas following delivery of the education programme.

4.3 Philosophical perspective

The approach of this current study exhibits elements from a positivist philosophical perspective, where the inquiry is based upon empirical data collection rather than philosophical speculation. It is anticipated that the majority of data obtained will be based upon specific particulars of equipment and practice and not personal opinion or values of the sample. The topic of accurate measurement of blood pressure will be broken down into specific parts that can be examined and thus categorised in a numerical form. The researcher will set the framework and choose the range of data to be collected. This study will utilise quantitative data to provide evidence to answer the research questions as outlined in 4.2 above.

Whilst the study has aspects of positivist philosophy it cannot be classed as pure research conducted in a laboratory setting with an experimental approach. This study is applied clinical research with the emphasis being on measurable outcomes that are specific to health professionals who conduct BPMs on pregnant women. Whilst the findings of the study would be applicable to midwifery and obstetric practice they could also be relevant to nursing and other health care professionals.

4.4 Research design

Previous studies conducted around this topic have been quantitative, descriptive and non-experimental with the focus mainly being on one aspect of equipment or practice as discussed in section 3.8. In order to answer the research questions and address the overall aim an evaluation research study was required.

4.4.1 Evaluation research

Evaluation research is often involved in education, professional development programmes and within the health service. Robson (2011) argues that an evaluation is not a new or different research strategy but a study that has a specific purpose, the assessment of the effectiveness of an innovation, intervention, policy, practice or service. This is done through the rigorous and systematic collection of research data utilising a scientific method. As such it can be a sensitive activity where there is the risk or even duty that the researcher will reveal inadequacy or their intentions can be misconstrued, findings misused or ignored.

Gray (2004) states that the process of evaluation can be traced back to the 1970's and was strongly influenced by the work of Kirkpatrick in 1959 who focused on the evaluation of training programmes. Kirkpatrick laid down the basis of the areas of concentration for the evaluation of training programmes (Kirkpatrick & Kirkpatrick, 2006). Gray states there are four levels of evaluation: Obtain the reactions

of participants, assessment of achievement of specified learning objectives, assessment of changes in behaviour and attitudes and the impact of the training upon the organisation. Therefore, evaluation research provides a means of measuring outcomes.

Bond (1996) suggests that there are three main categories of purpose for an evaluation these being a needs assessment, formative evaluation and summative evaluation. Needs assessment is the gathering of information of needs, problems, conditions, prior to the commencement of the project to determine what actions are required and the clarification goals to meet the needs. Formative evaluation is usually conducted for the benefit of the person/persons managing the intervention with the focus being on how aspects could be improved or enhanced and the identification of those aspects that work well. It involves monitoring of all the processes involved (Bond, 1996; Nagarajan & Vanheukelen, 1997; Robson, 1993; Robson, 2011). Summative evaluation is concerned with assessment of the effectiveness of a program. This can also be known as impact evaluation the evaluation of what the direct and indirect impact on participants, the organisation or the community of a particular programme has been. Decisions may be taken to continue or discontinue, expand or reduce an innovation or programme based on the summative evaluation. Summative evaluation can have a formative effect on future developments if

presented at the end of a programme or intervention. (Robson, 1993; Bond, 1996; Gray, 2004; Robson, 2011).

Evaluations utilise different types of research strategies either singly or as a combination and ideally, the strongest evaluation study from a positivist standpoint would follow an experimental strategy in the comparison of two groups one of which has received the intervention and one of which has not. However, there are difficulties applying this approach in some contexts such as conducting experiments in the clinical setting of a hospital. Unlike a laboratory setting the natural environment of a hospital ward cannot be sealed from external influences, thus, maximising control over extraneous variables becomes impossible. In addition identifying an appropriate control group and securing effective isolation between the two groups would be difficult or unachievable. Cross contamination due to interaction between participants during the study would invalidate random assignment to groups and consequently, violate group assignment independence (Robson, 2011).

Patton (1997) suggests that experimental results lack relevance in a real-world situation as it is impossible to manipulate the few experimental factors in isolation to everything else. Whereas, an important factor of the purpose of research conducted in natural settings is often concerned with evaluating something. Thus not only does the research study determine what the situation is but there is

an intention that the findings will help change or improve, the lives/situation or practice of those involved in the study and or/others (Robson, 2011). Robson (1993 & 2011) suggests that evaluation findings from clinical practice settings are more likely to influence clinical practice because the integration of research and practice can have benefits. When the study is concerned with and for those involved a more positive response is likely. The involvement of practitioners in research is a way in which change can be facilitated. If practitioners actively participate in the research in conjunction with the researcher acting partly as an advocate, debate and discussion is created so change can occur and helps focus participants to bring about changes in their practice.

.

Patton (1997) suggests that it is more important to choose appropriate methods for specific evaluation purposes than adhere to orthodoxy of an inherent preferred approach. For the purposes of this current study, it was impossible to use a classical experimental approach such as a randomised controlled trial. The researcher was unable to meet the strict criteria of an experiment, randomisation and control of influences within the intended research environment of a clinical midwifery setting when the sample population was the health professionals themselves. Thus, for this current study as with previous studies, a non-experimental approach was taken.

As discussed above the purpose of evaluation research is not just to assess the value or effect of something but also to serve as a means to make improvements to what is being evaluated. Professional accountability and evidenced-based practice are at the forefront of clinical practice. As discussed at 2.5 both the GMC duties of a doctor (2006) and NMC code (2008a) identify that health professionals are personally accountable for their practice. In addition professional knowledge and skills should be kept up to date to ensure delivery of care is of a high standard and based on the best available evidence. The utilisation of an evaluation research approach is justified, firstly, as a means to assess the limitations in the body of knowledge around accurate BPM. Secondly, the health professionals will be active participants in a study focusing on a skill they undertake daily. Therefore, where appropriate the results or participation in the study has the potential to act as the catalyst for a a move towards a more evidence based practice approach to BPM.

4.4.2. Summary of current study's research design

The design approach of the current study was evaluation research, with three phases. Phase one being the baseline survey; the needs assessment element, the appraisal of the current situation in regards the BPM practice and condition and type of BPM equipment. The results from Phase one were used to inform Phase 2, the development and delivery of the education programme. Phase 3 provided the formative and summative evaluation of the

effectiveness of the introduction of the innovation the education programme. The development and delivery and evaluation of the education programme itself (Phase 2) of the study is discussed separately in the next chapter.

4.5 Research methods

After determining that the study would comprise of three phases the next stage of the process was to establish which data collection methods were to be utilised. The survey was the most common approach in previous studies as shown in table 3.7 utilising questionnaires in various formats. Fewer common methods were direct observations, semi-structured and structured interviews and telephone interviews. The least common approach was the testing accuracy of readings by use of a videotape (Carney, et al. 1999). Methodological consideration was given to these possible approaches alongside other influencing factors such as setting and sample size in the selection of the most appropriate methods.

4.6 Setting

Initially, the settings considered for this study were selected for convenience within a one hour traveling distance for the researcher. Four units were approached, and three agreed to participate in the study. Refusal to participate in the study was due to the involvement of the unit in several other research projects at that time. The selected maternity units had similar profiles within the range of 2,500

– 4000 births per annum. They were located in two different regions but three separate NHS Trusts. The main educational provider of each unit was from three different universities. Thus, the sites whilst geographically connected were unrelated to each other. During the study period number of deliveries conducted within the units chosen was similar to the majority of maternity units in England (BirthChoice UK, 2006).

4.7 Triangulation

To test the accuracy, reliability and validity of data, research studies often incorporate some form of triangulation into the design. The original use of triangulation was to confirm the accuracy of a measurement but there is widespread agreement that triangulation can take a variety of forms (Denzin, 1970; Jick, 1979; Leininger, 1985; Mitchell, 1986; Burns & Grove, 1993; Janesick, 1994). Denzin (1970), Identifies four types of triangulation, methods, data, investigator and theoretical.

The use of more than one method of data collection within one study is methodological triangulation. This can also be broken down into, method triangulation, which tests the reliability of the data, where one method of data collection is used, (such as a survey), but utilises two or three methods to examine the data such as, three different rating scales to measure the same phenomenon. Across method, triangulation is the use of data collected by different

techniques such as questionnaires, interviews and observations and is useful for validity of data. Both methods are useful to confirm results (Denzin, 1970; Dootson, 1995; Nolan & Behi, 1995; Burns & Grove, 1997).

Data triangulation is when different sources of data for the same phenomenon are collected from different people at different times and in different places, this is useful to reveal similarities and differences in different settings. Investigator triangulation is when more than one investigator is involved in the study. Theoretical triangulation is when a range of theoretical models are used in the same study (Denzin, 1970; Dootson, 1995; Nolan & Behi, 1995; Burns & Grove, 1997).

It was considered that the study design would lend itself to the incorporation of methodological triangulation with the use of across method triangulation and data triangulation through the use of more than one setting. It was considered that the survey approach via questionnaires and observations for Phase one (the baseline survey) and Phase three (the evaluation of outcomes) would be the most feasible option.

4.8 Methodological consideration of the survey approach

Fink (1995) states that survey research is a system that can be used to collect information to describe, explain or compare knowledge,

attitudes and behaviour. Survey research means that significant amounts of data can be collected from a sample of individuals that can be representative of a defined population. Advantages of surveys are that answers from individual participants can be collated to produce results which apply to the whole sample. The questions can be designed to be unbiased. Surveys lend themselves well to future replication and have a high degree of generalisability. Because of the structural nature of a survey this means that the data produced is often in a numerical form which is amenable to statistical analysis and as such their findings are considered to be objective (Wagstaff, 2000).

The disadvantages of surveys that need to be considered in the design and administration of tools used to obtain data, are that data can be affected by the characteristics of the respondents such as their memory, knowledge, personality, motivation and experience. The truth or accuracy of the answers may be suspect there can be interviewer and or questionnaire bias and they depend heavily upon participant motivation (Baxter, Hughes & Tight, 2001). Another disadvantage of survey methods that respondents do not accurately report their beliefs or attitudes, particularly if they think their response will not show them in a ‘good light’ (Robson, 1993; Robson 2011).

Surveys usually collect data from human beings but in social science there is a related meaning of survey, in which the subject matter under question can be objects, materials or artefacts rather than people (Baxter, Hughes, & Tight, 2001). The use of objects, materials or artefacts is known as the unobtrusive research approach or unobtrusive measures or indirect observation (Robson, 1993; Gray, 2004; Robson 2011). This means objects can be surveyed by unobtrusive observation, for example examining the natural wear and tear of an object could reveal evidence of how often it is used and its general condition. An advantage of using unobtrusive observation is, because the researcher is in effect dealing with 'dead data', as with inanimate objects the researcher cannot influence the object. Thus the risk of reactive measurement effects, such as interviewer bias or questionable research tools does not exist (Robson, 1993; Gray, 2004; Robson 2011). However, bias can still be introduced if there is inconsistency in the judgements particularly if there is no ideniified criteria on which judgements are based, this would then render the results invalid.

4.9 Equipment surveys

Two equipment surveys were planned as part of the study. The first conducted as part of the baseline survey during phase 1 and is referred to as Equipment Survey 1. Equipment Survey 2 would be conducted as part of the Phase 3 evaluation of the impact of the education programme. As the sample for these equipment surveys

was inanimate objects, unobtrusive observation (as discussed at 4.8) was used. The literature review had revealed that very little data were available as regards the type and condition of BPM equipment within maternity units.

To standardise and facilitate the recording of the data obtained, a proforma identifying the aspects to be surveyed was required. Analysis of the format utilised by other equipment studies had identified limitations in regards to the components assessed thus the results obtained lacked detailed data. For example not recording details such as model type, cuff size or cuff labelling. Neither have previous studies included observation of the condition of stethoscopes or the type and location of automated devices. Therefore, specific tools were developed for this study.

4.9.1 Tools for the equipment survey

Using the BHS, AHA, British Standards (2004) and the proforma used in study by O'Brien & O'Malley (1981) the aspects to be observed were identified and collated. Separate proformas were developed for mercury, aneroid, automated devices and for the assessment of stethoscopes (Appendix 1). This provided a detailed checklist used by the researcher for the survey of the condition of the equipment. This facilitated a standardised approach to the equipment observations and consistency of judgements made. As there was an existing proforma for checking the function and

performance of manual sphygmomanometers based on guidelines from BHS and the British Standards this was used in the study. This is shown in the table 4.1.

Table 4.1 – Performance testing of Sphygmomanometers

Function	Test
Inflation	Wrap cuff around large glass jar, test ease of inflation, ability to halt and restart at any desired pressure.
Deflation	Rate of fall of mercury or pointer should be easily controlled to 2mmHg/second.
Leakage	Inflate cuff pressure to 250mmHg close control valve and note any loss of pressure greater than 10mmHg in 10 seconds.
Gauge accuracy	Detach gauge from sphygmomanometer and connect via Y tube to accurate mercury manometer. Check pressures at 10mmHg over entire pressure range. Errors greater than 4mmHg are not acceptable (mean difference of 3mmHg is considered acceptable)

4.9.2 Equipment sample

No central database existed in regards to hospital equipment, thus it was not possible to determine an estimation of the total number of BP devices located within maternity settings in England. Neither was it possible to estimate how many devices would be located within the maternity settings used in the study. For Eqiupment Survey 1 the sample size was determined by the number of devices that could be located within the settings selected for the study.

4.9.3 Equipment Survey 1- Sample

The sample included 165 blood pressure measuring devices and 92 stethoscopes. BP devices in hospital one and three were situated within five clinical areas and each community midwives had a portable BP device. In hospital 2 BP devices were located in four

clinical areas and with individual community midwives. A further 25 handheld BP devices belonging to individual community midwives, across all three Trusts were identified. These devices were not surveyed as access was not obtained, due to staff absence because of sickness or annual leave or staff not bringing their device into the hospital for assessment. As the ethical approval for the study was with the three NHS Trust maternity units devices that belonged to GP practices or Children's Centres in the community services were not included in the study as these were not Trust property.

4.9.4 Data collection for Equipment Survey 1

BP measuring devices and stethoscopes in each identified clinical area were surveyed by the researcher using the previously designed proformas (4.9.1). On the first visit to each clinical area the overall number and type of devices was established. Coded coloured stickers were used to identify devices that had been surveyed. As devices could be in use several visits were required to each clinical environment to complete the equipment survey. Arrangements were made for the researcher to access the equipment held by community midwives.

In addition to the equipment proformas other tools used in the survey included a new standard tape measure to measure cuffs and tubing. In order to check the ease of inflation, deflation, valve condition and any existence of an air leak, the cuff was placed around a large glass jar, thus stimulating the circumference of an arm, enabling the

cuff to be inflated. Performance checks were conducted as described in table 5.2. A new mercury manometer and Y tube required for calibration testing was obtained and used as the control device. Dynamic calibration testing was conducted by the main researcher and the same assistant. The researcher recorded the pressure level of the control device and the assistant recorded the pressure on the test device. The two observers were unable to see each other's device. The points at which readings were taken were randomly selected across the whole pressure range with the researcher calling 'now' to indicate when the assistant had to record the pressure on the device being assessed. If there was any doubt the test was repeated.

4.9.5 Equipment Survey 2 - Sample

The sample included 119 blood pressure measuring devices and 78 stethoscopes. BP devices in Hospitals 2 and 3 were situated within five clinical areas and with individual community midwives. In Hospital 1 BP devices were located in four clinical areas and with individual community midwives.

4.9.6 Data collection for Equipment Survey 2

The researcher pre-arranged dates to spend two days in each unit with an assistant to survey any available equipment of BPM equipment and stethoscopes. Equipment was surveyed and data

collected using the same methods and tools as discussed above at (4.9.4).

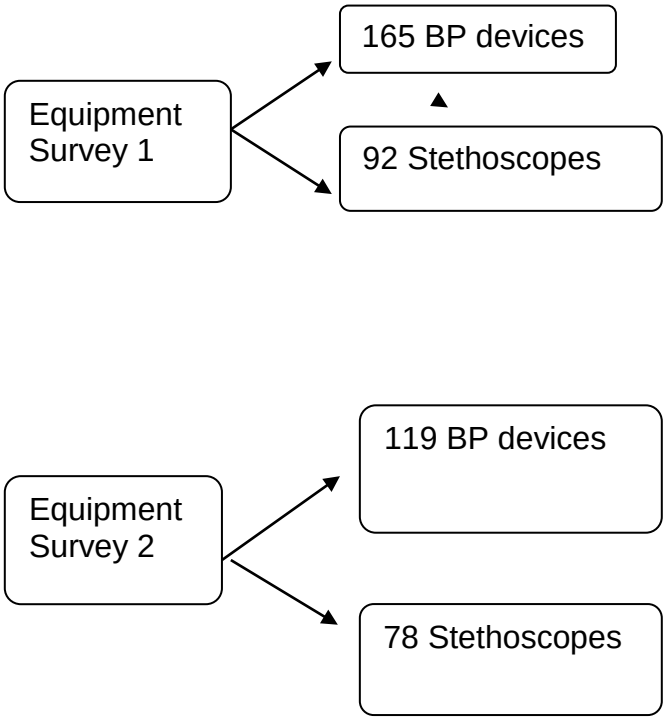


Figure 4.1 Flow chart for Equipment Surveys

4.10 Practice Survey

To evaluate the clinical practice of BPM on pregnant women to indicate if theory is being applied to practice (discussed at 3.7.5), required an appropriate method. An estimation of the total number of people employed in the chosen settings was four hundred to five hundred health professionals. Utilising a questionnaire survey provided a feasible method of data collection, as time restrictions and accessing staff to conduct face to face or telephone interviews would have considerably limited the number of participants that

could have been included in the study. Therefore, two practice surveys were planned Practice Survey 1 and 2, conducted in Phase 1 and Phase 3 of the study respectively, before and after delivery of the education programme.

4.10.1 Methodological considerations of the use of questionnaires

A standard set of written questions that a respondent answers is the basis of a questionnaire (Wagstaff, 2000). Advantages of questionnaires are the low cost of data collection and that information can be obtained from a large number of participants. Methods of administration include, postal surveys, self administered questionnaires, group administered questionnaires and internet administered questionnaires. The disadvantages of utilising questionnaires are that the data may lack depth, poor response rates. In addition with certain types of administration, for example a mail survey, the respondent has no opportunity to ask questions or to seek clarification (Dane, 1990; Cluett and Bluff, 2000).

4.10.2 Consideration of methods of administration for questionnaires

Methods of questionnaire administration that were considered included, self–administered, group administered questionnaires and internet administered questionnaires. The most feasible option was a self administered postal questionnaire. The internal mail system available within each unit provided a feasible, cost effective, equal access method for the postal distribution of a questionnaire to all

eligible participants. The other methods of administration were discounted due to practical barriers imposed by the setting of the study being within a clinical environment and restrictions of access to participants.

4.10.3 Disadvantages of self administered questionnaires

The disadvantages of self administered questionnaires as opposed to interviews are that there is no opportunity for researchers to correct misunderstandings, to probe, offer explanations or help. The researcher has no control over the order in which the questions are answered and cannot check or clarify an incomplete response or missing answer. The respondent could ask someone else to complete the questionnaire or choose not to complete the questionnaire (Clifford, 1997).

In general postal questionnaires have a low response rate which can lead to biases in the results. Response rates to mailed questionnaires can be lower than other forms of self report, Burns and Grove (1997) suggesting that a rate of around 25 -30% is average. However, several strategies can be employed to increase the response rate. Oppenheim (1992) identifies steps that have been shown to improve response rates to survey questionnaires. Personally addressing the letters to the respondent, ensuring the name and initials are correct, is also important to encourage a response. Pre-survey contact with recipients prior to the

questionnaire being administered and advanced publicity have been shown to increase response rates. Other steps include postal reminders and another questionnaire after the date for return has been reached to those who have not returned the questionnaire. The inclusions of a stamped addressed return envelope and a covering letter have been shown to increase response rates. The length of the questionnaire, the time required for completion and whether the topic itself is of interest to the respondent can impact on the number of responses.

4.10.4 Methodological considerations in the construction of a questionnaire

The previous studies identified in table 3.7, have generally utilised a structured multiple choice questionnaire approach with a maximum of five responses. As this study has stated aims and objectives with a specific purpose this lends itself to the use of a structured questionnaire. Assessment of whether maternity health professionals are applying relevant theory to their practice of BPM is required. Thus the same pre-determined questions in the same order and same way with pre-coded response choices provides a means to elicit if the professional can provide the correct response to the question asked. This would provide quantitative data for analysis. An unstructured approach is more suited to obtaining data on attitudes, behaviours or social processes and does not use specific or fixed questions. In order to utilise a structured

questionnaire it is important that the researcher is familiar with the issues being investigated and the individuals being studied before any research questions are constructed (Peterson, 2000). When constructing a questionnaire the administration of the questionnaire through a postal survey lends itself more to closed ended questions rather than open questions.

With closed ended questions the researcher pre-determines the questions and provides a selection of answers. Thus the questions and answers are known prior to the questionnaire being administered. The selection of a pre–specified answer from the range of possibilities is considered to be easier to answer for respondents rather than having to write an answer in full or mentally construct an answer (Peterson, 2000). Open ended questions do not have pre-determined answers and require respondents to provide an answer that they believe is appropriate. Respondents use their own words to express feelings, values or beliefs (Barker, 1996; Peterson, 2000). Thus open ended questions are not suitable when pre-specified information is a requirement.

Closed questions can be dichotomous or have a number of alternative answers or mutually exclusive response categories. Peterson (2000) recommends that no more than nine possible answers are used. Whereas, Fink (1995) suggests that there should be no more than five alternative responses for category questions.

Burns and Grove (1997) suggest that there should be a response category for every possible answer and if the sample could include respondents who might not have or know the answer for a factual question then a ‘don’t know’ or similar response should be included. To avoid guessing requires the participant to leave the question unanswered if they don’t know the answer thus the inclusion of a ‘don’t know’ option may prevent this. However, too many options can introduce confusion and possible bias if respondents become confused or impatient due to answer overload or the question takes too long to read. Thus questions compiled should be brief, relevant, unambiguous, specific and objective. The language and terminology should be appropriate for the target sample, with attention given to the sequencing of questions so they flow and fit in with the respondents thought processes (Barker, 1996; Cluett & Bluff, 2000).

4.10.5 Development of the Practice Questionnaire

The literature review identified the documented sources of error in auscultatory BPM as summarised in tables 3.4 & 3.5. The BHS guidelines on how BPM should be conducted incorporates how this conceptual knowledge is applied to the practice of BPM. A comparison was made between this theoretical information and the topics included in previous studies. Table 4.2 was compiled to summarise the frequency of questionnaire topics addressed in previous studies and differentiates the setting in which the topics were addressed. This highlighted that the identification of diastolic

pressure was included in every questionnaire. Other aspects such as equipment, rest periods, bladder size and arm position have not been included as questionnaire topics administered in maternity settings and less frequently included as questionnaire topics in other settings.

Table 4.2 Summary of questionnaire topics used in previous studies Key Yes = included in questionnaire No = not included in questionnaire

Identified topic areas of questioning	**Brown & Simpson (1992) Australia New South Wales Midwives Association and Obstetricians in Sidney**	**Duggan & Miller (1998) Australia 5 teaching hospitals with maternity units**	**Perry et al. 1991 in a UK Maternity Unit**	**Included in studies conducted in settings other than maternity units** **Red = general hospital setting** **Green = primary care**
Servicing of equipment	Yes	No	No	Villegas et al. (1995), Ahmed (1997), Armstrong (2002)
Types of devices	No	No	No	Villegas et al. (199)5 , Gillespie, Curzio (1998)
Identification of systolic	No	YES	No	Carney et al. (1999), Villegas et al. (1995), Kemp et al. (1994), Armstrong (2002)
Identification of diastolic	YES	YES	YES	McVicker (2001), Carney et al. (1999),Villegas et al. (1995) Markandu et al. (2000), Gillespie, Curzio (1998) Ahmed (1997), Armstrong (2002)
Position when having BP measured	YES	YES	YES	Villegas et al. (1995), Ahmed (1997)
Cuff size	YES	YES	YES	Carney et al. (1999), Villegas et al. (1995), Markandu et al. (2000), Gillespie, Curzio (1998), Ahmed 1997, Armstrong (2002)
Bladder encircling arm	No	No	No	Carney et al. (1999), Markandu et al. (2000), Gillespie, Curzio (1998), Armstrong (2002)
Rate of deflation	No	YES	No	McVicker (2001) , Carney et al. (1999), Markandu et al. (2000), Kemp et al. (1994), Gillespie, Curzio (1998), Armstrong (2002)
Resting before measurement	No	YES	No	Nolan and Nolan (1993)
Resting after ingestion of coffee, smoking a cigarette exercise or eating	No	No	No	Nolan and Nolan (1993)
Rounding of readings	No	YES	YES	McVicker (2001) , Kemp et al. (1994), Gillespie, Curzio (1998) , Ahmed (1997), Armstrong (2002)
Arm position	No	No	No	McVicker (2001), Carney et al. (1999), Villegas et al. (1995), Markandu et al. (2000), Gillespie, Curzio (1998), Armstrong (2002)
Which arm used	YES	YES	No	Villegas et al. (1995), Ahmed (1997)

Thus, no single previously used questionnaire covered all the aspects identified above. Hence, while some of the questions from previous questionnaires could be used or adapted it was necessary to compile a questionnaire tailored to meet the specific needs of this study. This would address some of the limitations of previous studies, in particular, appraising staff knowledge of the requirement for servicing and maintenance of equipment, an awareness of the effect of arm position and the practical aspects that the method of BPM should include a rest period prior to measurement and following eating, smoking, ingesting caffeine or exercising.

After consideration of the above points, a questionnaire was designed using twenty closed ended categorical questions with multiple choice answers (Appendix 2). At the end of the questionnaire an open ended question invited respondents to comment about the topic. The number of response categories ranged between two and six and a check box was provided so respondents could tick their chosen response. As discussed at 4.10.3 the inclusion of a covering letter is a way to improve response rates and thus consideration at this stage was given to the content of a covering letter (Appendix 2).

4.10.6 Pilot study

A pilot study was conducted to validate this specially designed questionnaire before it was used in the study. This was to facilitate

the identification of questions for modification or elimination if they would mislead participants or result in bias. Oppenheim (1996) states that piloting helps with the wording of the questions and with procedural matters such as the covering letter or the sequencing of questions. Piloting determines the effectiveness of the instructions, the time required to complete the questionnaire and the success of the data collection technique and informs how the data can be coded and inputted for statistical analysis. Piloting is essential to ensure that the final questionnaire will be accurate, unambiguous and simple to complete and free from typographical errors. The respondents selected for the pilot study need to be similar to sample intended for the main study. The technique used needs to be as similar as possible to those planned, such as if the completion of the questionnaire is to be self-completion then this should be the method used in the pilot study (Oppenheim, 1992; Burns & Grove, 1997).

The respondents used for the pilot study included a sample of forty student midwives and midwives who did not work in any of the settings chosen for the main study. Following self-completion of the pilot questionnaire, comments in both verbal and written format were collected in regards to the clarity of the questions and answers, instructions, covering letter, format and length of time needed to complete the questionnaire. It was determined that the questionnaire took on average ten minutes to complete and thus this was considered an acceptable for use in the clinical environment.

Following the comments some adaptations were made to wording and layout, combining the five demographic questions into one table format, clarification of the first Korotkoff sounds and a 'don't know' option to one question. The covering letter was amended to clarify aspects around coding of the questionnaire (Appendix 3 revised questionnaire and covering letter). The final questionnaire had sixteen structured questions and is referred to as the Practice Questionnaire in the study. This questionnaire had three demographic questions, two questions related to equipment, four questions in relation to accuracy of measurement and seven on technique/method of measurement (table 4.3). The pilot data were utilised to determine how the final questionnaire responses could be encoded and analysed.

Table 4.3 Category of topics used in the Practice Questionnaire

Question	Category of topic
1. Gender	Demographic
2. Age	Demographic
3. Qualifications	Demographic
4. Calibration	Equipment knowledge
5. Type of equipment used	Equipment knowledge
6. Position of client	Method used in practice
7. Systolic method	Method used in practice
8. Diastolic method	Method used in practice
9. Cuff size	Factors affecting accuracy
10. Arm Circumference	Factors affecting accuracy
11. Rate of deflation	Method used in practice
12. Resting before measurement	Method used in practice
13.Time elapsed after, smoking, eating, caffeine, exercise	Factors affecting accuracy
14. Rounding off reading	Method used in practice
15. Arm used	Method used in practice
16. Effect of arm position	Factors affecting accuracy

4.11 Sample of health professionals for Practice Survey

As identified at 2.5 these health professionals would be midwives, obstetricians and student midwives/doctors or health care assistants. According to the NHS information centre statistics for medical and non–medical staff (2011), showed 32,473 qualified staff (26,825 midwives and 5648 medical staff) work within NHS maternity settings. At the time of Phase one the study the estimation of the whole population of qualified health professionals who could conduct BPMs during pregnancy was 30,987. Midwives constituted 87% of the workforce and doctors 13%. Figure 4.2 summarises the age grouping of these midwives from 2004 – 2010 compiled from the NHS information centre (2011). As it can be seen from these data the workforce of midwives is aging and this could have implications for future training needs. No information was located to provide data regarding ages of the medical staff that specifically practice within obstetrics and or gynaecology services. Neither are records available on the number or ages of student midwives/doctors or heath care assistants who would conduct BPMs within maternity settings.

Practically, it was not feasible in terms of time, cost or obtaining access to include the whole population group of health professionals working in English maternity units as the study sample. A true random sample could not be obtained as it was impossible to identify all the health professionals within England, who conduct BPM's on

pregnant women. Thus, a non-probability sample approach was taken. The actual number of participants available as a sample group was determined by the settings used for the study. All members of staff who measured blood pressure in the chosen maternity units were invited to participate in the study in both surveys.

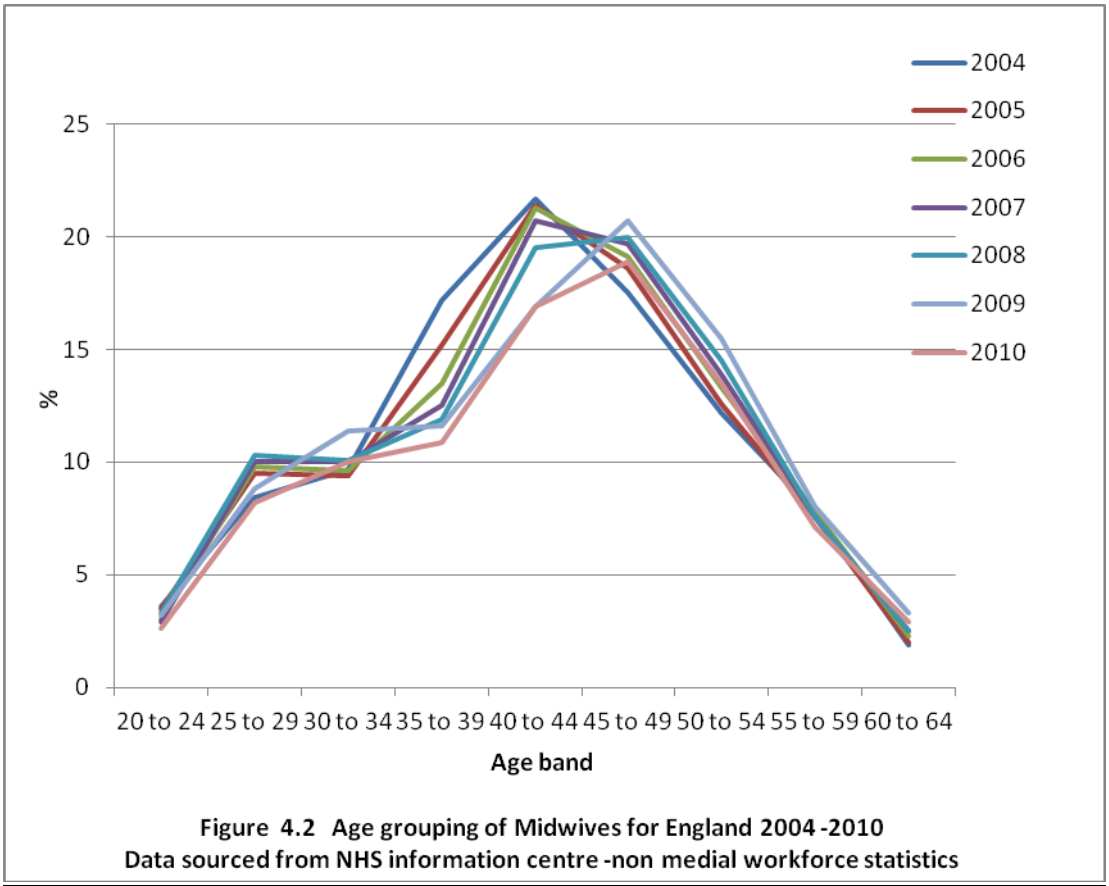


Figure 4.2 Age grouping of Midwives for England 2004 -2010
Data sourced from NHS information centre -non medial workforce statistics

4.12 Preparation for Practice Survey 1

Once ethical approval was granted meetings with Heads of Midwifery and midwifery clinical managers were conducted to discuss the purpose and logistics of the study. The researcher was provided with a list of employee's names and area of work in preparation for the practice survey. It was arranged for the researcher to spend a period

of four consecutive weeks in each of the three units. Prior to commencement of the study, the ward managers agreed to inform their staff that the unit would be involved in the research study on accurate BPM. In addition, a flyer (Appendix 4) detailing the study was prepared and this was displayed in a prominent place on each ward area at least two weeks before the data collection commenced.

4.12.1 Sample for Practice Survey 1

Using the provided information of employees' names it was established that within the three settings, 465 personnel conducted BPM. Of these 85% (380) were midwives, 10% (48) medical staff, 7% (31) student midwives and 1% (5) others such as nursing assistants.

4.12.2 Administration of the Practice Questionnaire

Each of the 465 identified members of staff who recorded BP was identified by a unique number. The Practice Survey questionnaire was forwarded to each identified employee together with a covering letter and a freepost return envelope. The forwarded questionnaire contained the appropriate unique participant number. On the first visit to the maternity unit, each ward area was accessed by the researcher to conduct introductions and confirm commencement of the data collection period. Due to the flyers and ward managers' staff appeared to be aware that the study was to be undertaken and thus

no problems were encountered on gaining access to the clinical areas.

The hospital internal mail system within each unit was used to deliver the questionnaires. However, as this method involved leaving the questionnaires in a central point on each clinical area, those staff present at the time of delivery requested that their questionnaire envelope was handed to them directly. It is estimated that a maximum of fifty five questionnaires were delivered by this method. The participants could return the questionnaire in one of two ways, either by Royal Mail or into clearly identified collection boxes located by the internal mail collection points. These collection boxes were checked, emptied and resealed by the researcher twice a week. At the end of the four weeks the boxes were removed and questionnaires then had to be returned by the Royal Mail.

4.12.3 Follow up of non-respondents of Practice Survey 1

Once the date requesting a response had passed, another copy of the questionnaire with a follow-up letter and freepost return envelope was sent to non-respondents via the internal mail system (Appendix 5). Completed questionnaires were returned using the Royal Mail. No one asked to withdraw from the study.

4.12.4 Sample for Practice Survey 2

Using updated information of employees' names it was established that within the three settings, 452 personnel conducted BPM. Of

these 86% (391) were midwives, 11% (51) medical staff, 3% others such as, student midwives (2) or nursing assistants (8).

4.12.5 Administration of Questionnaire - Practice Survey 2

The original version of the Practice Survey questionnaire (see Appendix 3) was used as the tool for this second survey. Following coding and preparation as for Practice Survey 1 it was distributed using the hospital internal mail system with a covering letter (Appendix 6) and a SAE for its return. Respondents returned the questionnaire via the Royal Mail. Non-respondents were followed up with another questionnaire and a letter once the deadline date had passed (Appendix 7).

4.13 Observations

Assessment of a practical procedure solely by a questionnaire had some obvious limitations. To verify and enhance the data obtained by Practice Survey 1 and inform the content of the educational programme further data were required. The method selected was direct observations of staff measuring BP and in particular, if staff followed the recommended BHS technique. The data obtained from the observations of a practical skill facilitated comparisons to be made with the data obtained from the Practice Survey 1 questionnaire, of what the respondents indicated their current BPM practice was. Thus, the observations provided addition evidence to demonstrate if theoretical knowledge was being utilised in practice. For example, what position the client was in during measurement, what device was used, the size and placement of the cuff.

4.13.1 Methodological considerations of observations

Conducting observations on people for the purpose of research can be through participant observation, where the observer is involved in the activities of the group under study and non-participant observation where the observer remains separated from the study situation (Barker, 1996; Bowling, 2002). The observations may be overt or concealed from the participants. The observation data can be recorded by a structured and quantitative method by using a checklist or pro-forma or unstructured and qualitative recording of events or stories as they occur. Advantages of observations are that they produce better quality data than retrospective interview accounts. They are adaptable to many research problems and can be used with experimentation. They may be useful to obtain data which may not be available through survey methods, such as when the participants may not be articulate or introspective. The researcher can control the specific data to be collected (Barker, 1996; Bowling, 2002).

The disadvantages are that the presence of the observer can change people's behaviour as a result of being observed. Some people may not wish to be observed and access to observations in health care settings can be difficult to arrange. Questions can be raised about the possible lack of objectivity and observer bias. The management of this method can be complex and it can be very time consuming. Another issue for observations being conducted in health care

settings is the ethical issue of observing health care practices and what would happen if poor or unsafe practice was observed. To intervene would cause conflict, as this would result in a change to the situation or actions being observed and consequently the data from the observation may be invalidated. Not to intervene if observing a situation of unsafe practice could lead to significant consequences for all involved. The researcher therefore, needs to decide in advance what they would do if faced with such an event (Clifford, 1997; Robson, 2011).

The observations in this study were conducted after Equipment Survey 1 and Practice Survey 1 had been completed and prior to the delivery of the educational programme. Thus, those being observed who were unaware of the correct technique would not be able to demonstrate it during the observation. Those members of staff who had knowledge of the correct technique would be unlikely to change this to an incorrect technique during any observation. The ethical implications of observing clinical practice involving staff and clients are discussed at 4.16.

4.13.2 Tool used for observations

The observations were non-participative, open, structured and quantitative. Using the BHS, AHA and ESH guidelines for BPM and reference to the Practice Questionnaire a list of factors was drawn up in regard to the aspects to be observed (Appendix 8). These were

then subdivided under headings of communication, position, arm, cuff and technique. This information was then collated into a proforma to enable the researcher to record the observed actions quickly and easily in a standardised manner and aid in analysis of the data collected (Appendix 9). This highlighted two actions that the researcher would not be able to be visualise. These being which Korotkoff sound was used for diastolic readings and if the reading was being rounded off. The use of a dual headed or Y stethoscope was considered as a tool that could be used to determine which Korotkoff sounds were being used. However, this was discounted due to the aim of the observation being the evaluation of the whole process of BPM not just the accurate interpretation of Korotkoff sounds. Utilisation of the Y stethoscope by the researcher would focus the observation on listening for the Korotkoff sounds rather than the steps being followed by the person conducting the BPM. Therefore, conducting a short semi structured interview following the observation addressed this issue. This also provided an opportunity to ask if staff had ever been updated on BPM and if they had ever changed their technique of measurement.

4.13.3 Sample for observations

The sample size of observations was limited by several factors. The main reasons being one researcher to conduct the observations and the environment itself, having to wait until there was a client who need a BPM. It was not feasible to conduct observations on every

member of staff or every questionnaire respondent. Thus an opportunistic sample was used. A convenience sample of fifty seven members of staff from the selected maternity units was utilised for the BPM observations. The sample of staff from each site included midwives, doctors and health care assistants.

4.13.4 Observation of staff conducting BPMs

Two consecutive days were spent on each clinical site conducting the observations in different clinical areas. Staff working on those days were approached and informed that the researcher wished to observe BPMs and when a staff member was undertaking a measurement the researcher would be contacted. No member of staff refused to be observed and prior to the observation written consent was obtained (Appendix 10). The type of device utilised to measure BP and the technique used was solely at the discretion of the participant. The prepared observation checklist (Appendix 9) was used to record the observation data required. Participants being observed did not have sight of the observation checklist. The client who was having a measurement undertaken was provided with an explanation of the study and verbal consent was obtained for the researcher to be present at the time of BP measurement. Reassurance was provided that the client's personal or clinical details would not be divulged to the researcher. BPM were only observed on clients who were over sixteen years of age and could understand or speak English. Following the recording of the blood

pressure and away from the client a short semi structured interview was conducted with the staff member. The purpose of the interview was to collect data for the items set out in section 4.13.2. The data obtained was hand recorded on the pre-prepared proforma.

4.14 Data input and analysis

All data collected on prepared proformas and the questionnaires was checked to identify any possible errors prior to data input being performed. Using SPSS for Windows (version 10 to 17) data were inputted into prepared databases for analysis. Frequency and exploration testing was undertaken as a second accuracy check and errors rectified. The majority of the data were analysed as nominal variables apart from demographic information in regards age and number of years performing BPM which were interval variables. Descriptive statistics were utilised to obtain percentage and frequency distributions from the nominal variables. Non-parametric tests were conducted on nominal data obtained from the questionnaires following recoding of answers into two categories, correct or incorrect. Statistical tests used were bivariate analysis with Chi-squared test and Fisher exact, Spearman correlation coefficient test, Mann-Whitney U test, Wilcoxon matched pairs signed rank test and McNemar related samples test. The three most frequent statistically significant levels used in research reports are 0.05, 0.01 and 0.001. There is a variation in previous studies as to which significance level was selected. For example three studies (Bailey &

Bauer, 1993; Ahmed, 1997; Villegas, et al. 2005) used 0.05 and two studies (Burke, et al. 1982; Brown & Simpson (1992) used 0.001. For this current research study the significance level was set at 0.001 because a large number of tests were planned for questionnaire responses and thus the type II error rate would be unacceptably high at the P=0.05 level. To avoid concluding that a significant difference had occurred when the risk of that difference being due to a chance fluctuation was high, the more conservative level of 0.001 was considered to be the most appropriate.

4.15 Dissemination of Baseline Survey results

The researcher arranged to present the results from the baseline survey at a clinical research audit meeting at each Trust Site. Presentations incorporated individual Trust data with regards to equipment and practice surveys. The clinical research and audit meetings were attended by Consultant Obstetricians, Registrars and Senior House officers, midwives, students, neonatal staff and at one site a medical engineering department representative

4.16 Ethical issues of the study

Ethical approval for the project was submitted to the relevant Ethics Committees and approval obtained (Appendix 11).

4.16.1 Participants

This was considered to be a minimal risk study, minimal risk of discomfort and harm, with no foreseeable risks or harm to participants. Minimal risk studies are those in which the discomfort encountered by participating in the study is similar to what the participant would experience in their daily life and does not continue after the experiment (Burns & Grove, 1997). Participants in the study were volunteers. Throughout, the participants were treated fairly with respect and as autonomous agents.

4.16.2 Consent

Consent was obtained from the Heads of Midwifery to enter the maternity units and survey the equipment. The community midwives voluntarily submitted their personal blood pressure measuring devices for examination. Assurances were given that in no way did participation in the study affect their employment. No threats, force or incentives, were offered or used to coerce people to participate. The participants were fully aware that they were part of a research project and withdrawal was possible at any point of the study. Information was provided in both written and verbal formats to enable participants to make an informed decision regarding their participation in the study. Choosing to complete and return questionnaires and voluntary attendance at one of the education sessions was taken as participants consent to be involved in the study.

The observation of staff measuring blood pressure on a client in clinical practice was approved by the appropriate ethical committees. However it was stipulated that the person being observed had to give their written consent for the observation. This had to be in the form of a letter that detailed the requirements of the observation and reasons why the observation was being performed plus specifying that any observation of gross bad practice that placed a client at risk would lead to action being taken by the researcher and loss of confidentiality of the participant (Appendix 10). Verbal consent from the person having their blood pressure measured was considered acceptable by the ethics committees.

4.16.3 Confidentiality and anonymity

Participants in research studies have the right to anonymity and confidentiality of data. Complete anonymity only exists if the identity of the participant cannot be linked with individual responses even by the researcher (Burns & Grove, 1997; Gray, 2004). As identified at 4.10.3 a disadvantage of self administered postal questionnaires is a low response rate. It has been shown that a follow up letter and repeat questionnaire can increase the response rate. However, this requires the coding of the questionnaires to identify the non-responders. The disadvantage of coding is that some people would not respond as they prefer to remain anonymous even to the researcher. Coding was used on questionnaires utilised for Practice

Surveys 1 and 2 and Knowledge Questionnaire 2. The reasons for this, was to improve response rates by being able to send follow up letters and to provide the potential to allow comparison analysis of the data obtained. The covering letter informed potential respondents that the questionnaire was coded and why and assurance was given that individual responses would not be divulged to a third person. To maintain the confidentiality of the participants only the researcher had access to the participant's names and assigned codes compiled in a master list. These were kept in a locked cabinet separate from the data collected. Data input and analysis was through the codes.

4.17 Summary

The whole study was designed to address the overall aim as identified at 4.1 and answer the research questions as described at 4.2. However, this means the study has several phases, various tools and samples therefore Figure 4.3 provides a summary of the study. The repeated use of the surveys introduces a clear chronological sequence of the data obtained; however, this is not a panel study.

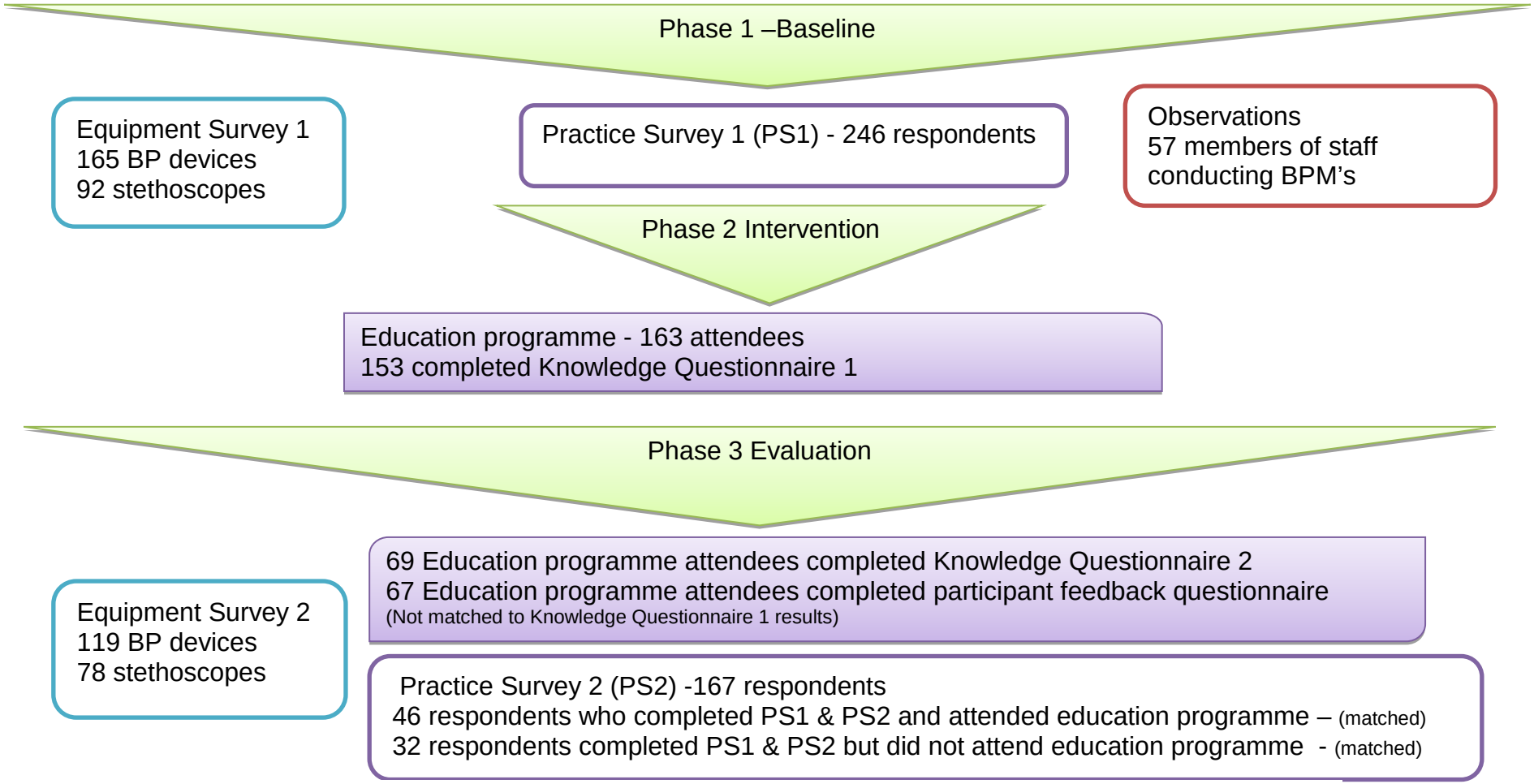


Figure 4.3 Stages of the study

CHAPTER FIVE

EDUCATION PROGRAME

5.0 Introduction

The purpose of this chapter is to present the methodological considerations given to the development and delivery of the education programme. The discussion will include the effectiveness of education as a means to change clinical practice and a justification of the method selected to deliver the education programme. The programme aim, objectives and learning outcomes are identified, followed by how the programme content and appropriate teaching and learning strategies were selected. The final section of the chapter focuses on how programme was delivered and the tools used to evaluate its effectiveness.

5.1 The effectiveness of education as a means to change practice

The maintenance of clinical competency is a professional requirement for qualified health professionals as previously discussed (2.5). The effectiveness of using educational activities as a tool to improve professional practice, knowledge and ultimately client health outcomes has been shown to be successful (Coomarasamy & Khan, 2004; Bordage, Carlin & Mazmanian, 2009; Forsetlund, et al. 2009; O'Neil & Addrizzo-Harris, 2009). Whilst the effectiveness of continuing education varies in its impact, several systematic reviews, (Lloyd & Abrahamson, 1979; Umble, & Cervero, 1996; Davis, et al. 1999; O'Brien, et al. 2001b; Bloom, 2005; Forsetlund, et al. 2009), have concluded that the use of continuing education for health professionals

does lead to small or moderate improvement in professional outcomes. The participants of the studies included in these systematic reviews consisted of health professionals from disciplines such as primary and secondary care medical staff, nurses, physiotherapists, midwives, health visitors and pharmacists. The systematic reviews by O'Brien, et al. (2001b) and Bloom (2005) found that interactive education was more effective that didactic education. Utilisation of interactive workshops as part of educational activities led to participants making moderately large changes to their professional practice. A more recent systematic review by Forsetlund, et al. (2009) concluded that mixed interactive and didactic education was more effective than either one alone, in regards to improvements in professional practice. Bordage, Carlin & Mazmanian (2009) found that the use of multiple instructional techniques and multi-media and if possible multiple exposure with the educational activity, improved the knowledge of health professionals and led to short and long term gains. Thus, the continued use of education to improve knowledge, practice and health outcomes is recommended by these studies.

Other factors that impacted upon the degree of effectiveness of continuing education of health professionals included the motivation of participants, knowledge of the problem being addressed. In particular the perception of the gap between participant's existing knowledge and skills and what was required to address this (Bordage, Carlin & Mazmanian, (2009). Forsetlund, et al. (2009) concluded that a limitation

of educational activities to improve health professional's competence, performance or health outcomes was that they are unlikely to be effective by themselves if complex behaviour changes were needed. In addition it was found that the impact upon knowledge and practice was reduced if the health professionals attending the educational activity did not perceive that there would be any serious consequences for the client. What the systematic reviews do not indicate, due to the lack of data provided by the studies examined, is any useful data regarding if group size, length of activity, number of sessions, teaching techniques used and when sessions are conducted have any impact upon the effectiveness of the education upon knowledge and/or practice. Neither is it possible to establish the best design of the implementation strategy to be used for education activities. These are areas that require further study and improvements in the descriptions of the interventions in the published data (O'Brien, et al. 2001b; Forsetlund, et al. 2009). In addition few studies address the longevity of the changes detected. Thus, while it was confirmed that education could be an effective method to improve practice, skills and knowledge in the development of an education programme utilisation of educational theories and concepts would be required.

5.2 Methodological considerations in the development of an education programme

To ensure an education programme is suitable for purpose and to enable evaluation it was important to consider factors that would impact on the development and delivery of the programme. A major

consideration was how the programme was to be delivered. Two different approaches were possible, the first being the direct involvement of the researcher in the delivery of the programme either within the clinical environment or within the university setting. The other main approach was participants would be directed to access learning materials, in a written, audio or visual format via the internet or available to participants in DVD or booklet format that could be mailed to given to the staff within the maternity units.

Participant self directed learning using written audio or visual materials was discounted as an approach for several reasons. When learning is self directed participants could chose to do all, part or none of the intended learning activities. The administration of staff access to a DVD for individual use would be problematic, in terms of the number of discs to have available within each maternity unit or the alternative would require, issuing an individual copy to each staff member. Similarly whilst an internet based program could be developed for the purposes of monitoring and evaluation of participants actual engagement with the materials could be an issue. Salaway, Caruso & Nelson (2007) found that the primary use of internet technology was as a source of information rather than a tool to learn.

The IT skills of the participant also impacts upon how individuals utilise technology for learning. Thus it was considered that accurate recording of the data required would not be achieved. Consistency of the

information participants had received and who and what activities participants had engaged with would be important in terms of evaluating the effectiveness and any impact upon professional practice of the education programme. In addition it was considered that participant engagement with a self-directed learning activity that would likely have to be undertaken in personal time away from the work environment may not provide sufficient participants for the study. Another reason for not using written information as a delivery method is that printed educational materials have been shown by systematic reviews to have little or no effect on professional practice (Freemantle, et al. 1997; Grimshaw, et al. 2004; Farmer, et al. 2011). Whereas, formal educational programs that used interactive techniques such as small group discussions and practice workshops were shown to be more effective for changing practice (Davis, et al. 1999; O'Brien, et al. 2001; Forsetlund, et al. 2009) and thus this was the approach chosen.

5.2.1 Adult learning theory

When choosing an appropriate teaching strategy for the facilitation of adult learning it is important for the teacher to have an understanding of how adults learn. Brookfield (1986), summarises the principles of understanding how adult learns from the work of Gibbs, Miller, Kidd, Knox, Brundage and Mackeracher, Smith, Darkenwald and Merriam. Adults exhibit diverse learning styles and learn in different ways at different times and for different purposes learning throughout their lives. They tend to prefer problem solving activities which are meaningful to

their life situation and like to put the learning into practice as soon as possible. Current learning is affected by past experiences and this can serve as a negative effect acting as a barrier or a positive effect enhancing the learning. The adult's self-concept as a learner is linked to how effective the learning will be and adults have a tendency to prefer some self-directedness in their learning. This summary of understanding of how adults learn by Brookfield suggests that for the facilitation of adult learning the use of cognitive or humanistic leaning theories where the student takes a more active role in their learning would be more appropriate than the behaviourist approach which tends to be more teacher led.

The assumptions of Knowles (1980) who developed the andragogy approach to the teaching of adults would support this view. Knowles suggests that adults bring with them a variety of life experiences that they can draw upon when learning. If the learning is related to their real-life situation, in particular, if they feel it is something they need to know their motivation to learn will be higher. Therefore, for adults it is important for them to know why they need to learn something. Adults are responsible for their own lives they have self-concept so need to be seen and treated by others as being capable of self-direction. Criticism of this type of approach to adult learning centre around issues of if it can be applied to all adults in all situations and because some principles could be effectively used with children and it is not an exclusive adult approach (Merriam, et al. 2007).

Following on from the work of Knowles and the andragogy approach to learning a transformative learning theory was pioneered by Mezirow in 1991. This is a uniquely adult theory based upon the nature of human communication (Taylor, 2007) and is critical in helping people think differently. It is more than the acquisition of factual knowledge where adult learning leads to adding to what is already known. Through the interpretation of the knowledge or experience a new or revised interpretation is construed thus existing knowledge is changed or transformed in order to guide future actions. The learner is empowered as knowledge is being created and thus this approach can be used as aid to help people think differently, learners will question assumptions, beliefs and values, consider different points of view. The role of the educator is to help learners to critically reflect upon and examine the underlying assumptions upon which they base their beliefs, feelings or actions and explore alternatives. By learners being more reflective and critical they can be more open to other view points or perspectives and thus more acceptable to new ideas and less defensive (Boyd & Myers, 1998; Mezirow, 2000). The provision of learning experiences in which students are directly engaged and stimulated to reflect upon personal experiences act as powerful tools to foster transformative learning (Taylor, 2007).

The challenge for the facilitator of any adult learning programme is to ensure that they have an understanding the participants' needs, the

intended outcomes or changes in behaviour and/or attitude that is required and the context within which the learning is to occur. With an understanding of all the different learning theories and techniques that can be used the potential is there for all of them to have some valuable contribution to offer. The application of one theory or technique to the exclusion of all the others is unlikely to lead to the best results. Thus the facilitator needs to select and apply the most appropriate theory(s) and techniques to the particular intended audience requirements.

The important factors therefore, for this proposed education programme are the facilitation of critical reflection upon current BPM practice and beliefs around their competency to conduct BPM. Ensuring the participants are motivated to learn, gain an understanding the consequences of incorrect actions and integrating new learning into clinical practice and utilising a mixture of interactive and didactic teaching activities.

5.2.2 Domains of learning and the education programme

Learning can be differentiated into three main domains the psychomotor, which involves the acquisition of motor skills and physical dexterity, cognitive which is related to knowledge and intellectual ability and affective which concerns attitudes and values and emotions (Reece & Walker, 2007). When planning the teaching and learning approach it is important that consideration is given to the subject matter being taught and what learning domain or domains it is

intended to facilitate the learning in. The teacher in planning the learning experience needs to consider the level or taxonomy within each domain. This relates to the degree of difficulty within the domain and takes the form of a hierarchy. Thus progression from level to level is founded in the acquisition of the skills from the levels below. For example in the cognitive domain this goes from lowest level of knowledge, remembering or recall, to the highest of using intellectual process such as decision making to evaluate the knowledge (Quinn, 1995; Curzon, 1997; Reece & Walker, 2007). Consideration of the domain of learning and taxonomy can facilitate the formulation of objectives of learning and to ascertain if effective learning has occurred (Quinn, 1995; Curzon, 1997).

The importance for the teacher is that learning in these domains requires different learning and teaching approaches but in practice simultaneous learning in all three domains can occur. The teacher also needs to appreciate that whilst they may identify objectives for a teaching session often there can be unanticipated learning outcomes that have importance in the students learning experience. Normally the acquisition of a skill such as blood pressure measurement would be taught mainly through the psychomotor domain. However, in this instance the participants already had the skill to some degree. What was required was updating of this knowledge and skill. Many participants would need to transform their existing knowledge and understanding, beliefs so future changes to their BPM technique could

occur. Therefore, the initial domain of learning need was cognitive not psychomotor. Analysis, synthesis and evaluation, the three higher levels of the cognitive taxonomy were required to enable the participants to judge how any new information should or could be incorporated into their own clinical practice. That is the perception of the gap between the new and existing knowledge and what was required to change. However, for those participants who need to relearn the correct technique of BPM leaning in the psychomotor and affective domain would also be required. Thus in planning the learning session for the education programme cognitive and transformational learning theories were predominant however, behaviourist and humanist and social constructivist theories were not discounted (Reece & Walker, 2007; Taylor, 2007).

5.3 Aim and learning outcomes for the education programme

The identification of the aim and learning outcomes for the education programme provided direction for the content and the teaching and which specific learning strategies were required. They are also used as measurement indicators for evaluation purposes. The overall aim of the education programme was for participants to:-

Update knowledge on blood pressure measurement and be able to adhere to published recommendations on the execution of the measurement.

The intended learning outcomes were that by the end of the session, participants should be able to:-

1. Demonstrate understanding of factors that affect the accurate measurement of blood pressure in pregnancy.

2. Identify defects in blood pressure measuring devices.

3. Conduct a blood pressure measurement according to current BHS guidelines.

The specification of the improvements to the practice of BPM as a clear expectation in the aims and learning outcomes of the education programme is one way to ensure that short courses for continuing professional development are efficient (Moon, 1999). This essential expression of the learning that must occur as a result of the course implies to participants there are implications for practice from the beginning. Thus, acting as the key to start the reflective process and provide participant's the opportunity to reflect upon learning as it occurs. Through guiding and supporting reflective activities within the content of the programme this will appropriately direct the learning of participants to reflect on current practice, consider alternatives and then be in a position to change and improve personal skills/behaviours (Moon, 1999).

5.4 Content of the education programme

The content of the education programme was initially based upon the analysis of the literature the factors such as observer and client factors that have been shown to affect accurate BPM and the results from previous studies that identified the failure of health professionals to apply theory to the practice of BPM (as summarised in tables 3.4, 3.5 and 3.7). This was enhanced with the data obtained from phase one the baseline survey. Thus, the researcher not only identified what should have been known by the participants but was able to pinpoint the gaps between that and participants' existing knowledge. Thus, the content of the education programme could be specifically related to the how current practice within the maternity units was not adequate to prevent the introduction of errors into their BPMs and highlight the possible subsequent consequences for their clients. Figure 5.1.summarises the sources from which the content of the education programme was based upon. The tables 5.1 and 5.2 identify the aspects included within the education programme.

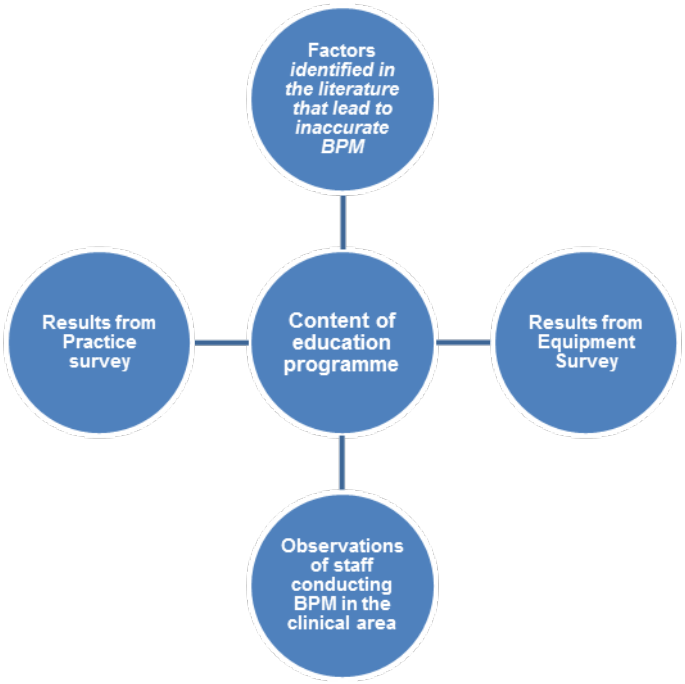


Figure 5.1 Sources of information used to determine the content of the education programme

Table 5.1 Observer factors affecting accurate measurement of blood pressure

FACTORS identified in the literature as having an effect on accurate measurement of blood pressure	Included in the questionnaires	Included in observation and or interview	Included in the education programme session
Digit Preference (rounding off to a 0 or 5)	Yes	Yes	Yes
Cut off Bias	No	No	Yes
Fatigue or poor memory	No	No	Yes
Cuff Size	Yes	No	Yes
Cuff not centred	No	Yes	Yes
Cuff over clothing	No	Yes	Yes
Manometer position above or below eye level	No	Yes	Yes
Diastolic - Using phase IV (Korotkoff)	Yes	Yes	Yes
Stethoscope bell or diaphragm end used	No	Yes	Yes
Stethoscope head applied incorrectly to firm or too loose	No	Yes	Yes
Stethoscope head touching tubing or cuff	No	Yes	Yes
Inflation rate incorrect	Yes	No	Yes
Deflation rate incorrect	Yes	Yes	Yes
Palpatory pressure omitted	Yes	Yes	Yes
Ever had any update since training	No	Yes	Session was an update
Servicing requirements of equipment	Yes	No	Yes

Key Yes = included No = Not included

Table 5.2 Client factors affecting accurate measurement of blood pressure

FACTORS identified in the literature as having an effect on accurate measurement of blood pressure	Included in questionnaires	During observations found to be discrepancies between guidelines and observations	Included in education programme session
Arm position above or below heart	Yes	Yes	Yes
Arm unsupported	No	Yes	Yes
Position of client supine or sitting	Yes	Yes	Yes
No resting prior to measurement	Yes	Yes	Yes
Back unsupported	No	Yes	Yes
Legs dangling/crossed	No	Yes	Yes
White coat hypertension	No	N/A	Yes
Pain anxiety	No	No	Yes
Smoking	Yes	Yes	Yes
Caffeine ingestion	Yes	Yes	Yes
Recent meal	Yes	Yes	Yes
Distended bladder	No	Yes	Yes
Talking or signing	No	Yes	Yes
Cold environment	No	Yes	Yes
Exercise	Yes	Yes	Yes

5.4.1 Teaching and learning strategies for the education programme

The group size, ability and motivation of students and location of the activity determine which activities can be used and impact upon the choice of teaching strategy. Smaller groups provide opportunities for more participative strategies to be used such as discussion, group work, role play or simulation. The ability of the group in regards to their attention span, previous knowledge and experience, skills, intelligence needs to be considered. Student motivation and interest can be affected by the teaching strategy and the enthusiastic approach of the teacher is crucial here to encourage a positive attitude to learning. The selection of appropriate teaching and learning strategies facilitates effective delivery of content (Reece & Walker, 2007).

Prior to selection of the teaching and learning strategies consideration was given to the impact of factors such as location, equipment, length

of session and anticipated group size had on the intended programme. The feasibility of accessing staff to deliver an education programme session during a working day had to be addressed. Following discussion and negotiation with senior managers from each setting, it was agreed that staff could be withdrawn for one hour from the clinical area. Attendance would be voluntary and several sessions would be offered in one day, thus providing staff more than one opportunity to attend. This provided a standardised but flexible approach to lessen any impact upon clinical activity. A small equipped teaching room was available for use on each clinical site. The anticipated numbers of participants attending a session ranged from one to a maximum of 15. As the anticipated group size for single sessions were small this facilitated the use of participation activities and the locations enabled the use of audio visual aids via data projection equipment.

The specification of the intended learning outcomes (5.3) and selection of the topics enabled differentiation of when teacher led or student led approaches were most appropriate. Teacher centred activities are suitable to provide the initial theoretical perspective and associated inconsistencies and act as a foundation point in a lesson (Fry, Ketteridge & Marshall, 2003). Thus were suited for learning outcomes one and two based on the knowledge of factors that affect accuracy in regards to technique and equipment. However in order to initiate reflection and challenge previous learning the activities included interaction between the teacher and participants through the use of

questioning, discussion and reflection on current practice (Brownhill, 2002). Learning outcome three concentrated on the practical application of conducting a BPM according to current guidelines. This facilitated the use of more interactive student centred activities, utilising audio-visual aids, demonstration of the procedure followed by a student led discussion and reflection of how this recommended technique differed from current practice. The combination of teacher led and student led activities was intended to facilitate active thinking so participants could comprehend the relevance of the theory assimilate it to their own practice.

The use of more than one sense at a time is known to enhance understanding and memory (Reece & Walker, 2007). Planning a cognitive lesson aiming for the participant to acquire knowledge, the first level of the cognitive taxonomy requires emphasis on verbal and visual association. However for the higher level of understanding then the teacher needs to use questioning and comparing knowledge with what is known and problem solving (Reece & Walker, 2007).

The participants were adult learners thus consideration of individual ability, existing knowledge, motivation and clinical experience was important. However, they had in common a perceived ability to conduct a BPM and some knowledge on this subject. The findings from Nolan & Nolan (1993), suggested that staff were likely to feel competent in the skill of BPM. It was considered that the voluntary participation of the

education programme would be influenced by how receptive the staff were to a personal need for updating their knowledge on BPM. A lack of a perceived need or the session not being beneficial to practice could create a barrier to learning (Knowles, 1980; Boyd & Myers, 1998). Some participants may have been motivated to attend the session if they had encountered difficulty in answering the Practice Survey !Questionnaire.

Ensuring the session would be perceived as beneficial and of value would facilitate positive feedback from participants and provide encouragement to other staff members to participate in subsequent sessions. Participant motivation being receptive to the acceptance of new information, acknowledgement of previous learning and the exposure of limitations was facilitated through the use of an individual problem solving activity (Bordage, Carlin & Mazmanian, 2009). In addition as discussed earlier the direct engagement and stimulation of critical reflection on current experience fosters transformational learning (Taylor, 2007).

Through the BHS a CD-ROM was purchased a specifically designed learning aid for use with individuals or groups. The content of this CD-ROM included video clips of falling mercury levels on a mercury manometer combined with Korotkoff sounds designed for use as a self-assessment exercise. Using a sample of these video clips within the session provided non-threatening problem solving student led activity

that resembled a game. The inclusion of baseline survey data within the session added an aspect of personal clinical relevance to the unit in which the session was being conducted and inks the theory to current practice. Unless the affective domain could be stimulated it would be unlikely that participants would change their BPM practice. Student centred activities, participation; small group discussions, critical reflection, are strategies that stimulate the affective domain (Mezirow, 2000; Taylor, 2007). To ensure a logical structure to the education programme content, consistency of delivery and evaluation of achievement of intended learning outcomes a lesson plan was constructed (Appendix 12).

5 4.2 Ensuring consistency of delivery of the education programme

As the education programme was to be delivered more than once within three maternity units consistency of delivery was important in terms of being able to evaluate its impact upon practice. A PowerPoint presentation was developed to provide consistency in the information and order content was imparted by the teacher. Because of the time factor and the use of other resources a six slide presentation was prepared (Appendix 13). The use of the BHS CD-ROM for the introductory game activity and a video demonstration of how to conduct a BPM according to current guidelines ensured further consistency in delivery of programme content. Once this phase of the study commenced no changes were made to the delivery method, content, demonstrations or activities utilised. Thus prior to its use in the study a

pilot delivery of the session was undertaken to ensure the programme was fit for purpose.

5.5 Pilot delivery of the education programme

The agreed maximum time staff would be released to attend the session was for sixty minutes. Thus an important factor in the pilot delivery was assessment of the timing of the activities and the time taken to complete the whole session. It also enabled the collection of feedback in regards to participant reaction to the planned teaching and learning activities and perception of value and or benefit of attendance at an update session on BPM.

The pilot session was conducted in a clinical setting with a group of eight qualified and non-qualified staff in an NHS Trust that was not involved in the study. The session took ninety minutes to deliver as per the lesson plan. General feedback was positive with a total agreement that the session was informative, enjoyable and perceived as valuable to clinical practice. The participants particularly liked the self assessment exercise and if the education programme was made available within the Trust they would positively encourage their peers to attend. This confirmed that in general the structure and content, learning strategies and activities were appropriate and likely to be perceived as valuable to the intended audience.

On analysis of why the session had overrun by thirty minutes, two factors emerged. Following viewing the BHS video of the correct technique of BPM a group discussion/debate was initiated by the participants in relation to what they had seen demonstrated, the focus being on the factors that varied from how participants performed measurements. Critical reflection on current practice and how the new information presented could be integrated into future practice and is integral to transformation leaning. This was facilitated within the pilot session but had not been included in the timings of the lesson plan. The other factor that contributed to the increase delivery time was that the ten minutes allowed for the practical session for conducting a BPM using the correct technique was insufficient for one person to supervise, assess and give individual feedback. It was determined that a minimum of fifteen minutes would be required for every four people within a group.

This pilot delivery resulted in two changes being made to the lesson plan. Firstly the inclusion of the discussion and debate following viewing of the BHS video on BPM as this appeared to facilitate critical reflection on current practice and understanding of the need for participants to alter their technique of BPM. Secondly the practical activity of practising BPM was removed from the session. This decision to remove this activity from the final programme was related to the requirement that the delivery of the education programme needed to be consistent and completed within sixty minutes. The number of participants at any single

session would vary but could be a maximum of fifteen members of staff. The pilot session had identified that the practical activity alone for fifteen people would require at least one hour. Thus the inclusion of this practical activity with each participant conducting BPM was not a feasible option for groups of more than four participants.

To ensure consistency of programme delivery of the same content it would not be possible to vary the inclusion of the practical activity when smaller numbers of staff attended and exclude it if a large number attended the advertised session. An alternative would be to reduce the theoretical cognitive content to increase the psychomotor skills aspects. Reduction of theoretical content would impact upon the updating of knowledge of factors that affect accuracy of measurement. However, as the participants already had a degree of psychomotor skills in the measurement of blood pressure it was feasible for the participants to practice the psychomotor components of the skill individually on completion of the theory session. Another alternative would have been to limit the group size to three people this would have repercussions on overall sample size and limit the flexibility of attendance required by the setting of the study. A revised lesson plan was constructed and used for the delivery of the education programme (Appendix 14).

5.6 Sample

One hundred and sixty three members of staff including midwives, doctors, student midwives and health care assistants from the selected settings voluntarily participated in the education programme.

5.7 Delivery of the Education Programme

The educational programme was delivered via one hour sessions from March 2005 to September 2005, (excluding August 2005), at different times and days of the week for each site. The sessions were advertised in advance and more than one session was available on any single day (Appendix 15). A minimum of eight days to a maximum ten days were spent on each site and up to four sessions delivered on any one day. Staff attended any one of these sessions at their convenience. Thus opportunities were provided to ensure that those who wished to attend a session could do so at a time when their attendance would not impact on clinical activity. Pre-arranged dates and times were agreed to deliver the education programme to the medical staff and those staff who worked in defined areas such as antenatal clinic, day unit and community staff to suit their specific needs. The education programme was delivered by the same researcher using the pre designed slides and teaching aids with the content delivered as laid out in the lesson plan. At each session an attendance list was completed and retained by the researcher.

5.8 Evaluation

The general methodological considerations of evaluation research have been previously discussed at 4.4.1. As discussed pre and post evaluation was imperative as the intention of the introduction of educational training was to improve performance (Bramley, 2003). In this current study the baseline survey results formed the basis of the pre-evaluation. Equipment Survey 2 and Practice Survey 2 provided some post-evaluation data for comparative analysis to determine if the education programme had resulted in any changes within the study settings. However, the completion of the evaluation process required the collection of data regarding participant's reactions and if the programme had led to the acquisition of knowledge.

Assessment of changes in practice by repeating observations of staff conducting BPM following the educational programme were not undertaken. It was considered that following the update participants would be more aware of what aspects were being observed in relation to the correct technique that should be utilised. As the observations would not be anonymous this could lead to the participants changing their practice during the observation to what they felt the researcher was expecting and thus would lead to a potential bias in the data collected.

Through the utilisation of a modified version of Kirkpatrick's four level model of educational outcomes (as discussed at 4.4) table 5.3

summarises the methods and tools used to evaluate the effectiveness of the study's education programme

Table 5.3 Evaluation of educational outcomes of education programme

Factors to be evaluated	Purpose	Method of evaluation
Learning needs	Pre-evaluation to determine content of education programme	Equipment Survey 1 Practice Survey 1 Observations of Staff conducting BPMs
Reactions	Participants reactions to the educational programme – value or perceived need for programme	Participant evaluation of education programme
Learning	Achievement of intended learning outcomes – acquisition of knowledge and skills	Knowledge questionnaire 1 – initial evaluation Knowledge questionnaire 2 – longer term evaluation
Changes	Have participants made any changes to their professional practice – evidence of learning being applied to practice	Participant evaluation of education programme & paired sample results from Practice Survey 2
Results	Wider changes in organisation /delivery of care - more accurate BPM	Equipment survey 2 Practice survey 2

It should be noted that the outcomes above are not hierarchical and the overall aim of the evaluation is to better inform future practice and development. This evaluation would determine if the programme was suitable and effective for the intended target population and facilitate the identification of any necessary changes that are required to the education programme. As the details of the equipment and practice surveys have been discussed in Chapter 4 (at 4.9 onwards) the following discussion will focus on the other elements of evaluation process used in this study.

5.8 1 Evaluation of Learning

The utilisation of appropriate teaching and learning strategies within the education programme could be evaluated by assessing participant achievement of intended learning outcomes. This would be conducted in two stages. An initial evaluation would be conducted immediately following delivery of the education programme and a follow up longer term evaluation conducted later once delivery of the education programme had ceased on any site thus allowing attendees the opportunity to process their leaning.

As the content of the education programme was based around the identification of limitations on knowledge identified by Practice Survey one results (discussed at 5.4) adaption of this questionnaire for use as an evaluation tool was considered a feasible option. However, a change to the wording of some of the questions was required as many of the questions for the practice survey were phrased to elicit information on what the respondents did in practice. For example “what do you usually do …..?” Whereas, following participation in education programme it was necessary to evaluate whether respondents could identify the correct method that should be used. Therefore the wording of these questions was altered to ‘what should you….. ’ The choice of answers remained the same. As the content of the education programme did not include specific measurements in relation to cuff size, question nine was omitted. Other alterations and reasons why changes were made are summarised in table 5.4 for the initial evaluation and table 5.5 for

the longer term evaluation referred to as Knowledge Questionnaire 1 and Knowledge Questionnaire 2 respectively (Appendix 16 and 17).

Table 5.4 Category of topics used in Knowledge Questionnaire 1

Question	Changes from Practice Questionnaire	Reason for change	Category of topic
Demographic questions	Removed	Not relevant for evaluation of achievement of intended learning outcomes /attendance register taken at session	None
1. Identify type of equipment that can used	Question type changed from closed to open	Original question asked which type they used most needed to know if they could differentiate between different types of devices	Equipment knowledge
2. Calibration	*No changes*		Equipment knowledge
3. Position of client	Wording - usual to should	Identification of knowledge of correct method not what they actually did in practice	Correct method
4. Systolic method	Wording - usual to should		Correct method
5. Diastolic method	Wording - usual to should		Correct method
6. Arm Circumference	No changes		Factors affecting accuracy
7. Rate of deflation	Wording - do you to should		Correct method
8. Resting before measurement	Wording - usual to should		Correct method
9.Time elapsed after, smoking, eating, caffeine, exercise	*No changes*		Factors affecting accuracy
10. Rounding off reading	Wording - usual to should	Identification of knowledge of correct method not what they actually did in practice	Correct method
11. Arm used	Wording - normally to can you		Correct method
12. Does arm position affect readings	Question type close to open	Poorly answered in PS1 to evaluate if they understood how arm position affects readings	Factors affecting accuracy
13. List other factors that affect accuracy	New question	to test memory on factors introduced in session	Factors affecting accuracy

Key PS1 = Practice Survey 1

The purpose of Knowledge Questionnaire 2 was to ascertain if the educational programme had any possible long term benefits or impact and whether, there was the need for ongoing continuing education. In addition it would aid in the evaluation of if appropriate planning of learning to enhance memorability through teaching and learning strategies and utilisation of audio-visual aids had aided in the subject matter taught being retained in the participant's long term memory.

Table 5.5 Category of topics used in Knowledge Questionnaire 2

Question	Changes from KQ1/reasons for change	Category of topic
1. Gender	*Added to questionnaire as distribution was some time after attendance at session and anonymous*	Demographic
2. Age		Demographic
3. Qualifications		Demographic
4. Calibration	No changes from KQ1	Equipment knowledge
5. Position of client	No changes from KQ1	Correct method
6. Systolic method	No changes from KQ1	Correct method
7. Diastolic method	No changes from KQ1	Correct method
8. Arm Circumference	No changes from KQ1	Factors affecting accuracy
9. Rate of deflation	No changes from KQ1	Correct method
10. Resting before measurement	No changes from KQ1	Correct method
11.Time elapsed after, smoking, eating, caffeine, exercise	No changes from KQ1	Factors affecting accuracy
12. Rounding off reading	No changes from KQ1	Correct method
13. Arm used	No changes from KQ1	Correct method
14. Effect of arm position	Changed back to multiple choice as in PQ1	Factors affecting accuracy
15 List factors that affect accuracy	No changes from KQ1	Factors affecting accuracy
NB Equipment question removed, as by this time Practice Survey 2 had identified mercury devices had been removed from clinical settings Key KQ1 = Knowledge Questionnaire 1 PQ = Practice Questionnaire		

5.8.2 - Administration of Knowledge Questionnaires 1 and 2

At the end of education programme session each participant was handed Knowledge Questionnaire 1. This anonymous questionnaire was completed in the presence of the researcher and returned.

In January 2006 two months after the last education session had been conducted Knowledge Questionnaire 2, a covering letter and freepost return envelope was distributed via the internal mail system to all the participants who attended the educational programme. This meant that the maximum time since attendance was nine months and the minimum two months. The questionnaire was coded to aid in the comparison of data and to follow up non-responders. A follow-up letter (Appendix 18),

Knowledge Questionnaire 2 (Appendix 17) and a freepost envelope was further distributed to the non responders in March 2006.

5.8.3 Data input and analysis

Data were entered on prepared SPSS databases and analysed as discussed at 4.14.

5.8.4 Participant evaluation of the session

As discussed at 4.4.1 obtaining participant reactions of an education programme is an important part of any evaluation. In particular it provides a means to assess if there has been any change in behaviour or attitude, any perceived value or benefit to their participation in the programme. It also provides an opportunity to receive feedback on positive or negative aspects of the implementation and delivery so any necessary changes to a programme can be made.

Therefore, in this study each participant was provided with an opportunity to reflect and evaluate their learning experience following attendance at the education programme. As previously discussed it was anticipated there could be variation in the number of attendees in any single session (range 1 to 16). Therefore it was considered the request to complete a formal evaluation at the end of the session in the presence of the researcher could be perceived as daunting if there number of participants was small. This could potentially not elicit truthful responses. Neither would this allow the participant's time to think and digest and reflect on what they have learnt from the content of the

session or an opportunity to change their practice. Therefore, allowing some time to elapse before evaluation was undertaken would address both these issues.

A simple questionnaire consisting of 6 items with a combination of open and closed questions with an accompanying letter was developed (Appendix 19). The focus was on the participants' perception of the content and length of the educational programme, its value to them and if since their attendance they had changed their technique of BPM. In addition the evaluation provided an opportunity to obtain data regarding participant's engagement in any previous forms of continuing education regarding BPM.

5.8.5 Administration of participant evaluation questionnaire

Using the attendance lists 4-6 weeks after attending the education session all participants were sent the prepared participant evaluation form with an accompanying letter and a SAE for postal return. Follow up letters and another evaluation form were sent two weeks later if there had been no response.

5.8.6 Data input and analysis

The returned questionnaires were examined and the data were manually collated and frequency counts calculated.

5.9 Wider evaluation of impact of study

As discussed at 2.5 once obtaining competency in the skill of BPM it appears that staff take for granted their ability to conduct what is seen as a basic skill. As there is no formal requirement for ongoing assessment of competency or updating staff appear to be complacent about their competency of BPM. By conducting a research study on BPM within the real world setting of clinical maternity practice provides the opportunity to raise awareness of accurate BPM. The surveys of staff and equipment plus the observations and delivery of the education programme itself will serve as different mediums to raise the profile of accurate BPM and disseminate evidenced based information about BPM. Within such a clinical setting this dissemination of information and raising awareness of the topic could impact on different members of staff whether or not they actively participate in the study.

Interpersonal contact can play a pivotal role in the diffusion and utilisation of information as part of a social process (Ryan & Gross, 1943; Backer, 1991). Diffusion of knowledge in organisations or communities such as health care settings is a communicative and interactive social process (Rogers, 2003). Thus the communication of research, knowledge or innovations to groups can occur through various formats. Wenger (1998) suggests that by participation in the daily interactions and shared experiences of members of a community new knowledge is created. The starting point is often a person either internal or external to the organisation acts formally to influence or

promote the utilization of knowledge. Communication of the information within the organisation follows with individuals and or groups. This communication can occur in different formats such as through the influence of peers, one to one discussions, persuasion, expert influence and a structured intervention with the intention to change in practice (Thompson, Estabrooks & Degner, 2006). Diffusion theory indicates that, if the change is perceived as beneficial then individuals will change (Rogers, 2003). Initially only a few members of a group/organisation will adopt an innovation but the diffusion of innovations process indicates that over time more individuals will adopt the new idea (Rogers, 2003; Valente, 1993). Coleman, Katz & Menzel (1957) identified that within the medical community diffusion occurred like a snowball process through the interpersonal connection of doctors influencing each other within their social network, thus integrating an innovation into their practice.

Dissemination of information to a group of people within an organisation is often done with a certain intention and if this is the key reason for the dissemination an evaluation needs to occur to determine if the dissemination has occurred. Thus, as in this research study a key intention was to raise awareness of factors that affect BPM to as many staff as possible within the three maternity units and to promote evidence based practice in regards to BPM.

CHAPTER SIX - RESULTS

This chapter presents the results of the study in the following order equipment surveys, observation results and practice survey. This is followed by the initial, longer term and participant evaluation of the education programme. As discussed previously at 4.14 the threshold of significance for this study was set at P=0.001.

6.1 Baseline Survey - Equipment Survey 1

In total 165 BP measuring devices, were included in Equipment Survey 1. Aneroid devices were the most common type and automated devices the least common type of instrument being used in these clinical settings (table 6.1).

Table 6.1 Type and number of blood pressure devices in Equipment Survey 1

Type of device	Hospital 1 Survey 1	Hospital 2 Survey 1	Hospital 3 Survey 1	Total number
Mercury	36	24	0	**60**
Aneroid	27	15	41	**83**
Automated	8	8	6	**22**
Total number of devices in each setting	**71**	**47**	**47**	**Total = 165**

As discussed at 4.9.1 the general working condition of these devices was evaluated through the assessment of nineteen standard components as discussed at 3.5 shown in table 3.2. The results indicate that most of the BP devices surveyed had components that would not meet the quality standards for acceptable working condition (table 6.2).

Table 6.2 Summary of the working condition of BP devices assessed in Equipment Survey 1

Component standard assessed N = number of devices	Test	Number of BP devices that failed assessed standard test n (%)	Number of BP devices that passed assessed standard test n (%)
Date of last service N = 165	Sticker on device with date of service	148 (89%)	17 (11%)
Glass tube/face plate * n = 143	Oxidation,(mercury) Damage to face plate (aneroid)	34 (24%)	109 (76%)
Zero * n= 142	Mercury meniscus level or pointer is at zero prior to inflation	36 (25%)	106 (75%)
Cuff type and condition N=165	Identify type, general condition (manual) same manufactures cuff as device (automated)	21 (13%)	144 (87%)
Cuff size N=165	Labelled with a size – adult, extra large	60 (36%)	105 (64%)
Bladder size N=165	Bladder size labelled	136 (82%)	29 (18%)
Artery centre line N=165	Artery centre line indicated	58 (35%)	107 (65%)
Arm range N = 165	Arm range of cuff identified	52 (32%)	113 (68%)
Bladder N = 165	General condition of bladder	15 (9%)	150 (91%)
Tubing N = 165	Intact not cracked, holes or crumbling/ perished Presence and condition of connectors	52 (37%) 67 (41%)	113 (63%) 64 (59%)
Control Valve * n = 142	Open and close with ease, Conduct inflation, deflation and leakage tests	17 (12%) 63 (38%)	125 (88%) 79 (62%)
Pump Bulb * n=142	Condition of rubber Ease of pumping during function tests	16 (11%) 11 (8%)	126 (89%) 118 (92%)
Legibility of gauge* n = 143	Legibility of markings	19 (13%)	124 (87%)
Mercury * n = 60	Check level, general condition , air or dirt, bouncing or hesitation when mercury is rising or falling	19 (32%)	41 (68%)
Instruction booklet ** n = 22	Identity if instruction booklet is present with automated device	5 (45%)	17 (55%)
Calibration test * n = 131	Errors greater than -+ 4mmHg are not acceptable	28 (21%) UTT 12	103 (79%)

KEY
* = Not applicable to automated devices
** = Not applicable to manual devices
UTT = unable to test due to connections

6.1.1 Servicing of BP equipment

For 148 (89%) of the 165 devices surveyed there was no indication when or if the BP devices had ever been serviced (table 6.2). Of those devices with an indication that servicing had been undertaken, only 17 (11%), had been serviced within the recommended timeframe of twelve months, five of these being manual devices and twelve automated (table 6.3). Chi-square analysis revealed that automated devices were more likely to have undergone servicing than manual devices and aneroid devices were least likely to undergo servicing (χ^2=26.20, df=2, P<0.001). This analysis excludes six of the twelve automated devices which were recent purchases and thus were not due a service.

Table 6.3 Servicing data of mercury, aneroid and automated BP devices assessed in Equipment Survey 1

Type of device N = number	Within 6 Months	Within 12 months	Within 2 Years	Within 3 years	>4 Years	Date Unknown	Total number serviced within 12 months (%)	Total number serviced > 12 months (%)
Mercury survey 1 (N = 60)	0	3	7	7	2	41	3 (5%)	57 (95%)
Aneroid survey 1 (N = 83)	1	1	5	8	2	66	2 (2%)	81(98%)
Automated survey 1 (N = 22)	11	1	2	0	0	8	12 (55%)	10 (45%)
Total for Equipment Survey 1 (N = 165)	12 (7%)	5 (4%)	14 (8%)	15 (9%)	4 (2%)	115 (70%)	17 (11%)	148 (89%)

6.1.2 Calibration testing of BP equipment

Calibration testing was conducted on 131 of the 165 BP devices by the method summarised in table 4.1. Twenty two automated devices were excluded from testing as they required the manufacturer's specialist machinery to conduct a calibration test. Eleven manual devices were

also excluded because the type of connection made it impossible to connect to the control device. A mercury leak was identified on another manual device and thus it was immediately removed from the ward in line with the Trust mercury spillage policy. Table 6.2 indicates that 28 (21%) manual BP devices failed the calibration testing, deviating from the control device by 4mmHg. Separation of the calibration testing results by device type (aneroid or mercury) showed that a higher proportion of aneroid devices failed the calibration test (Fishers exact P<0.001, table 6.4).

Table 6.4 Calibration testing results for manual BP devices Equipment Survey 1

Type of manual device	**Number of devices that passed calibration testing**	**Number of devices that failed calibration testing (%)**
Aneroid	50	*24 (32% of aneroid) 8 > 6mmHg difference)*
Mercury	53	*4 (7% of mercury)*
Total	**103**	*28 (21% of all manual devices)*

6.1.3 The working condition of BP equipment

Assessment of the general working condition of manual device types showed that a higher proportion of mercury devices (30% compared to 1.2% for aneroid), were found to have illegible markings (Fishers exact P<0.001). Table 6.5 provides a summary of the proportion of mercury and aneroid devices that failed to meet the working condition of each assessed component. More detailed results about cuff condition, type, labelling, size and availability are summarised at 6.1.5. Just five devices out of the 165 were found to have no component faults whatsoever.

Table 6.5 Proportion of mercury and aneroid devices that failed to meet assessed component standards in Equipment Survey 1

Component Fault	Number of devices identified with the component fault		Comparison of proportion failing (fisher's exact p)
	MERCURY N = 60 (%)	ANEROID N = 83 (%)	P=
Cuff in a poor condition/missing	11 (18%)	8 (10%)	0.142
Cuff size not identified	15 (25%)	37 (45%)	0.021
Bladder size not labelled	51 (85%)	76 (92%)	0.284
Arm range not labelled	15 (25%)	29 (35%)	0.270
Artery centre line not labelled	19 (32%)	31 (37%)	0.594
Tubing in a poor condition	27 (45%)	18 (22%)	0.003
Missing or faulty connections	26 (43%)	31 (37%)	0.492
Faulty valve	13 (22%)	4 (5%)	0.003
System leaks	19 (32%)	30 (36%)	0.597
Poor condition of bulb	3 (5%)	2 (3%)	0.649
Faulty Bulb (pumping)	4 (7%)	8 (10%)	0.761
Poor condition of bladder	3 (5%)	4 (5%)	0.492
Poor condition of glass	16 (27%)	17 (20%)	0.425
Device not at zero	11 (18%)	25 (30%)	0.183
Illegible markings	*18 (30%)*	*1 (1.2%)*	*<0.001*

(Threshold of statistical significance used for this study is P=0.001)

Data were collected that enabled the differentiation of BP devices by type (mercury, aneroid or automated BP) and by model (fixed wall mounted or various portable models) and this is summarised in table 6.6. Overall 30% of the 165 devices were wall mounted and 70% portable models. Analysis of these data showed that 30 (50%) of mercury devices were wall mounted whereas 42 (51%) of aneroid devices were of the small handheld type and 12 (54%) of automated devices were attached to a portable wheel stand (table 6.6). Chi-squared analysis revealed that a greater proportion of handheld models failed calibration testing (35%) when compared to the other manual model types (fixed wall mounted 4%; all other portable models 22%; (χ^2=20.947, df= 4, P<0.001).

Table 6.6 Number of BP devices by type and model in Equipment Survey 1

Model → / Type of device ↓	Wall mounted	Portable on a wheel stand	Portable in a box	Portable free standing	Portable handheld device	Portable on a trolley	Total
Mercury	30 (50%)	10 (17%)	5 (8%)	15 (25%)	0	0	**60**
Aneroid	18 (22%)	8 (10%)	0	15 (18%)	42 (51%)	0	**83**
Automated	2 (9%)	12 (55%)	0	0	0	8 (36%)	**22**
TOTAL	**50 (30%)**	**30 (18%)**	**5 (3%)**	**30 (18%)**	**42 (25%)**	**8 (5%)**	**165**

6.1.4 Size, type, labelling and availability of blood pressure cuffs

Across the three sites, four large adult cuffs were located. Of these, only two were labelled as large. No small adult cuff or adult thigh cuffs were located in the clinical areas. The majority of cuffs (64%) were labelled as being of an adult or extra-large size. Only seven of the cuffs that were labelled conformed to the BHS recommended size for an adult arm circumference of 23–33cm. The other 29 labelled cuffs varied considerably in size from 25–51.5cm measurements and do not conform to either the BHS or AHA recommendations for cuff size as previously discussed at 3.7.3 and shown in table 3.6. The Velcro cuffs were significantly more likely to be labelled with arm range, bladder size and artery centre line, compared to the wrap around cuffs (Fisher's exact $P<0.001$).

6.1.5 Number, type, location and validation of automated BP devices

Automated blood pressure devices were available within all three of the maternity units, located on the delivery suites, antenatal and postnatal wards, but none in any of the antenatal clinics (table 6.7). At the time of Equipment Survey 1 (2002), none of the automated devices surveyed were independently validated for use on pregnant women (table 6.8). One device the 'Datascope Accutorr Plus' was independently validated for clinical use in hospitals, but not for use on pregnant women. The 'Welch Allyn vital signs' model was present in Hospitals 1 & 2. As discussed at 3.2 it was determined that this device was not suitable for measuring BP on pregnant women with pre-eclampsia. In addition

following further validation testing it was deemed unsuitable for clinical use in 2002. The Dinamap Critikon model, of which there were five in Hospital 2, had failed independent validation testing for clinical use.

Table 6.7 Number and clinical location of automated BP devices in Equipment Survey 1

Clinical area	Hospital 1 Number of automated BP devices	Hospital 2 Number of automated BP devices	Hospital 3 Number of automated BP devices	Total Number
Delivery suite	6	6	2	14
Antenatal clinic	0	0	0	0
Antenatal ward	1	1	1	3
Postnatal ward	1	1	2	4
Day unit	0	0	1	1
TOTAL	8	8	6	22

Table 6.8 Number, model and validation evidence of automated devices

Manufacturer and model of automated device	Number	Evidence of independent validation for clinical use and or use in pregnancy (Judgement based upon BHS and dabl validation device lists and manufacturers device literature)
Agilent Series 50XM	2	No evidence of ever being independently validated for clinical use
Dinamap Crtikon compact 7	1	
Datex Ohmeda	1	
Datascope Passport	2	
Diascope NT 3050	1	
PM 9000	2	
Dinamap No model number	1	Unable to determine as a very old model and no model number but no evidence of any dinamap device passing validation testing
Welch Allyn No model number	2	Unable to verify but only vital signs model on list for independently validated devices
Dinamap critikon 1846SX	5	Tested but only received a BHS C/C grade questionable for clinical use not tested in pregnancy (Discontinued model)
Datascope Accutorr Plus	1	Validated for clinical use in hospitals A/A grade by BHS and AAMI not validated in pregnancy
Welch Allyn Vital Signs	4	Not validated at time of study was given BHS A/A grade for use in pregnancy in 2001 but also in other testing received a C/D grade and not recommended for clinical use 2002
TOTAL	22	

6.2 Number, type and working condition of stethoscopes surveyed in Equipment survey 1

In total 92, stethoscopes were examined in Equipment Survey 1, the dual headed stethoscope was more common (61), than the single headed stethoscope (31). The general working condition was assessed through four quality components, the condition of tubing, ear pieces and diaphragm and the length of the tubing, as discussed at 3.6 (summarised in table 3.2). Overall, the condition of the tubing, ear pieces and diaphragm was good, with 85% or more of the stethoscopes meeting the standard (table 6.9). The results show that for the assessment of the length of tubing, only three of the stethoscopes had tubing measuring between, 30-38cm the recommended length (Perloff, et at. 1993; AHA, 2001). Overall, the length of tubing ranged from 33-35cm to 56–58.5cm with the most common length being 53.4 – 56cm with 77 stethoscopes having tubing of this length.

Table 6.9 – Working condition of stethoscopes in Equipment Survey 1

Quality Component assessed	Test	Number passed Survey 1 (%)	Number failed Survey 1 (%)	Total number
Faults in tubing	Holes or perished rubber	90 (98%)	2 (2%)	92
Length of tubing	Measure length from ear piece to diaphragm (recommended length 30-38cm)	6 (3%)	89 (97%)	92
Ear pieces	Plastic ear piece present/absent	91(99%)	1 (1%)	92
	Ear pieces clean/dirty	90 (98%)	2 (2%)	92
Diaphragm	Missing completely	91 (99%)	1 (1%)	92
	Rubber missing	90 (98%)	2 (2%)	92
	Diaphragm cracked	91 (99%)	1 (1%)	92
	Diaphragm noticeable crease	78 (85%)	14 (15%)	92

6.3 Results from Equipment Survey 2

In Equipment Survey 2 the total number of BPM devices surveyed was 119. No mercury devices were located in any of the clinical areas; aneroid BP devices remained the most common type of instrument being used in the study settings (table 6.10).

Table 6.10 Comparison of the type and number of blood pressure devices in Equipment Survey 1 & Equipment Survey 2

Type of Device	Total number of each device Equipment Survey 1	Total number of each device Equipment Survey 2
Mercury	60	0
Aneroid	83	90
Automated	22	29
Total	Total = 165	Total = 119

The assessment of the working condition was through the evaluation of the eighteen of the nineteen standard components (mercury component excluded as not relevant) as used in Equipment Survey 1. The results indicated that some of the BP devices surveyed in Equipment Survey 2 still had components that failed to meet acceptable quality working standard (Figure 6.1). Fisher's exact P was calculated to compare the proportion of devices that 'passed' or 'failed' each assessed component between Equipment Survey 1 and Equipment Survey 2. (These statistical tests should be interpreted with caution, since there was an overlapping population of devices surveyed in Equipment Survey 2. However, it was not possible to identify devices between the two occasions so paired tests were not possible.) Excluding servicing there were no significant differences in the proportion of components failing ($P>0.001$).

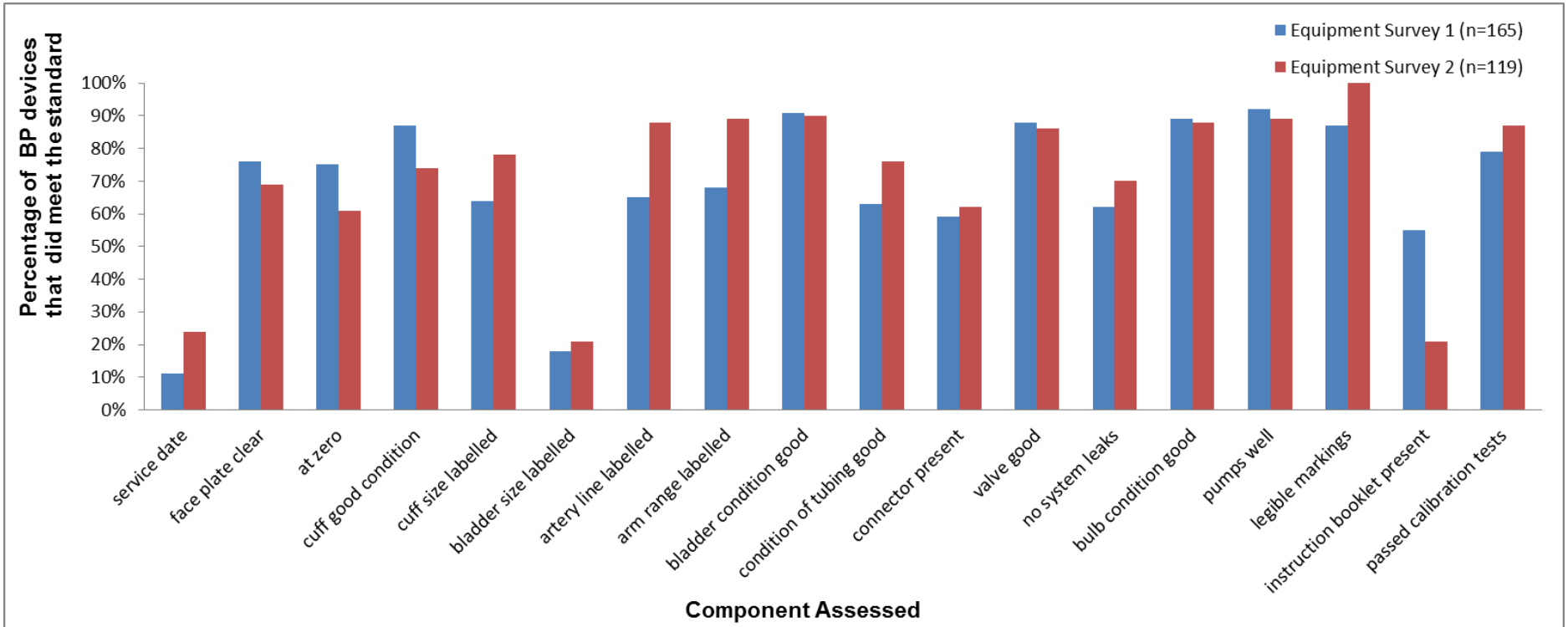


Figure 6.1 Comparison of Equipment Survey data for BP devices that did meet component quality standands

6.3.1 Servicing of BP equipment

In Equipment Survey 2, evidence of when individual BP devices had undergone servicing was found on 24% (29) of instruments a 13% increase from Equipment Survey 1. The proportion of devices that met the recommended servicing requirement increased between Equipment Survey 1 and Equipment Survey 2 (Fisher's exact P<0.001: again, caution should be used in interpreting this finding since ideally a paired test should be carried out). The evidence indicated that for twenty two aneroid and seven automated BP devices, a service had been undertaken, within the recommended timeframe. Comparison of these data with those obtained in Equipment Survey 1 revealed an increase in the number of aneroid devices and a reduction in the number of automated devices that had undergone a service (table 6.11).

Table 6.11 Comparison of servicing data by type of device between Equipment Surveys 1 & 2

	Equipment Survey 1 Aneroid N = 83 (%)	Equipment Survey 2 Aneroid N = 90 (%)	Equipment Survey 1 Automated N = 22 (%)	Equipment Survey 2 Automated N =29 (%)
Serviced as per recommendations minimum once every 12 months	2 (2%)	22 (24%)	12 (55%)	7 (24%)
Not serviced as per recommendations	81 (98%)	68 (76%)	10 (45%)	22 (76%)

6.3.2 Calibration testing of BP equipment

Eighty six devices were included in the calibration testing for Equipment Survey 2. Thirty three devices were excluded due to incompatibility of connections, for six manual devices, plus the twenty seven automated devices. Comparison of the calibration results between the two equipment surveys showed an increase in the proportion of devices (from 79% to 87%) that passed calibration testing (Figure 6.1). However, this was not found to be of a statistical significance by Fishers exact analysis (P=1.000: but as with previous caveat, caution should be used in interpreting this finding since ideally a paired test would have been carried out).

6.3.3 The working condition of BP equipment

The proportion of aneroid devices with cuffs in a poor condition increased from 10% in Equipment Survey 1, to 20% in Equipment Survey 2 and the number of devices found not to be at zero had increased from 30% in Equipment Survey 1, to 39% in Equipment Survey 2 (table 6.12). Whereas, the proportion of devices with the cuff size not being labelled on the cuff dropped from 45% in Equipment Survey 1 to 17% in Equipment Survey 2 and the proportion of cuffs not labelled with an arm range dropped from 35% to 3% respectively between Equipment Survey 1 and Equipment Survey 2. Similarly, the

proportion of devices with cuffs not labelled with an artery centre line, decreased from 37% in Equipment Survey 1 to 4% in Equipment Survey 2. As shown in table 6.12 Fishers exact tests showed that for the labelling of cuff size, artery centre line and arm range this decrease was of statistical significance (P<0.001). However, as ideally, a paired test should have been conducted, the statistical significance should be interpreted with caution.

Table 6.12 Comparison of aneroid devices between Equipment Surveys 1 & 2 that failed to meet assessed component standards

Component Fault	Number of devices identified with the component fault		Comparison of proportion failing (FISHER'S EXACT P)
	Aneroid N = 83 (%) ES1	Aneroid N = 90 (%) ES2	P=
Cuff in a poor condition/ missing	8 (10%)	18(20%)	0.082
Cuff size not identified	*37 (45%)*	*15(17%)*	*<0.001*
Bladder size not labelled	76 (92%)	81(90%)	0.796
Arm range not labelled	*29 (35%)*	*3 (3%)*	*<0.001*
Artery centre line not labelled	*31 (37%)*	*4 (4%)*	*<0.001*
Tubing in a poor condition	18 (22%)	20(22%)	1.000
Missing or faulty connections	31 (37%)	36(40%)	0.756
Faulty valve	4 (5%)	8(9%)	0.375
System leaks	30 (36%)	17(19%)	0.016
Poor condition of bulb	2 (3%)	3(3%)	1.000
Faulty Bulb (pumping)	8 (10%)	1(1%)	0.014
Poor condition of bladder	4 (5%)	1(1%)	0.195
Poor condition of glass	17 (20%)	28(31%)	0.121
Device not at zero	25 (30%)	35(39%)	0.264
Illegible markings	1 (1.2%)	0	0.479
Key ES1 = Equipment survey 1 ES2 = Equipment Survey 2 Threshold of statistical significance used for this study is P=0.001			

6.3.4 Size, type, labelling and availability of blood pressure cuffs

The number of large cuffs had increased from eight to twenty eight in Equipment Survey 2. The labelling on the cuffs ranged from outside thigh (11), large adult (8), extra large (7), adult long (1) and alternative adult (1) and two small cuffs were identified. Whilst 85 (71%) cuffs were labelled as adult size, no bladder size was specified on 83 (70%) of the cuffs. Of the twenty seven cuffs that were labelled with a bladder size, only one conformed to the BHS recommended size of 23-33cm. The bladder size of the other twenty six labelled cuffs varied from 25-40.6cm. There was no significant difference (Fisher's exact test) between the proportion of Velcro and wrap around cuffs in Equipment Survey 2 that were accurately labelled with the artery centre line (P=0.567), bladder size (P=1.000) or arm range (P=1.000).

6.3.5 Number, type, location and validation of automated BP devices

In total, twenty nine automated devices were assessed in Equipment Survey 2. This was an increase of seven from the first survey, none of automated devices were located in the antenatal clinic areas, but unlike in Equipment Survey 1 all the Day assessment units now had at least one automated device for clinical use.

None of the devices surveyed in either Equipment Survey 1 or Equipment Survey 2 were independently validated for use on pregnant women. However, two models surveyed in Equipment Survey 2, were identified on the BHS website as passing independent validation for clinical use, the Datascope Accutor Plus and the Huntley H Care smart signs. Two models present in Equipment Survey 2 had failed

independent testing for clinical use. Thirteen devices from Equipment Survey 1 were no longer present in the clinical areas (table 6.13).

Table 6.13 Summary of automated devices by manufacturer, model and independent validation evidence

Device	Equipment Survey 1	Equipment Survey 2	Evidence of independent validation for clinical use and or use on pregnant women (Judgement based upon BHS and dabl validation device lists and manufacturers device literature)
Agilent Series 50XM	2		No evidence of ever being independently validated for clinical use
Dinamap Crtikon compact 7	1	1	
Datex Ohmeda	1	1	
Datascope Passport	2	3	
Datascope Duo		5	
Diascope NT 3050	1		
Dash 4000		1	
PM 9000	2	3	
Dinamap No model number	1		Unable to determine as no model number but no evidence of any Dinamap device passing independent validation testing
Welch Allyn No model number	2	7	Unable to verify but only vital signs model on list for independently validated devices
Dinamap critikon 1846SX	5		Tested but only received a BHS C/C grade questionable for clinical use No evidence of validation for use on pregnant women (Discontinued model)
Datex Cardiocap 11		1	Failed BHS grade D/D not suitable for clinical use (Discontinued model)
Datascope Accutorr Plus	1	5	Validated for clinical use in hospitals A/A grade by BHS and AAMI protocols/No evidence of validation for use on pregnant women
Huntley H Care smart signs		1	Validated for clinical use A/A grade by BHS protocol/No evidence of validation for use on pregnant women
Welch Allyn Vital Signs	4	1	Originally given a BHS A/A grade for use in pregnancy in 2001 but in other testing received a C/D grade and not recommended for clinical use in 2002
Total	22	29	

6.4 Number, type and working condition of stethoscopes

A total of 78 stethoscopes were examined in Equipment Survey 2. The dual headed stethoscope was still more common (61) than the single headed stethoscope (17). None of the stethoscopes in Equipment Survey 2 had faults with tubing (table 6.14) but there had been an increase in the number found with dirty ear pieces which by Fisher's exact was statistically significant (P<0.001 interpretation with caution as

with the previous caveat, was not a paired test). As with Equipment Survey 1, the majority of stethoscopes did not have tubing at the recommended length of 30-38cm (table 6.14).

Table 6.14 – Comparison of the condition of stethoscopes

Component	Test	Passed Survey 1 N= 92 (%)	Passed Survey 2 N=78 (%)	Failed Survey 1	Failed Survey 2
Faults in tubing	Holes or perished Rubber	90 (98%)	78 (100%)	2 (2%)	0
Length of tubing	Measure length from ear piece to diaphragm (recommended length 30-38cm)	3 (3%)	3 (4%)	89 (97%)	75 (96%)
Ear pieces	Plastic ear piece present/absent	91(99%)	78 (100%)	1(1%)	0
	Ear pieces clean/dirty	90 (98%)	65 (71%)	2 (2%)	13 (29%)
Diaphragm	Missing completely	91 (99%)	78 (100%)	1 (1%)	0
	Rubber missing	90 (98%)	77 (99%)	2 (2%)	1 (1%)
	Diaphragm cracked	91 (99%)	76 (97%)	1 (1%)	2 (3%)
	Diaphragm noticeable crease	78 (85%)	71 (91%)	14 (15%)	7 (8%)

6.5 Results of the observations of staff undertaking BPM

In total 57 observations on staff undertaking BPMs were conducted. Clients were a mixture of inpatients on the wards or outpatients attending antenatal clinic or Maternal and fetal assessment day unit. A minimum of two members of staff were observed from each individual clinical area. The aspects observed were based upon factors related to observer technique or environment that are known to affect accuracy (as discussed at 3.7 and summarised in tables 3.4 and 3.5). The observation proformas were divided into five aspects, communication, position, arm, cuff and technique (as identified at 4.13.2). All staff introduced themselves to the client, gained consent and ensured that the client understood the procedure. Not one client was questioned as to whether or not they had recently smoked, eaten, exercise or ingested caffeine. Of the 57 staff observed, 18 members of staff used automated

devices and 39 used manual devices to undertake the BPM. In 12 out of the 18 measurements undertaken with an automated device talking during the procedure was observed. During the observations, it was noted that BPM on clients was undertaken whilst in the supine position, other clients had no back support, legs crossed or dangling (table 6.15). In addition, during the measurement in 23 (40%) of the observations, the arm was not at the level of the heart and with 44 (77%) clients the arm was unsupported. All staff observed used the standard sized cuff attached to the device irrespective of the clients' arm circumference. Incorrect placement of the cuff and stethoscope was observed and no estimation of systolic pressure was undertaken in 79% (31) of the measurements undertaken with manual devices (table 6.15).

All the staff observed were questioned at the end of the procedure as discussed at 4.13.2. None of the 57 staff members observed undertaking BPMs had ever had any updating on measurement of BP following their original training. The technique used by 45 (79%) participants was the same one as they had been originally taught with 16 (28%) members of staff stating that they rounded off the reading to the nearest 0 or 5mmHg. In addition, 26 (46%) stated they used Korotkoff phase 4 sound for the diastolic measurement.

Table 6.15 Summary of observations of staff undertaking BPM

Communication aspects observed	Number %	Position aspects observed	Number %	Arm aspects observed	Number %	Cuff aspects Observed	Number %	Technique aspects Observed	Number %
Staff member introduced themselves to client	57 100%	Client sitting in chair with back supported during measurement	31 54%	Clients arm above heart level during measurement	13 23%	Cuff placed on bare arm	38 67%	Palpation of the pulse undertaken by staff to determine position of brachial artery (manual devices only)	17 out of 39 44%
Consent / request to undertake BPM /explanation provided to client	57 100%	Clients sitting back unsupported during measurement	10 17%	Clients arm below heart level during measurement	10 17%	Cuff placed over loose clothes	17 30%	Estimation of systolic pressure undertaken (manual devices only)	8 out of 39 21%
Staff member asked Client if they had recently eaten/smoked/ exercised//caffeine	0 100%	Client sitting with legs crossed during measurement	6 10%	Clients right arm used for measurement	32 54%	Centre of cuff bladder placed correctly on arm	21 37%	No estimation of systolic pressure (manual devices only)	31 out of 39 79%
Lot of Background noise during measurement	18 32%	Clients sitting with legs dangling during measurement	4 7%	Clients left arm used for measurement	25 44%	Edge of cuff placed 2-3cm above ACF	35 61%	Stethoscope head placed under cuff (manual devices only)	19 out of 39 49%
Talking during procedure either staff or client	12 21% (All with automated devices)	Client sitting with feet flat on floor during measurement	15 26%	Clients arm supported during measurement	11 19%	Edge of cuff placed at level of ACF	20 35%	Diaphragm end of stethoscope used in manual reading	39 out of 39 100%
		Client sat in or on bed during measurement	19 33%	Arm unsupported during measurement	44 77%			Manometer placed below eye level during measurement (manual devices only)	23 out of 39 59%
57 BPM observations undertaken				Client 's elbow flexed during measurement	8 14%	Cuff placed with tubing exiting from bottom of cuff (manual devices only)	39 out of 39 100%	Manometer placed above eye during measurement (manual devices only)	15 out of 39 38%
18 with automated devices		Client in supine position during measurement	7 12%	Clients elbow straight during measurement	48 81%			Finding recorded immediately after measurement	57 100%
39 with manual devices									

6.6 Results from Practice Survey 1

A total of 246 completed questionnaires were received, from 436 distributed, giving a 56% response rate ranging from 50% to 62% for the individual settings (table 6.16). Two questionnaires were returned without location/person identification codes. These questionnaires were included in the data analysis of individual question responses but excluded in the comparison analysis of staff practice between hospital sites and paired testing for individuals.

Table 6.16 Summary of Practice Survey 1 response rates by hospital site

Hospital	Number of questionnaires distributed	Number of Questionnaires returned	Percentage response rate for hospital
Hospital 1	163	93	57%
Hospital 2	143	71	50%
Hospital 3	130	80	62%
Total	**436**	**244** + 2 unknown	Overall percentage response rate for all questionnaire returned = 56%

6.6.1 Demographic data of respondents

Of the 246 respondents, 94% (230) were female, 4% (10) male and 2% (6) unknown. Responses were received from respondents from all three hospital sites were highest in the 36-45 age group (table 6.17) and all settings had respondents from each age group (Figure 6.2).

Table 6.17 Summary of age groupings for Practice Survey 1 respondents

Age group of respondent	Number of respondents per age group	Distribution of respondents ages % of total respondents
19-25	11	5%
26-35	43	18%
36-45	122	51%
46-55	52	22%
56 or over	10	4%

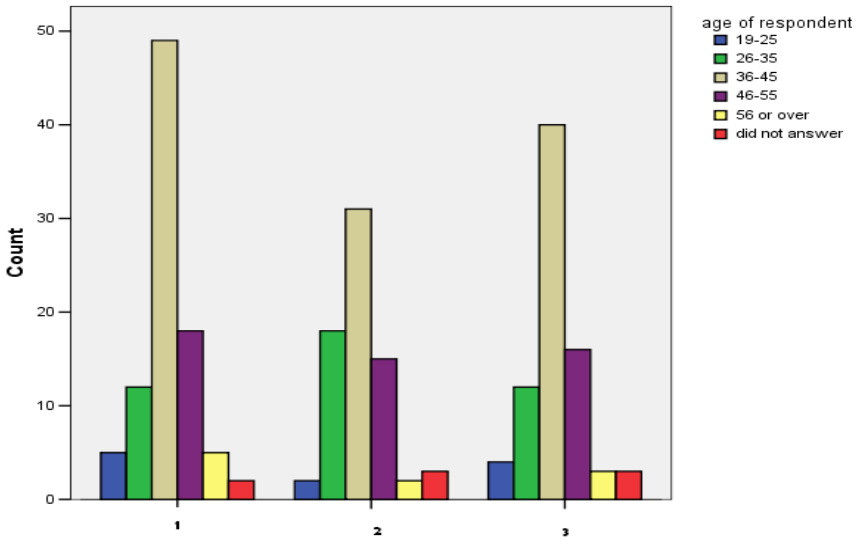


Figure 6.2 Respondents age group summarised per hospital site

Questionnaires were distributed to 370 (85%) midwives, 45 (10%) medical staff 45 (10%), 16 (4%) midwifery students and 5 (1%) nursing assistants. Of the 246 responses received, 224 (91%) were from midwives, 16 (6.5%) from medical staff, 4 (1.6%) from midwifery students and 2 (0.8%) from nursing assistants. Respondents had been performing blood pressure measurements on average for 19.48 years with a range of six months to 42 years.

6.6.2 Practice Survey 1 questionnaire responses

The right arm was used to measure BP by 78 (32%) respondents, the left arm used by 52 (21%) and 114 (47%) used either arm. The manual blood pressure device, in particular, the mercury device was selected as the most common type of instrument that 113 (46%) of respondents used to measure BP.

The remainder of the questionnaire was of a multiple choice format, with one correct response among the choice of answers that could be selected by the respondents. Thus, it was possible to record responses as 1 for a correct response and 0 for an incorrect response. Twelve out of the sixteen questions had a higher proportion of respondents with an incorrect rather than a correct response (table 6.18). As discussed at 4.10.6 question were grouped into categories and the results revealed that apart from one question (rate of deflation), the percentage of respondents providing correct responses was higher in the method category than those provided to questions in the equipment and accuracy categories.

Table 6.18 Practice Survey 1 questionnaire responses

Question category	Question topic	Total number or respondents N =246			
		Correct answer		Incorrect answer	
		Number	%	Number	%
Equipment Knowledge (Calibration)	Mercury	74	30%	172	70%
	Aneroid	38	15%	208	85%
	Automated	89	36%	157	64%
Method	Position	158	64%	88	36%
Method	Systolic	219	89%	27	11%
Method	Diastolic	143	58%	103	42%
Method	Rate of deflation	90	37%	156	63%
Method	Resting before measurement	118	48%	128	52%
Method	Rounding off	151	61%	95	39%
Accuracy	Cuff size	27	11%	219	89%
Accuracy	Arm circumference	68	28%	178	72%
Accuracy (time elapsed after)	Smoking	43	17%	203	84%
	Eating	24	10%	222	90%
	Exercise	32	13%	214	87%
	Caffeine	24	10%	222	90%
Accuracy	Arm position	58	24%	188	76%

6.6.3 Results of respondents scores for Practice Survey 1

By assigning one point for every correct response meant individual respondents could score a maximum of 16 points. The median score for respondents was 6 out of 16, (range 1-12). Summary of respondents' scores is shown in Figure 6.3.

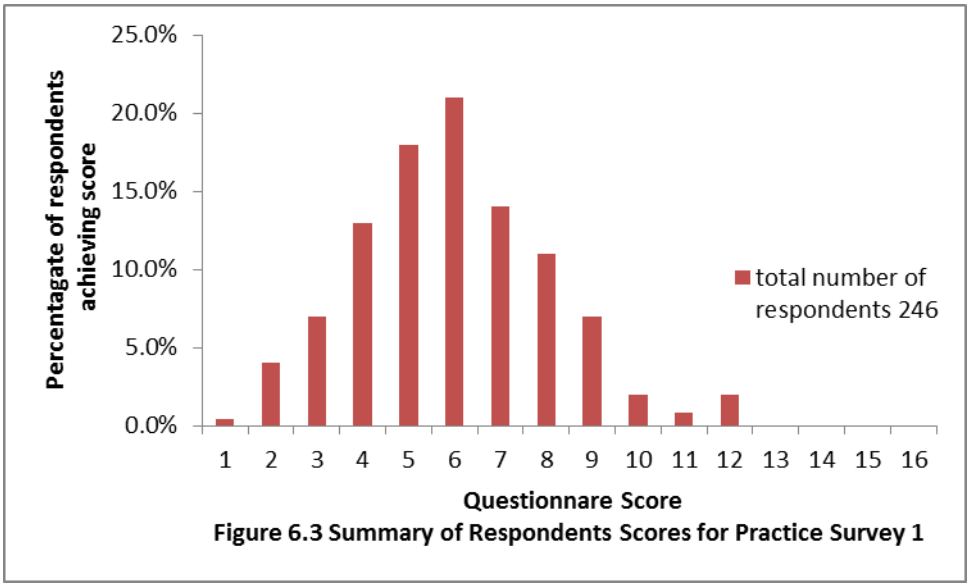


Figure 6.3 Summary of Respondents Scores for Practice Survey 1

Bivariate correlation analysis using Spearman's correlation coefficient found no significant relationship between the score achieved and the number of years that respondents had performed BPMs (r= - 0.134, P=0.042).

6.7 Evaluation of the Education Programme

Various tools were used to evaluate the effectiveness of the education programme that included evaluation of achievement of learning outcomes, participant reactions and impact upon practice shown in table 5.3 and discussed at 5.8. The following provides the results of those individual evaluations.

6.7.1 Initial evaluation of the Education Programme

The learning package was delivered to a total of 163 participants. The anonymous Knowledge Questionnaire 1 (KQ1) was completed by 153 participants. A total of 10 participants either had to leave the session before the end (4) or did not have time to complete the questionnaires (6). As previous it was possible to classify the responses as correct or incorrect. For eleven out of the thirteen questions more than 90% of participants provided a correct response and for the other two questions the percentage of correct responses was 85% (resting after exercise) and 86% (calibration testing) as shown in table 6.19.

Table 6.19 Question category results for Knowledge Questionnaire 1

		Total number or respondents N = 153			
		Correct answer		Incorrect answer	
Question category	**Question topic**	Number	%	Number	%
Equipment	Calibration	132	86%	21	14%
Method	Position	153	100%	0	0%
Method	Systolic	138	90%	15	10%
Method	Diastolic	147	96%	6	4%
Method	Rate of deflation	152	99%	1	1%
Method	Resting before Measurement	145	95%	7	5%
Method	Rounding off	149	97%	4	4%
Accuracy	Arm circumference	148	97%	5	3%
Accuracy (time elapsed after)	Smoking	142	93%	11	7%
	Eating	137	90%	15	10%
	Exercise	130	85%	23	15%
	Caffeine	138	90%	14	10%
Accuracy	Arm position	151	99%	2	10%

The maximum score that could be achieved for Knowledge Questionnaire 1 was thirteen. The median score for respondents was 13 (interquartile range 8), with 143 (94%) who scored 10 or more (figure 6.4).

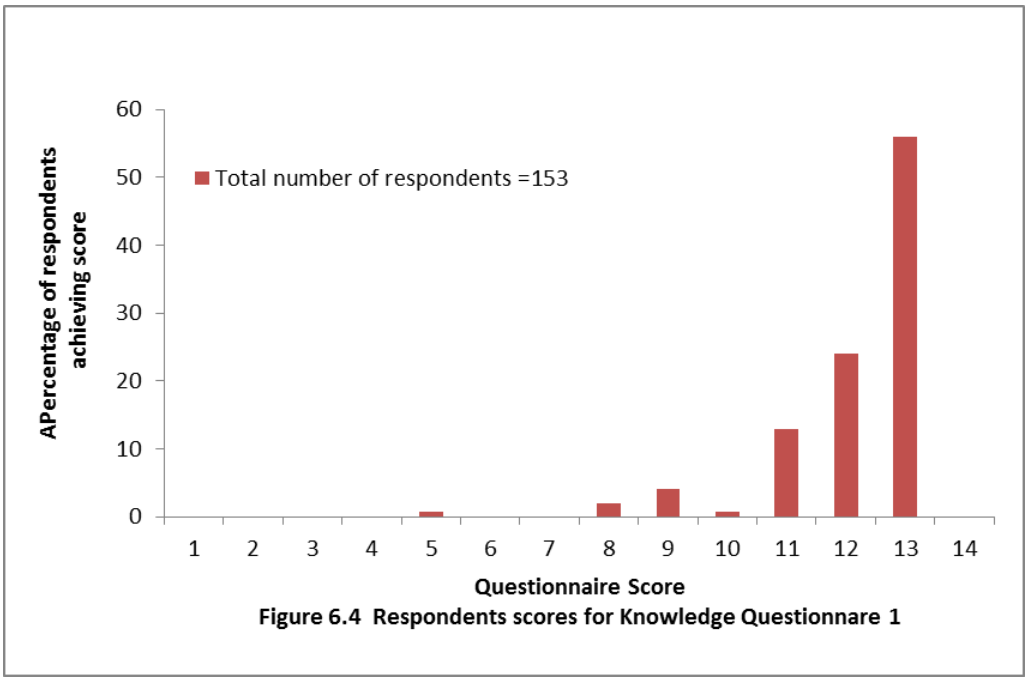


Figure 6.4 Respondents scores for Knowledge Questionnare 1

The final question requested participants to recall factors identified in the education session that affected the accuracy of BPM, by listing them. The majority of participants 79% (121) were able to identify three or more of these factors. The three most common factors identified by the respondents as affecting the accuracy of BPM were faulty equipment, position of client and talking during measurement (Figure 6.5).

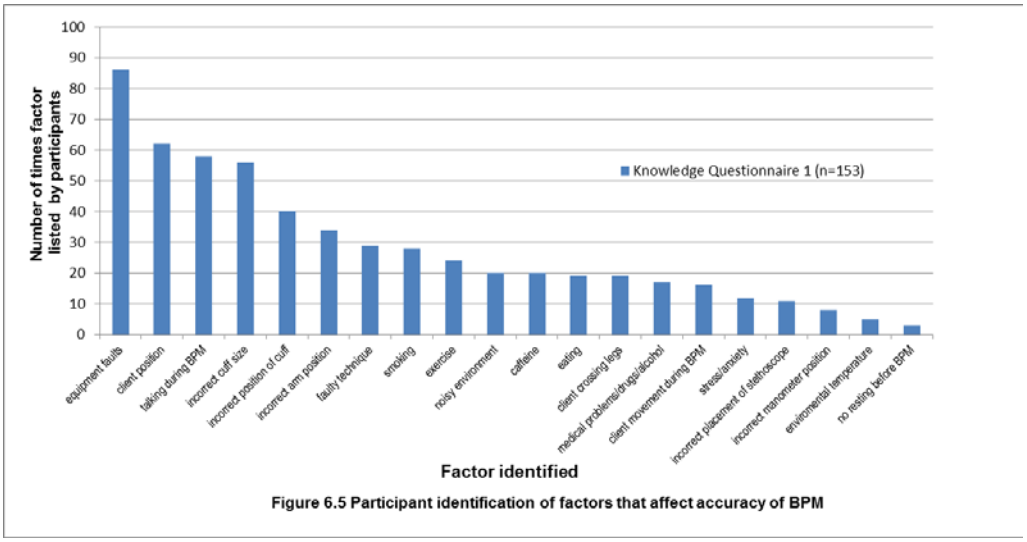


Figure 6.5 Participant identification of factors that affect accuracy of BPM

6.7.2 Longer term evaluation of the Education Programme

Knowledge Questionnaire 2 (KQ2) was distributed to 146 of the 163 participants of the education programme as 17 of the participants were no longer employed within the Trusts. Completed questionnaires were returned from 69 (47%) participants. Whilst the respondents of Knowledge Questionnaire 2 had completed Knowledge Questionnaire 1, a direct match with individual responses was not possible as Knowledge Questionnaire 1 was anonymous. The median score for Knowledge Questionnaire 2 was 9 (interquartile range 11), out of a possible maximum of 15 (figure 6.6).

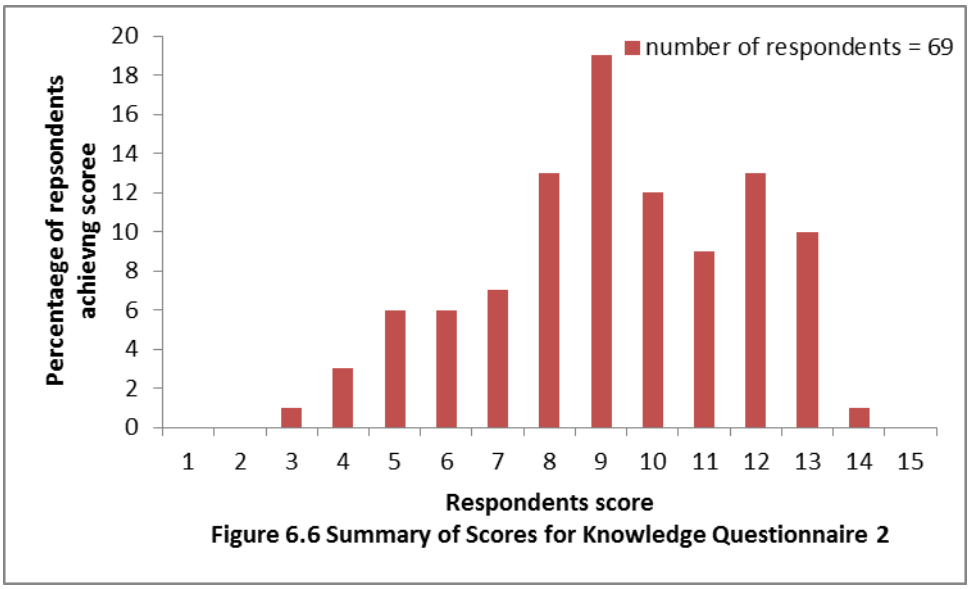


Figure 6.6 Summary of Scores for Knowledge Questionnaire 2

The method questions were generally well answered (70% or more participants answered correctly table 6.20), with the exception of the systolic question (41%). The accuracy questions were poorly answered (29% to 58% of respondents correct). However, the accuracy for the equipment category questions was the poorest with the percentage of respondents who provided a correct response ranging from 30% to 45%.

Table 6.20 Question category results for Knowledge Questionnaire 2

Question category	Question topic	Total number or respondents N = 69			
		Correct answer		Incorrect answer	
		Number	%	Number	(%)
Equipment Knowledge (Calibration)	Mercury	21	30%	48	70%
	Aneroid	29	42%	40	58%
	Automated	31	45%	38	55%
Method	Position	59	85%	10	15%
Method	Systolic	28	41%	40	59%
Method	Diastolic	55	80%	14	20%
Method	Rate of deflation	51	74%	18	26%
Method	Resting before Measurement	62	90%	7	10%
Method	Rounding off	48	70%	21	30%
Accuracy	Arm circumference	33	48%	36	52%
Accuracy (time elapsed after)	Smoking	36	52%	33	48%
	Eating	28	41%	41	59%
	Exercise	40	58%	29	42%
	Caffeine	30	44%	39	56%
Accuracy	Arm position	48	29%	21	71%

In order to determine whether the time since completion of the intervention affected the overall scores achieved on KQ2, the group was split into those who completed the KQ2 within 2–5 months (n=14) and completion of KQ2 within 6–9 (n = 54) months and Mann-Whitney U tests conducted. This analysis showed that there was no significant difference in median scores (Z= -0.971, P=0.332). The 2–5 month group had a median score of 9.5, (interquartile range 3) and for the 6-9 month group the median score was 9, (interquartile range 4).

Assessment of the 69 respondents' ability to recall of the factors that affect accuracy found that three or more factors were identified by 30 (43%) of respondents (Figure 6.7). The three most common factors were stress, equipment faults and using an incorrect sized cuff to measure BP.

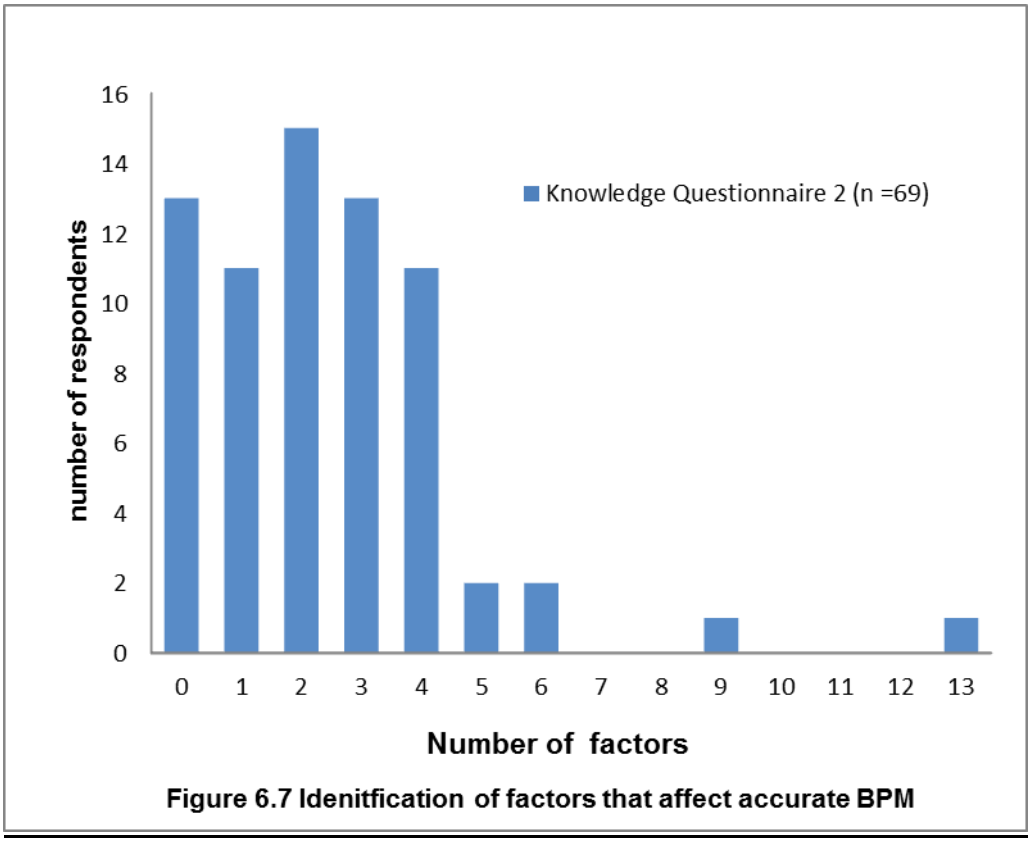


Figure 6.7 Idenitfication of factors that affect accurate BPM

The percentage of respondents who identified three or more factors fell from 79% in Knowledge Questionnaire 1 to 43% for Knowledge Questionnaire 2. There was an increase from 1% to 19% in the number of respondents who did not identify any factors between Knowledge Questionnaire 1 and Knowledge Questionnaire 2. Comparison of the five factors that were identified most by respondents showed three common factors listed by respondents on both questionnaires being equipment faults, talking during measurement and incorrect cuff size.

6.7.3 Participant evaluation of the Education Programme

Sixty seven (44%) of the 153 participant feedback questionnaires were returned. The results indicated that prior to attending the education programme 85% (57) of participants had never had an update on BPM. 92% (62) found the session useful, with 85% (57) indicating the length of the session was right. Nine separate features were indicated in regard to what attendees liked best about the programme. The most popular features were the self-assessment by the video clips (31% /21) and the fact that the session was informative (17%/11). Only two people did not provide an answer to this question. With regard to aspects of the education programme disliked, 36% (24) respondents wrote 'nothing at all' and 33% (22) did not answer the question. Of the thirteen features participants identified that they disliked; eight were from two participants and five from one participant. These features included concerns related being away from the ward during a shift, the realisation they were using an incorrect technique, being unable to provide a correct answer on the self-assessment exercise and the length of the session being too short.

Following participation in the education programme 42% (28) had made more than one change to their clinical practice but 12% (8) had made no changes at all. Thus, 88% of participants had made some change to their clinical practice of BPM. With regards to aspects they had changed, 17% stated they were much more careful with their technique when conducting BP measurements and aware of factors

that affect accuracy such as client crossing legs, position of client, not rounding off readings, using correct deflation rate, checking if women have smoked, eaten or ingested caffeine just prior to measurement and listening more carefully to the Korotkoff sounds. Stated changes included the use of K5 instead of K4, correct cuff placement, not talking during measurement, not using an automated device, checking device is at zero at the start of procedure and ensuring women rest before a measurement is taken. General comments stated by respondents indicated there was a need for regular BPM updating to be undertaken and that it was enjoyable to learn something new and very relevant to practice.

6.8 Practice Survey 2 results evidence of changes

A total of 452 questionnaires were distributed and 172 (38%) returned. However, five of these questionnaires were blank, which left 167 (37%) completed questionnaires for analysis. Of these, it was determined through the unique code system utilised, that 46 respondents had completed Practice Survey 1 and 2 and attended the education programme. A further 32 respondents who did not attend the education programme but had completed both practice surveys were identified. This resulted in 78 of the 167 questionnaires being analysed.

A comparison of the overall scores from these matched questionnaire scores for before and after the education programme are shown in figures 6.8 and 6.9. Further analysis was undertaken using Wilcoxon matched pairs signed rank tests for the paired samples of Practice

Survey responses. There were no significant changes in scores for the 32 respondents who completed both practice survey questionnaires but did not attend the education programme (Table 6.21). There were significant increases in overall scores (P<0.001) and accuracy scores (P<0.001) for the paired questionnaire responses for the 46 respondents who completed both practice survey questionnaires and attended the education programme (table 6.8).

The participants were part of a self-selected non-random sample in that they chose to attend or not attend the education programme. Thus, although highly suggestive of a positive impact of the programme the fact that there was no significant change in the scores of the non-attendant group cannot be causally linked to their not having undertaken the education programme. However, it should be noted that individual participants were not provided with their scores at any point during the study.

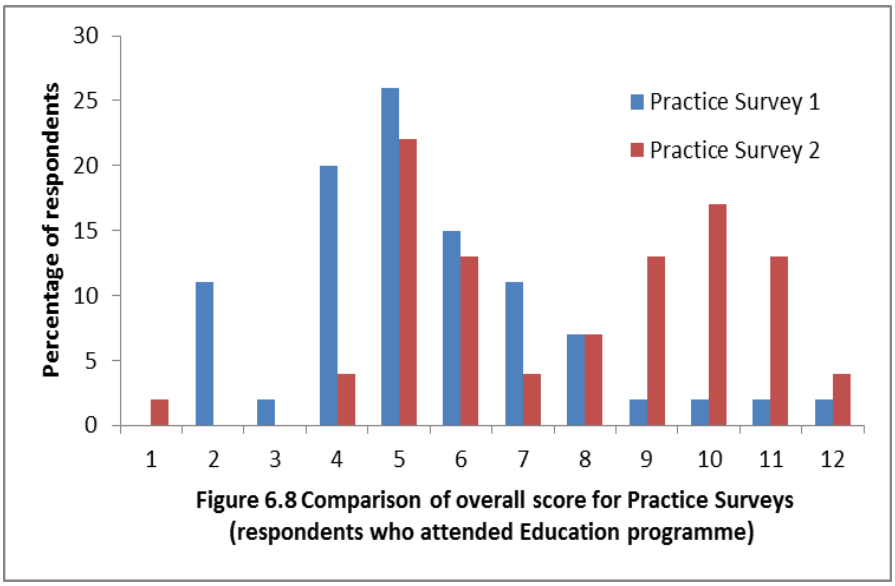


Figure 6.8 Comparison of overall score for Practice Surveys (respondents who attended Education programme)

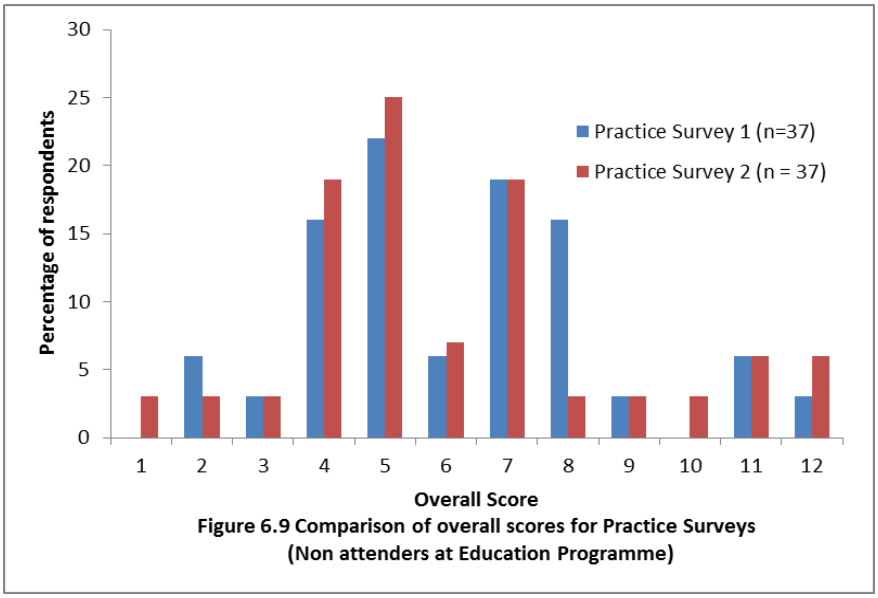


Figure 6.9 Comparison of overall scores for Practice Surveys (Non attenders at Education Programme)

Table 6.21 Comparison of respondents scores for Practice Surveys 1 & 2

	Wilcoxon matched pairs signed rank test comparing results for practice survey scores for non attendees of education programme (n=32)		Wilcoxon matched pairs signed rank test comparing results for practice survey scores for for attendees of education programme (n=46)	
	Z	P	Z	P
Overall score	-0.023	0.982	-4.437	*<0.001*
Equipment score	-0.032	0.974	-1.983	0.047
Method score	-1.078	0.281	-3.117	0.002
Accuracy	-1.389	0.165	-3.659	*<0.001*

Threshold of statistical significance used for this study is P=0.001

Further analysis was undertaken on the data from the group of 46 Practice Survey 1 and Practice Survey 2 respondents who had attended the education programme to evaluate if the education programme had any impact on improving answers to individual questions. McNemar analysis was undertaken for each individual

question and this revealed an increase in correct responses for 13 questions, two of which were significant at the P<0.001 level selected for this study. A further three showed marginal non-significant increases (P<0.01 table 6.22).

Table 6.22 McNemar test results of individual question responses for Practice Surveys

Question Category	Question topic	Total number or respondents =46			
		Correct answer PS1	Correct answer PS2	χ^2	P value
Equipment Knowledge (Calibration)	Mercury	30	28	1.232	1.000
	Aneroid	15	*22*	1.820	0.035
	Automated	36	43	2.807	0.322
Method	Position	64	69	10.572	1.000
Method	Systolic	89	82	0.080	1.000
Method	Diastolic	58	69	4.384	0.302
Method	*Rate of deflation*	*37*	*56*	*2.144*	*0.001*
Method	*Resting before Measurement*	*48*	*60*	*0.053*	0.015
Method	*Rounding off*	*61*	*81*	*1.026*	*0.002*
Accuracy	Cuff size	11	15	0.552	0.727
Accuracy	Arm circumference	28	28	7.527	0.549
Accuracy (time elapsed after)	*Smoking*	*17*	*41*	*7.327*	*0.001*
	Eating	*10*	*25*	*14.240*	*0.008*
	Exercise	*13*	*31*	*4.211*	0.013
	Caffeine	*10*	*31*	*6.370*	*0.003*
Accuracy	Arm position	24	27	0.513	1.000

Threshold of statistical significance used for this study is P=0.001
PS1 = Practice Survey 1
PS2 = Practice Survey 2

CHAPTER SEVEN DISCUSSION

The purpose of this chapter is to present a discussion and evaluation of the results of the study. The discussion will commence with the equipment surveys, observations then the practice surveys. Within in each of these sections the implications for clinical practice will be identified. The focus of the discussion will then turn to the evaluation of the impact of the education programme followed by recommendations. Finally the limitations of the study will be explored through a critical reflection of the research process.

7.1 Equipment Survey 1

It was ascertained as part of this study that neither the medical engineering departments, nor the individual clinical areas at the study sites, kept any information on the type or number of BP devices available for use within the maternity unit. Thus, prior to this study it was not possible to verify what types of BPM devices were being used in these settings, or what the ratio of manual to automated devices was. This lack of information would also hinder the negotiation and initiation of an external servicing contract for the BP devices, or the implementation of an internal maintenance programme as it would be difficult to determine the manpower, equipment and time required to conduct the necessary servicing and calibration checks.

Overall the ratio of automated devices to manual BP devices was 1: 7, and mercury BP devices were still present in two of the three hospitals.

Thus, the implementation of regulations around the use of mercury device discussed in section 3.3, since 1988 and moves to replace mercury devices had not been incorporated into equipment policy within these two hospitals at that time.

7.1.1 Servicing and calibration of BP devices

The results from Equipment Survey 1 revealed that the majority of devices had not been regularly serviced or maintained and thus devices had components that did not meet acceptable quality standards for working condition. The findings are consistent with previous studies conducted in non-maternity settings which found that manual BP devices were not regularly serviced and maintained (Hussain & Cox, 1996; Carney, et al. 1999; Knight, et al. 2001; Markandu, et al. 2001; Rouse & Marshall, 2001).

The calibration testing results were similar to those of previous U.K. studies, (Burke, et al. 1982; Ashworth, et al. 2001; Knight, et al. 2001; Waugh, et al. 2002) where it was found that a higher percentage of aneroid devices compared to mercury devices failed calibration testing (as discussed in section 3.4). In addition, like this study, the results from previous worldwide studies in non-maternity settings also found when comparing mercury and aneroid BP devices that the aneroid device was more likely to fail calibration testing (Perlman, et al. 1970; Fisher, 1978; Bowman, 1981; Jones, et al.1981; McKay, et al. 1990; Bailey, Knaus & Bauer, 1991).

7.1.2 Working condition of the BP devices

The results of the working condition of BPM devices from Equipment Survey 1 are consistent with previous research studies, which have used the same assessment criteria (Burke, et al. 1982; Markandu, et al. 2000; Thompson, Gillespie & Curzio, 2002). Whilst other studies have been conducted, (Hussain & Cox, 1996; Maskery, et al. 1997; Carney et al. 1999; Canzanello, Jenson & Schwartz, 2001; Rouse & Marshall, 2001; Waugh, et al. 2002), the assessment criteria for the operational condition of the equipment is not specified in enough detail such to allow for a comparison of the results.

As discussed in chapter 3, a limitation of some of these previous studies is that no differentiation has been made between mercury and aneroid devices and whether or not the pointer or meniscus was at zero prior to inflation (Burke, et al. 1982; Bailey & Bauer, 1993; Carney, et al. 1999). The results of this study are similar to the findings of Markandu, et al., (2000) in that a higher percentage of aneroid devices deviated from zero prior to inflation. However, unlike in this study Markandu et al., (2000) does not specify if this deviation was above or below zero and thus impossible to determine if BP was likely to be under or overestimated. Whereas the Equipment Survey 1 results of this study suggest the risk was likely to be underestimation of BP.

All three maternity units in the study had devices, which did not meet the quality standards for equipment as determined by the AHA, BHS

and British standards (discussed at 4.9.1) This study is unique in providing information on missing or faulty connections, an assessment of cuff labelling and working condition by differentiation of type and model of device, it is impossible to compare the findings with those from previous studies. This study has revealed that within these hospitals that manual portable devices, in particular, the small handheld devices used by the community midwives were inaccurate compared to the fixed wall mounted models.

Previous studies have assessed equipment within hospital settings or community settings such as GP surgeries but not equipment allocated to individuals who work in community settings such as community midwives. The handheld type of device is the smallest, lightest and the most transportable type of BP device specifically designed for use by health professionals who need to transport their own equipment when working in community settings. As discussed at 3.3.2 the accuracy of an aneroid device is affected by the jolts and bumps of everyday use and portable hospital aneroid devices are more affected than fixed wall mounted devices. The results of this study would support this, as the findings from this study suggest that the more portable the device is, the more likely it is to be inaccurate.

The finding that only 3% (5) devices met all the assessed quality standards is less than the 12% of 507 aneroid devices that met the assessed standards found by Carney, et al. (1999). On the other hand

it is a slight improvement on the findings reported by Knight, et al. (2001), when, not one of the 472 manual sphygmomanometers tested, met the assessed standard.

7.1.3 Size, labelling and availability of blood pressure cuffs

Results from this study confirm the suggestions identified in the literature review (as discussed at 3.7.3), that even when a cuff is labelled as a standard adult by manufacturers, there is a variation in size between the different manufacturers. This demonstrates a lack of compliance with the published recommendations of the internationally recognised organisations (AHA, BHS, ESH), in regards cuff size and how BP cuffs should be labelled. These results are consistent with those from previous studies, (Conceicao, Ward & Kerr 1976; Burke, et al. 1982; Thomas, Radford & Dasgupta, 2001), where inconsistency of cuff size labelling was identified. The results of this study identifies that it was the wrap around cuff that was the type least likely to be appropriately labelled with arm range, bladder size and artery centre line. However, it is impossible to compare these results to other studies, as an assessment of cuff labelling, apart from size, was not included in these studies.

The results of this survey revealed that the clinical availability of large cuffs was extremely limited which is consistent with previous studies, (Conceicao, Ward & Kerr, 1976; Burke, et al. 1982; Perry, et al. 1991; Markandu, et al. 2000; Thompson, Gillespie & Curzio, 2002). In

addition, within this study it was found that staff had no access to a small manual cuff.

7.1.4 Number, type and validation of automated BP devices

No previous equipment studies within maternity settings have identified the number, location or type of automated devices, therefore, no comparison of the results can be made. The finding that the majority of automated devices were located in delivery suite provides some research evidence to support anecdotal reports, that automated devices are more likely to be used on labouring women. These results verify that unsuitable automated devices were being used within the study settings. Also only one device had passed independent clinical validation tests, nine had failed clinical validation testing and none were suitable for use on pregnant women and particularly for those with pre-eclampsia. The results showed that seven of the nine unsuitable devices were located in the same hospital.

7.2 Number type and working condition of stethoscopes

None of the previous studies have included stethoscopes as part of an equipment survey, therefore, the body of knowledge with regards to their type and working condition is limited. The results of this Equipment Survey have addressed that limitation. Unlike the BP devices the majority (85% or more) of the stethoscopes, met the assessed quality standards for working condition. In the majority (97%) of the stethoscopes the length of tubing was longer than that

recommended by the AHA (2001), although the BHS does not specify the length of tubing for stethoscopes. As stethoscopes are provided by manufacturers, the length of the tubing appears to be determined by the manufacturer and thus like cuff size there seems to be a variation between manufacturers. The clinical implication of tubing that is too long, is one of sound distortion. However, there is no evidence provided by the AHA about the impact this has on accuracy of blood pressure measurements and if an under or overestimation of blood pressure occurs when the sounds are distorted.

7.3 Equipment Survey 2

As the purpose of this phase of the study was to determine if the education programme had resulted in any changes to the BPM equipment the discussion will focus upon any improvement or deterioration of the working condition of BPM equipment since Equipment Survey 1 had been conducted.

7.3.1 Type and model of BP devices found in Equipment Survey 2

Data collected from Equipment Survey 1, ensured that information was available in regards the potential number and types of BP devices that would be located within the three maternity units. Equipment Survey 2 established that sixty mercury devices had been removed from the clinical areas. These mercury devices appeared to have been replaced with thirty four aneroid and seven automated devices, a total of forty one devices. Therefore, excluding the number of individual community

midwives' handheld devices the overall number of devices within the units had decreased. In regards model type, there had been a decrease in the number of wall mounted and free standing BP devices, but an increase in portable devices on a wheel stand. The move away from mercury devices and the increase in the number of aneroid devices however, has implications for servicing and maintenance. The results indicated by this study and other studies show, that compared to mercury devices, aneroid devices are more likely to develop component faults. The minimum recommendation is that they need to be checked every twelve months for calibration and servicing requirements. However as Waugh, et al. (2002) and the MHRA (2006) recommend the results of this study would indicate a six monthly calibration check was required particularly on the more portable models.

7.3.2 Equipment Survey 2 results for the working condition, servicing and calibration of BP devices

The initial data from Equipment Survey 2 indicated there had been an increase in the proportion of manual BP devices that passed the assessed quality component standards in all model types of manual devices and a reduction in the number of devices that failed calibration testing. However, the only differences to reach statistical significance was that of servicing, which improved between the two time points. The lack of general records and method of an individual device identification labelling system, meant that it was not possible to pair the

Equipment Survey 1 and Equipment Survey 2 data for individual devices. From a research perspective, this would have been the best option to allow paired data analysis when testing and retesting the same item for the working condition. Paired tests such as this have a greater power to detect any difference should a difference exist. Therefore, it is not possible to determine whether the lack of a statistically significant improvement reflects the poor study design (which was not in the researchers control), or a true lack of improvement in the condition of the devices.

Overall there had been an increase in the number of manual aneroid devices that had been serviced in all the maternity units. This could partially account for the reduction in the number of devices that had component faults and the reduction in the number of devices that failed calibration testing. However, another possible reason for the reduction, was the removal of all mercury devices and their replacement with aneroid devices. The working condition of a device will be affected by the length of time it has been in use and how often used.

Other possible influences that could have affected the working condition of device include; following the education programme staff were more vigilant in reporting faults and ensuring devices were repaired but this cannot be substantiated. In addition the researcher was informed that the presence of the Senior Medical Engineer at the dissemination of Equipment Survey 1 results at one of the study

settings, had resulted in a medical engineer being specifically allocated to conduct servicing and maintenance checks on all BP equipment within the Trust. However, whilst the Equipment Survey 2 data collection found that this had resulted in BP devices being labelled as to when servicing was due or had taken place, the timeframe had not always been adhered to. When investigating why, the medical engineer suggested that the large number of BP devices within the hospital required more than one person to ensure the devices were serviced with the required timeframe. Nevertheless a routine servicing and maintenance programme had been commenced when none had been in existence before.

7.3.3 The size, type, labelling and availability of blood pressure cuffs in Equipment Survey 2

The results from Equipment Survey 2 established that all units had seen an increase in the number large adult cuffs available. This increase could be attributed in part the researcher being informed that at the study site where the servicing programme had been initiated, the community midwives after attending the education programme had made a formal request for each of them to be issued with a large cuff and this was sanctioned.

As the manufacturers control the labelling details and size of BP cuffs it was no surprise to find the continued lack of labelling of bladder size and conformity to BHS recommended cuff sizes. However, there was

an improvement in the number of cuffs that included labelling of the artery centre line, cuff size, bladder size and arm range. This improvement was most likely due to the replacement of the old mercury devices with aneroid devices. The standard cuff attached to new devices is of the Velcro type. Thus, as identified in the results Velcro cuffs were more appropriately labelled.

7.3.4 Automated BP devices

Equipment Survey 2 found an increase in the total number of automated devices with these extra devices located within ward and day units. However, as thirteen devices identified in Equipment Survey 1, were not present at the time of Equipment Survey 2 this meant that twenty new devices had been purchased or acquired. However, still none of these new automated devices had been independently validated for use on pregnant women, although six had been validated for clinical use. There had been a reduction from 9 to 2 devices that were not recommended as suitable for clinical use, one that was present in Equipment Survey 1 and the other a new addition.

It has been stated by the MHRA (MHRA, 2005; MHRA, 2006; NHS, 2008) and reiterated in Maternal Mortality reports (Lewis, 2007; CEMACE, 2011) that only clinical validated devices suitable for the clinical environment in which they are to be used should be purchased and used in practice. It is not known if the people responsible for the acquisition of the new devices were unaware of or ignored these

recommendations/requirements or if budget restrictions limited the purchases.

7.3.5 Equipment Survey 2 results for the number, type and working condition of the stethoscopes

The Equipment Survey 2 results for the number, type and working condition of stethoscopes were comparable to Equipment Survey 1 results. The overall working condition of the stethoscopes continued to be of a good standard. Not unexpected was the finding that the majority of the stethoscope tubing would still be deemed too long according to the AHA recommended length of 30-38cms. As discussed previously at 6.2 tubing length is determined by manufacturers who do not comply with the AHA recommended length for stethoscope tubing. Further research is required on this topic to determine if this needs to be addressed in the clinical area and with manufacturers.

7.4 Practice implications of the results of the equipment surveys

An essential requirement of BPM is a device that can accurately measure BP across all ranges of pressures. As discussed in chapter 3 and shown in figure 1.1 faulty equipment is one of the fundamental sources of errors for inaccurate auscultatory BPM readings. The lack of evidence that routine servicing and calibration checks generally have not been conducted is portrayed in the number of devices that did not meet the required standards. This lack of servicing and maintenance of BPM devices within the three maternity units means that the Trusts were not complying with the MHRA recommendations

or manufacturers' requirements that were in place at the time of the study. MHRA (2006, 2008 and 2013) state that all BP devices need to be regularly checked and calibrated. It is specified that these checks include inspection of cuff, hoses and identification of air leaks, as all of these can lead to erroneous measurements and have significant effects on patient care. Thus, the health professionals working in the study settings have failed to take responsibility to ensure their equipment is in full working order. It is acknowledged that the findings of Equipment Survey 2, showed some improvements in working condition such as a 13% increase in the number of devices that had evidence of servicing being undertaken and a reduction in the number of devices that failed calibration testing. The instigation of a formal servicing and maintenance programme should continue to have a positive impact upon the working condition of devices within that maternity unit. However, the clinical ramifications of using faulty equipment remain.

The condition of some BPM equipment examined rendered devices inoperable as they had missing pumps and or cuffs, yet they had not been removed from the clinical settings. On other devices observable faults were visible, such as, perished rubber tubing, cuffs that could not be secured due to worn Velcro and the pointer not at zero. In some instances attempts had been made to repair the fault such as spigots used in place of connectors, cuffs held together with safety pins and in one instance the perished rubber tubing was completely encased in

micropore tape. As temporary repairs had been made to some of the devices, it must have been identified that a repair was required for the device to be operable. Despite these visible defects to the devices and obvious inappropriate temporary repairs, it was established that these devices were still being used to measure BP in the clinical environment. As the study setting was in clinical practice areas, clients still required to have their BP measured whilst the equipment survey was being undertaken. Devices were retrieved from the staff after being used and prior to them being required again, in order for the assessment of working condition to be conducted. This suggests that the staff were either unaware of, or ignored the implications of using faulty equipment to measure BP. These findings once again would be in conflict with the MHRA (2008) guidance for health professionals using medical devices in that they should ensure the device is in full working order and has been checked, maintained and calibrated before they use it.

The unsatisfactory condition of perished tubing and faulty connectors and control values are prime examples of the impact that the lack of regular maintenance and failure of staff to act upon visibly observable defects has upon BP equipment. Perished tubing and faulty control values result in leakage in the system and the operator is then unable to control the rate of inflation or deflation (Burke, et al. 1982). This has been shown to lead to an underestimation of systolic and an overestimation in diastolic pressures (table 3.4). Devices not at zero

prior to inflation or those that do not pass calibration testing will result in inaccurate readings of both systolic and diastolic pressures. The inaccuracy could either be an under or over estimation depending on if error is above or below zero. The results from this study showed 39% of devices were not at zero prior to inflation in Equipment Survey 2 with the majority of these (66%) the pointer was below zero which would lead to an underestimation of BP measurement by these devices.

Of the devices that failed calibration testing in Equipment Survey 2, 9% (10) were more than 6mmHg out from the control device. Rouse & Marshall (2001) suggest that sphygmomanometer calibration error would result in 7000 non pregnant women in England and Wales aged between 16 and 34 being misclassified with hypertension. Turner, et al. (2006) suggests that an uncalibrated sphygmomanometer error leads to the non-detection of systolic hypertension in 20% of adults and for diastolic hypertension, 28% of cases would be undetected. In addition, 15% of systolic and 31% of diastolic hypertension is falsely detected in the general adult population, due to uncalibrated sphygmomanometers. Campbell & Mckay (1999) suggest that in the general population consistent underestimation of BP by 5mmHg would lead to up to two thirds of people with hypertension being missed. Overestimation of 5mmHg would lead to more than a 50% increase in diagnosis in the number of people with hypertension. There is no modelling data regarding the identification of hypertension in pregnancy and this is an area where future research is required.

However, even the possibility of the implication that 15 – 31% of women could be falsely diagnosed with hypertension in pregnancy or up 28% of cases undetected is a major concern.

It cannot be determined from this study how often individual devices are used each day, or on how many women, in order to provide an accurate estimate of the number of women that could be affected within a maternity unit. Personal communication with a manager at one of the study settings with a current birth rate of 4,800 women a year suggested that around 136 women per day (>900/week) would be accessing hospital based maternity services having at least one BPM undertaken. The risk of misclassifying or failure to detect hypertension is possible every time a defective device is used. If the same woman has BPMs undertaken several times a day or different women have a single BPM over the course of the day with the defective device the same degree of calibration inaccuracy will occur each time. Therefore, each BPM taken with the defective device puts the woman at risk. Thus errors due to uncalibrated devices are of clinical importance.

The lack of cuff labelling and devices with cuffs that vary from the recommended standard cuff sizes increase the risk of incorrect placement of cuff on the arm and the utilisation of an incorrectly size of cuff to measure blood pressure. The British Standards (1996) have a requirement for all cuffs to be labelled with the bladder and arm size. Despite this requirement whilst there was an improvement in

Equipment Survey 2 on all the different cuff labelling requirements across all the sites 79% of cuffs did not indicate bladder size. Therefore, like the failures of manufacturers to produce cuffs that adhere to the AHA or BHS recommended measurements (as discussed at 7.1.4) compliance with this labelling requirement is also not adhered to. However, as no records were available in regards age and service history of devices prior to this study, it cannot be discounted that some of the cuffs could have been purchased prior to 1996. However this would indicate they had been in use for 20 years or more which raises issues in regards general condition and fitness for clinical use.

This lack of labelling along with the limited availability of large or small alternative cuffs within the maternity units for larger arms or leaner arms has consequences. If the cuff selected is too small this will lead to an underestimation of systolic pressure by an average of 8mmHg and an overestimation of diastolic by 8mmHg but the range can be up to 12mmHg for systolic and up to 30mmHg for diastolic pressures in obese clients (table 3.4). Similarly if the standard adult cuff is too large and a smaller cuff not used for leaner arms the BP will be underestimated by up to 23mHg for systolic and up to 20mmHg for diastolic pressures (Olivera, et al. 2002). The importance of using the correct cuff size is necessary for both manual and automated devices. Schoenfield, et al. (1985) found diagnosis of hypertensive disorder of pregnancy increased fourfold if an inappropriate cuff size was used.

More recently Kho, et al. (2009) found that when a standard cuff was used on pregnant women with large arms 25% were diagnosed with hypertension compared to only 18% who had BP undertaken with a large cuff. Under diagnosis of hypertension was found in 5% - 7% of pregnant women when an inappropriate large cuff was used instead of a standard cuff on a woman with a small arm.

The CEMACH report Saving Mothers' Lives (Lewis, 2007) states that the lack of a suitably sized cuff for obese women led to delayed diagnosis of pre-eclampsia. This information is based upon professional self and peer evaluation of evidence from when women have died. However, no previous research studies conducted within a maternity unit has collated information on the number of large BP cuffs that are actually available for staff use. This present study provides some research evidence that the number of large BP cuffs was limited within these maternity units which inevitably would lead to delays if a large cuff had to be sourced from another clinical area. The lack of immediate availability of a large cuff increases the risk of an incorrect cuff size being used or the utilisation of an inappropriate automated device, particularly if a large cuff could not or was not obtained. It has been suggested that up to two third of referrals to Fetal and maternal day assessment units are due to hypertension (section 2.5). In addition, as obesity in the general population and in pregnancy has increased over the years (Heslehurst, et al. 2007; ONS, 2008; CMACE

2010b) there is an increased need for health professionals to have easy access to a range of cuff sizes.

Another issue is around the use of unvalidated automated devices and their known inaccuracy in hypertensive or hypotensive, pregnancy and pre-eclampsia as discussed at 3.1.1, 3.1.2 and 3.2. Equipment Survey 2 results indicated an increase in the number of automated devices and removal of some older devices. However, for the majority (72%) of the devices there was no evidence that independent validation testing had been undertaken, at the time of the study. This is consistent with the discussions at 3.1.2 that few automated devices used in clinical practice have been independently validated according to a recognised protocol. On average blood pressure is underestimated by 5mmHg or more when using automated devices (Franx, et al. 1994; Quinn, 1994; Gupta, et al. 1997; Reinders, et al. 2005). In addition even a grade A BHS validated device can have an error of 15mmHg for 5% of readings. Gerin, et al. (2002) found that commercially available devices that had passed validation were inaccurate by a minimum of 5mmHg in 20-38% of individuals assessed in the study. Schwartz, et al. (2003) found more than 50% of individuals tested had an average measurement error of 5mmHg when using validated devices. Thus this raises concerns in regards to the accuracy or perceived accuracy and reliability of using an automated device for single BPM and 'within subject' BPMs (Skirton, et al. 2010). The removal of mercury devices from clinical practice to reduce the use of mercury and thus reduce the

potential health risks (as discussed at 3.3.1) means that health professionals have to use alternative equipment. The finding that two of the automated devices examined in Equipment Survey 2, had actually failed validation testing, yet were present in the clinical area is a concern, particularly as one had been acquired after Equipment Survey 1 has been conducted. As these devices had been graded as C/D or D/D (table 6.16) this means that only around 40% of readings would be accurate to within 5mmHg for the C grade and 0 readings for a D grade. Thus, the degree of inaccuracy of measurement obtained from these machines renders them totally unsuitable for use when making any clinical management decision.

The results of these equipment surveys are comparable with previous studies conducted in non-midwifery settings and provide evidence that the condition of BPM equipment particularly within these maternity settings did not meet the required standards. The three maternity units used in the study were unrelated and thus raises the issue that it is unlikely, that these findings are peculiar to the BPM equipment located within these maternity units.

7.5 Observations

The observation data provided evidence to confirm that the methods used to measure BP by the staff within these maternity units did not comply with best practice guidelines. The results are in line with previous observation study findings (McKay, et al. 1990; Villegas, et al.

1995; Veiga, et al. 2003; Bhalla, et al. 2005), which revealed that nurses and doctors in non-maternity settings did not comply with recommended BPM technique when observed conducting BPMs. The observation results were comparable with findings from Practice Survey 1, questionnaire results, regarding how respondents undertook BPM. Not one person observed conducted a BPM correctly in line with the current BHS guidelines on how to measure BP. The majority of incorrect factors witnessed would lead to an overestimation of blood pressure measurement by 2-15mmHg or more as identified in tables 3.4 and 3.5. These factors included talking, back unsupported, legs crossed, arm unsupported, arm above heart level, use of Korotkoff 4 for diastolic pressure. This data provided further evidence that the current practice of BP within these maternity settings would question the reliability of BP measurements obtained.

7.6 Practice Survey 1

7.6.1 Demographic data of respondents

The demographic findings were consistent with midwifery being a female dominated profession and midwives constituting the majority of the workforce. In addition the age range of the majority of respondents and the ratio of responses from midwives, medical staff and unqualified staff was representative of the distribution of their fraction within the national demographic of the UK maternity services workforce (as discussed at 4.11).

7.6.2 Type of devices used by respondents to measure BP (question 5)

Twenty two respondents from Hospital 3 indicated they used a mercury device to conduct BPMs. Yet Hospital 3 did not have any mercury devices. A possible reason for this response was that the respondents were community midwives using mercury devices in GP surgeries. However, eighteen of the respondents were hospital based staff who had no access to mercury devices. Other reasons are that these respondents could not distinguish between mercury and aneroid devices or that they classify/describe all manual devices the same i.e. mercury, similar to the way in which automated devices are often referred to in clinical practice as ‘dinamaps’. It is acknowledged that the mercury response may have been selected by error.

7.6.3 Practice Survey 1 Questionnaire responses

The results revealed a variation in the way staff recorded BP in pregnant women. The higher proportion of incorrect responses compared to correct responses for twelve of the sixteen questions revealed that many respondents did not appear to comply with the current BHS recommendations on BPM technique. By categorising the question topics into equipment, method and accuracy (as discussed at 4.10.6) the scores obtained by respondents for each category group pinpointed the particular aspects in which respondents varied their practice or demonstrated a lack of understanding. This information was essential to the determination of the content of the education programme and the overall evaluation of the impact of its introduction.

Prior to Practice Survey 1, limited data existed as to the current practice of BPM by maternity health professionals and the extent to which practice complies with current guidelines. Only one UK study (Perry, et al. 1991) and two studies in Australia (Brown & Simpson, 1992; Duggan & Miller, 1998) have examined the practice of BPM within maternity services. The results of these previous studies are similar to those of this study in that there was a variation in clinical practice and a lack of compliance with recommended BPM guidelines.

7.7 Practice Survey 2

7.7.1 Demographic data and response rates

As expected due to the previously discussed normal demographic characteristics of staff within maternity units the majority of respondents were female and midwives. Comparison of response rates between the two surveys showed a decline in the response rate for Practice Survey 2. Surveys that involve a longitudinal element i.e. where the sample population is approached more than once to complete questionnaires, is known to lead to a reduced response rate (Cormack, 1996; Bowling, 2002; Statistical Services Centre, 2003; Tourangeau, 2004). Bowling (2002) states there is no agreed standard for an acceptable minimum response rate. Response rates for mail surveys have declined over the years (Yu & Cooper, 1983; Brennan, 2004; Finn, et al. 2004; Tourangeau, 2004). Doyle (2004) states a single mailing can result in a response rate of 20% or lower. Brennen (2004) states that even sending three reminders are not sufficient to

obtain a response rate greater than 50%. Yu & Cooper (1983) found the average response rate for mail surveys to be 47.3% and this reduced to 41.6% if a convenience sample was used. Thus, it would appear that the range of response rates for self-administered mail surveys is 20% to 50%. However Cook, Dickinson & Eccles (2009) found the response rate for nurses to postal surveys ranged from 37% to 71% with a mean of 56%. This studies response rates would fit within this range. Studies within maternity settings that used self-administered postal questionnaires, had response rates of 46% from a sample size of 555 (Brown & Simpson, 1992) and 48% Duggan & Miller (1998) from a sample size of 440.

7.8 Clinical implications of deviation from recommended BPM technique

The Practice Survey results identified the specific factors where respondents deviated from current best practice guidance. The magnitude of the errors that can be introduced into BPM vary and can cause discrepancies in readings from anything between 6–30mmHg. It has not been determined by research if the errors are cumulative. However, errors of 10mmHg or more in BP readings during pregnancy will have consequences for clients. In particular if measurements are close to the threshold of 140/90 or 160/110 (as discussed at 2.4). This variability in the standardisation of BP technique indicates a lack of understanding of how to measure BP correctly by the auscultation method. The following discussion will highlight some of the particular

aspects for which the results identified a variation from best practice and identify the clinical implications.

7.8.1 Sound used to determine diastolic pressure

These results from this study are comparable with previous studies (Perry, et al. 1991; Brown & Simpson, 1992; Duggan & Miller, 1998; Gillespie & Curzio, 1998) where over 50% of respondents used the correct Korotkoff 5 (K5) sound to determine diastolic pressure. However, one cannot ignore the number of respondents using Korotkoff 4 (K4), as the measure for diastolic end point. In the previous studies mentioned above this was between 44% – 47% of respondents. In this study 42% of Practice Survey 1 and 46% of the participants observed conducting BPM indicated they used K4. This implies that there could be some confusion as to which sound K4 or K5 determines diastolic pressure or that staff have failed to update their knowledge about the correct end point for diastolic reading.

The clinical significance of using K4 instead of K5 is an overestimation of diastolic pressure by 5-10mmHg, with an average of 15mmHg in pregnancy (Duggan, 1997; European Society Hypertension, 2003). To put this into a clinical context this could result in a diastolic BP of 90mmHg being recorded instead of 75-80mmHg if K5 was used. According to PRECOG (2004) Community guidelines a diastolic reading of 90mmHg should result in referral of the client to the hospital for further assessment. The subsequent diagnosis and management of

hypertension or normal BP for this client will depend upon which sounds are utilised to determine diastolic pressure. Thus, one observer using K4 could determine a client is hypertensive and another using K5 could determine the client is normatensive. It is not normal practice for health professionals to record on client records which Korotkoff sound has been used to determine diastolic pressure. If this simple action was implemented as recommended by the BHS guidelines for BPM, it would provide confirmation for health professionals that the correct end point had been used and remove the confusion or incorrect use of K4 that appears to exist in practice.

7.8.2 Rate of deflation

This is the first time this question topic has been used to assess the current BP practice of staff working in U.K maternity units. The results from this study are comparable with the findings of previous studies conducted in non-maternity settings that found staff used an incorrect rate of deflation, Nolan & Nolan, 1993, (69%), Armstrong, 2002, (52%), Veiga, et al. 2003, (47%), Bhalla, et al. 2005, (80%).

Reinders, et al. (2006), found that a fast deflation rate of the cuff (>5mmHg/second) for BP measurements in pregnancy, led to a significant underestimation of systolic pressure by an average of 9mmHg. Diastolic pressures were found on average to be overestimated by 2mmHg when the deflation rate was too fast. In contrast a deflation rate that is too slow (<2/3mmHg/second), leads to

an overestimation of diastolic pressure of up to 6mmHg (table 3.4). It was revealed from the results of this study that 40% of Practice Survey 1 respondents used a deflation rate that was too fast and respectively 20% indicated they used a deflation rate that was too slow. Thus, indicating that at least 156 members of staff were underestimating systolic pressures and overestimating diastolic pressures when conducting BPM's on clients.

7.8.3 Resting period prior to BPM

Non-compliance with the BHS recommendation that clients should be allowed a five minute rest period prior to a BPM, was reported by 128 (52%) respondents from Practice Survey 1. This is less than the 68% of respondents in the results reported by Duggan & Miller (1998) with Obstetricians and midwives in Australia. An inadequate resting period leads to an overestimation of blood pressure of varying degrees (Perloff, et al. 1993; Campbell, et al. 1994(a); AHA, 2001; AHA, 2005; ESH, 2003). This is the first study in the U.K. to survey current practice of maternity staff in regards to the rest period before measurement and the results suggests that for every hundred staff employed within a maternity unit who conduct BPMs, fifty or more would not follow this recommendation.

7.8.4 Arm circumference

The majority (72%) of respondents from Practice Survey 1 could not identify that, when placing the cuff on the arm the bladder should

encircle a minimum of 80% of the arm circumference. The results are comparable with the two previous studies (Gillespie & Curzio, 1998; Markandu, et al. 2000) conducted in non-maternity settings who also found the majority of respondents (84% and 76%) did not know that the bladder should encircle at least 80% of the arm circumference. This question has not been included in the previous studies conducted within maternity settings (Perry, et al. 1991; Brown & Simpson, 1992; Duggan & Miller, 1998). Therefore prior to this study it was not known if maternity health professionals were aware of this requirement. Failure to ensure the bladder encircles 80% of the arm and not correctly centring the cuff over the artery leads to an overestimation of BP for both diastolic and systolic pressures. In addition bladder size is linked to cuff size and as discussed in 3.7.3 the use of an incorrect cuff size and incorrect cuffing will lead to an inaccurate BP measurement being recorded.

7.8.5 Increasing the rest period prior to BPM

No previous studies conducted in maternity settings have included assessing if staff are aware of the need to increase the resting period following smoking, eating, exercise or ingesting caffeine. The study conducted with general nurses by Nolan & Nolan (1993) reported only 28-38% of the nurses provided a correct answer to the required resting periods. The results from this study ranged from 13 – 17% of correct answers for Practice Survey 1 respondents. The ‘don’t know’ response was selected by 55- 63% of respondents for this section of questions.

The results of this study imply that, due to respondents limited or lack of knowledge about the need to increase the resting period, compliance with this recommended practice when undertaking BPMs was not being adhered to. The clinical impact of failure to increase the resting period BP is an overestimation of both systolic and diastolic BP from 5mmHg to 33mmHg (as identified in table 3.5). It cannot be determined from these results as to the numbers of pregnant women who will have smoked, eaten, exercised or ingested caffeine immediately prior to BPM. However all health professionals should be aware that these factors increase BP and ensure that when an increased BPM has been recorded consideration of these factors have been undertaken and excluded as a contributing to the high reading prior to other actions being initiated.

7.8.6 The effect of arm position on BPM

Few Practice Survey 1 respondents (24%) could identify the effect of arm position on BPM. Whilst the topic has been included in studies using questionnaires conducted in non-maternity settings (table 5.3), the format of the question varies and thus direct comparison of results is not possible. Armstrong (2002), found that only 14% of respondents were aware that error can be introduced into the measurement with an incorrect arm position whereas, 64% of respondents in the Villegas, et al. (1995), study were reported as being aware of the effect of arm position. However, in the observation of staff conducting BPMs during

the Villegas study in 73% of the observations, the client had an inadequate arm position. The clinical significance of an incorrect arm position is an 8mmHg discrepancy in BP measurement for every 10cms the arm is above or below the heart, as discussed at 3.7.2 and table 3.5. The observational data of staff conducting BPM in this study indicated 40% of those observed did not have the arm at the right level and for 77% of BPMs the arm was unsupported.

7.9 Evaluation of the Education Programme

The content of the education programme was tailored to the intended target population through the data provided from the baseline survey incorporating the Equipment Survey 1, Practice Survey 1 and the observations of staff conducting BPMs. The achievement of the intended learning outcomes (as discussed at 5.3) by the end of the session was indicated by the high overall scores attained by the respondents on Knowledge Questionnaire 1 and 85% or more respondents providing correct answers in all question category groups. The factors identified by the participants as affecting accuracy of measurement corresponded to the content of the education programme. In particular the three most common factors identified by the participants were aspects that had been highlighted as areas of concern arising from the Practice Survey 1 (baseline survey) results.

The reduction in the respondents median score and overall score achieved on Knowledge Questionnaire 2 compared to those achieved on Knowledge Questionnaire 1, indicated that for some respondents some aspects had not been retained in the long term memory. As no significant difference was found between the median scores of those who completed Knowledge Questionnaire 2 within 2 - 5 months and those who completed it within 6-9 months, suggests, that time was not a significant variable in the retention of knowledge for these participants. It was in the questions grouped in the equipment and accuracy categories where there was the greatest reduction in respondents' scores. Respondents of Practice Survey 1 had demonstrated limited understanding or failure to comply with recommended guidelines in these category groups, which had resulted in their inclusion within the education programme. Therefore, for some participants of the education programme this could have been their first exposure to this information. A lack of motivation to being receptive to new knowledge or perceiving the information had no personal benefit could have created a barrier to learning. Other participants may have required further input to assimilate the amount of new information received. Whilst a variety of learning theories were utilised within the education programme (as discussed at 5.4.1), for some participants' further stimulation of the psychomotor and or affective domain may have been required. It is suggested by data from previous studies (Curb, et al. 1983; Mee, et al. 1994) where further education has been

provided continued input was necessary to maintain accuracy requirements in measurement technique (as discussed at 3.7.6).

With any new education programme participant feedback is invaluable to determine is effectiveness and participants' perception of the need for such a programme and to identify changes needed if the programme is to be utilised in the future. The results indicated that some stimulation of the affective domain had been achieved, as the majority (88%) of participants stated that they had made changes to their clinical practice of BPM. The results also provide evidence to confirm anecdotal reports that updating on BPM seldom occurs. In addition, the participants acknowledged that there was a need for staff to be regularly updated on factors that affect accurate BPM. Thus overall there was a positive reaction to the programme and it appeared to be of value to them clinically.

7.10 Impact of Education Programme

The results from the participant feedback indicated that changes had been made to their clinical practice of BPM. These changes were around the aspects of deflation rate, the use of K5 instead of K4, not rounding off readings and checking if women had smoked, eaten, exercised or ingested caffeine within thirty minutes of BPM. These stated changes were also reflected in the paired sample results for those who attended the education programme and completed Practice Survey 1 and 2 questionnaires. These data confirmed that for the rate

of deflation and time allowed for resting before smoking, there was a significant increase in the number of correct responses and for five other aspects marginal non-significant increases (P values from 0.002 to 0.012). This, resulted in a significant increase in the overall score for these respondents, and the possibility that the education programme had a positive impact on BPM practice.

The general working condition of manual BP equipment had improved, It could not be verified however, if this was directly as a result of the education programme Also more devices had been serviced, with older mercury devices removed and replaced with aneroid devices. It would appear that the education programme had little impact on ensuring that appropriate independently validated automated devices were the type available for clinical use. Equipment Survey 2 data revealed one Hospital had implemented a servicing programme and acquired four independently validated automated devices suitable for clinical use. However, the findings from this study cannot verify if this was by chance or as a result of the education programme. The fulfilment of the request from the community midwives at this Hospital to each be issued with a large cuff following their participation in the education programme was one aspect where the education programme had directly impacted upon equipment available.

7.10.1 Development of the Education Programme

There are no quick solutions to improving the quality of care or professional practice by the use of continuing professional education. Systematic reviews of the methods used for continuing education have concluded that the impacts are mixed and variable. Some studies suggest that continuing education has little or minimal impact on improving client care or compliance with clinical guidelines. Outcomes about the effectiveness of the impact of education on improving client care or health professional's compliance with clinical guidelines have not been systematically measured and studies use a wide variation of measures, methodology and tools. Therefore, this leads this variation in research findings and therein lies the difficulty with research evidence that aims to address the elusive link between education and practice (Grol, 1997; Davis, et al. 2009; Forsetlund, et al. 2009; Baker, et al. 2010; Giguère, et al. 2012; Health Foundation, 2012; Ivers, et al. 2012). Nevertheless, there is a general acceptance that education and training does impact positively upon attitudes, knowledge and behaviours of the participants. Also health professionals themselves acknowledge that continuing professional development is an essential component in the maintenance of and acquisition of new skills and competencies and in improving performance (Grol, 2002; Wun Dickinson & Chan, 2002).

Maintaining a skilled workforce requires some form of continuing education and as has been shown by this study and previous research

that even basic skills such as BPM need updating. Continuing professional development is an essential requirement to advance professional practice and is intended to facilitate the improvement of client care through promotion of beneficial clinical practice and discouraging ineffective procedures. However, the implementation of evidence based care often requires health professionals to change practice, attitudes or behaviours and this often requires a multifaceted approach for effective change to occur.

Implementation of changes to health care procedures and ultimately quality improvements can be effectively promoted though continuing education if one considers the influences of various theories as was done within this study. Educational cognitive theory incorporates adult learning theory and should link the professionals' desire to learn, to be competent and motivation for improvement into the development for change to occur. Addressing attitudes, beliefs, perceived social norms, and relating this to the desired performance will influence the motivation to change is what is suggested by motivational theories (Knowles, 1980; Reece & Walker, 2007). Professional loyalty, pride and endorsement by a professional body are seen as important factors in professional development theories. The important elements of social influence theories are factors such as the content being endorsed or delivered by a credible or respected person within or outside the organisation as discussed at 5.9. Also the method of delivery in

continuing education needs to be appropriate to the target audience and where possible tailored to their specific needs (Giguere, et al. 2012). The features of effective education as outlined by Price, 2005 were incorporated into the content of the education programme developed for the study. These included the assessment of a learning need, the inclusion of data showing the gap between current and best practice, targeted content applied to the participants work environment with a set objective, evidence based sources for content and time for questions about the evidence. However, even when all the above is taken into consideration within different healthcare settings, groups of healthcare professionals and different clinical tasks, various barriers to change in professional practice will be encountered and can this prevent the implementation of best practice.

The UK like many other countries stipulates that Continuing Professional Development is a mandatory requirement to maintain professional registration for all health professionals.. The current health care system is characterised by a continuously expanding body of knowledge, thus, in order to facilitate effective modes of continuing professional education that improves both practice behaviour and client health outcomes, requires Interactive, challenging sequenced activities preferably situated in the clinical environment and with multiple interventions over time (Davis & Galbraith, 2009; Baker, et al. 2010; Chipchase, Johnston & Long, 2012). Clinicians themselves have a personal responsibility in terms of professional growth and

development and this requires them to be reflective, obtain feedback on performance, and have the skills and confidence to critically appraise the research evidence.

Evaluation of the education programme determined that its potential for future use would be enhanced if the delivery time was increased. This could be done by increasing the time allocated for a single session or incorporating two sessions into the programme. The increased delivery time would provide an opportunity for staff to practice the correct BPM technique identify personally where their BP method differs and if deemed necessary individual competency assessments could be conducted. As discussed (at 5.5) it had been the intention to include a practical session within the education programme but this was not feasible within the allotted time period. The inclusion of a practical 'hands on' session would be a way in which the learning method could be enhanced to facilitate further stimulation of the psychomotor and affective domains of learning as discussed at 5.4.1 and 7.9. Consideration could be given to the use of a dual headed or Y stethoscope for training purposes within the practical session to aid the instructor in determining which Korotkoff sounds were being utilised. One to one education would enable reinforcement and assessment of competency of BPM skills but the process can be tedious and time consuming and is not a cost effective method if large numbers need educating. In addition, if staff had multiple exposures to the topic via multiple instructional approaches then influencing staff to make

changes to practice could be even more effective (Bordage, Carlin & Mazmanian, 2009).

Following the education programme self-directed learning could be encouraged through the development of an online package or DVD that health professionals could utilise and also be combined with discussion forums. As identified previously self-motivation and relevance to their own clinical practice can be key factors in encouraging health professionals to change their behaviours, attitudes in order to improve their clinical skills. The use of respected influential and trusted clinicians to disseminate, educate staff or implement practice changes or promote evidence based practice by linking the theory to the practice sometimes referred to as 'opinion leaders,' (Flodgren, et al. 2011,) can play a key role in being agents of enabling individuals to change their practice. Thus, it would be worth considering who would be best placed within a clinical setting to deliver or promote any continuing educational topics.

7.11 Study limitations

The research approach used was of a quantitative and non-experimental nature similar to previous studies conducted around this topic (see section 4.4). This study does differ from past studies, in that it took an evaluative approach but this non-experimental design could be seen as a limitation of the study. A limitation of the descriptive non-experimental approach is that firm conclusions about cause and effect

cannot be made (Walker, 2005). However, quantitative non-experimental research studies make valuable contributions to evidenced based health care (Walker, 2005). They are frequently utilised with educational research studies (Johnson, 2001) and can provide important answers in the development of new knowledge. They are also used to generate questions about practice and provide evidence to inform best practice (Seers & Critelton, 2001; Walker, 2005).

7.11.1 Sample limitations

As discussed at 4.11 and 5.1 it was not feasible, nor possible due to issues of confidentiality and/or lack of records to access the information that would be required to contact all the eligible health professionals who conduct BPMs in maternity units. Utilising participants from the same setting can lead to data contamination, but the introduction of a number of confounding variables can occur if respondents are from different settings. Accessing a true random sample when conducting research with health care professionals can be complex, unwieldy and unrealistic, (Clifford, 1990) and thus a non-probability sample was selected for this study. It was anticipated that using three sites for the study the number of Practice Survey respondents would have produced a larger sample size for evaluation.

There are inherent difficulties in determining if continuing education programmes meet desired outcomes and ultimately lead to

improvements in the provision of client care (Griscti, Jacono, 2006). Observation studies can be an appropriate method to evaluate change but as Jordan (2000) highlights, aside from the increased risk of the Hawthorne effect this method of enquiry can have practical, ethical and budgetary issues. The evaluation of application of theory into practice by valid research methods that are reliable and efficient is an ongoing goal as no one system is perfect (Griscti, Jacono, 2006; Jordan 2000). Attree (2006) states there is no standardised scientifically verified tools or designs to aid in the evaluation of educational processes or outcomes, with the evidence base of educational practice being derived from small scale studies. Within health care settings, the researcher has limited control over human subjects and the events being studied (Ellis, Davies & Laker, 2000). In addition, there were the complexities of learning and its evaluation within a complex learning environment. Furthermore the incorporation of a time delay within a research study is known to lead to a decrease in the numbers of participants at the time of follow up (Jordan 2000). Ultimately this limited the size of the sample on which the impact of the educational programme was measured and thus the transferability of the findings is limited. A larger sample size and a mixed method approach would have addressed some of the limitations. In addition from a statistical analysis perspective the small sample size increases the risk of type II errors when the statistical analysis does not detect a difference when one exists. At the same time the large number of statistical tests carried out on a small dataset increased the type I error rate, therefore,

the decision was made to adopt the conservative criterion of P=0.001. This allows extra caution to be applied to the interpretation of this small-scale study.

It is acknowledged therefore, that the main limitation of using natural settings is that participants were not randomly assigned to groups. The group of participants that completed both practice surveys but did not attend the education session appeared to show less improvement. However this may have been the result of different characteristics from the other participants such as grade, seniority within the team, whether or not they felt the needed to be updated or considered that their deficit of knowledge was not as great and these data were not collected. However, as this was a preliminary investigation into a topic not previously researched these results may lend support to the results of future studies and can be used to direct changes in the clinical practice of BPM.

Jordan (2000) suggests that when the researcher is a teacher this can act as a stimulus for respondents to modify practice and fosters collaboration between academic and clinical environments. It is widely reported that health care professionals are reluctant to adopt findings of large research studies whereas small-scale studies by practitioners are likely to impact upon the practice of participants and other clinicians who can identify with the situations being described.

7.11.2 Limitations of using the survey questionnaire method

A limitation of using the survey questionnaire method, is that it does not always provide the data to determine the cause of an observed relationship between X and Y, it only identifies if a casual relationship exists. As discussed at 5.9 diffusion and utilisation of information within organisations is a communicative and interactive social process in which interpersonal contact can play a pivotal role. It has been shown that a person external to the organisation can formally act to influence or promote knowledge, which is then disseminated and utilised within the organisation (Rogers, 2003; Thompson, Estabrooks & Degner 2006). The data obtained from this study did not determine if it was specifically the education programme that acted as the main catalyst for the changes seen or whether it was the study itself or the presence of the researcher that initiated the changes or if the changes were coincidental.

The use of the survey questionnaire method was appropriate to study a large group of people by one researcher. However, with hindsight supplementing this with the use of focus groups or individual interviews in Phase 3 could have added another facet to the study. This method would have provided a qualitative dimension to the study with the potential to provide more data on what aspects of BPM practice staff had changed or not changed and the reasons why. Thus, confirming or providing some empirical evidence to increase confidence in the identification of the specific elements that had or had not contributed to

staff making changes to their practice. In addition, it may have been possible to obtain data on why staff did or did not participate in the different phases of the study. However, the number of focus groups or individual interviews that one researcher would be able to conduct would have been limited, due to the time consuming nature of these methods as discussed at 4.10 and thus, was not selected as an appropriate method for this study.

Another highlighted disadvantage of face to face individual or group interviews is interview bias. In this study follow up face to face individual or focus group interviews would have been conducted by the researcher that carried out all the previous phases of the study. Thus there was a high risk that the answers provided could be biased. The respondents may have felt they were being tested or checked up upon and thus provided the answers that they felt were expected of them (Cormack, 1996; Bowling, 2002). The interpretation of responses collected from a small number of interview respondents would be unlikely to produce sufficient data for meaningful comparison analysis. Therefore, for this study it was felt that the addition data obtained by interviews would not have provided much added value.

However, if the study was replicated in other maternity units, consideration of the feasibility of including focus groups interviews in should be contemplated particularly if more than one researcher was involved in the study. From a teaching and learning perspective the

collection and evaluation of narrative from focus groups following the educational programme could provide useful insight into factors that facilitate or hinder changes being made to clinical practice.

7.12 General discussion of the study BP Practice and Equipment and continuing education

As discussed at 4.1 the aim of the study was to evaluate the equipment, practice and the impact of continuing education in regards to BPM in maternity settings and four research questions were posed. The baseline survey (Phase 1), incorporating Equipment Survey 1, Practice Survey 1 and the observations of staff conducting BPMs, provided the data to answer the research questions 1 and 2 around the type, working condition of BP equipment and the current practice of BPM within maternity units. To address questions 3 and 4 the evaluation of the impact of the education programme upon practice and equipment was addressed by the data obtained from Practice Survey 2, Equipment Survey 2 (Phase 3). This study was a preliminary investigation into a topic that has not previously been addressed in maternity settings and thus further research will be required to corroborate these findings

The minimum requirement of health professionals having access to an accurate BP device to measure BP was not being fully met in any of these maternity units. Conducting a BPM with a defective machine could potentially result in harm for the client. There are thresholds of

measurement that define the diagnosis, degree of hypertension and its management, as discussed at 2.4 and 2.5. NICE (2010) Hypertension in Pregnancy guidelines clearly explain how the degree of hypertension of mild, moderate or severe impacts upon client admission to hospital, how often BP should be measured and when hypertensive treatment is commenced and these have been summarised in table 7.1.

Table 7.1 Summary of how degree of hypertension impacts upon clinical management

Degree of Hypertension	Mild hypertension 140/90 -149/99	Moderate hypertension 150/100 t0 159/109	Severe hypertension 160/110 or higher
Gestational Hypertension			
Admit to hospital	No	No	Yes (until BP is 159/109mmHg or lower
Measure BP	Not more than once a week	Twice a week minimum	4 times a day minimum
Treat	No	Yes Antihypertensive drugs Keep diastolic between 80-100mmHg Keep systolic pressure less than 150mmHg	Yes Antihypertensive drugs Keep diastolic between 80-100mmHg Keep systolic pressure less than 150mmHg
Pre-eclampsia			
Admit to hospital	Yes	Yes	Yes
Measure BP	4 times a day minimum	4 times a day minimum	More than 4 times a day – clinical circumstances will dictate
Treat	No	Yes Antihypertensive drugs Keep diastolic between 80-100mmHg Keep systolic pressure less than 150mmHg	Antihypertensive drugs Keep diastolic between 80-100mmHg Keep systolic pressure less than 150mmHg

The woman's BP should be regularly checked and measurement accuracy and 'within patient' reliability is essential to verify if BP remains below the 150/100mmHg level, using antihypertensive medication if necessary. This will help prevent the morbidity and mortality problems linked to hypertension that result in end organ damage. Increasing hypertension is associated with placental abruption, pre-eclampsia, eclamptic convulsions, cardiac arrest, cerebral vascular haemorrhage, liver haemorrhage, renal failure and retinal damage as discussed at 2.1. All these maternal conditions can lead to pre-term birth or fetal death and thus impact upon fetal morbidity and mortality. Therefore, appropriate monitoring and management of BP will enable the pregnancy to continue as long as possible and help prevent these complications.. In addition the NICE (2010) guidance regarding what fetal monitoring should be undertaken is based upon the type and severity of the degree of hypertension. Inaccurate BP measurement of 6mmHg, due to calibration error or an overestimation of diastolic pressure by ≤ 8mmHg could lead to the non–prescribing of or incorrect prescribing of antihypertensive medication, particularly if the BPM is at or near a threshold of when management would alter, i.e. at a BP reading of 150/100, when it is recommended antihypertensive medication is commenced (table 7.1). Either way this inappropriate management has implications for the woman. As discussed in detail earlier in this chapter, the findings of this study would suggests the possibility of the introduction of measurement errors of anywhere between 6mmHg to 30mmHg, due to

equipment and or observer errors within these study sites. The consequences of inaccurate measurement are not just related to antenatal management as hypertensive disorders of pregnancy impact upon the intrapartum and postpartum periods and thus inappropriate readings could affect mode of delivery, length of postnatal hospital in-patient stay, follow up care and ongoing surveillance.

Current evidence suggests that hypertensive disorders of pregnancy are no longer just self-limiting and can continue to have long term implications for both mother and offspring. Women who have suffered from Pre-eclampsia appear to be predisposed to a variety of pathological conditions such as chronic hypertension, ischaemic heart disease, neurological defects, thromboembolic conditions, cardiovascular disorders, diabetes, chronic renal failure, thyroid disease and premature death (Tranquilli, et al. 2012). The health of the off-spring from women who had Pre-eclampsia are known to be at risk off chronic lung disease, cerebral palsy, learning disabilities, diabetes, pulmonary hypotension and in later life their risk of cerebral vascular haemorrhage and cardiovascular disease is increased (Tranquilli et al 2012). Thus it is important that women who develop a hypertensive disorder during pregnancy are informed of these risks and health professionals need to ensure they are correctly diagnosed and managed thorough accurate blood pressure monitoring.

There is considerable evidence to raise concerns about the accuracy of oscillometric devices when they are compared to the gold standard mercury device. The accuracy of the reading using a manual or automated device will depend upon the consistency of the method used to obtain the reading in addition to the actual device chosen to undertake the reading. The health professionals responsible for taking the readings, such as the midwives in this study need to be aware of the issues of measurement accuracy. Track and Trigger early warning systems such as the modified early obstetric warning system (MEOWS) as highlighted in the Saving Mothers' Lives maternal mortality report (Lewis, 2007) have been incorporated into clinical practice. The routine use of such a recording system is recommended to aid in the timely recognition of a deterioration of the woman's condition so referral and treatment is not delayed when a critical illness has developed and ongoing scoring enables tracking of the response to the treatment (RCOG, 2008). The accuracy of the scoring system is dependent upon the initial and ongoing recording of the vital signs from which the score is generated and BPM is one of the vital signs recorded. Therefore, variation in measurements due to different devices (manual or automated) or inappropriate devices (out of calibration or unvalidated) or different methods used to obtain the reading such as K4 instead of K5 will result in an incorrect reading and affect the score. The effective application of the early warning score system is dependent upon the detection of physiological changes in the condition of the client not changes due to inaccurate measurement.

Women with mild or moderate gestational hypertension or chronic hypertension who do not require hospital admission will have their BP monitored antenatally within the community setting. There is an increase in the number of pregnant women purchasing their own home BP monitors, (Crafter & Garland, 2011), which are known to produce erroneous readings, (O'Brien, 2001; Pickering, et al. 2005). Therefore, these measurements should not be utilised as part of the monitoring process, particularly if the device is one that is not suitable for use in pregnancy. Plus there are issues around education of the woman on the correct use of the device to prevent errors of measurements. Wong, et al. (2005) found that with the use of home BP devices in 73 known hypertensive patients, 85% had not received any training on how to operate the device. Whilst 63% had read the user's manual only 50% knew that the arm should be on level with the heart and the importance of resting for five minutes prior to undertaking the measurement and only 20% had an appreciation of the importance of using the correct cuff size. Thus health professionals encountering women who are conducting their own BPMs at home should ensure that the woman understands how to use the device correctly. Additionally Pickering, et al. (2005) suggest that the device should be checked against a fully working manual device to see how valid the readings are. To do this of course the health professional themselves has to be knowledgeable about the factors that impact upon accuracy and know the correct technique for BPM. It would appear that staff are not aware of the servicing or calibration requirements of BP equipment

to maintain accuracy of measurement thus have no expectations that they are conducted or even needed. Thus, prior to use equipment is not checked or if defects are identified there appears to be little initiation of appropriate actions to remedy the faults. It could be argued that clinical decisions would not be instigated solely upon the BPMs recorded by the woman's own device and measurements would be checked using a hospital device. However, the results of this study indicate that the accuracy of the hospital device used could also be questionable ,particularly if it was a handheld portable BP device as used by community midwives. In addition, one has to consider the effect of anxiety caused if the woman thought her BP was raised when it was not or the financial implications for the woman in relation to travel costs to the day unit/hospital for BP assessments. Similarly, there are the financial implications for the Trust in terms of staff time and resources.

Achievement of competency in a clinical skill such as BPM requires the underpinning theoretical knowledge of what BP is; what factors influence BP and its accurate measurement and how to conduct the measurement itself. The skill of measurement is obtained by practicing the procedure and achieving the physical dexterity in the performance of the skill. The final stage the competency is achieved when the theory is applied to the practice and the person can obtain an accurate BPM by ensuring the factors that would lead to an inaccurate measurement are accounted for and the significance of the reading

obtained informs the future management of the client. Thus ensuring the clients are not misdiagnosed or receive inappropriate clinical management.

As discussed at 3.7.5, at the point of registration all midwives and doctors are deemed competent in the core skill of BPM. However it seems that ongoing formal testing of competency in the skill of BPM or updating knowledge on this topic does not occur thus ongoing competency in the skill of BPM appears to be taken for granted. Midwives and doctors are bound by their professional responsibilities and are personally accountable for all actions or omissions in their clinical practice. Care provided to clients should be based on the best available evidence or best practice and there is the requirement that knowledge and skills have to be kept up to date (GMC, 2006; NMC, 2008a). Thus, there is the expectation that in order to maintain and develop competency and performance of all clinical skills, ongoing learning and practice activities will be required throughout the professionals working life. However observers conducting BPMs can only correct mistakes if they are aware of them and understand the consequences of not following the recommendations practice.

The importance of achieving initial adequate preparation of health professionals taking BPMs and the need for periodic review of their performance is highlighted in the NICE Hypertension guidelines for the general population (NICE, 2011). In addition, there is also some limited

guidance on how to take BP correctly and the importance of only using validated automated devices in clinical practice. However, in the Hypertension in Pregnancy NICE guidelines (2010) there is no mention of how a BPM should be conducted or any information about issues around automated devices. The guidelines refer the reader to the NICE Antenatal guidelines where there is some guidance on how BPM should be conducted but not the implications of not following the recommended technique. In addition discussion around inaccuracy of automated devices has been removed from the modified 2010 version. Similarly it has been observed that within midwifery and obstetric textbooks the importance of or implications of using a casual BPM technique as opposed to following recommend measurement technique are not addressed. Therefore it would appear that generally there could be an omission in the general or basic information being provided to staff caring for pregnant women on factors that affect accurate BPM.

Despite the importance of detecting elevations of blood pressure in all the various definitions and classifications it would appear that little attention is paid to the details of recording accurate blood pressure measurements in both the clinical or research arena. Harlow and Brown (2001) suggest that some research studies conducted in the topic area of pre-eclampsia, factors such as the device used to measure the blood pressure or which Korotkoff sounds were used for diastolic measurement or what cuff size was used are not normally

documented. Thus, in the research arena questions could be asked regarding the subsequent classification of a woman being identified in a study as being pre-eclamptic or not. For example, women could be included or excluded from a study on the basis of an inaccurate blood pressure measurement due to the wrong size cuff being used or a machine not validated for use on pregnant women or use of the wrong Korotkoff sound for determining diastolic pressure. This then could raise issues around the validity of the study itself in regards to selection of participants or method of recording blood pressure.

The health professional who is unaware of the factors that affect accurate measurement on reviewing this literature would not be able to take this into consideration when formulating an opinion on the usefulness of the research findings to their practice. This lack of attention to details regarding how accurately BPMs are performed in the clinical and research arena suggests that they may not be considered to be important or it is mistakenly believed that the measurement is always performed accurately. This suggests that the importance or implications of not obtaining an accurate and precise BPM are being ignored and there is no impetus for staff to update their existing knowledge and competency in BPM continues to be taken for granted. As highlighted in the discussion at 5.1 health professionals are more likely to change clinical practice or behaviour if they perceive there to be significant consequences to clients.

The planned focused interactive educational intervention designed and utilised in this study was intended to not only enhance or reaffirm conceptual knowledge of factors that impact upon accurate BPM but also to facilitate staff to change practice where appropriate and thus demonstrate the application of the knowledge into their BPM practice. Therefore the education programme was available to all staff not just to those who participated in the baseline survey via Practice Survey 1. Improvement in clinical skills can be initiated by integrated teaching of knowledge into clinical practice through incorporating evidenced based medicine (Coomarasamy & Khan, 2004).

Quality improvement initiatives around the care of women with hypertensive disorders in pregnancy need to incorporate performance assessment of staff BPM technique and equipment standards. Myers, et al. (2010) state that comparing casual BPM technique with that of the correct standard shows on average the casual method results in a reading that is 10/5mmHg higher than it actual is. In a recent study by Burgess, et al. (2011) comparing BPMs obtained using a casual and recommended technique in an outpatient clinic found significant differences ($P<0.0001$) in the readings obtained. The systolic and diastolic readings on average were 12.4mmHg and 6mmHg respectively lower when strict procedures were followed. Whilst the participants in these studies were not pregnant women the results still imply that the discrepancy seen would lead to significant clinical implications. Tomlinson (2010) reports the clinical consequences of the actions taken because of inaccurate BP readings due to cuff size

and arm position that resulted in a patient having antihypertensive medication unnecessarily increased twice which led to the patient being unable to mobilise or sit up due to being dizzy and light headed.

Inadequate preparation of the client such as failure to allow the recommended resting period prior to BP measurement, deviations from recommended technique and inaccurate devices due to poor working condition have been shown to result in measure errors of 10mmHg or more (Mckay, et al. 1990). This results of this study as with previous studies in non-maternity settings indicates that health professionals should be concerned that it is extremely likely that decisions are being based on inaccurate BPM and risking unexpected or adverse effects of inappropriate clinical management decisions for their clients. Current clinical guidance policies and procedures around blood pressure measurement should reflect best evidence. However, it was clear from the results of the baseline survey from this study, like many other health professionals identified in previous studies, the staff within these maternity units required updating. The results from this study did not identify any statistical significance between the number of years staff had been conducting BPMs for and the percentage of correct responses on the Practice Questionnaires. One may have expected more junior staff to be more up to date with the evidence based theory around BPM but this was not found to be the case. However, as discussed at 3.7.5 there are implications regarding where health professionals learn and who from. There is limited evidence on the

mentors' impact upon a student mastering the skill of BPM but it has been shown that the clinical educators rarely or never reinforce recommended standards. In addition, as shown in table 3.2 and the results of this study there appears to be a lack of compliance by health professionals with recommended standards for BPM. Thus, even though students may have received appropriate theory and classroom based knowledge either during the student period or upon transition from student to qualified health professional, practice may change to comply with the dominant culture and context of the hospital environment.

The wider issue related to that of the education of student midwives and doctors is relevant to the study setting as all three hospitals are used as placement areas for these students. Therefore, the results of the study highlight the risk that the students within these units could be taught to measure blood pressure with defective equipment and will observe the incorrect technique of measurement and a failure of staff to apply theory to practice. Conceptual knowledge of BPM is taught to students within the University setting application of theory to practice and competency in the skill is achieved in the clinical setting. Qualified staff support and assess students in the achievement of the skill of BPM. If these qualified staff are themselves not performing the skill according to best practice, by not following current measurement guidelines and applying theory to practice, then one could question if they are they the best people to support others to achieve competency

in the core skill of BPM. Thus that would also call into question are the students actually competent in the skill at the point of registration which would need to be ascertained by further research.

7.13 Recommendations for clinical practice

The results of the study have highlighted various elements that if addressed would help to standardise BPM and facilitate accurate BPM within maternity units. Thus, several recommendations are proposed and they have been divided into actions that can be taken by individual health professionals or by a person or persons with specific responsibility within a Trust.

7.13.1 Recommendations for actions to be taken by individual health professionals

Health professionals need to be more vigilant and take individual responsibility to ensure that they are not using defective equipment. All members of staff have a responsibility to ensure that the equipment they use to obtain a blood pressure measurement is to the best of their knowledge in full working order regularly serviced and maintained. Any defective equipment should be removed from the clinical area and sent for repair or renewal. Individuals should have up to date knowledge on servicing, maintenance and calibration requirements for manual and automated BP devices.

Staff should ensure they access appropriate updating on a regular basis and not take for granted their competency in this basic skill.

Individuals need to ensure an appropriate size cuff is always used for undertaking BPM's and the recommended procedure is followed. In addition, staff need to be aware of the limitations in the use of automated devices on pregnant women in particular that they are likely to underestimate BP. Prior to using automated devices staff should have verified that the automated devices available within their clinical environment have been independently validated for clinical use and in particular for use on pregnant women. When obtaining a BPM with an automated device this should be compared to a BPM obtained from an accurate manual device to ensure the automated device is not underestimating blood pressure.

7.13.2 Recommendations for actions to be taken by ward managers

Each clinical area should identify a person on each ward area to co-ordinate sending equipment for repair ensuring service checks are conducted. The person or persons who are responsible for the purchase of blood pressure measuring equipment should have sufficient knowledge to ensure only appropriate equipment is acquired. Equipment that has not been independently validated for the intended population or clinical use should not be purchased. An assessment of current automated equipment should be conducted to identify any device that has been deemed unsuitable for clinical use and removed. Each area should have at least one large cuff for manual devices and individual community midwives should have their own large cuff. Ward

areas also should keep a stock of or have easy access to spare parts, such as connectors, cuffs, which can easily be replaced by clinical staff

7.13.3 Recommendations for actions to be taken by Medical Engineers

Hospital Trusts should establish formal routine maintenance schedules for the servicing and calibration checks of all equipment used for the measurement of blood pressure. Portable aneroid devices in particular handheld aneroid devices should be checked on a regular basis at least every 6 months for accuracy. A fully working mercury device should be retained in order to conduct calibration checks on manual devices. Staff could be trained how to check the accuracy of a device. Preferably this should be through dynamic testing that mimics clinical use and not subject to bias. The department should be able to provide the appropriate support and guidance and check that any new automated equipment ordered has been independently validated as suitable for clinical use and preferably for use on pregnant women.

7.13.4 Recommendations actions to be taken by Risk managers, research/Audit teams

Units need to produce guidelines on how to measure blood pressure satisfactorily including factors that impact upon accuracy. These guidelines should be referred to in the Trust policies on the management of hypertensive disorders in pregnancy and easily available for prompt referral by staff on the hospital intranet. When reviewing hypertension cases at clinical review meetings etc., questions need to be asked to determine how accurate the BP

readings were obtained focusing on aspects such as device used, cuff used and diastolic sound used to raise awareness of the factors that lead to inaccurate measurement. Regular updating of knowledge could be achieved by including the topic in mandatory training sessions and consideration given to conducting a competency assessment of BPM skill to assess staff compliance with recommended BPM technique. In addition as the sphygmomanometer is a medical device an assessment of competency in the safe use of any medical device is recommended by the MHRA (2008). Examples of competency assessment tools devised by the researcher for both an automated and manual BP device can be found in Appendix 20 & 21. If regular audits of staff practice/ knowledge and equipment were conducted then the information obtained could be incorporated into the content of update sessions. This would enable the content to be tailored to target specific factors that need to be addressed. Other aspects that could be audited are issues around women attending the day unit for hypertension problems. Such as the number referred to the day unit or antenatal clinic, who, are subsequently found to be normatensive possibly due to calibration issues with community or hospital devices or incorrect measuring techniques such as K4 being used instead of K5.

7.13.5 Other recommendations

Some other recommendations fall outside of the maternity units themselves. The content of undergraduate and post registration and postgraduate courses needs to be examined to ensure that it includes

all the factors that affect accurate measurement as discussed in this thesis under equipment, observer and technique. It is recommended that all midwifery and medical and nursing students are assessed on their ability to conduct a BPM according to recommended technique each year of their course. This will help to reaffirm the correct technique and counterbalance incorrect information or the non-identification of incorrect technique by clinical staff. National bodies such as the BHS, AHA, ESH need to work with and pressure the manufacturers of BP devices to produce appropriately labelled standardised cuffs in sizes that meet their recommendations and suitable for the intended population.

Recommendations for future research would be to determine if equipment faults and BPM technique errors are cumulative and thus what is the degree of error introduced into BPMs particularly if faulty technique is combined with faulty equipment. In addition future research could determine the impact of inaccurate measurement upon clients and maternity services in relation to time, financial aspects and the diagnosis and management of a hypertensive disorder and the potential number of women having an inaccurate measurement recorded.

7.14 Conclusion

This study is an original piece of work as it encompasses an assessment of BP equipment, practice of BPM and continuing

education within one study gathering data from three different maternity units. In addition throughout this study data was obtained and evaluated regarding aspects previously not reported by any other studies. This study has been able to verify that within these three maternity units mercury BP devices have mainly been replaced with aneroid devices and regulations and awareness of the toxic effects of mercury have resulted in staff having no access to the gold standard mercury BP device. Initially it was identified that wall mounted devices were more common but by Equipment Survey 2 this changed to portable devices. Whilst the study confirmed that portable aneroid devices failed to meet quality standards the results identified that it was the small handheld devices used by community midwives that appeared to be more prone to defects. The Equipment Surveys collected data to determine the specific components which do not meet the quality standards. The results showed that missing or incorrect connectors, devices not at zero prior to inflation, cuff labelling, condition of the rubber tubing and glass faceplate plus lack of servicing and calibration testing were the components in which a higher percentage of devices failed to meet the quality standard. The results of this study provided evidence for the first time that generally stethoscopes were found to be in a good condition.

This study has verified anecdotal evidence that automated devices are available for use within some maternity units with the majority located on delivery suite. However none of the automated devices examined

had been independently validated as accurate in the measurement of BP on pregnant women. In addition both equipment surveys found the presence of automated devices that were not recommended for clinical use having failed independent validation testing but the number had reduced by Equipment Survey 2. In addition Equipment Survey 2 results found an increase in the number of automated devices that had passed independent validation tests for clinical use. As there are very few devices that have been independently validated for use on pregnant women (BHS, 2012) this is problematic for maternity units who wish to purchase automatic devices. The study has provided evidence to verify anecdotal evidence and add to the limited research evidence around the availability of large cuffs within maternity units. The availability of alternative cuff size to a standard adult was limited in all three maternity units but the number had increased by Equipment Survey 2. The majority of cuffs examined did not conform to the recommended size stipulated by the BHS or the AHA.

The results suggest that equipment and practice in these maternity units is similar to that of other health settings and health professionals. The findings of this study would suggest that greater attention by staff within maternity settings needs to be paid to the factors that affect accuracy of blood pressure measurement. Otherwise one could call into question the validity of how useful readings actually are and should we be doing them if they are not accurate. There is a need to evaluate university education on how students learn to take BP and how the

initial achievement of competency of the skill and ongoing competency within the hospital setting occurs. The study showed that the introduction of continuing education programme to update staff on factors that affect accurate BPM impacted positively on practice and equipment. It would appear that ongoing education and assessment is required to maintain the health professional's ability to conduct an accurate BPM and embed the evidence into clinical practice.

Measurement of blood pressure is a key tool in the diagnosis of hypertension in pregnancy. Readings are required for ongoing assessment and surveillance of maternal and fetal wellbeing and used to base decisions regarding what treatment if any is appropriate. If antihypertensive therapy is commenced then measurements are used to determine the effectiveness of the drug therapy. If BPM is taken casually with no regard for client, observer or equipment factors that lead to errors of measurement this would not support the measurement obtained being used to identify if a client had hypertension or not. To ensure women to benefit fully from therapeutic interventions and inform decisions about long term cardiovascular risk or alternatively to prevent unnecessary treatment, anxiety or increased perception of disease then BPM must be accurately and appropriately conducted.

The introduction of a BPM education programme within maternity units would enable all staff to update their knowledge and act as a means to highlight the importance of applying theory to BPM practice. In addition

it would raise awareness that competency in a basic skill should not be taken for granted. Combined with implementation of the recommendations discussed above could help to ensure accuracy of BPM are not being compromised by equipment or failure of staff to apply theory to practice through lack of knowledge.

In conclusion by answering the research questions the aim of the study was achieved, equipment, practice and impact of continuing education in regards to BPM in maternity settings has been evaluated. Overall the study has added information to the previous limited body of knowledge. Following the findings of this study it would be advisable for other staff from other U.K. maternity units to conduct assessments of their BPM equipment and staff practice of BPM to determine if the women receiving maternity care are not being comprised by clinically significant errors being introduced into BPMs. If a risk is identified then appropriate actions could be implemented. As the factors that impact upon accuracy are well documented as is the methodology that should be used to obtain an accurate measurement it should not be difficult for the health professional to minimise common errors if they are updated and be aware of the importance of applying theory to BPM practice.

Compared to other clinical procedures BPM is on the surface quite a simple basic skill. The difficulty appears to be in health professionals taking for granted competency or a failure to appreciate their actions, omissions or arbitrary clinical practice of BPM will impact upon

accurate measurement. The best person to undertake a BPM is one who is up to date on the sources of inaccuracies due to equipment, observer technique or client. In addition they will have the ability to teach others and facilitate them to achieve competency in this basic but vital skill.

REFERENCE LIST

Abalos, E., Duley, L., Steyn, D., Henderson-Smart, D. (2007) Antihypertensive drug therapy for mild to moderate hypertension during pregnancy. *Cochrane Database Syst Rev* CD002252

ACOG, (2002) American College Obstetricians and Gynaecologists Diagnosis and Management of Preeclampsia and Eclampsia. *ACOG* Practice Bulletin 33*,* Obstet Gynecol; 183:S1-22

AHA, (1993) American Heart Association Human Blood pressure determination by sphygmomanometry *Circulation* 88 Supplementation Pt 1 2460-70

AHA, (2001) American Heart Association Human Blood pressure determination by sphygmomanometry Writing group American Heart Association http://circ.ahajournals.org

AHA, (2005) American Heart Association Scientific statement Recommendations for Blood pressure measurement in Humans and experimental animals Part 1 Blood pressure measurement in humans *Hypertension* 45: 142-161

Ahmed, M. (1997) Knowledge of Blood Pressure Measurement among a Teaching hospital staff in a developing nation. *Journal of Human Hypertension* 11: 495-499

Alderman, C. (2002) Pressure Point *Nursing Standard* 16(35):16-17

Ali, S., Rouse, A. (2002) Practice Audits: reliability of sphygmomanometers and blood pressure recording bias *Journal of Human Hypertension* 16 (5): 359-361

Ananth, C., Savitz, D., Bowes, W. (1995). Hypertensive disorders of pregnancy and stillbirth in North Carolina, 1988-1991. *Acta Obstetricia et Gynecologica Scandinavica* 74:788–93.

Anthony, J. (1992) Improving antenatal care: the role of an antenatal assessment unit. *Health Trends* 24 (4):123–5.

Anumba, D., Lincoln, K., Robson, S. (2009) Predictive value of clinical and laboratory indices at first assessment in women referred with suspected gestational hypertension, *Hypertension in pregnancy* 1 -17 (may)

ANSI/AAMI (2002) see Association for Advancement of Medical Instruments

APEC - Action on Pre-eclampsia group, (2009) http://www.apec.org.uk/

Armstrong, R. (2002) Nurses knowledge of error in blood pressure measurement technique *International Journal of Nursing Practice* 8: 118-126

Ashworth, M., Gordon, K., Baker, G., Deshmukh, A. (2001) Sphygmomanometer calibration: a survey of one inner-city primary care group *Journal of Human Hypertension* 15: 259-262

Association for the Advancement of Medical Instrumentation, (1993) A*merican National standard electronic or automated sphygmomanometers* Arlington, VA: AAMI

Association for the Advancement of Medical Instrumentation, (2002) Manual, electronic or automated sphygmomanometers, Arlington Virginia USA *Association for the advancement of Medical Instrumentation,* American National Standard ANSI/AAMI SP10

Atkins N., O'Brien, E., Wesseling, K., Guelen, I. (1997) Increasing observer objectivity with audio-visual techniques the sphymocorder *Blood Pressure Monitoring,* 2, 269-272.

Attree, M. (2006). Evaluating healthcare education: issues and methods. *Nurse education in practice*, *6*(6), 332-338.

Aylett, M. (1999) Pressure for change: unresolved issues in blood pressure measurement *British Journal of General Practice* 49: 136-139

Backer, T. (1991) Knowledge Utilization The Third Wave *Science Communication* 12 (3) 225-240

Badger, T., Rawstorne D. (1998) An evaluative study of pre-registration nursing student's skills in basic life support *Nurse Education today* 18 231-236

Bailey, R., Knaus, V., Bauer, J. (1991) Aneroid sphygmomanometers: An assessment of accuracy at a university hospital and clinics. *Arch Int Med* 151: 1409-1412

Bailey, R., Bauer, J. (1993) A review of common errors in the indirect measurement of BP. *Arch of Int Med.* 153: 2741-2748.

Baillie, L., Curzio, J. (2009). Students' and facilitators' perceptions of simulation in practice learning. *Nurse Education in Practice*, *9*(5), 297-306.

Baker, R., Camosso-Stefinovic, J., Gillies, C., Shaw, E., Cheater, F., Flottorp, S., Robertson, N. (2010) Tailored interventions to overcome identified barriers to change: effects on professional practice and health care outcomes. *Cochrane Database of Systematic Reviews*

Issue 3. Art. No.: CD005470. DOI:0.1002/14651858.CD005470.pub2.

Barker, P. (1996) In *The Research Process in Nursing (3rded), edited by* Cormack, D. Blackwell Science, Oxford.
Bartelt, T., Ziebert, C., Sawin, K., Malin, S., Nugent, M., Simpson, P. (2011) Evidence-Based Practice: Perceptions, skills and activities of Pediatric Health Care Professionals *Journal of Pediatric Nursing 26:114-121*

Bateman-Webb, T. (2006) How do clinicians assess and respond to raised blood pressure in pregnancy. *British Journal Midwifery* 14 (1) 33-38

Baxter L., Hughes. C., Tight M. (2001) *How to Research,* Open University Press, Philadelphia.

Beevers, G., Lip, G., O'Brien, E. (2001) Blood pressure measurement Part 1 Sphygmomanometry: factors common to all techniques *British Medical Journal* 322: 981-985

Becker, M. (1970) Factors affecting diffusion of innovations among health professionals *American Journal Public .Health* 60; 2, pp294-304

Bellamy, L., Casas, J., Hingorani, A ., Williams, D. (2007) Pre-eclmapsia and risk of cardiovascular disease and cancer in later life: systematic review and metaalysis *British Medical Journal* 335 (7627) 974

Bergel,E., Carroli, G., Althabe, F. (2002) Ambulatory versus conventional methods for monitoring blood pressure during pregnancy. *Cochrane Database of Systematic Reviews*, Issue 2. Art.No.: CD001231. DOI: 10.1002/14651858.CD001231.

Bhalla, A., Singh, R., D'Cruz, S., Lehl ,S., Sachdev, A. (2005) Accurate blood pressure recording is it difficult? *Indian Journal Med SCi,* 59, 480-487

BHS, (1990) British Hypertensive Society Blood pressure measurement video recording. *BMJ* London

BHS, (1997) O'Brien, E., Petrie, J., Littler, W. *Blood pressure measurement Recommendations of the British Hypertensive Society* (3rd Edition) *British Medical Journal* London

BHS, (2004), Williams, B., Poulter, N., Brown, M., Davies, M., McInnes, G., Potter, J., Sever, P., Thom, S. Guidelines for management of hypertension: Report on the fourth working party of the British Hypertensive Society BHS IV. *Journal of Human Hypertension* 18: 139-185

BHS, (2009) British Hypertensive Society
http://www.bhsoc.org/default.stm

BHS, (2010) British Hypertensive Society
http://www.bhsoc.org/default.stm

BHS (2012) Blood pressure monitors validated for clinical use
http://www.bhsoc.org//index.php?cID=247

Bird, A., Wallis, M. (2002) Nursing knowledge and assessment skills in the management of patients receiving analgesia via epidural infusion *Journal advanced nursing* 40 (5) 522-531

Birth Choices. (2006) http://www.birthchoiceuk.com/

Blackburn, S., Loper, L. (1992) *Maternal and Neonatal Physiology: A clinical perspective* Saunders St Louis

Bloom, B. (2005) Effects of continuing medical education on improving physician clinical care and patient health: a review of systematic reviews. *International Journal of Technology Assessment in Health Care*; **21**:380–5.

Bogan, B. (1993) Nursing student compliance to standards for blood pressure measurement *Journal of Nursing Education,* 32: 90-92.

Bond, S. (1996) In *The Research Process in Nursing*, Cormack. D (Ed) Blackwell Science, Oxford.

Bordage, G., Carlin, B., Mazmanian, P. (2009) Continuing Medical Education Effect on Physician Knowledge: Effectiveness of Continuing Medical Education: American College of Chest Physicians Evidence-Based Educational Guidelines *Chest* 135 29S-36S
http://chestjournal.chestpubs.org/content/135/3_suppl/29S.full.html

Bowling, A. (2002) *Research methods in Healt*h (2nd edition) Open University Press Maidenhead

Bowman, C. (1981) Blood pressure errors with aneroid sphygmomanometers *Lancet* 1:1005

Boyd, R., Myers, J.(1998) Transformative education. *International Journal of Lifelong Education, 7(4)*, 261-284.

Bramley, P. (2003) *Evaluating Training from personal insight to organisational performance (2nd edition),* Chartered Institute of Personnel and Development, London.

Brennan, M. (2004) A test of two procedures for increasing responses to mail surveys *Marketing Bulleting* 15 research note 3 1-9

British Standard (1996) *BS EN 1060-1: 1 Specification for Non-Invasive Sphygmomanometers. General Requirements.* 15-6-1996
British Standard (2004) 1060-4: Non-invasive sphygmomanometers – Test procedures to determine the overall system accuracy of automated non-invasive sphygmomanometers. Available from BSI *www.bsonline.bsi-global.com*

Brookfield, S. (1986) *Understanding and facilitating adult learning,* Open University Press, Milton Keynes.

Brown, M., Simpson, J. (1992) Diversity of blood pressure recording during pregnancy: implications for the hypertensive disorders *Medical Journal of Australia* 156:306-308

Brown, M., de Sweit, M. (1999) Classification of Hypertension in Pregnancy Ballieres *Clinical Best Practice Obstetrics Gynaecology* 13(1) 713-726

Brown, M., Lindheimer, M., De Swiet, M., Van Assche, A., ,Moutquin, J. (2001) The classification and diagnosis of the hypertensive disorders of pregnancy: statement from the international society for the study of hypertension in pregnancy (ISSHP) *Hypertension in Pregnancy* 20(1):ix–xiv.

Brownhill, B. (2002) “The Socratic Method” in Jarvis, P (2002) (Ed) *The theory and Practice of Teaching* London:Kogan Page. pp 70-78

Bruce, N., Shaper, A., Walker, M., Wannamethee, G. (1988) Observer bias in blood pressure studies *Journal of Hypertension,* 6 (5) 375-380.

Burgess, S., MacLaughlin, E., Smith, P., Arch, A., Salcido, A., Benton, J. (2011) Blood pressure rising: differences between current clinical and recommended measurement techniques *Journal of American Society of Hypertension* 5 (6) 484-488

Burke, M., Towers, H., O’Malley, K., Fitzgerald, D., O’Brien, E. (1982) Sphygmomanometers in hospital and family practice: problems and recommendations. *British Medical Journal* 285: 409-411

Burns, N., Grove, S. (1997) *The Practice of Nursing Research,* W.B. Saunders Company, Philadelphia.

Burton, J. (2000) Oscillometric blood pressure monitors *Br J Perioperative Nursing* 10(12):624-6

Campbell, N., McKay, D., Chockalingam, A., Foder, G. (1994a) Errors in assessment of blood pressure: Patient factors *Canadian Journal of Public Health* 85 Supplement 2 S12- S17

Campbell, N., McKay, D., Chockalingam, A., Foder, G. (1994b) Errors in assessment of blood pressure: Blood pressure measuring technique *Canadian Journal of Public Health* 85 Supplement 2 S19- S21

Campbell, N., McKay, D. (1999) Accurate blood pressure measurement; Why does it matter? *Canadian Medical Association* 161 (3) 277-278

Canzanello, V., Jenson, P., Schwartz, G. (2001) Are aneroid sphygmomanometers accurate in hospital and clinic settings *Archives of Internal Medicine* 161 (5) 729 - 731

Carney, S., Gillies, A., Green, S., Paterson, O., Taylor, M., Smith, A. (1999) Hospital blood pressure measurement: Staff and device assessment *J Qual Clin.Practice* 19 95-98

CEMACH (2009) *Confidential enquiry in maternal and child health perinatal mortality UK*. CEMACH: London

CEMACE (2010a) *Management of women with obesity in pregnancy CMACE and RCOG Joint guideline*. CMACE: RCOG :London

CEMACE (2010b) *Maternal Obesity in the UK: Findings from a national project:* CMACE London:

CEMACE (2011) Centre for Maternal and Child Enquires (CMACE). *Saving Mother's Lives: reviewing maternal deaths to make motherhood safer: 2006-2008*. The Eighth Report on Confidential Enquires into Maternal Deaths in the United Kingdom. BJOG 118 (Suppl 1) 1-203.

CESDI (1999) 6th Annual Report Confidential enquiries into Stillbirth and deaths in infancy *Maternal and Child Health Research Consortium*

CESDI (2000) 7th Annual Report Confidential enquiries into Stillbirth and deaths in infancy *Maternal and Child Health Research Consortium*

Chappell, L., Poulton, L., Halligan, A., Shennan, A. (1999) Lack of consistency in research papers over the definition of pre-eclampsia *British Journal of Obstetrics and Gynaecology,* 106, 983-985.
Chipchase, L., Johnston, V., Long, P. (2012) Continuing professional development: The missing link *Manual Therapy 17 89 -91*

Clifford, C. (1997) *Nursing and Health Care Research,* Prentice Hall, London.

Cluett, E., Bluff. R. (Ed.) (2000) *Principles and Practice of Research in Midwifery,* Bailliere Tindall, Edinburgh.

Coleman, J., Katz, E., Menzel, H. (1957) The Diffusion of an Innovation among Physicians *Sociometry* 20 (4) 253-270

Coomarasamy, A., Khan, K. (2004) Learning in practice *British Medical Journal* 329 pp1-5

Conceicao, S., Ward, M., Kerr, D. (1976) Defects in sphygmomanometers: an important source of error in blood pressure recording *British Medical Journal* 1 886 -888

Cook, J., Dickinson, H., Eccles, M. (2009) Response rates in postal Surveys of healthcare professionals between 1996 and 2005: An observational study. BMC Health Services Research 9:160 *http://www.biomecentral.com/1472_6963/9/160*

Cormack, D. (Ed.) (1996) *The research process in nursing,* Blackwell Science, Edinburgh.

Curb, J., Labarthe, D., Cooper, S., Cutter, G., Hawkins, C. (1983) Training and Certification of blood pressure observers. *Hypertension* 5 (4) 610-614

Curzon, L. (1997) *Teaching in further education an outline of principles and practice* (5th edition) Cassell: Gt Britain

Crafter, H., Garland, D (2011) NICE clinical guidelines Hypertension in Pregnancy –the role and responsibilities of midwives MIDIRS Midwifery Digest 21:2. 177-182

Dabl Educational Trust (2011) http://www.dableducational.org/accuracy criteria.html

Dane, F. (1990) *Research Methods,*Brooks/Cole Publishing Company, California.

Davies, A., Caczkes, J., Sardorsky, E., Prywes, R., Weiskopf, P., Sterk, W. (1970) Toxameia of pregnancy in Jerusalem Epidemiological study of an Israel community. *Isr J Med Sci* 6 253-266

Davis, D., O'Brien, M., Freemantle, N.,Wolf, F., Mazmanian, P., Taylor-Vaisey, A. (1999) Impact of formal continuing medical education: do conferences, workshops, rounds, and other traditional continuing education activities change physician behavior or health care outcomes?.*JAMA* **282**:867–74

Davis, D., Evans, M., Jadad, A., Perrier, L., Rath, D., Ryan, D., Sibbald, G., Straus, S., Rappolt, S., Wowk, M., Zwarenstein, M. (2003) Learning in practice The case for knowledge translation: shortening the journey from evidence to effect. *BMJ* 327:33-35

Davis D, Galbraith, R. (2009) Continuing medical education effect on practice performance: effectiveness of continuing medical education: American College of Chest Physicians Evidence-Based Educational Guidelines*. Chest* 135 (3 Suppl):42S-48S.

Dawson, L., Parfrey, P., Hefferton, D., Dicks, E., Cooper, J., Young, D., Marsden, P. (2002) Familial risk of preeclampsia in Newfoundland: a population-based study. *Journal of the American Society of Nephrology* 13:(7)1901-6.

de Greeff, A., Lorde, I., Wilton, A., Seed, P., Coleman, A., Shennan, A. (2010). Calibration accuracy of hospital-based non-invasive blood pressure measuring devices. *Journal of human hypertension*, *24*(1), 58-63.

Denzin, N. (1970) *The Research Act in Sociology, A Theoretical Introduction to Sociological Methods* Butterworths: London.

DH (2004) Department of Health *Why Mothers Die. The sixth report on confidential enquiries into maternal deaths in the United Kingdom2000-2002*. London: RCOG Press, 2001

DH (2006) Forecasting Obestiy to 2010 National Centre for Social Research Department of Epidemiology and Public Health at the Royal Free and University College Medical School available at http://www.dh.gov.uk/prod_consum_dh/groups/dh_digitalassets/documents/digitalasset/dh_073033.pdf

DH (2010) Confirmation of Payment by Results arrangements for 2010-11 available at *http://www.dh.gov.uk/en/Publicationsandstatistics/Publications/PublicationsPolicyAndGuidance/DH-112284_*

DH (2012) Department of Health Maternity Services Pathway Payment System A Simple Guide 2012/13 Gateway Reference 17184, *http://www.dh.gov.uk/health/2012/02/maternity-pathway-payment-system/*

DOH (1998) *Why Mothers Die*. Report on Confidential Enquiries into Maternal Deaths in the United Kingdom 1994-1996: The Stationary Office Ltd Norwich.

Dootson, S. 1995 An in-depth study of triangulation *Journal of Advanced Nursing* 22 183-187

Douglas, K., Redman, C. (1994) Eclampsia in the United Kingdom *British Medical Journal* 309 1395-1399

Doyle, J. (2004) Handbook for IQP Advisors and Students *Chapter 10: Introduction to Survey Methodology and Design* Global Perspective Program Worcester Polytechnic Institute

Drife, J., Lewis, G. (2001). Why Mothers Die 1997-1999: Fifth Report of the Confidential Enquiries into Maternal Deaths in the United Kingdom. *London: Royal College of Obstetricians and Gynaecologists*.

Duckitt, K., Harrington, D. (2005) Risk factors for pre-eclampsia at antenatal booking: systematic review of controlled studies *British Medical Journal* 330 565-572

Duggan, M., Miller, J.1998) Blood Pressure Measurement in Pregnancy: A survey of methods used in teaching hospitals in South Australia. *Australian New Zealand Journal of Obstetrics and Gynaecology.* 38: (2), 197 –199

Duggan, P. (1997) Interobserver agreement for indirect Blood pressure measurement in pregnancy. In *Proceedings of the Australasian Society for the Study of Hypertension in Pregnancy Annual Scientific Meeting* Canberra.

Edwards, P., Roberts, I., Clarke, M., DiGuiseppe, C., Pratap, S., Reinhard, W., Kwan I (2002) *British Medical Journal* 324:1-9

Ellis, L., Davies, S., Laker, S. (2000) Attempting to set up a randomised controlled trial. *Nursing Standard* 9th Feb Vol 14:21:32-36

Engels, Y., Verheijen, N., Fleuren, M., Mokkink, H., Grol, R. (2003) The effect of small peer group continuous quality improvement on the clinical practice of midwives in the Netherlands *Midwifery* 19:250-258

European Commission for Standardisation (1995) *European Standard EN1060 -1 (British Standard BSSEN 1060-1:1996) Specification for Non-Invasive sphygmomanometers Part 1. General Requirements.* European Commission for Standardisation

ESH European Society of Hypertension (2003) recommendations for conventional ambulatory and home blood pressure measurement *Journal of Hypertension* 21: 821-848

Farmer, A., Légaré, F., Turcot, L., Grimshaw, J., Harvey, E., McGowan, J., Wolf, F. (2011) Printed educational materials: effects on professional practice and health care outcomes (Review) *Cochrane Database of Systematic Reviews* 2008, Issue 3. Art. No.: CD004398. DOI:10.1002/14651858.CD004398.pub2.

Feher, M., Harris ST-John, K., Lant, A. (1992) Blood pressure measurement by junior hospital doctors – a gap in medical education? *Health Trends*. 4: 59-61

Fink, A (1995) *The survey handbook* Thousand Oak CA sage

Finn, A., Gendall, P., Hoek, J. (2004) Two attempts to increase the response to a mail survey *Marketing Bulletin 15* research note 1 1-5

Fisher, H. (1978) The aneroid sphygmomanometer: an assessment of accuracy *Med Cardiovas*3:769-771

Flodgren, G., Parmelli, E., Doumit, G., Gattellari, M., O'Brien, M., Grimshaw. J., Eccles, M. (2011) Local opinion leaders: effects on professional practice and health care outcomes *Cochrane Database of Systematic Reviews* 2011, Issue 8. Art. No:CD000125. DOI:10.1002/14651858.CD000125.pub4

Forsetlund, L., Bjørndal, A., Rashidian, A., Jamtvedt, G., O'Brien, MA., Wolf ,F., Davis, D., Odgaard-Jensen, J., Oxman, AD. (2009) Continuing education meetings and workshops: effects on professional practice and health care outcomes *Cochrane Database of Systematic Reviews* 2009, Issue 2. Art. No.: CD003030. DOI: 10.1002/14651858.CD003030.pub2.

Fox, R., Clarke, C., Dacre, J. (2000) A study of pre-registration house officers clinical skills *Medical Education* 34: 1007 -1012

Franx, A., Vander Post, J., Van Montfrans, G., Bruinse, H. (1997) Comparison of an auscultatory versus an oscillometric ambulatory blood pressure monitor in normotensive, hypertensive and pre-eclampsia pregnancies. *Hypertension in Pregnancy* 6: 187-202

Freemantle N, Harvey E., Wolf, F, Grimshaw, J., Grilli, R., Bero, L. (1997) Printed educational materials: effects on professional practice and health care outcomes. *Cochrane Database of Systematic Reviews* Issue 2. [DOI: 10.1002/14651858.CD000172

Fry, H., Ketteridge, S., Marshall, S. (2003) (Eds). *A handbook of Teaching and Learning in Higher Education. Enhancing Academic Practice* 2nd Edition, London: Kogan Page

Geddes, L. (1991) *Handbook of Blood pressure measurement* Humana Press New Jersey

Gerin, W., Schwartz, A., Schwartz, J. (2002): Limitations of current validation protocols for home blood pressure monitors for individual patients. *Blood Press Monit*, 7:313-318.

Gibson, P., Carson, M. (2009) Hypertension in Pregnancy eMedicine Obstetrics & Gynaecology http://www.medscape.com/article/261435 accessed 30.10.09

Gillespie, A., Curzio, J. (1998) Blood pressure measurement: Assessing staff knowledge. *Nursing Standard.* 12 (23): 35-37

GMC (2006) *Good Medical Practice Guidance for Doctors* GMC London

GMC (2009a) Online Guidance on continuing professional development http://www.gmc-uk.org/

GMC (2009b) Tomorrow's Doctors http://www.gmc-uk.org/education/undergraduate/8889.asp

Graves, J., Bailey, K., Sheps, S. (2003). The changing distribution of arm circumferences in NHANES III and NHANES 2000 and its impact on the utility of the 'standard adult' blood pressure cuff *Blood Pressure Monitoring:* 8 (6):223-227

Gray, D. (2004) *Doing research in the Real World,* Sage London.

Greer, I. (2005) Pre-eclampsia matters *British Medical Journal* 330:549-550

Griscti, O., Jacono, J. (2006). Effectiveness of continuing education programmes in nursing: literature review. *Journal of Advanced Nursing*, *55*(4), 449-456.

Giguère. A., Légaré, F., Grimshaw, J., Turcotte, S., Fiander, M., Grudniewicz, A., Makosso-Kallyth, S.,Wolf, F., Farmer, A., Gagnon, M. (2012) Printed educational materials: effects on professional practice and healthcare outcomes. *Cochrane Database of Systematic Reviews* Issue 10. Art. No.: CD004398.
DOI: 10.1002/14651858.CD004398.pub3.

Grim, C., Grim, C. (1995) A curriculum for the training and certification of blood pressure measurement for health care providers *Can J Card* 11 Suppl H 38H -42H

Grim, C. (2002) *Human accuracy of Blood Pressure measurement with nonelectronic and electronic devices*. National High Blood pressure education program, National Heart, Lung and Blood Institute and American Heart Association Working meeting on Blood pressure measurement Bethesda Maryland
Grimshaw, J., Thomas, R.,, MacLennan, G., Fraser, C., Ramsay, C., Vale, L., Whitty, p., Eccles, M., Matowe, L., Shirran, L., Wensing, M., Dijkstra, R., Donaldson, C. (2004) Effectiveness and efficiency of

guideline dissemination and implementation strategies. *Health Technology Assessment*; *8* (6):iii-iv, 1-72.

Grol, R. (1997) Beliefs and evidence in changing clinical care. *BMJ* 315:418-421.

Grol, R. (2002) Changing physicians' competence and performance: finding the balance between the individual and the organisation. *J Contin Educ Health Prof* 22(4):244- 251.

Guidotti, R., Jobson D., (2005) Safe Motherhood Pre-eclampsia: *A practical guide WHO Geneva*

Gupta, M., Shennan, A., Halligan, A., Taylor, D., De Sweit, M. (1997) Accuracy of oscillometric Blood pressure measurement in pregnancy and pre-eclampsia *BJOG* 104 (3) 350-355

Harlow, F., Brown, M. (2001) The diversity of diagnoses of preeclampsia *Hypertension in pregnancy,* 20,(1) 57-67.

Health Care Commission (2008) Maternity Review Towards a better birth A review of maternity services in England *Health Care Audit and Inspection*
http://www.cqc.org.uk/_db/_documents/Towards_better_births_200807221338.pdf

Health Foundation 2012 Quality improvement training for healthcare professionals *The Health Foundation Inspiring Improvement* Evidence Centre
http://www.health.org.uk/public/cms/75/76/313/3731/Qualityimprovementtraininforhealthcareprofessionals.pdf

Health and Safety Executive (HSE) Control of Substances Hazardous to Health in 1988.

Hernandez-Diaz, S., Toh, S., Cnattingius, S. (2009) Risk of pre-eclampsia in first and subsequent 27 pregnancies: prospective cohort study. *British Medical Journal* 338:(18) b2255

Heslehurst, N., Ells, L., Simpson, H., Batterham, A., Wilkinson, J., Summerbell, C. (2007) Trends in maternal obesity incidence rates, demographic predictors, and health inequalities in 36,821 women over a 15-year period. *BJOG: An International Journal of Obstetrics and Gynaecology* 114(2):187-94

Hockey, L. (1991) The nature and purpose of research IN Cormmack D ed *The research process in nursing* (2nd edition) Blackwell science London
Hospital Episode Statistics (2009) www.hesonline.nhs.uk

Hussain, A., Cox, J. (1996) An audit of the use of sphygmomanometers *British Journal of Clinical Practice* 50, 136-137.

Ivers, N., Jamtvedt, G., Flottorp, S., Young, J., Odgaard-Jensen, J., French, S., O'Brien, M.,Johansen, M., Grimshaw, J., Oxman, A. (2012) Audit and feedback: effects on professional practice and healthcare outcomes. *Cochrane Database of Systematic Reviews* Issue 6
Art. No.: CD000259. DOI: 10.1002/14651858.CD000259.pub3.

Jacobs, D., Vreeburg, S., Dekker, G., Heard, A., Priest, K., Chan, A. (2003) Risk factors for hypertension during pregnancy in South Australia. *Australian and New Zealand Journal of Obstetrics and Gynaecology* 43: (6) 421-8. 24

James, P., Nelson-Piercy, C. (2004) Management of hypertension Before, during, and after pregnancy. *Heart* 90:1499–1504. doi: 10.1136/hrt.2004.035444

Janesick, V., (1994). The Dance of Qualitative Research Design: Metaphor, Methodolatry, and Meaning Pp. 209-219 in *Handbook of Qualitative Research.* Norman K. Denzin and Yvonna S. Lincoln (Eds.). Thousand Oaks, CA: Sage.

Jansen, J., Tan, L., van der Vleuten, C., van Luijk, S., Rethans, J., Grol, R. (1995) Assessment of competence in technical clinical skills of general practitioners *Medical Education* 29:247-253

Jick,T. (1979) Mixing Qualitative and Quantitative Methods: Triangulation in Action *Administrative Science Quarterly* 24 (4) 602-611

Johnson, B. (2001) Toward a new classification of nonexperimental quantitative research *Educational Researcher* 30:2:3-13

Johnson, R., Taylor, W. (2000) *Skills for midwifery practice* Churchill Livingston Edinburgh

Jones, J., Ramsey, W., Hetrick, T. (1987) Accuracy of pre-hospital sphygmomanometers *J Emerg Med* 5 23-27

Jones, D., Appel, L., Sheps, S., Roccella, E., Lerfant, C. (2003) Measuring Blood pressure accuracy new and persistent challenges *JAMA* 289 (8) 1027

Jones B., Higginson, R., Santos, A. (2010) Critical Care: assessing blood pressure, circulation and intravascular volume *British Journal of Nursing* 19 (3) 153-159

Jordan, S. (2000). Educational input and patient outcomes: exploring the gap. *Journal of Advanced Nursing*, *31*(2), 461-471.

Katz, V., Farmer, R., Kuller, J. (2000) Pre-eclampsia into eclampsia ; toward a new paradigm *American Journal of Obstetrics and Gynecology,* 182, 1389-96.

Kay, L. (1998), Accuracy of blood pressure measurement in the Family practice centre *J AM B Fam Prac* 11,(4) 252-258.

Kelly, M. (1982) Maternal positions and blood pressure during pregnancy and delivery *American journal of Nursing* 809-812

Kemper, K., Kynvi, A., Dvorkin, L., Whelan, J., Woolf, A., Samuels, R., Hibberd, P. (2003) Herbs and other dietary supplements: Healthcare professionals' knowledge, attitudes and practices *Alternative Therapies* 9 (3) 42-49

Kemp, F., Foster, C., Mckinlay, S. (1994) How effective is training for blood pressure measurement? *Professional Nurse* 9 (8) 521- 522

Kennedy, S., Curzio, J. (1996) Blood pressure points *Practice Nurse* 11(1) 27

Kho, C., Brown, M., Ong, S., Mangos, G. (2009) *Blood pressure measurement in pregnancy: the effect of arm circumference and sphygmomanometer cuff size* Obstetric Medicine 2:116-120

Kirkpatrick, D., Kirkpatrick J. (2006) (3rd Edition) *Evaluating Training Programs: The Four Levels* USA Berrett-Koehler

Knight, M. (2007) Eclampsia in the UK 2005 *BJOG* 114(9) 1072-1078

Knight, T., Leech, F., Jones, A., Walker, L., Wickramainghe, R., Angris, S., Rolfe, P. (2001) Sphygmomanometers in use in general practice: an overlooked aspect of quality in patient care *Journal of Hypertension* 15(10) 681 684

Knowles M (1980) *The modern practice of adult education: From pedagogy to andragogy* Chicago Association Press

Lanford, N., Ferner, R. (1999) Toxicity of Mercury *Journal of Human Hypertension* 13 651-656

Lawler, J., Osman, M., Shelton, J.,Yeh, J. (2007) Population-based analysis of hypertensive disorders in pregnancy. *Hypertension in Pregnancy* 26:(1) 67-76.

Le Paileur, C., Helft, G., Landais, P., Montegermont, P., Feder, J., Metzger, J., Vacheron, A. (1998) The effect of talking, reading and

silence on the “white coat” phenomenon in hypertensive patients *AM Journal Hypertension* 11, 203-7

Lee, W., O'Connell, C., Baskett, T. (2004) Maternal and perinatal outcomes of eclampsia: Nova Scotia, 1981-2000. *Journal of Obstetrics and Gynaecology Canada: JOGC* 26:(2)119-23.

Leininger, M. (Ed.).(1985) *Qualitative research methods in nursing*. Saunders.

Lewis, G. (ed) (2007) *The Confidential Enquiry into Maternal and Child Health* (CEMACH) Saving mothers lives: reviewing maternal deaths to make motherhood safer 2003 – 2005 The Seventh report on Confidential Enquiries into Maternal Deaths in the United Kingdom: CEMACH: London

Lindheimer, M., Taler, S., Cunningham, G. (2009) ASH Position Paper: Hypertension in pregnancy: *Journal Clinical Hypertension:*11:214-225

Lloyd, JS., Abrahamson, S. (1979) Effectiveness of continuing medical education:a review of the evidence. *Evaluation & the Health Professions*; **2**:251–80

Lowe, S., Brown, M., Dekker, G., Gatt, S., Mclintock, C., McMahon, L., Mangos, G., Moore, M., Muller, p., Paech, M., Walters, B. (2009) Guidelines for the management of hypertensive disorders of pregnancy 2008: *Australian and New Zealand Journal of Obsetrics and Gyanecology; 49:242-246*

Lyriboz., Y., Hearon, C., Edwards, K.,. (1994) Agreement between large and small cuff in sphygmomanometry: a quantitative assessment *Journal of Clinical Monitoring,* 10, 127-133.

Mansfield B., Mitchell, L. (1996) *Towards a Competent Workforce*. Gower, Aldershot, Hants.

Manpower Services Commission (1988) Definition of Competence and Performance Criteria. *The Development of Assessable Standards for National Certification. Series Guidance* Note 3.HMSO, London.

Markandu, N., Whitcher, R., Arnold, A., Carney, C. (2000) The mercury sphygmomanometer should be abandoned before it is proscribed. *Journal of Human Hypertension* 14 31-36

Maskrey N., Parker, C., Powell, S. (1998) *THINYCE – Treating Hypertension Through Clinical Effectiveness in North Yorkshire*, North Yorkshire Clinical Advisory Service: North Yorkshire Health Authority.

Maternal and Child Health Research Consortium (1999) *Confidential enquiry into stillbirths and deaths in infancy: 6th annual report, 1 January-31 December 1997*. London: Maternal and Child Health Research Consortium.

McAlister, F., Strauss, S. (2001) Measurement of Blood Pressure an evidenced based review *British Medical Journal* 322 908 -911

McCowan, L., Buist, R., North, R., Gamble, G. (1996) Perinatal morbidity in chronic hypertension *BJOG* 103 123-9

McKay, D., Campbell, N., Parab, L., Chockalingam, A., Foder, J (1990) Clinical assessment of blood pressure *Journal of Human Hypertension,* 4, 639-45

McMullan, M., Endacott, R., Gray, M., Jasper, M., Miller, C., Scholes, J., Webb, C. (2003) Portfolios and assessment of competence: a review of the literature. *Journal of Advanced Nursing* 41:3 283–294.

McVicker, J. (2001) Blood pressure measurement – Does anyone do it right?: An assessment of the reliability of equipment in use and the measurement techniques of clinicians *The Journal of Family Planning and Reproductive Health Care* Vol 27:3:163-164

MDA Medical Device Agency (2000) *Device Bulletin Blood pressure measurement devices mercury and non mercury* (DB2000(03)) London

Mee, F., Atkins, N., O'Brien, E. (1994) Problems associated with observer training in blood pressure measurement *Journal of Human Hypertension* , 8: 293.

Meert, R. (2000) Causes and control of inaccurate blood pressure measurement. *Dispatch of the American Society of Hypertension*. www.docguide.com

Meher ,S., Duley, L. (2005) Prevention of Pre-eclampsia Cochrane Review Authors. Interventions for preventing pre-eclampsia and its consequences: generic protocol. *Cochrane Database of Systematic Reviews*, Issue 2. Art. No.: CD005301. DOI: 10.1002/14651858.CD005301

Merriam, S., Caffarella, R., & Baumgartner, L. (2007). Learning in adulthood (3rd ed.). San Francisco: John Wiley & Sons. (Original work published 1991)

Mezirow, J. (2000). *Learning as transformation: Critical perspectives on a theory in progress*. San Francisco: Jossey-Bass.

MHRA (2001) *Medicines and Healthcare products Regulatory Agency Devices in Practice: a guide for professionals in health and social care*
MHRA (2005a) *Medicines and Healthcare products Regulatory Agency* Report of the Independent Advisory Group on Blood pressure Monitoring in Clinical Practice

MHRA (2005b) Medicines and Healthcare products Regulatory Agency *Medical Device Alert* Ref MDA/2005/069

MHRA (2006) Medicines and Healthcare products Regulatory Agency *Device Bulletin BPM Devices* DB2006 (03)

MHRA (2006b) Medicines and Healthcare products Regulatory Agency *Medical Device Alert Blood pressure monitors and Sphygmomanometers* Issued: 13 July 2006 at 11:00 Ref: MDA/2006/037

MHRA (2008) Medicines and Healthcare products Regulatory Agency *Devices in Practice: a guide for professionals in health and social care* MHRA http://www.mhra.gov.uk/home/groups/dtsbs/documents/publication/con007424.pdf (web version 2011)

MHRA (2013) Medicines and Healthcare Products Regulatory Agency Blood pressure measurement devices MHRA http://www.mhra.gov.uk/home/groups/dtsac/documents/publication/con2024250.pdf

Miller, G. (1990) The assessment of clinical skills/competence/ performance *Acad Med* 65:S63-S67

Mitchell, E. (1986) Multiple triangulation a methodology for nursing science *Advances in Nursing Science* 8 (3) 18-26

Moon, J. (1999) *Reflection in Learning & Professional Development* New York: Kogan Page

Mourad, A., Carney, S., Gillies, A., Jones, B., Nanra, R., Trevillian, P. (2003) Arm position and blood pressure: a risk factor for hypertension *Journal of Human Hypertension* 6: 389-95
.
Nagarjan, N., Vanheukelen, M. (1997) *Evaluating EU Expenditure Programmes*: A Guide, Ex post and Intermediate evaluation European Commission pp 92,94,103

Naqv,i N., Blaufox, M. (1998) *Blood pressure measurement*: An Illustrated History New York Parthenon

NHBPEP, NHLBI, AHA (2002) Working meeting on Blood pressure measurement summary report
http://www.nhlbi.nih.gov/guidelines/index

NHLBI (2003) The seventh report of the joint National Committee on Prevention, detection, evaluation and treatment of high blood pressure National High Blood pressure Education Program National Institutes of Health NHLBI US department of health and human sciences
http://www.nhlbi.nih.gov/guidelines/index.htm

NOO (2012) National Obesity Observatory Trends in obesity prevalence accessed at
http://www.noo.org.uk/NOO_about_obesity/trends

National Obesity Observatory NOO (2010)
http://www.noo.org.uk/NOO_about_obesity/trends accessesd 14.4.2010

NICE, (2003) *Antenatal Care: Routine care for the pregnant woman Clinical Guideline National Collaborating Centre for Women's and Children's Health* London RCOG Press

NICE (2008) *Antenatal care Routine care for the healthy pregnant woman* NICE clinical guideline 62 National Collaborating Centre for Women's and Children's Health: London

NICE (2010) *Hypertension in pregnancy. The management of hypertensive disorders during pregnancy* (revised reprint January 2011) NICE clinical guideline 107 National Collaborating Centre for Women's and Children's Health: London

NICE (2011) Hypertension The clinical management of primary hypertension in adults Clinical Guideline 127 National Clinical Guideline Centre
http://www.nice.org.uk/nicemedia/live/13561/56007/56007.pdf
Netea, R., Smits, P., Lenders, J., Thien, T. (1998) Does it matter whether blood pressure measurements are taken with subjects sitting or supine *Journal of Hypertension* 16 263 268

Nolan, J., Nolan, M. (1993) Can nurses take and accurate blood pressure? *British Journal of Nursing,* 2, 724-729.

Nolan, M., Behi, R. (1995) Triangulation: The best of all worlds *British Journal of Nursing,* 4, (14) 829-832.

NHS (2008) *Purchasing and Supply agency Buyers' guide Hospital grade* non-invasive blood pressure monitors CEP 08018

NHS (2012) Commissioning Maternity Services A Resource Pack to support Clinical Commissioning Groups http://www.commissioningboard.nhs.uk/files/2012/07/comm-maternity-services.pdf

NMC (2001) http://www.nmc-uk.org/Registration/

NMC (2002) Requirements for pre-registration midwifery http://www.nmc-uk.org/Educators/Standards-for-education/programmes.

.

NMC (2004a) Standards of proficiency for pre-registration midwifery education. Nursing and Midwifery Council, London. http://www.nmc-uk.org/Educators/Standards-for-education/

NMC (2004b) Requirements for pre-registration nursing programmes http://www.nmc-uk.org/Educators/Standards-for-education/

NMC (2008a) *The code: Standards of conduct, performance and ethics for nurses and midwives* http://www.nmc-uk.org/Publications/Standards/

NMC (2008b) *The Prep Handbook* http://www.nmcuk.org/Publications/Standards/

NMC 2009 Standards for pre-registration midwifery education http://www.nmc-uk.org/Educators/Standards-for-education/

NMC. 2010 Standards for preregistration nursing education http://www.nmc-uk.org/Educators/Standards-for-education/

O'Brien, E. (1996) Review A century of confusion; which bladder for accurate blood pressure measurement *Journal of human hypertension* 10 565 -572

O'Brien, E., O'Malley, K. (1981) *Blood pressure measurement* Churchill Livingston: New York

O'Brien, E., O'Malley, K., Sheridan, J. (1989) The need for a standardized protocol for validating non-invasive ambulatory blood pressure measuring devices. *Journal of Hypertension* (suppl. 3): S19-S20

O'Brien, E., Mee, F., Tan, S., Atkins, N., O'Malley, K. (1991) Training and assessment of observers for blood pressure measurement in hypertension research. *Journal of Human Hypertension* 5 7-10

O'Brien, E., Petrie, J., Littler, W., de Swiet,, M., Padfield, P., Altman, D., Bland, M., Coates, Atkins, N. (1993) The British Hypertensive

Society Protocol for the evaluation of blood pressure measuring devices *Journal of Human Hypertension* 11 (suppl 2) S43-63

O'Brien, E., Atkins. N. (1994) A comparison of the British Hypertensive Society and Association for the advancement of medical instrumentation protocols for validating blood pressure measuring devices: can the two be reconciled *Journal of hypertension* 12 1089-1094

O'Brien, E., Petrie, J., Littler, W. (1997) Blood pressure measurement *Recommendations of the British Hypertensive Society (3rd Edition)* British Medical Journal London

O'Brien E. (2001) State of the market for devices for blood pressure measurement. *Blood Press Monit*. 6:281–286

O'Brien, E., Beevers, G., Lip, Y. (2001) ABC of Hypertension Blood pressure measurement Part IV- Automated sphygmomanometry: self blood pressure measurement *British Medical Journal* 322 1167-1170

O'Brien, E., Waeber, B., Parati, G., Stassen, J., Myers, G. (2001a) Blood pressure measuring devices: recommendations of the European Society of Hypertension *British Medical Journal* 322 pp 531-536

O'Brien, M. Freemantle, N., Oxman, A., Wolf, F., Davis, D., Herrin, J. (2001b) Continuing education meetings and workshops: effects on professional practice and health care outcomes. *Cochrane Database of Systematic Reviews* 2001, Issue 1. DOI:10.1002/14651858.CD003030]

O'Brien, E., Pickering, T., Asmar, R., Myers, M., Parati, G., Staessen, J., Mengden, T., Imai, Y., Waeber, B., Palatini, P., Atkins, N., Gerin, W. (2002) Working Group on Blood Pressure Monitoring of the European Society of Hypertension International Protocol for validation of blood pressure measuring devices in adults. *Blood Pressure Monitoring* 7:3-17

O'Brien, E., Asmar, R., Beilin, L., Imai, Y., Mancia, G., Mengden, T., Myers, M., Padfield, P., Palatini, P., Parati, G., Pickering, T., Redon, J., Staessen, J., Stergiou, G., Verdecchi, P. (2003) European Society of hypertension recommendations for conventional ambulatory and home blood pressure measurement *Journal of Hypertension* 21 821-848

O'Brien, E., Asmar, R., Beilin, L., Imai, Y., Mancia, G., Mengden, T., Myers, M., Padfield, P., Palatini, P., Parati, G., Pickering, T., Redon, J., Staessen, J., Stergiou, G., Verdecchia, P. (2005) on behalf of the European Society of Hypertension Practice guidelines for clinic ambulatory and self measurement of blood pressure *Journal of Hypertension* 23 697-701

O'Brien, E., Atkins, N., Stergiou, G., Karpettas, N., Parati, G., Asmar, R., Imai, Y., Wang, J., Mengden, T., Shennan, A. (2010) on behalf of the Working Group on Blood Pressure Monitoring of the European Society of Hypertension. European Society of Hypertension International Protocol revision for the Validation of Blood Pressure Measuring Devices In Adults. *Blood Press Monitoring* **15**:23–38.

O'Conner, S., Pearce, J., Voegeli D., Walton, P. (2001) An evaluation of the clinical performance of newly qualified nurses: a competency based assessment *Nurse Education Today* 21 (7) 559-568

O'Neil, K., Addrizzo-Harris, D. (2009) Continuing Medical Education Effect on Physician Knowledge Application and Psychomotor skills. American College of Chest Physicians Evidence-Based Educational Guidelines 135:3 S37 – 42

Odegard, R., Vatten, L., Nilsen, S., Savesen, K., Austgulen, R. (2000) Risk factors and clinical manifestations of Pre-eclampsia*. British Journal Obstetrics and Gynaecology* 107 1410-6

Office for National Statistics (2008) Statistics on Obesity, Physical Activity and Diet: England, January 2008. London,

Oliveira, S., Arcuri, E., Santos, J. (2002) Cuff width influence on blood pressure measurement during the pregnant-puerperal cycle *Journal of Advanced Nursing* 38 (2) 180-189

Oppenheim, A. (1992) *Questionnaire Design and attitude measurement,* Pinter Publishers Ltd: London.

Ostchega, Y., Dilon, C., Prineas, R., McDowell, M., Carroll, M. (2006) Tables for the selection of correct blood pressure cuff size based on self-reported height and weight and estimating equations for mid-arm circumference: data from US National Health and Nutrition Examination Survey *Journal of Human Hypertension* 20 15 -22

Patton, M. (1997) *Utilization focused evaluation* New Century Text (3rd edition) Sage: California

Payne, F., Harvey, K., Jessop, P., Plummer, S., Tylee, A., Gournay, K. (2002) *Knowledge, confidence and attitudes towards mental health of nursing working in NHS Direct and the effects of training Journal of Advanced Nursing* 40 (5) 549-559

Perlman, L., Chiang, B., Keller, J., Blackburn, H. (1970) Accuracy of sphygmomanometers in hospital practice *Arch of internal medicine* 125:1000-1003

Perloff, D., Grim, C., Flack, J., Frohlich, E., Hill, M., McDonald, M., Morgenstern, B. (1993) AHA Medical/Scientific statement, Human blood Pressure determination by Sphygmomanometry *Circulation* Vol 88 No 5 Pt 1 2460-70

Perry, I., Wilkinson, L., Shinton, R., Beevers, D. (1991) Conflicting views on the measurement of blood pressure in pregnancy. *British Journal of Obstetrics and Gynaecology* Vol 98 241-243
Peterson, R. (2000) *Constructing Effective Questionnaires,* Sage: London.

Petrie, J., O'Brien, E., Litler, W., deSwiet, M. (1986) *British Hypertension Society Recommendations on Blood pressure measurement* (2nd edition) BHS: London

Pickering, T., Hall, J., Appel, L., Falkner, B., Graves,J., Hill, M., Jones, D., Kurtz, T., Sheps, S., Roccella, E. (2005) Recommendations for Blood Pressure Measurement in Humans and Experimental Animals: Part 1: A Statement for Professionals from the Subcommittee of Professional and Public Education of the American Heart Association Council on High Blood Pressure Research:.Hypertension; 45:142-161

Poole, J. (2003) Neuraxil analgesia for labour and birth implications for mother and fetus *Journal of Perinatal and Neonatal Nursing* Vol 17 n4 252

PRECOG (2004) PRE – Eclampsia Community Guideline APEC http://www.apec.org.uk/

PRE-Eclampsia Foundation (2008) http://www.preeclampsia.org/about.asp

Price, D. (2005) Continuing medical education, quality improvement, and organisational change: implications of recent theories for twenty-first-century CME. *Medical Teacher* 27(3):259-268.

Quinn, M. (1994) Automated blood pressure measurement devices: a potential source of morbidity in severe pre-eclampsia *Am J obstetrics and Gynaecology* 170 1303-1307

Quinn, F. (1995) *The Principles and Practice of Nurse Education,* Stanley Thorne, London

RCM (2011) State of Maternity Services report 2011 Royal Collage of midwives http://www.rcm.org.uk/college/policy-practice/government-policy/state-of-maternity-services/

RCOG (2006) http://www.rcog.org.uk/our-profession/good-practice/medical-workforce-census

RCOG (2008) Standards for Maternity Care Report of a Working Party RCOG Press London http://www.rcog.org.uk/files/rcog-corp/uploadedfiles/WPRMaternityStandards2008.pdf

Reece, I., Walker, S. (2007) *Teacher training and Learning A practical guide (6th edition revised)* Business Education Publishers, Tyne & Wear

Reeves, R. (1995) Does this patient have hypertension How to measure blood pressure *JAMA* 273 (15) 1211-1218

Reinders, A., Cuckson, A., Jones, C., Poet, R., O'Sullivan, G., Shennan, A. (2003) Validation of the' Welch Allyn Vital Signs' blood pressure measurement device in pregnancy and pre-eclampsia *BJOG* 110 (2): 134-138

Reinders, A., Cuckson, A., Shennan, A. (2005) An accurate automated blood pressure device for use in pregnancy and pre-eclampsia: the Microlife 3BTO-A *BJOG* 112(7) 917-20

Reiss, R., O'Shaughnessay, R., Quilligan, T., Zuspan, F. (1987) Retrospective comparison of blood pressure course during Pre-eclampisa and matched control pregnancies *Am J Obstet Gyneocol* 156: 894-8

Remmen, R., Derese, A., Scherpbier, A., Denekens, J., Hermann I., van der Vleuten C., Royen, P., Bossaert, L. (1999) Can medical schools rely on clerkships to train students in basic clinical skills *Medical Education* 33 600-605

Roach, S. (1992) *The Human Act of Caring: a Blueprint for Health Professionals* (revised edition) Canadian Hospital Association Press Ottawa

Roberts, J., Cooper D. (2001). "Series, Pre-eclampsia trio. Pathogenesis and genetics of pre-eclampsia.". *The Lancet. 357:53-56*.

Roberts, J., Pearson, G., Cutler, J., Lindheimer, M. (2003) Summary of the NHLBI working group on research on hypertension during pregnancy *Hypertension* 41 437-445

Roberts, C., Algert, C., Morris, J., Ford J., Henderson, S., Mark, D. (2005) Hypertensive disorders in pregnancy: a population-14 based study. *Medical Journal of Australia* 182:(7) 332-5. 15

Roberts, C., Bell, J., Hadfield, R., Morris, J., (2008) The accuracy of reporting of the hypertensive disorders of pregnancy in population health data. *Hypertension in Pregnancy* 27: 285-297

Robson, C. (1993) *Real World Research A resource for Social Scientist and Practitioner Researchers,* Blackwell, Oxford.

Robson, C. (2011). *Real world research: a resource for users of social research methods in applied settings*. Wiley Chichester

Rogers, E. (2003) *Diffusion of Innovations (5th ed)* Free Press London

Rosenberg, K., Twaddle, S. (1990) Screening and surveillance of pregnancy hypertension--an economic approach to the use of day care. *Baillieres Clinical Obstetrics and Gynaecology* 4(1):89–107.

Rouse, A., Marshall, T. (2001) The extent and implications of sphygmomanometer calibration error in care. *Journal of Hypertension* 15 (9) 587-591

Ryan, B., Gross, N. (1943) The Diffusion of Hybrid Seed Corn in Two Iowa Communities *Rural Sociology* 8: 15-24

Sadler, M. (1997) Serum screening for Down's syndrome: how much do health professionals know? *British Journal of Obstetrics and Gynaecology* 104 176-179

Salaway, G., Caruso, J. Nelson, M. (2007) *The ECAR Study of Undergraduate Students and information Technology.* http://www.educause.edu/ir/library/pdf/ers0706/rs/ERS0706w.pdf (accessed 26.6.12)

Schoenfeld, A., Ziv, I., Tzeel, A., Ovadia, J. Roll over test-errors in interpretation, due to inaccurate blood pressure measurments *Europ.* (1985) *Journa. Obstet. Gynec. reprod. Biol.,* 19 23-30

Schwartz, A., Haas, D., Gerin, W., Pickering, T. (2003) Accurate Measurement of Blood Pressure. *JAMA* 289(21):2792

Scott, C., Chavez, G., Atrash, H., Taylor, D., Shah, R., Rowley, D. (1997) Hospitalizations for severe complications of pregnancy, 1987-1992. *Obstetrics and Gynecology*; 90(2):225-9

Seers, K., Critelton, N. (2001) Quantitative research: Designs relevant to nursing and healthcare. *Nursing Times research* 6: 487-500
Shennan, A., Halligan, A. (1999) Measuring blood pressure in normal and hypertensive pregnancy *Clinical Obs and Gynae Best Practice and Research* V13(1) 1-26

Sibai, B., Gordon, T., Thom, E., Cartis, S., Klebanoff, M., McNellis, D., Paul, R. (1995) Risk factors for Pre-eclampsia in healthy nulliparous women a prospective multicentred study *AM J Ob Gyb* 172:642-8

Sims, A., Menes, J., Bousfield, D., Reay, C., Murray, A. (2005a) Automated non-invasive blood pressure devices: are they suitable for use? *Blood Pressure Monitoring* 10 (5) 275-281

Sims, A., Reay, C., Bousfield, D., Menes, J., Murray, A. (2005b) Oscillometric blood pressure devices and simulators:measurement of repeatability and differences between models *J Med Engineering and Technology* 3: 112-118(7)

Skirton, H., Chamberlain W., Lawson C., Ryan, H., Young, E. (2011) A systematic review of variability and reliability of manual and automated blood pressure readings *Journal of Clinical Nursing* 20, 602-614

Slattery, M., Geary, M., Morrison, J. (2008) Obstetric antecedents for pre-term delivery. *Journal of Perinatal Medicine* 36: (4) 306-9

Smith, D., Slack, J., Shaw, R., Marteau. T. (1994) Lack of knowledge in health professionals: a barrier to providing information to patients? *Quality in Health Care* 3 75-78

Smith, G. (2008) Medical Devices Containing Mercury EU Directive 2007/51/EC Medicines and Healthcare Regulatory Agency

SOGC (2008) Society of Obstetricians and Gynacologists of Canada Clinical Practice Guideline Diagnosis, Evaluation and Management of the Hypertensive Disorders of Pregnancy: *Journal of Obstetrics and Gynaecology* Canada:30:3 supp : 1-52

Stables, D., Rankin, J. (2005) *Physiology in childbearing: with anatomy and related biosciences* (2nd Edition) Elsevier: London

Stamilio, D., Sehdev, H., Morgan, M., Propert, K., Macones, G. (2000) Can Antenatal Care and biochemical markers predict the development of severe Pre-eclampsia *AM J Obs Gyne* 182 :589-94

Statistical Services Centre (2003) Statistical Good Practice Guidelines; Guidelines for planning effective surveys University of Reading http://www.rdg.ac.uk/ssc/publications/guides/toppes.html

Stryker, T., Wilson, M., Wilson, T. (2004) Accuracy of home blood pressure readings: monitors and operators. *Blood Press Monit* 9: (3) 143-7.

Tamblyn,, R., Abrahamowicz, M., Dauphinee D., Wenghofer, E., Jacques, A., Klass, D., Smee, S., Blackmore, D., Winslade, N., Girard, N., Du Berger, R., Bartman, I., Buckeridge, D., Hanley, J. (2007) Physician Scores on a National Clinical Skills Examination as predictors of complaints to medical regulatory authorities *JAMA* 208:9:993-1001

Taylor, E. (2000) *Fostering Mezirow's transformative learning theory in the adult education classroom: a critical review*. Canadian Journal for the Study of Adult Education, 14(2), 1-28.

Taylor, E., (2007) An update of transformative learning theory: a critical review of the empirical research (1999 -2005) *Int J of Lifelong Education* vol 26:2 173-191

The Magpie Trial Collaborative Group (2002) Do women with pre-eclampsia and their babies benefit from Magnesium Sulphate. The Magpie Trial: A randomised placebo control trial *Lancet* 359:1877-1890

Tholl, U., Forstner, K., Anlauf, M. (2004) Measuring blood pressure pitfalls and recommendations. *Nephrolo Dialysis transplant* 19 (4) 766-770

Thomas, M., Radford, T., Dasgupta, I. (2001) Unvalidated blood pressure devices with small cuffs are being used in hospitals. *British Medical Journal.* 323: 398

Thompson, G., Estabrooks, C., Degner, L. (2006) Clarifying the concepts in knowledge transfer: a literature review *Journal of Advanced Nursing* 53(6) 691-701

Thomson, J., Gillespie, A., Curzio, J. (2002) Changes in equipment for blood pressure measurement. *Professional Nurse* 17(6) 350-353

Tomlinson, B. (2010) Accurately Measuring Blood Pressure: Factors that contribute to false measurements. *MEDSURG Nursing* 19 (2) 90-94

Tourangeau, R. (2004) Survey Research and Societal Change *Annual Review Psychol* 55 775-801

Tortora, G., Grabowski, S. (2002) *Principles of Anatomy and Physiology* (10th ed) Wiley New York

Torrance, C., Serginson, E. (1996) An observational study of student nurses' measurement of arterial blood pressure by sphygmomanometry and auscultation *Nurse Education Today* 16 (4) 282-286

Tranquilli, A., Landi, B., Giannubilo, S., Sibai, B. (2012) Preeclampsia: No longer solely a pregnancy disease. *Pregnancy Hypertension An International Journal of Women's Cardiovascular Health* 2:350-357

Tuffnell, D., Jankowicz, D., Lindlow, S., Lyons, G., Mason, G., Russell, I., Walker, J. (2005) Outcomes of severe pre-eclampsia /eclampsia in Yorkshire 1999/2003 *BJOG* 112 :875-880

Turner, M., Irwig, L., Bune, A., Kam, P., Baker, A. (2006) Lack of sphygmomanometer calibration causes over-and under-detection of hypertension: a computer simulation study *Journal of Hypertension* 24 (10) 1931-1938

Twaddle S. Day care for women with high risk pregnancies. *Nursing Times 1995;**91**(4):46-7*

UKCC (1999) Fitness to practice UKCC London

Umble, K., Cervero, R. (1996) Impact studies in continuing education for health professionals. *Evaluation & the Health Professions* ;**19**:148–174.

Valente, T. (1996) Social network thresholds in the diffusion of innovations *Social Networks* 18 69-89

Veiga, E., Nogueira, M., Carnio, E., Marques, S., Lavrador, M., Moraes, A., Souza, C., Lima, N., Nobre, F.(2003) Assessment of the techniques of blood pressure measurement by health professionals *Arch Bras Cardiology* V80 (1) 89-93

Villegas, I., Arias, I., Botero, A., Escobar, A. (1995) Evaluation of the technique used by Health Care workers for taking blood pressure. *Hypertension* 26:2: 1204-1206

von Dadelszen, P., Magee, L. (2002) Fall in mean arterial pressure and fetal growth restriction in pregnancy hypertension: an updated metaregression analysis. *J Obstet Gynaecol Can*. 24:941–945.

Waggstaff, P. (2000) In *Principles and Practice of Research in Midwifery* (Ed, Cluett E., Bluff. R.) Bailliere Tindall, Edinburgh.

Walker, W. (2005) The strengths and weaknesses of research designs involving quantitative measures Journal of Research in Nursing 10: 571-579

Wan, Y., Heneghan, C., Stevens, R., McManus, R. J., Ward, A., Perera, R., Mant, D. (2010). Determining which automatic digital blood pressure device performs adequately: a systematic review. *Journal of human hypertension*, *24*(7), 431-438.

Waterstone, M., Bewley, S., Wolfe, C. (2001) Incidence and predictors of severe obstetric morbidity: case control study. *British Medical Journal* 322 (7294) 1089-93

Watson, T., Lip, G. (2006) Blood pressure measurement in atrial fibrillation: goodbye mercury? *Journal of Human hypertension* 20:638 640

Waugh, J., Gupta, M, Rushbrook, J., Halligan, A., Shennan H. (2002) Hidden errors of aneroid sphygmomanometers *Blood Pressure Monitoring* 7:6: 309-312

Webster, J., Newham, D., Petrie, J., Lovell, H. (1984) Influence of arm position on measurement of blood pressure *British Medical Journal* 288 :1576-1575
Whichman, K., Ryeden, G., Whichman, M. (1994) The influence of cuff position and Korotkoff sounds on BPM in pregnancy *Acta Obsteric Gynae Scand* sup 118: 25-28

White, W., Berson, A., Robbins, C., Jamieson, M., Prisant, L., Roccella, E., Sheps, S. (1993) National standard for measurement of resting and ambulatory blood pressures with automated sphygmomanometers *Hypertension* 21 504-509

WHO (1988) World Health Organization International Collaborative Study of Hypertensive Disorders in Pregnancy. Geographic variation in the incidence of hypertension in pregnancy. *American Journal of Obstetrics and Gynecology* 1988;158:80–3

WHO, (2004) 2nd ed Bethesda, M., *Global burden of Disease for the Year 2001 by World Bank Region, for Use in Disease Control Priorities in Developing Countries, National Institutes of Health*: WHO. Make every mother and child count. Geneva: World Health Organisation

WHO (2005a) World Health Report- Make every mother and child count. Geneva World Health Organisation http://www.who.int/whr/2005/en, accessed 14 August 2008).

WHO (2005b) *Affordable Technology Blood pressure measuring devices for low resource settings* World Health Organisation

WHO (2006) *Neonatal and Perinatal Mortality Country, Regional and Global Estimates France* World Health Organisation

WHO (2008) *Managing eclampsia Midwifery Education module 2nd edition* World Health Organisation

WHO 2009 factsheet 333 Newborns reducing mortality http:/who.int/mediacentre/factsheets/fs333/en/

Williams, B., Poulter, N., Brown, M., Davies, M., McInnes, G., Potter, J., Sever, P., Thom, S. (2004) Guidelines for management of hypertension: report on the fourth working party of the British Hypertensive Society BHS IV *Journal of Human Hypertension* 18:139-185

Wingfield, D., Pierce, M., Feher, M. (1996) Blood pressure measurement in the community do guidelines help *Journal of Human Hypertension* 10:805

Wong, W., Shiu, I., Hwoung, T., Dickinson, J. (2005) Reliablity of automated blood pressure devices used in hypertensive patients *Journal of the Royal Society of Medicine98:11-113*

World Health Organisation (WHO)/International Society of Hypertension (2003) Statement on management of hypertension. *World Health Organization International Society of Hypertension Writing Group*

Wun, Y., Dickinson, J., Chan, C. (2002) Primary care physicians in public and private sectors perceive different learning needs. *Med Teaching* 24(1):62- 66.

Wynne, G., Marteau, T., Johnston, M., Whiteley, C., Evans, T., (1987) Inability of trained nurses to perform basic life support *British Medical Journal* 294 1198-99

Yentis, S. (2011) From CEMD to CEMACH to CMACE to ? where now for the Confidential Enquiry into maternal deaths *Anaesthesia* 66:10 859-860

Yu, J., Cooper, H. (1983) A quantitative review of research design effects on response rates to questionnaires *Journal of Marketing research* vol xx 36-44

BIBLIOGRAPHY

AHA, (1989) Office evaluation of hypertension a statement for health professionals by a writing group of the council for high blood pressure research. *Hypertension* 13: 283-290

AHA, (2005) Recommendations for Blood pressure measurement in Humans and experimental animals Part 2 Blood pressure measurement in experimental animals *Hypertension:* 45 299 -310

Allen, R. (1997) Midwifery Education : Part 3 The Northern and Yorkshire region *British Journal Midwifery* 5 (4): 188-191

Altman, D. (1991) *Practical statistics for Medical research,* Chapman and Hall, London.

American Society of Hypertension (1992) recommendations for routine blood pressure measurement by indirect cuff sphygmomanometry *American Journal of Hypertension* 5: 207-209
Anderson, F., Maloney, J. (1994) Taking blood pressure correctly - Its No off- the -cuff matter *Nursing* 24(11)34-40

Armstrong, R., Waters, E., Crockett, B., Keleher, H. (2007) The nature of evidence resources and knowledge translation for health promotion practitioners *Health Promotion International* 22(3) 254-260

Atterbury, J., Groome, L., Baker, S. (1996) Elevated midtrimester mean arterial blood pressue in women with severe pre-eclampsia *Applied Nursing Research* 9 (4) 161-166

Australasian Society for the Study of Hypertension in Pregnancy (1993) Management of hypertension in pregnancy: executive summary. *Med Journal Australia* 158:700-702

Aylett, M., Marples, G., Jones, K., Rhodes, D. (2001) Evaluation of normal and large sphygmomanometer cuffs using the Omron 705CP *Journal of Human Hypertension* 15 (2) 131-134

Baha, M., Sibai, M. (2002) Chronic Hypertension in Pregnancy *Obstetrics and Gynaecology* Vol: 100 (2) 269-77

Bailey, K. (1987) *Methods of Social Research,* The Free Press, London.

Bardwell, J. (1995) For Good Measure *Nursing Times* 91(27) 38-40

Bates, B. (1987) *A Guide to the Physical Examination and History Taking,* Lippincott, Philadelphia.

Bauer, M., Huynh, M. (1998) Nursing student's blood pressure measurement following CD-ROM and conventional classroom instruction a pilot study *International Journal of Medical informatics* 50 :103-109

Bazell, J. (1997) Midwifery education: Part 5 The North West region *British Journal Midwifery* vol 5 (6) 320-326

Bean, A., Roszkowski, M. (1995) The Long and Short of It When does questionnaire length affect response rate *Marketing Research* Vol 7 (1) 21-26

Beevers, G., Lip, G., O'Brien, E. (2001) Blood pressure measurement Part II- Conventional sphygmomanometry: technique of auscultatory blood pressure measurement *British Medical Journal* 322:1043-1047

Beevers, G., Lip, G., O'Brien, E. (2001) ABC of hypertension the Pathophysiology of Hypertension *British Medical Journal* 322:912-916

Beevers, M., Beevers, G. (1996) Blood pressure measurement in the next century a pleas for stability *Blood Pressure Monitorin*g 1 supp 2 S117-S120

Bell, M., Siklos, P (1984) Recording blood pressure Two. Accuracy of staff and equipment. *Nursing Times* 80 (27) 32-34.

Bellomo, G., Narducci, P, Rondoni, F., Pastorelli, G., Stangoni, G., Angeli, G. (1999). Prognostic value of 24-hour blood pressure in pregnancy. *JAMA*;282(15):1447–52.

Betts, H. (1997) Midwifery Education: Part 2 The South and West region *British Journal Midwifery* 5 (3) 128-130

Banta, J. (2003) What is the efficacy/effectiveness of antenatal care and the Financial and Organizational implications? Health Evidence Network Report *WHO Regional Office for Europe Copenhagen* :http://www.euro.who.int,

Bigge, M.(1982) *Learning Theories for Teachers* Harper Row, Cambridge.

Blaikie, N. (2009) Designing Social Research (2nd edition) Poilty Press Cambridge

Boylan, A., Brown, P., (1985) Student observations the pulse and blood pressure *Nursing Times* 81,7, 26-29

Boynton, P. (2005) *The research companion a practical guide for the social and health sciences* Psychology press East Sussex

Bramley, P., Kitson, B. (1994) Evaluating Training against Business Criteria *Journal of European Industrial Training,* 18; (1) 10-14.

Brennan, M., Hoek, J. (1992) The behaviour of respondents , non respondents and refuse's across mail surveys *Public opinion quarterly* 56:530-535

Brennan, P., Greenberg, G., Miall, W., Thompson, S. (1982) Seasonal variation in arterial blood pressure *British Medical Journal* 285 919-923

Briggs, J. (2001) Best Practice Vital Signs Systematic review of research literature Practice information sheet Joanne Briggs Institute for evidence based nursing and midwifery Best Practice http://www.joannabriggs.edu.au/bp8.html accessed 22.1.2001

Bryman, A., Crammer, D (2001) *Quantitative Data analysis with SPSS release 10 for Windows*: A guide for social scientists Routledge London

Byrom, J., Bennison, D. (2000) The effect of personalisation on mailed questionnaire response rates *International Journal of Market Research* Vol 42 issue 3 357-358

Campbell, C. (1998) Training course/program evaluation: principles and practice *Journal of European Industrial Training,* 22, 323-44.

Campbell, N., Chockalingam, A., Foder, G., McKay, D (1990) Accurate, reproducible measurement of blood pressure *Canadian Medical Association* 143(1) 19-24

Carter, D. (1996) In *The research process in Nursing* (Editor Cormack , D.) Blackwell Science, Edinburgh.

Chen, P., Khan, K. (2001) Evaluation of a clinical test. II: Assessment of validity *British Journal of Obstetrics and Gynaecology* 108 568-572

Churchill, D., Beevers, G., Meher, S., Rhodes, C. (2007). Diuretics for preventing pre-eclampsia. Cochrane 12 Database of Systematic Reviews;(1)CD004451. 13

Clark, J. E. (Ed). (1990) *Clinical Nursing Practice Manual,* Prentice Hall International, Hemel Hempstead.

Collington, V. (1997) Midwifery Education: Part 7 The South Thames region. *British Journal Midwifery* 5 (8) 456-461

Colquitt, P. (2001) Doctors, Nurses and Grocers aren't different *British Medical Journal* 322:1248

Corner, J. (1991) In search of more complete answers to research questions Quantitative versus qualitative research methods is there a way forward *Journal of Advanced Nursing,* 16:718-27.

Cowman, S. (1993) Triangulation: A means of reconciliation in nursing *Journal of Advanced Nursing,* 18(5): 788-792.

Cuckson, A., Reinders, A., Hussain, S., Shennan, A. (2002) Validation of the Microlife BP 3BTO-A oscillometric blood pressure monitoring device according to a modified British Hypertension Society Protocl *Blood pressure monitoring* 7 (6) 319-324

Curzio, J., Butters, L., Kennedy, S., Reid, J. (1994) Assessing a method for blood pressure observer training *Journal of Human Hypertension* 8: 293 295

Darley, J,. Latane, B. (1968) Bystander intervention in emergencies: diffusion of responsibility. *J Personality Soc Psychol* 8:377–83.

De Rada, V, (2005) Influence of questionnaire design on response to mail surveys *International Journal Social Research Methodology* 8 (1) pp 61-78

Dickson,B., Hajjar, I. (2007) Blood pressure measurement Education and evaluation program improves measurement accuracy in community based nurses. A pilot study *Journal of American Academy of Nurse Practitioners* 19, 2 pp93-102

Dillman, D. *(1991)* The design and administration of mail surveys *Annual Review Sociol 17 225-249*

Dimond, B. (2002) Step 43: Legal aspects of research 3 B*ritish Journal of Midwifery* 10 (7) 426

Dodd, J., Robinson, J., Crowther, C. (2002) Guiding antenatal care *Medical Journal of Australia* 176 (6) 253-254

Draper, P. (1987) Not a job for juniors *Nursing Times,* 83, 58-62.

Eccles, M., Grimshaw, J., Walker, A., Johnston, M., Pitts, N. (2005) Changing the behaviour of healthcare professionals: the use of theory in promoting the uptake of research findings *Journal of Clinical Epidemiology* 58 107-112

Edwards, P., Roberts, I., Clarke, M., DiGuiseppi, C., Pratap, S., Wentz, R., Kwan, I. (2002). Increasing response rates to postal questionnaires: systematic review. *Bmj*, *324*(7347), 1183.

Emonts, P., Seaksan S., Seidel, L., Thoumsin, H., Gaspard, U., Albert, A., Foifsty, J. (2008), Prediction of maternal predisposition to preeclampsia *Hypertension in pregnancy* 27: 237-245

Eser, I., Khorshid, L., Gunes, U., Demir, Y. (2006) The effect of different body positions on blood pressure *Journal of Clinical Nursing* 16 :137-40

European Society of Hypertension (2005) Practice guidelines for clinic ambulatory and self measurement of blood pressure *Journal of Hypertension 23 697-701*

Feather, C. (2001) Blood Pressure Measurement. *Nursing Times* 97:4 33-34

Fedder, D. (1994) Measuring blood pressure: Why readings go wrong *American Pharmacy* NS34 :6 39-43
Fisher, C. (1985) The ascendancy of diastolic blood pressure over systolic *The Lancet* December 14 1349-1350

Floras, J., Jones, J., Hassan, M., Osikowska, B., Sever, P., Sleight, P. (1981) Cuff and ambulatory blood pressure in subjects with essential hypertension *The Lancet* 8238 107-109

Foss, C., Ellefsen, B. (2002) The value of combining qualitative and quantitative approaches in nursing research by means of method triangulation *Journal of Advanced Nursing,* 40 (2), 242-248.

Frankel, D. (1999) How to measure blood pressure often forgotten *The Lancet,* 353, 9167 1858

Fraser, M., Richman, J., Galinsky, M., Day, S. (2009) *Intervention research developing social programmes* Oxford university press

Frohlich, E., Grim, C., Labarthe., D, Maxwell., M, Perloff, D., Weidman, W. (1988) Recommendations for human blood pressure determination by sphygmomanometers *Circulation* 77 501-514

Frohlich, E., Grim, C., Labarthe, D., Maxwell, M., Perloff, D., Weidman, W. (1988) Recommendations for human blood pressure determination by sphygmomanometers Reports of a special task force appointed by the steering committee American Heart Association *Hypertension* 11 210A-222A

Gallery, E., Ross, M., Hunyor, S., Gyory, A. (1977) Predicting the development of pregnancy associated hypertension the place of standardised blood pressure measurement *The Lancet* 8025 1273-1275

Gillman, M., Cook, N., Evans, D., Rosner, B., Hennekens, C., (1995) Relationship of alcohol intoxication with Blood pressure in young adults Hypertension 25 1106-1110

Goldkrand, J., Jackson, M. (1996) Blood pressure measurement in pregnant women in the left lateral recumbent position *American Journal Obs & Gynae* 176 (3) 642-643

Graham I., Logan, J., Harrison, M., Straus, S., Tetroe, J., Caswell W., Robinson N (2006) Lost in Knowledge Translation: Time for a Map? *Journal of Continuing Education in the Health Professionals* 26:13-24

Grim, C., Grim, C. (1993) Blood Pressure Measurement, AHA, Dallas *.American Journal of Hypertension,* 8:79.

Gupta, P., Dewan, P., Singh, T (2009) Objective Structured Clinical Examination (OSCE) Revisited *Journal of Postgraduate Medical Education Training & Research IV 6 1 - 5*

Hallworth, C., Sisto, S., Dickenson, A., Emery, S. (1997) Midwifery Education: Part 6 The North Thames region *British Journal Midwifery* 5 (7) 428-433

Hart, C. (1998) *Doing a Literature Review,* Sage, London.

Haines, A., Kuruvilla, S., Borchert, M. (2004) Bridging the implementation gap between knowledge and action for health Policy and practice *Bulletin of the World Health Organization* 82 (10) 724-732

Henderson, C. (1997) Midwifery Education: Part 1 The West Midlands region *British Journal Midwifery* 5(2) 66-69

Hensley, W. (2001) Increasing response rate by choice of postage stamps *Public Opinion Quarterly* 38:280-283

Hicks, C. (1996) *Undertaking Midwifery Research A basic guide to design and analysis* Churchill Livingstone London

Higgins, J., de Sweit, M. (2001) Blood Pressure measurement and classification in pregnancy *The Lancet* 357 9250 131-135

Hill, M., Grim, C. (1991) How to take a blood pressure American *Journal of Nursing* 38-42

Hopkinson, N. (1997) Midwifery Education: Part 11 Anglia and 0xford *British Journal Midwifery* Vol 5 no 12 724-727

House, J., Gerber, W., McMichael, J. (1977) Increasing Mail questionnaire response: A controlled replication and extension *Public Opinion Quarterly* 41 95-97
Jolley, A. (1991) Taking blood pressure *Nursing Times,* 87, 40-43.

Jones, W., Lang, J. (1980) Sample composition bias and response bias in a mail survey: A comparison of inducement methods *Journal of Marketing Research* Vol xvii 69-76

Jones, D., Frohlich, E., Grim, C., Grim, C., Taubert, K. (2001) Mercury sphygmomanometers should not be abandoned: An advisory statement from the council for High Blood pressure research American Heart Association *Hypertension* 37:185

Jones, S., Simpson, H., Ahmed, H. (2006) A comparison of two methods of blood pressure measurement *British Journal of Nursing* 15 (17) pp548-551

Kahle, L., Sales, B. (1978) Personalization of the Outside envelope in mail surveys *Public Opinion Quarterly* 547-550

Katz, E. (1960) Communication research and the image of society convergence of two traditions *American Journal of Soicology* LXV (5) 435-440 http://repository.upenn.edu/asc_papers/156

Kelly, M., Mongiello, R. (1982) Hypertension in pregnancy, labour, delivery and postpartum *American Journal Nursing 82(5)* 813

Kennedy, S. (1991) Monitoring hypertension in pregnancy home self testing of blood pressure levels *Professional Nurse* 6:10 566-568

Kennedy, S. (1991) A measure of independence teaching home blood pressure monitoring *Professional Nurse* 6 12 730 -31

Kim, S. (1993) Identifying alternative linkages among philosophy, theory and nursing science. *Journal of Advanced Nursing 18(5):* 793-800.

Laher, M., O'Brien, E. (1982) In search of Korotkoff *British Medical Journal* 285:1796-1798

Lane, B., Thompson, D. (1981) Questionnaire Page length and return rate *Journal of Social Psychology* 113: 291-292

Lawes, E. (2000) In praise of mercury sphygmomanometers *British Medical Journal* 321 1534

Loudon, I. (1992) *Death in childbirth An International study of maternity care and maternal mortality 1800-1950* Clarendon Press Oxford

Lovallo, W., Wilson, M., Vincent, A., Sung, B., Mckey, B., Whitsett, T. (2004) Blood pressure response to Caffeine shows incomplete tolerance after short term regular consumption *Hypertension* 43 760

Limpanigul T, (2009) Methodological considerations in a Quantitative study examining the relationship between job attitudes and citizen ship behaviours 18th *EDAMBA Summer academy Soreze France*

Maggs, C. (1994) Direct but different: Midwifery Education since 1989 *British Journal Midwifery* 2 (12) 612-616

Maggs, C. (1994) Midwifery Education in England : direct entry is different *Brithsh Journal Midwifery* vol2 no 8 353-354

Magee, L., Ornstien, M., von Dadelszen, P. (1999) Management of hypertension in pregnancy *British Medical Journal* 318 1332-1336

Maharaj, B., Moodley, J. (1994) Management of hypertension in pregnancy *Cont Med Educ* 12:1581-1589

Malhorta, A. (2001) Blood pressure measurement: more issues *British Medical Journal* 322 letters 1043

Mattar F., Sibai, B. (2000) Eclampsia VIII Risk factors for maternal morbidity *AJOG* 182(2) 307-312

Mattoo, T. (2002) Arm cuff in measurement of blood pressure American *Journal of Hypertension* 15 675-685

Maxwell, M., Waks, A., Schroth, P., Karam, M., Dornfield, L. (1982) Error in blood pressure measurement due to incorrect cuff size in obese patients *The Lancet* July 3 33-35

Mckay, D., Raju, M., Campbell, N. (1992) Assessment of blood pressure measuring techniques *Medical Education* 26 208-212

Macleod-Clarke, J., Hockey, L. (1989) *Further research for Nursing* Scutari Press London

Milne, F., Redman, C., Walker, J., Baker, P., Bradley, J., Cooper, C., de Sweit, M., Fletcher, G., Jokinen, M., Murphy, D., Nelson Piercy, C.,

Osgood, V., Robson, S., Shennan, A., Tufnell, A., Twaddle, S., Waugh, J. (2005) The pre-eclampsia community guideline (PRECOG): How to screen for and detect onset of pre-eclampsia in the community *British Medical Journal* 330: 576-580

Mion, D., Pierin, A. (1998) How accurate are sphygmomanometers? *Journal of Human Hypertension* 12: 245-248

Moller, B., Lindmark, G. (1986) Eclampsia in Sweden, 1976-1980. *Acta Obstetricia et 25 Gynecologica Scandinavica*; 65:(4)307-14. 26

Murrray, A. (2001) In praise of mercury sphygmomanometers *British Medical Journal* 322 1248

Myers, J., Haug, A. (1969) How a preliminary letter affects mail survey returns and costs *Journal of advertising research* 9(3): 37-39
National Collaborating Centre for Women's and Children's Health (2009) *Hypertension in pregnancy the management of hypertensive disorders during pregnancy full guideline* NICE

NHLBI (1997) The sixth report of the Joint National Committee on Prevention, Detection, Evaluation and Treatment of High Blood pressure. National High l Blood pressure Education Program National Institutes of Health NHLBI US department of health and human sciences http://www.nhlbi.nih.gov/guidelines/index.htm

NHLBI (2000) National High Blood pressure education program working group report on high blood pressure in pregnancy US Department of Health and Human services
http://www.nhlbi.nih.gov/guidelines/index.htm

O'Brien, E., O'Malley, K. Sheridan, A. (1979) *British Medical Journal,* a)775-6 sept 29th, b) 851-3, oct 6th c) 920-21 13th Oct, d) 982-4 20th Oct, e)1048-9 27th Oct, f) 1124-6 3rd Nov, g) 1201-2 10th Nov.

O'Brien, E., Petrie, J., Littler, W., deSweit, M., Padfield, P., Dillon, M., Coats, A., Mee, F. (1999) *Blood pressure Measurement Recommendations of the British Hypertension Society* British Medical Journal Books London

O'Brien, E., Beevers, G., Lip, Y. (2001) ABC of Hypertension Blood pressure measurement Part III- Automated sphygmomanometry: ambulatory blood pressure measurement *British Medical Journal* 322 1110-1114

O'Brien, E., Asmar, R., Myers, M., Parati, G., Staessen, J., Mengden, T., Imai, Y., Waeber, B., Palatini, P., Atkins, N., Gerin, W. (2002) *Blood Pressure Monitoring special article,* 7, 3-17.

O'Rourke, M. (2003) Accurate measurement of arterial pressure *Journal of Human Hypertension* 11 445-447

Patten, M. (1981) *Creative Evaluation,* Sage, Newbury Park London.

Petrie, J., O'Brien, E., Littler, W., deSwiet, M. (1986) Recommendations on Blood pressure measurement *British Medical Journal* 293 611-615

Pietz, L. (1994) Variations in teaching and practices of blood pressure measurement *Nurse Educator,* 19, 9-14.

Plante, C. (2005) Blood pressure measurement: A worthwhile technique for nurses *Outlook* Fall 28 -2 35-39

Polit, D., Hungler, B. (1995) *Nursing research principles and methods* 5th edition Lippincot London

Polland, R. (1998) Vol. 2006 *Adolescent Pregnancy Prevention* Grant Duval County Health Department

Prisant, L., Alpert, B., Robbins, C., Berson, A., Hayes, M., Cohen, M., Sheps, S. (1995) American National Standard for non-automated sphygmomanometers summary report *American Journal of Hypertension* 8 (2): 210-213

Proctor, S., Renfrew, M., Eds (2000) *Linking Research and Practice in Midwifery* Bailliere Tindall London

Quinn, M. (1991) Blood pressure measurement in pregnancy *Lancet* 338: 8759: 130

Quinn, M. (1995) Korotkoff sounds in pregnancy *Ultrasound in Obstetrics and Gynaecology* 6 58-61

Quinn, M. (2001) Blood pressure measurement *British Medical Journal* 323 805

Redman, C. (1995) Hypertension in Pregnancy. In: de Swiet M. ed *Medical Disorders in Obstetric Practice,* 2nd Edition. Blackwell Science, Oxford: 182 –225

Redman, C., Jefferies, M. (1988) Revised definition of pre-eclampsia *The Lancet* April 9 809-812

Repke, J., Robinson, J. (1998) The prevention and management of pre-eclampsia and *eclampsia International Journal of Gynaecology and Obstetrics* vol 62 issue 1 pp1-9

Roscoe, A., Lang, D., Sheth, J. (1975) Follow up methods Questionnaire length and market difference in mail surveys *Journal of Marketing* vol 39 20-27

Rothman, J., Thomas, E. (eds) (1994) *Intervention research design and development for human services* New York Hawthorn Press
Royal College of Obstetricians and Gynaecologists (2003) Good Practice Pre-eclampsia study group recommendations

Rowe, C. (1995) Incorporating competence into the long term evaluation of training and development *Industrial and Commercial Training,* 27 (2), 3-9.

Rowntree, D. (1987) *Assessing Students: How shall we know them?,* Kogan Page, London.

Sapsford, R., Jupp, V. (1996) *Data collection and analysis* Open University Press Sage Publications: London

Schutte, J., Schuitemaker, N., van Roosmalen, J., Steegers, E. (2008) Substandard care in maternal mortality due to hypertensive disease in pregnancy in the Netherlands *BJOG* 115 732-736

Sechrest, L. (2005) Validity of measures is no simple matter *Health Research and Educational Trust* 40:5 part 11 pp1584

Semple, M., Cook, R., Moseley, L., Torrance, C. (2001) Social influence and the recording of blood pressure by student nurses: an experimental study *Nurse Researcher: International Journal of Research Methodology in Nursing and Health Care* 8 (3) 60-72

Shaw, A., Deehan, C., Lenihan, J. (1979) sphygmomanometers: errors due to blocked vents *British Medical Journal* march 789-790

Shennan, C., SHennan, A. (1996) Blood pressure in pregnancy: The need for accurate measurement. *British Journal Midwifery* 2 (2) 102-198

Sibai, B. (1990) Eclampsia VI Maternal-perinatal outcomes in 254 consecutive case *American Journal of Obstetrics and Gynecology* 163 1049-1055

Sibai, B. (1996) Treatment of hypertension in pregnant women *New England J* Med 335 257-265

Sibai, B. (2002) Chronic Hypertension in pregnancy *Obstetrics and Gynaecology* 100:2 369-377

Sibai, B., Taslimi, M., Abdella, T., Brooks, T., Spinnato, J., Anderson, G. (1985) Maternal and perinatal outcome of conservative management of severe pre-eclampsia in midtrimester *American Journal of Obs and Gyn* 152 32-36

Smith, G. (2000) Devices for blood pressure measurement *Professional Nurse* 15 5 337-340

Staessen, J. (2000) Blood pressure measuring devices tine to open pandora' s box and regulate *Hypertension* 35 1037

Stark, S., Elzubeir, M. (1994) Effects of the lack of nurse training on preregistration midwifery students *British Journal Midwifery* vol 2 no 4 182-186

Tew, M. (1995) *Safer Childbirth 2nd edition A critical history of maternity care* Chapman & Hall London

Thangaratinam, S., Ismail, K., Sharp, S., Coomarasamy A., Mahony F., Khan, K., O'Brien, E. (2007) Prioritisation of tests for the prediction of preeclampsia complications: A Delphi survey *Hypertension in Pregnancy* 26 131- 138

Thompson, D. (1981) Recording a patients blood pressure : a review *Journal of Advanced Nursing,* , 283-290.

Torrance C., Semple, M. (1997) Practical procedures for nurses. Blood pressure measurement: the patient *Nursing Times* 93 39 supplement

Torrance C., Semple, M. (1997) Practical procedures for nurses. Blood pressure measurement: procedure *Nursing Times* 93 40 supplement

The national Institute of child health and human development Network of maternal fetal medicine units
http://www.nichd.nih.gov/about/org/cdbpm/pp/prog_hriskpreg/index.cf

Treece, E. Treece, J. (1986) E*lements of Research in Nursing* Mosby London

Valler –Jones, T., Wedgbury, K. (2005) Measuring blood pressure using the mercury sphygmomanometer *British Journal of Nursing* 14 (3) pp145-150

Vesalainen R., Kangassalo K., Kariluoto A., Kantola Bell, (2004) diaphragm or electronic amplification inmeasurement of blood pressure *American Journal Hypertension* v17 Issue 5 supp 1 558 -59

Vilar, J., Betran, A., Gulmezoglu, M. (2001) Epidemiological basis for the planning of maternal health services WHO/RHR

Varughese, G., Lip, G. (2005) Goodbye mercury? Blood pressure measurement and its future *Journal of the Royal Society of Medicine* 98(3) 89-90

Walker, M. (1984) Observation in a newly admitted patient *Nursing Times,* 80, 29-32.

Wallymahmed, M. (2008) Blood pressure measurement *Nursing Standard* 22 19 45-48

Wendler,, M. (2001) Triangulation using a meta-matrix *Journal of Advanced Nursing,* 35(4) 521-525.

Wells, D. (1990) A case for accuracy monitoring blood pressure *Professional Nurse* 6 1 30-32

Webb, E., Campbell, D., Schwartz, R., Secherst, L. (1966) *Unobtrusive methods: Non-reactive Research in the Social Sciences* Rand McNally Chicago

WHO (1996) "revised 1990 estimates of maternal mortality: A new approach by WHO and UNICED" WHO Geneva

WHO (2000) AbouZahr, C., Wardlaw, T. Maternal mortality in 2000: estimates developed by WHO, UNICEF, and UNFPA. http://www.who.int/reproductive-health/publications/maternal_mortality_2000/maternal_mortality_2000.pdf accessed 12 July 2004.

WHO 2009 factsheet 178 Children reducing mortality http://www.who.int/mediacentre/factsheets/fs178/en/

Wilson, M., Shepherd, L., Kelly, C., Pitzner, J. (2005) Assessment of a low-fiedelity human patient simulator for the acquitison of nursing skills *Nurse Education Today* 25 56-67

Wilton, A., De Greef, A., Shennan, A. (2007) Rapid assessment of blood pressure in the obstetric day unit using microlife MaM technology *Hypertension in Pregnancy* 26 31-37

Standards
Available from British Standards Institute, BSI
http://www.bsonline.bsi-global.com
BS EN 60601-1-1:2001 Medical electrical equipment. General requirements for safety. Collateral standard. Safety requirements for medical electrical systems. Section 1.1 Collateral standard: Safety requirements for medical electrical systems.
BS EN 60601-1-2:2002, IEC 60601-1-2:2002 Medical electrical equipment. General requirements for safety. Collateral standard. Electromagnetic compatibility. Requirements and tests.
BS EN 60601-2-30:2000, IEC 60601-2-30:1999 Medical electrical equipment. Particular requirements for safety. Particular requirements for safety, including essential performance, of automatic cycling non-invasive blood pressure monitoring equipment.
BS EN 1060-1:1996 Specification for non-invasive sphygmomanometers. General requirements
BS EN 1060-2:1996 Specification for non-invasive sphygmomanometers. Supplementary requirements for mechanical sphygmomanometers.

BS EN 1060-3:1997 Specification for non-invasive sphygmomanometers. Supplementary requirements for electromechanical blood pressure measuring systems. Clinical trial protocols
BS EN 1060-4:2004 Non-invasive sphygmomanometers. Test procedures to determine the overall system accuracy of automated noninvasive sphygmomanometers
.

APPENDIX 1

PROFORMAS FOR ASSESSMENT OF BP EQUIPMENT

ID ward equipment	aneroid	Mercury	automated	wall mounted	free standing	portable on wheels	date of service	named person
1								
2								
3								
4								
5								
6								
7								
8								

TYPE AND LOCATION OF DEVICE PROFORMA

formal maintenance programme	booklets	policy 1	policy 2	staff aware spillage policy	items available	staff knowledge	spares	

TYPE AND LOCATION OF DEVICE PROFORMA

ID	meniscus clear	meniscus oxidised	meniscus set at zero	mercury rise and fall freely	air vent blocked	air in column	column vertical	markings legible	markings illegible	cuff fabric	cuff fabric fault	Cuff size	Labelled	centre	Arm range
1															
2															
3															
4															
5															

MERCURY DEVICE PROFORMA

bladder good	bladder leaks	tubing good	tubing leaks, length	connections good	connection fault	valve good	valve faulty	bulb good	bulb faulty	calibration	calibration fail

MERCURY DEVICE PROFORMA

aneroid manometer	face plate	face plate faulty	gauge zero	gauge f	markings legible	markings ilegible	cuff fabric	cuff fabric fault	centre	cuff size	labelled	arm range
1												
2												
3												
4												
5												

ANEROID DEVICE PROFORMA

bladder good	bladder leaks	tubing good	tubing leaks, length	connections good	connection fault	valve good	valve faulty	bulb good	bulb faulty	calibration	calibration fail

ANEROID DEVICE PROFORMA

automated machine	type of machine	Validated	instructions	markings legible	markings illegible	cuff fabric	cuff fabric fault	cuff size	labelled	centre
1										
2										
3										
4										
5										

AUTOMATED DEVICE PROFORMA

arm range	bladder good	bladder leaks	tubing good	tubing leaks, length	connections good	connection fault	service

AUTOMATED DEVICE PROFORMA

Stethoscope	one sided	two sided	cracked bell or diaphragm	tubing length	faults in tubing	ear pieces dirty	ear piece poor
1							
2							
3							
4							
5							
6							

STETHOSCOPE PROFORMA

APPENDIX 2

PRACTICE QUESTIONNAIRE AND COVERING LETTER FOR PILOT STUDY

Dear Colleague
I am a Midwifery Lecturer at Liverpool John Moores University School of Health and Human Sciences. I am currently studying for an MPhil/PhD at LJMU conducting research on the measurement of blood pressure.

I would be grateful if you could spare ten minutes to complete and return this questionnaire in the envelope provided as soon as possible or by …**...**
Your contribution will be very valuable to the research and the findings would help inform practice.

Confidentiality is assured. The envelope is coded to enable me to follow up any not returned. Your questionnaire response is totally anonymous and whatever information is given will have no effect on your employment.

Thank you for your help in completing this.

With best wishes

Jacqui Gibson

PILOT QUESTIONAIRE

For each question please either tick the most appropriate box that is relevant to you or fill in the spaces that have been left blank.

1. Gender: Male ( ) Female ( )

2. Age: <25 ( ) 26-35 ( ) 36 –45 ( ) 46 –55( ) >56 ( )

3. Qualified member of staff ( )

Please state all qualifications_____

4. How many years have you been qualified_____

5. Unqualified member of staff Are you a?
Student midwife ( ) nursing assistant ( ) medical student ( )

Other please state _____

6. If a student what year of study are you in _____

7. If a nursing assistant how many years have you performed blood pressure measurements _____

8. Which type of device do you normally use to measure blood pressure?

a. Mercury ( )

b. Aneroid ( )

c. Electronic or digital ( )

9. How often should the manometer selected above be calibrated?

a. Every month ( )

b. Every 6 months ( )

c. Every 12 months ( )

d. Never ( )

e. Whenever it fails ( )

10. What position do you usually have the pregnant woman in when measuring her blood pressure?

a. Semi-recumbent ( )

b. Lying flat on her back ( )

c. Lying down on her side ( )

d. Sitting ( )

e. Standing ( )

11. What method do you usually use to identify the systolic blood pressure?

a. Palpation of the radial pulse ( )

b. Identifying the first Korotkoff sound ( )

c. Another method ( )

please state _____

12. What method do you usually use to identify the diastolic blood pressure?

a. Identifying the fourth Korotkoff sound (that is the muffling of sound heard through the stethoscope during cuff deflation) ( )

b. Identifying the fifth Korotkoff sound (that is the final disappearance of sound heard through the stethoscope during cuff deflation) ( )

c. Another method ( )

please state _____

13. Which size of cuff would you use on most women?

a. 12 x 23 cm ( )

b. 12 x 35 cm ( )

c. 12 x 26 cm ( )

d. 12 x 40 cm ( )

e. Don't know ( )

14. How much of the arm circumference should the bladder cuff cover?

a. 100 % ( )

b. 80 % ( )

c. 50 % ( )

e. 20% ( )

f. Don't know ( )

15. At what rate do you deflate the cuff?

a. In time with the woman's heart beat ( )

b. Quite fast I don't measure the rate ( )

c. 2-3mmHg per second ( )

d. 5-10mmHg per second ( )

16. Do you usually have the woman resting before having her blood pressure measured?

a. Yes for 5 minutes ( )
b. Yes for 1 minute ( )
c. No, it does not matter ( )
d. No, there is no time available ( )
e. Only after taking a high reading and before rechecking the reading ( )

17. Before taking a blood pressure measurement how much time should be allowed to elapse after the woman has

a. smoked a cigarette _____

b. eaten a meal _____

c. exercised _____

d. drunk a cup of coffee _____

18. Do you usually round the pressure reading?

a. No ( )
b. Yes to the nearest 5mmHg ( )
c. Yes to the nearest 10mmHg ( )
d. Yes to the nearest 2mmHg ( )
e. Yes to the nearest 1mmHg ( )

19. Which arm do you normally take a blood pressure reading from?

a. right arm ( )
b. left arm ( )
c. either arm ( )

20. Regarding arm position, which is correct?

a. If the arm is raised, blood pressure increases ` ( )
b. If the arm is lowered blood pressure decreases ( )
c. If the arm is raised, blood pressure decreases ( )
d. The arm position does not affect blood pressure readings ( )

Thank you for your co-operation in completing the questionnaire. If you have any comments you would like to make please feel free to add them below. Your contribution to the survey is greatly appreciated and valued.

APPENDIX 3

REVISED PRACTICE QUESTIONNAIRE AND

COVERING LETTER

Dear Colleague
I am a Midwifery Lecturer at Liverpool John Moores University School of Health and Human Sciences. I am currently studying for an MPhil/PhD at LJMU conducting research on the measurement of blood pressure.

The study will be conducted in stages. Stage 1 is the distribution of a questionnaire and an audit of the type and condition of equipment in the clinical area. Part of stage 2 will involve observation of a random selection of staff taking a blood pressure and you may be contacted and requested to participate at a later date.

I would be grateful if you could spare ten minutes to complete and return this questionnaire in the envelope provided as soon as possible or by …**...**
Your contribution will be very valuable to the research and the findings would help inform practice.

Confidentiality is assured. The questionnaire is coded to enable me to follow up any not returned and also to enable random selection of staff for stage 2 observations. Anonymity is assured only the researcher will have access to the codes, and they will be stored in a locked cabinet and destroyed as soon as they are no longer required. At no stage would individual responses be divulged to a third person. Staff who agree to participate can withdraw at any time and whatever information is given will have no effect on your employment.

Thank you for your help in completing this.

With best wishes

Jacqui Gibson

QUESTIONNAIRE (changes from Pilot questionnaire are highlighted in red font)

For each question please either tick the most appropriate box that is relevant to you or fill in the spaces that have been left blank.

1. Gender: Male ( ) Female ( )

2.Age: 19- 25 ( ) 26-35 ( ) 36 –45 ( ) 46 –55 ( ) >56 ( )

3. Please complete table as appropriate – changed from Pilot to this table

Qualifications	Number of years qualified or Date of qualification (if student year of study)	Number of years performed Blood Pressure measurements.
RN/RM		
Dip HE – RM (Direct entry)		
BA/BSc – RM (Direct entry)		
Dip HE or Degree (Post Registration)		
NVQ 3		
NVQ 4		
MD		
MRCOG		
Student midwife		
Medical student		
Other (please state)		

4. How often should the manometers be calibrated? Change from Pilot to this table

Timing of calibration	Mercury	Aneroid	Electronic /Digital
Every month			
Every 6 months			
Every 12 months			
Never			
Whenever it fails			
Don't know			

5. Do you use any one of these devices more frequently than the other
   Yes ( )

   Please state which one Mercury ( ) Aneroid ( ) Electronic ( )

   No ( )

6. What position do you **usually** have the pregnant woman in when measuring her blood pressure?

   a. Semi-recumbent ( )
   b. Lying flat on her back ( )
   c. Lying down on her side ( )
   d. Sitting ( )
   e. Standing ( )

7. What method do you usually use to identify the systolic blood pressure?

   a. Palpation of the radial pulse ( )

   b. Identifying the first Korotkoff sound ( )
   (the first appearance of clear sounds) change from pilot addition of explanation of Korotkoff 1

   c. Another method ( )
   please state _____

8. What method do you usually use to identify the diastolic blood pressure?

   a. Identifying the fourth Korotkoff sound ( )
   (that is the muffling of sound heard through the stethoscope during cuff deflation)

   b. Identifying the fifth Korotkoff sound ( )
   (that is the final disappearance of sound heard through the stethoscope during cuff deflation)

   c. Another method ( )
   please state _____

9. Which size of cuff would you use on most women?

   a. 12 x 23 cm ( )
   b. 12 x 35 cm ( )
   c. 12 x 26 cm ( )
   d. 12 x 40 cm ( )
   e. Don't know ( )

10. How much of the arm circumference should the bladder cuff cover ?

   a. 100 % ( )
   b. 80 % ( )
   c. 50 % ( )
   e. 20% ( )
   f. Don't know ( )

11. At what rate do you deflate the cuff?

   a. In time with the woman's heart beat ( )
   b. Quite fast I don't measure the rate ( )
   c. 2-3mmHg per second ( )
   d. 5-10mmHg per second ( )

12. Do you usually have the woman resting before having her blood pressure measured? (referring to antenatal or postnatal clients)

   a. Yes for 5 minutes ( )
   b. Yes for 1 minute ( )
   c. No, it does not matter ( )
   d. No, there is no time available ( )
   e. Only after taking a high reading and before ( )
   Rechecking the reading

13. Before taking a blood pressure measurement how much time should be allowed to elapse after the woman has

    a. smoked a cigarette _____

    b. eaten a meal _____

    c. exercised _____

    d. drunk a cup of coffee _____

    e. Don't know ( ) change to pilot addition of this box

14. Do you usually round the pressure reading?

    a. No ( )
    b. Yes to the nearest 5mmHg ( )
    c. Yes to the nearest 10mmHg ( )
    d. Yes to the nearest 2mmHg ( )
    e. Yes to the nearest 1mmHg ( )

15. Which arm do you **normally** take a blood pressure reading from?

    a. right arm ( )
    b. left arm ( )
    c. either arm ( )

16. Regarding arm position, which is correct?

    a. If the arm is raised, blood pressure increases ( )
    b. If the arm is lowered blood pressure decreases ( )
    c. If the arm is raised, blood pressure decreases ( )
    d. The arm position does not affect blood pressure readings ( )

Thank you for your co-operation in completing the questionnaire. If you have any comments you would like to make please feel free to add them below. Your contribution to the survey is greatly appreciated and valued.

APPENDIX 4

Example of Study Flyer for display in units

RESEARCH PROJECT FACTORS AFFECTING BLOOD PRESSURE MEASUREMENTS

I am conducting a research project on the measurement of blood pressure in pregnancy and factors that affect the accuracy of measurement. Stage 1 of the study involves staff completing a questionnaire and an audit of blood pressure equipment used in the clinical area. All staff who conduct blood pressure measurements will receive a questionnaire to complete. I will be in the clinical area for approx 4 weeks from the >>>>>>>>>>. Please feel free to ask any questions about the project.

School of Health and Human Sciences
79 Tithebarn Street
Liverpool
L2 2ER

Tel: 0151 231 4131
Fax: 0151 258 1593
Email: J.K.Gibson@livjm.ac.uk

APPENDIX 5

FOLLOW UP LETTERS
FOR NON RESPONDENTS

Dear Colleague

Recently you were asked to complete a questionnaire regarding the measurement of blood pressure. Whilst I have had some returned, for purposes of the study, in order to give a true picture, it would be very useful to have even more replies. Therefore, please could I urge you to spare 10 minutes to complete the questionnaire, all contributions are valuable and the research will help to inform future practice.

I have enclosed another questionnaire in case the original has been lost. If you could return the questionnaire in the pre-paid envelope as soon as possible or by the …….. at the latest. I would be most grateful. If you wish to discuss the study or any issues you can contact me at Liverpool John Moores University on 0151 231 4131 or email j.k.gibson@livjm.ac.uk.

At no stage will individual responses be divulged to a third person and staff who participated in the study, can withdraw at any time. The information given has no effect on your employment.

Hope you can help me in my study
Thank you for your time in completing this
Best wishes

Jacqui Gibson
Midwifery Lecturer
Liverpool John Moores University/UCLAN

APPENDIX 6

COVERING LETTER FOR PRACTICE SURVEY 2

Dear Colleague

As you may or may not recall, for the last few years I have been conducting a part time PhD study into the accurate measurement of blood pressure in pregnancy. I have been writing up my thesis and in order obtain a complete picture of the impact of the study overall within the unit, I require some further information. For this stage of the study I need to obtain responses from both staff who participated previously in the study and those who did not. Thus I am making a request to all members of staff who undertake blood pressure measurements to take 10 minutes to complete the attached questionnaire and return to me in the provided envelope.

I would be grateful, if you could spare ten minutes to complete and return the questionnaire as soon as possible or by …

Your contribution to this final stage of the study is very important, to enable me to complete the study. The findings would help inform future practice.

Confidentiality is assured. The only reason the questionnaire is coded is to enable me to follow up any not returned. Anonymity is assured only the researcher will have access to the codes, and they will be stored in a locked cabinet and destroyed as soon as they are no longer required. At no stage would individual responses be divulged to a third person. Staff, who agree to participate can withdraw at any time and whatever information is given will have no effect on your employment.

Thank you for your help in completing this.

With best wishes

Jacqui Gibson
Senior Midwifery Lecturer UCLAN
PhD Student at LJMU
Email jgibson1@uclan.ac.uk
01772 893820

APPENDIX 7

FOLLOW UP LETTER TO NON-RESPONDENTS OF PRACTICE SURVEY 2

Dear Colleague

Several weeks ago you should have received a request for you to complete a questionnaire regarding the measurement of blood pressure. Whilst I have had a number returned, I still require more responses in order to complete my study. Therefore, I have taken the liberty to resend you the questionnaire in case you misplaced it, or were on holiday at the time of the request, or if for some reason you did not receive the original questionnaire. To ensure I obtain a true picture of the impact of the education programme, I would be grateful if you could find the time to complete the questionnaire and return it in the envelope provided. It should not take more than 10 minutes and if possible if you are willing to complete the questionnaire please could you return it as soon as possible or by …….. at the latest.

Your contribution to this final stage of the study is very important to enable me to complete the study and ultimately my PhD. The findings will inform future practice.

Confidentiality is assured. The questionnaire is coded is to enable me to follow up non-respondents. Anonymity is assured only the researcher will have access to the codes, and they will be stored in a locked cabinet and destroyed as soon as they are no longer required. At no stage would individual responses be divulged to a third person. Staff, who agree to participate can withdraw at any time and whatever information is given will have no effect on your employment.

Thank you for your help in completing this.

With best wishes

Jacqui Gibson
Senior Midwifery Lecturer UCLAN
PhD Student at LJMU
Email jgibson1@uclan.ac.uk
01772 893820

APPENDIX 8

LIST OF BP OBSERVATION FACTORS

STAFF OBSERVATION FACTORS

Greet the client
Explanation of procedure given
Client asked if recently eaten, smoked, exercised etc
Client allowed to rest
– time cuff put in place recorded
Position of client
- sitting
- lying
- standing
- other

Position of sphygmomanometer.
Position of operator
Cleaning of stethoscope
Arm used
Position of arm
- arm supported
- arm unsupported
- elbow flexed
- elbow straight
- assessment of arm circumference – cuff used
- level of antecubital fossa – above heart /below heart

Application of cuff
- over bare arm
- over clothes
- over bunched clothes

Placement of bladder
- central
- 2 –3 cm above AC fossa
- level of AC fossa
- below AC fossa

Palpation of pulse
- before using stethoscope
- no palpation

Inflation of cuff for estimate of systolic
Placement of stethoscope with location of brachial pulse by palpation
Placement of stethoscope with no location of brachial pulse by palpation
Use bell of stethoscope/Use diaphragm of stethoscope
Rate of inflation/Rate of deflation
Reading of meniscus
- above eye level/below eye level/at eye level

Reading
- rounded off recorded on chart

APPENDIX 9

PROFROMA FOR BP OBSERVATIONS

Communication		Position		Arm		Cuff		Technique		Technique	
Introduction		Sitting back supported		Right arm		size		Estimation of systolic		Recording of findings	
Explanation		Sitting back unsupported		Left arm		Bare arm		No estimation		Rounding off Quest	
asked if eaten		Lying left Lateral		Supported		Loose clothes		Stethoscope under cuff		Diastolic Quest	
smoked		Standing		Unsupported		Bunched clothes		Bell end		Method same as taught	
Exercised		Other		Elbow flexed		Bladder central		Diaphragm		Change in method	
Caffeine		Legs crossed		Elbow straight		2-3cm acf		Rate of inflation		Training	
Time entered		Legs uncrossed		Above heart		At ACF		Height of inflation			
Time cuff put in place		Legs on floor		Below heart		Below ACF		Rate of deflation		Faulty equip	
Time BP completed		Legs dangling		At level of heart		Palpation of pulse		Manometer at eye level			
Noise						Tubing up		Manometer below eye			
Talking during procedure						Tubing down		Manometer above eye			

APPENDIX 10

OBSERVATION CONSENT FORM

Dear Colleague

I am a Senior Midwifery Lecturer at UCLAN. For my PhD I am conducting a research study on the measurement of blood pressure.

Last year you may have kindly completed a questionnaire, on the measurement of blood pressure. I am about to commence stage two of the research study, and this involves the observation of a random selection of staff. If you are willing to participate in stage 2, this involves me observing you conducting a blood pressure measurement on a client. I will not require any clinical details about the client, and only need to be present during the blood pressure measurement, itself. (I will of course explain my presence to the client, and obtain verbal permission to be present when she has her blood pressure taken).

Anonymity for participants is assured, as only the researcher will have the details of individual observations. However, for ethical purposes I must inform you that during the observation, if the researcher observes that client safety is at risk, due to gross bad practice, this would outweigh the confidentiality of the participants and would require action be taken by the researcher. As, would be expected of any midwife observing something, which puts client safety at risk.

Jacqui Gibson
Midwifery Lecturer

I have read the above information and agree to participate in stage two of the research study on the measurement of blood pressure in pregnancy.

Signature Date

APPENDIX 11

ETHICAL APPROVAL LETTERS

North Cheshire [illegible]
[illegible]

☎Direct Dial 01928 593356
Please ask for Angela Burton

Our Ref: EK/AB/ NC01-36

8th October, 2001

Lister Road
Astmoor West Estate
Runcorn
Cheshire
WA7 1UW

Tel: 01928 593000
Fax: 01928 560552
E-mail: [illegible]

Mrs. Jacqueline Gibson,
Midwifery Lecturer,
Liverpool John Moores University,
79 Tithebarn Street,
Liverpool
L2 2ER

Dear Mrs. Gibson,

ACCURATE BLOOD PRESSURE MEASUREMENT IN PREGNANCY. A SURVEY OF STAFF KNOWLEDGE AND EQUIPMENT. NC01-36

Thank you for your application to the North Cheshire Local Research Ethics Committee to carry out the above study. I am pleased to tell you that at the meeting held on Thursday 4th October, 2001 ethical approval was given for the study to proceed.

Could you please refer proposed amendments to the protocol to North Cheshire LREC for further review and approval prior to implementation (except only in cases of emergency where the welfare of the subject is paramount). The LREC should be informed if the research be discontinued or any subject withdrawn. North Cheshire LREC will also be pleased to receive details of the progress of the research project on a six monthly basis.

I enclose a copy of the LREC membership list, which I hope you will find useful.

If you have any queries or wish further clarification, please do not hesitate to contact me.

Yours sincerely,

Mrs. E. Groves
Acting Chairman - North Cheshire LREC

Enc.

NORTH CHESHIRE LOCAL RESEARCH ETHICS COMMITTEE

North Cheshire Hospitals NHS
NHS Trust

Warrington Hospital
Lovely Lane
Warrington
Cheshire WA5 1QG

Switchboard (01925) 635911

WOMEN'S HEALTH DIRECTORATE
CAROLE ARROWSMITH
DIRECTORATE MANAGER
Telephone 01925 662270

Secretary Wendy Matthews
Direct Line (01925) 662015

30th May 2001

Ms J Gibson
John Moores University
John Moores
Liverpool

Dear Ms Gibson

Thank you for your enquiry regarding undertaking research on the Maternity Unit at Warrington Hospital. I can confirm that we will be pleased to support your research.

Please could you get in touch with me to confirm the start dates and to clarify any outstanding details.

Yours sincerely

Melanie Hudson
Acting Head of Midwifery

PRESTON, CHORLEY AND SOUTH RIBBLE LOCAL RESEARCH ETHICS COMMITTEE

Telephone/Fax/Answerphone:
01772 710031

Trust Headquarters
Chorley & South Ribble DGH
Preston Road
01257 247140 CHORLEY PR7 2SP

The Committee Secretary, Research Studies
Royal Preston Hospital
Sharoe Green Lane North
Fulwood PRESTON PR2 9HT

14 August 2001

LREC ref: 2001.8.13

Mrs J Gibson
Midwifery Lecturer
School of Health & Human Sciences
Liverpool John Moores University
79 Tithebarn Street
LIVERPOOL L2 2ER

Dear Mrs Gibson

The application for your study entitled:

Accurate blood pressure measurement in pregnancy: a survey of staff knowledge and equipment

together with protocol, participant invitation letters and questionnaire, was reviewed by the Preston, Chorley & South Ribble Local Research Ethics Committee at the meeting held on 6 August 2001.

The Committee felt that, to ensure complete anonymity the coding for the questionnaires should be destroyed at the end of the study.

They were requested the following additional details.

- No statistical details have been submitted; can you please let us have these
- section C5 of the application form indicates that questionnaires adapted from previous studies will be used, although no explanation has been given as to how these have been validated, are further details are required

Once the above issues have been satisfactorily addressed, reviewed and recommended for approval by the statistician, the Committee indicated they would be happy for your study to be approved on the action of the Chairman.

Yours sincerely

DR DRAKE, BMedSci, BMBS, FRCP
Chairman

Enc/encl/copy(s)

PLEASE CONFIRM THAT YOU HAVE INCLUDED THE ABOVE REFERENCE NO. IN ALL FUTURE CORRESPONDENCE RELATING TO THIS STUDY

PRESTON, CHORLEY AND SOUTH RIBBLE LOCAL RESEARCH ETHICS COMMITTEE

Tel/Fax/Answerphone: 01253 342140
E-Mail: Mary.Sykes@btinternet.com

Trust Headquarters
Chorley & South Ribble
District General Hospital
Preston Road
CHORLEY PR7 1PP

18 September 2001

LREC ref: 2001/8/13
Please quote reference on all future correspondence relating to this study

Mrs J Gibson
Midwifery Lecturer
School of Health & Human Sciences
Liverpool John Moores University
79 Tithebarn Street
LIVERPOOL L2 2ER

Dear Mrs Gibson

Re: ***Accurate blood pressure measurement in pregnancy: a survey of staff knowledge and equipment***

Thank you for your letter dated 29 August 2001.

I am satisfied that you have addressed the Committee's concerns, and confirm that you now have approval on the action of the Chairman to proceed with your study.

To comply with National guidelines, all Ethics Committees need to compile an annual report of research activity in their district. We would like to receive a report on the progress of your study in 12 months' time and notification should the study be terminated prematurely or suspended for any reason. We would also wish to receive a final report, as well as details of any publications which may result from your study. LREC approval normally covers a period of 3 years, after which further review is necessary if the study has not been completed.

Yours sincerely

J M DRAPER, BMedSci, PhD, FRCP
Chairman

Incorporating Preston REC

PLEASE ENSURE THAT LREC/8/13 IS INCLUDED THE ABOVE CASE REFERENCE NO. IN ALL FUTURE CORRESPONDENCE RELATING TO THIS STUDY

Chorley & South Ribble NHS
NHS Trust
Preston Acute Hospitals
NHS Trust
Directorate of Women's Health
Sharoe Green Hospital
Sharoe Green Lane
Fulwood
Preston
PR2 8DU

Tel: 01772 711396
Fax: 01772 711795
email:rita.chauhan@patr.nhs.uk

Mrs C S Bell – Director of Women's Health
cs2/rc/lei/gibson-matunil

31 May 2001

Mrs J Gibson
Midwifery Lecturer
John Moores University
79 Tithebarn Street
LIVERPOOL
L2 2ER

Dear Jacqui

Thank you for submitting your research proposal which I have discussed with Mr S M Hughes, Clinical Director.

As previously stated we agree in principal to you conducting your research at Sharoe Green Hospital.

Mr Hughes wishes you to submit your proposal to the Trust's Ethical Committee and I therefore suggest you submit the full proposal to the following for their approval:

Mrs Mary Sykes
Local Research Ethics Committee
c/o Trust Headquarters
Chorley & South Ribble District General Hospital
Preston Road
CHORLEY
PR7 1PP

I look forward to hearing from you again once this approval has been given.

Yours sincerely

Mrs C S Bell
Directorate Manager Women's Health
cc. Mr S M Hughes, Clinical Director - Obstetrics & Gynaecology

ST HELENS & KNOWSLEY LOCAL RESEARCH ETHICS COMMITTEE

C/O C-GARD
Whiston Hospital
Prescot
Merseyside
L35 5DR

Tel: 0151 430 2334
Fax: 0151 430 1215

Chairman: Dr E Whelan
Administrator: Mrs H Lomax
Vice Chairman: Mr A Massey

21st November 2001

Jacqueline Gibson
47 Arrowsmith Drive
Hoghton
Preston
Lancs
PR5 0DT

Dear Mrs Gibson

Accurate blood pressure measurement in pregnancy
[Ref: 2001/2002 - 57]

Many thanks for attending the St Helens & Knowsley Local Research Ethics Committee meeting on Thursday 15th November 2001 where the above proposal was considered. As discussed at the meeting, the Committee felt that where patient/client safety may be at risk, due to identified poor practice or faulty equipment, this outweighs the confidentiality of the respondents and must be promptly dealt with. This should be made clear in the information given to participants.

Once we have received a copy of your amended information letters to participants the study will be approved by Chairman's Action.

Yours sincerely

Dr E Whelan
Chairman - St Helens & Knowsley LREC

ST HELENS & KNOWSLEY LOCAL RESEARCH ETHICS COMMITTEE

C/O C-GARRD
Whiston Hospital
Prescot
Merseyside
L35 5DR

Tel: 0151 480 2334
Fax: 0151 430 1218

Chairman: Dr E Whelan
Administrator: Mrs K Lomax
Vice Chairman: Mr A Massey

30th January 2002

Jacqueline Gibson
47 Arrowsmith Drive
Haghton
Preston
Lancs
PR5 0DT

Dear Ms Gibson

Accurate blood pressure measurement in pregnancy
[Ref: 2001/2002 – 57]

Many thanks for forwarding your amended letter to participants for the above study. I have reviewed this and can confirm that the study now raises no major ethical concerns and is approved by Chairman's Action.

Although approval has been granted by the St Helens & Knowsley LREC, you are still required to seek permission from the Management of the NHS Institution(s) in which your research will take place before you begin the study. Within St Helens & Knowsley NHS Trust you are required to write to the R&D Manager – C-GARRD (Mrs Barbara Thompson).

As I'm sure you are aware it is a requirement that you keep this Committee informed of the Study's progress and eventual outcome, therefore a copy of your final report would be welcomed.

Yours sincerely

Dr E Whelan
Chairman – St Helens & Knowsley LREC

St Helens and Knowsley Hospitals NHS
CHS Trust

CAWJH

When telephoning or calling please ask for:
Miss C A Whewell
Direct Line: 0151 430 1734
Fax: 0151 430 2362

Whiston Hospital
Warrington Road
Prescot
Merseyside
L35 5DR

Tel: 0151-426 1600
Fax:

9 May, 2001

Mrs J Gibson
Senior Lecturer
Liverpool John Moores
School of Health in Social Sciences
79 Tithebarn Street
LIVERPOOL
L2 2ER

Dear Mrs Gibson

ACCURATE BLOOD PRESSURE MEASUREMENT

Further to your letter re accurate blood pressure measurement in pregnancy; a survey of staff knowledge and equipment, I give permission to access staff working in the clinical area at Whiston Maternity Services when you have obtained ethical approval to conduct your research.

Yours sincerely

C A Whewell (Miss)
HEAD OF MIDWIFERY SERVICES
WOMAN AND CHILD HEALTH

CHK A61 REV 4/99

St. Helens and Knowsley Hospitals
NHS Trust

Whiston Hospital
Warrington Road
Prescot
Merseyside
L35 5DR

Tel: 0151 426 1600
Fax:

Ext 2315

6th February 2002

Ms J Gibson
47 Arrowsmith Drive
Haghton
Preston
Lancs
PR5 0DT

Dear Ms Gibson

Accurate blood pressure measurement in pregnancy
[Research Budget Number 362]
[Ethics Ref: 2001/2002 – 57]

Many thanks for forwarding your application for the above study. I can confirm that Trust approval is granted for this study to commence, subject to approval by the Local Research Ethics Committee.

It is a requirement that the Trust monitor the progress and outcome of all research activity undertaken within it's remit. To that end I would be grateful if you could forward me a copy of your final report on completion of the study.

All records accessed for research purposes should be stored for a minimum of 20 years to support monitoring of good research practice by regulatory and other authorities. Researchers should liaise with the Health Records department in identifying such records whilst maintaining client confidentiality.

Yours sincerely

Barbara

Barbara Thompson
Research & Development/Audit Manager

SHE A81 REV 01/01

JMU

Liverpool John Moores University

Ref 0145

08 August 2001

Jacqueline K Gibson
School of Health and Human Sciences
79 Tithebarn Street
Liverpool

Dear Jacqueline,

I am pleased to inform you that the Ethics Committee has now considered your application for approval of the project entitled:

Accurate blood pressure measurement in Pregnancy: A survey of staff knowledge and equipment.

and I am happy to confirm that it has been approved.

The Ethics Committee approval is given on the understanding that:

(i) any adverse reactions/events which take place during the course of the project will be reported to the Committee immediately;
(ii) any unforeseen ethical issues arising during the course of the project will be reported to the Committee immediately;
(iii) any change in the protocol will be reported to the Committee immediately.

Please note that ethical approval is given for a period of five years from the date granted and therefore the expiry date for this project will be July 2006. An application for extension of approval must be submitted if the project continues after this date.

Research and Graduate School Office

I am enclosing form EC5 and would be grateful if you could spare the time to complete the questionnaire and return it to me.

Yours sincerely

Maria Roberts
Ethics Committee Secretary
Tel: 0151 231 3109
E-mail: M.L.Roberts@livjm.ac.uk

Cc: Carol Hughes
Charles Crosby

Lancashire Teaching Hospitals NHS Foundation Trust

Royal Preston Hospital
Sharoe Green Lane
Fulwood
Preston PR2 9HT

Tel 01772 522034
Fax: 01772 523184
Email: Lin.Nelson@lthtr.nhs.uk

RESEARCH AND DEVELOPMENT DIRECTORATE
Director of Research: Professor J D Mitchell, R&D Manager: Lin Nelson
PA to Prof Mitchell: Debi Fowler
Research Support Assistant: Rasi Gunasekara

Our Ref: JDM/LN

Tuesday, 14th April 2009

Ms J Gibson
47
Arrowsmith Drive
Haghton
Preston
PR5 0DT

Dear Ms Gibson,

R&D Ref: 563 **MREC Ref: 2001.8.13**

Accurate blood pressure measurement in pregnancy: a survey of staff knowledge and equipment

The amendments to the above project – **follow-up survey**; has been noted by the Research Directorate at Lancashire Teaching Hospitals NHS Foundation Trust. It is understood that you may require access to complete follow up data on previously administrated questionnaires and that the Ethics Committee regard this as a minor amendment only. Please ensure that you continue to abide by the principles of the Research Governance Framework and inform the research directorate of the studies progress and any future amendments.

Yours sincerely

Mrs Lin Nelson
Research and Development Manager

Cheshire Research Ethics Committee
Research Ethics Office
Bishop Goss Complex
Rose Place
Liverpool
L3 3AN

Telephone: 0151 330 2070
Facsimile: 0151 330 2075

11 May 2009

Ms Jacqui Gibson
47 Arrowsmith Drive
Hoghton
Preston
Lancs
PR5 0DT

Dear Ms Gibson

Title: Accurate Blood Pressure Measurement in Pregnancy: A Survey of Staff Knowledge and Equipment
REC reference: EK/AB/NCO01-36

Amendment number: 1
Amendment date: 20 March 2009

Thank you for your letter of 20 March 2009, notifying the Committee of the above amendment.

The Committee does not consider this to be a "substantial amendment" as defined in the Standard Operating Procedures for Research Ethics Committees. The amendment does not therefore require ethical review by the Committee and may be implemented immediately, provided that it does not affect the research governance approval for the research given by the R&D Department for the relevant NHS care organisation.

Documents received

The documents received were as follows:

Letter dated 20 March 2009 (including study report)

Statement of compliance

The Committee is constituted in accordance with the Governance Arrangements for Research Ethics Committees (July 2001) and complies fully with the Standard Operating Procedures for Research Ethics Committees in the UK.

EK/AB/NCO01-36:	**Please quote this number on all correspondence**

Yours sincerely

R G Emmett

Committee Co-ordinator

E-mail: rob.emmett@liverpoolpct.nhs.uk

APPENDIX 12

ORIGINAL LESSON PLAN

Time	Content	Teacher Activity	Student Activity	Resources	Purpose
5 mins.	Introduction of self Background to study Aim and intended learning outcomes Content of Session	Explaining Talking	Listening and Looking	PP slides 1-4	Set the scent Introduce self and remind of research study. Stat e the purpose of the session topics to be covered – generate initial interest and motivation for attending
15 mins	Student activity – self assessment of skill	Explain activity Operate equipment Listening Looking Questioning Provide answer Informal assessment of participants knowledge and reaction to session	Watching and listening to video clips to determine BPM from K sounds looking at falling mercury column Writing answer Thinking and evaluating their answer with correct one Q & A	BHS CDROM video clips Paper for writing answers on	To motivate and inspire incentive in participants of the relevance of an update to them. Self evaluation of their current level of skill
20mins	Factors that affect accuracy Equipment Technique	Talking explaining /lecture Discussion informal assessment knowledge and understanding Q & A	Watching, listening, thinking Questioning, discussing	PP Slides 5-6 BPM equipment to illustrate points	To provide information regarding factors that affect accurate BPM thus developing cognitive skills Providing consistent information and knowledge to help participant assess their own skill against recommended guidelines
7mins	How to conduct a BPM according to guidelines	Operate Equipment to show video clip looking and listening to reactions	Watching, listening, thinking	BHS CDROM video clip on BPM	
10mins	Practical procedure – perform a BPM	Observing, assessing, explaining, Helping, answering questions	In pairs perform a BPM using guidelines just watched. Thinking, doing, talking, watching Listening, questioning,	BPM equipment	Opportunity to practice skill as it should be done consolidation of learning
5 – 10 mins	Sum up Questions Knowledge evaluation questionnaire	Q & A discussion	Writing and thinking Answering	Knowledge evaluation questionnaire	Answers any queries obtain informal views on the session formal evaluation of achievement of intended learning outcomes

APPENDIX 13

PowerPoint presentation for education programme

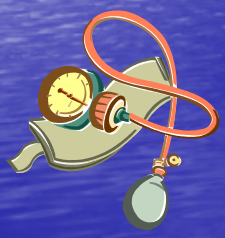
ACCURATE BLOOD PRESSURE MEASUREMENT

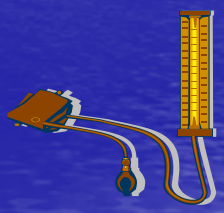
Continuing Education Session
Jacqui Gibson
Senior Midwifery Lecturer UCLAN

CONTENT

- Introduction and background
- Self evaluation
- Factors that affect accurate measurement
- How blood pressure should be measured
- Practical
- Questions and evaluation

AIM AND LEARNING OUTCOMES





BACKGROUND

- 2ND STAGE OF PhD –
  Accurate measurement of blood pressure in pregnancy
- 1ST STAGE - Questionnaire and Equipment audit

FACTORS THAT AFFECT ACCURACY

- Equipment – defects
  - manual/automated
  - maintenance
  - responsibility
- Technique
  - resting
  - position arm/device
  - external influences
  - cuff size

FACTORS THAT AFFECT ACCURACY

- Technique – inflation/deflation
  - terminal digit bias
  - diastolic reading K4/K5

APPENDIX 14

REVISED LESSON PLAN

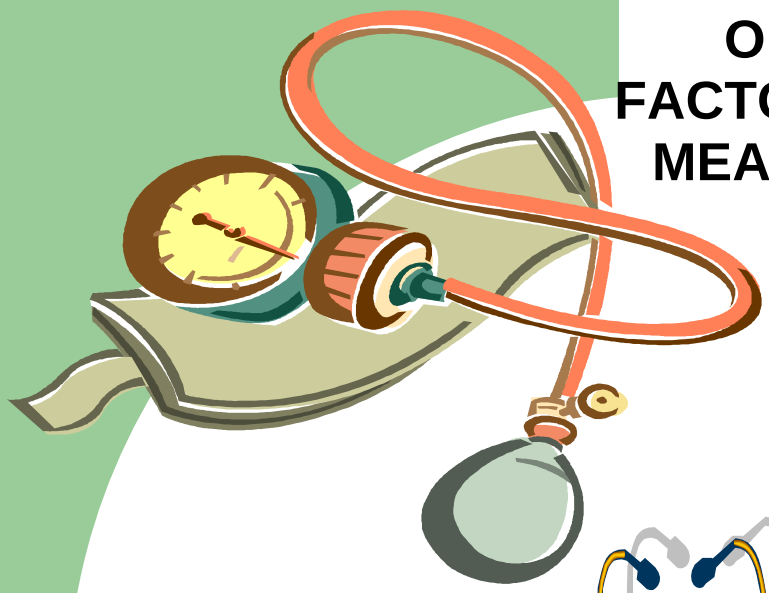
Time	Content	Teacher Activity	Student Activity	Resources	Purpose
5 mins.	Introduction of self Background to study Aim and intended learning outcomes Content of Session	Explaining Talking	Listening and Looking	PP slides 1-4	Set the scent Introduce self and remind of research study. Stat e the purpose of the session topics to be covered – generate initial interest and motivation for attending
15 mins	Student activity – self assessment of skill	Explain activity Operate equipment Listening Looking Questioning Provide answer Informal assessment of participants knowledge and reaction to session	Watching and listening to video clips to determine BPM from K sounds looking at falling mercury column Writing answers Thinking and evaluating their answer with correct one Q & A	BHS CDROM video clips Paper for writing answers on	To motivate and inspire incentive in participants of the relevance of an update to them. Self evaluation of their current level of skill
20 mins	Factors that affect accuracy Equipment Technique	Talking explaining /lecture Discussion informal assessment knowledge and understanding Q & A	Watching, listening, thinking Questioning, discussing	PP Slides 5-6 BPM equipment to illustrate points	To provide information regarding factors that affect accurate BPM thus developing cognitive skills
7mins	How to conduct a BPM according to guidelines	Operate Equipment to show video clip looking and listening to reactions	Watching, listening, thinking	BHS CDROM video clip on BPM	Providing consistent information and knowledge to help participant assess their own skill against recommended guidelines
10mins	BPM – according to guidelines	Facilitating discussion and debate on video just watched Q & A	Thinking, talking, questioning, listening	Teacher resource – knowledge of correct procedure	Allow discussion of beliefs, comparing contrasting existing knowledge with new providing reasons why changes to actions needed.
5 – 10 mins	Sum up Questions Knowledge evaluation questionnaire	Q & A discussion	Writing and thinking Answering	Knowledge evaluation questionnaire	Answers any queries obtain informal views on the session formal evaluation of achievement of intended learning outcomes

APPENDIX 15

FLYER TO ADVERTISE EDUCATION PROGRAMME

TO STAFF

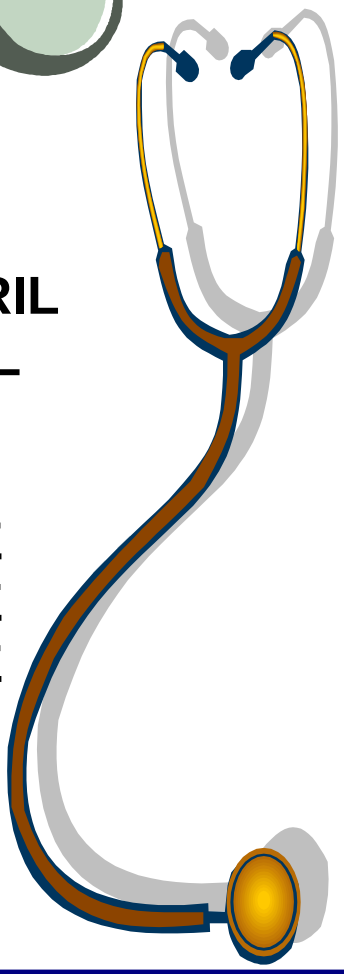
BLOOD PRESSURE MEASUREMENT
UPDATE SESSIONS
ON
FACTORS THAT AFFECT MEASUREMENTS



TIME
13.30– 14.30 pm

DATES

11TH APRRIL
27TH APRIL
18TH MAY
25TH MAY
10TH JUNE
17TH JUNE
20TH JUNE
7TH JULY
14TH JULY



All these sessions will be in the RESOURCE ROOM DELIVERY SUITE

All staff are welcome to attend a session.
(Alternative times can be arranged)
Jacqui Gibson Senior Midwifery Lecturer UCLAN - 01772 893820

APPENDIX 16

KNOWLEDGE QUESTIONNAIRE 1

Red font indicates how the question was asked in practice questionnaire and thus identifies the difference between knowledge and practice questionnaire.

1. What type of devices can be used to measure blood pressure?
What type of device do you normally use to measure blood pressure?

2 How often should the manometer be checked and calibrated?

a. Every month ( )
b. Every 6 months ( )
c. Every 12 months ( )
d. Never ( )
e. Whenever it fails ( )

3 What position should you have the pregnant woman in when measuring her blood pressure?
What position do you usually have the pregnant woman in when measuring her blood pressure?

a. Semi-recumbent ( )
b. Lying flat on her back ( )
c. Lying down on her side ( )
d. Sitting ( )
e. Standing ( )

4. What method should be used to estimate the systolic blood pressure?
What method do you usually use to identify the systolic blood pressure?

a. Palpation of the radial pulse ( )
b. Identifying the first Korotkoff sound ( )
c Palpation of the brachial pulse ( )

5 What method should be used to identify the diastolic blood pressure?
What method do you usually use to identify the diastolic blood pressure?

a. Identifying the fourth Korotkoff sound ( )

b. Identifying the fifth Korotkoff sound ( )

c. Another method please state
_____ ( )

6 How much of the arm circumference should the bladder cuff cover ?

a. 100 % ( )
b. 80 % ( )
c. 50 % ( )
e. 20% ( )
f. Don't know ( )

7. At what rate should you deflate the cuff?
At what rate do you deflate the cuff?

a. In time with the woman's heart beat ( )
b. Quite fast ( )
c. 2-3mmHg per second ( )
d. 5-10mmHg per second ( )

8. How long should the woman rest before having her blood pressure measured?
Do you usually have the woman resting before having her blood pressure measured?

a. 5 minutes ( )
b. 1 minute ( )
c. it does not matter ( )
d. Only after taking a high reading and before Rechecking the reading ( )

9. Before taking a blood pressure measurement how much time should be allowed to elapse after the woman has

a. smoked a cigarette _____

b. eaten a meal _____

c. exercised _____

d. drunk a cup of coffee _____

10. The measurement should be taken to the nearest
Do you usually round the pressure reading?

a. 5mmHg ( )
b. 10mmHg ( )
c. 2mmHg ( )
d. 1mmHg ( )
e. to the nearest 0mmHg ( )

11. Which arm can you normally take a blood pressure reading from?
Which arm do you normally take a blood pressure reading from?

a. right arm ( )
b. left arm ( )
c. either arm ( )

12. Does arm position affect blood pressure readings
New question

13 List some other factors that can affect the accuracy of a blood pressure measurement.
New question

APPENDIX 17

KNOWLEDGE QUESTIONNAIRE 2 AND COVERING LETTER

Dear Colleague

I am a Midwifery Lecturer at Liverpool John Moores University School of Health and Human Sciences. I am currently conducting a research study as part of a PhD at LJMU on the measurement of blood pressure.

The study is in its second stage and to ascertain if the continuing education programme has had any impact, I am distributing a similar questionnaire to the one you kindly completed previously at the end of the education session.

I would be grateful if you could spare ten minutes to complete and return this questionnaire in the envelope provided as soon as possible or by ……..
Your contribution has been very valuable to the research and the completion of this questionnaire will ensure that the study can be completed and the findings will help to inform practice.

Confidentiality is assured. The envelope is coded to enable me to follow up any not returned. Anonymity is assured only the researcher will have access to the codes, and they will be stored in a locked cabinet and destroyed as soon as they are no longer required. At no stage would individual responses be divulged to a third person. Staff who agree to participate can withdraw at any time and whatever information is given will have no effect on your employment.

Thank you for your help in completing this.

With best wishes

Jacqui Gibson

QUESTIONNAIRE **(Demographic questions returned to questionnaire)**

For each question please either tick the most appropriate box that is relevant to you or fill in the spaces that have been left blank.

1. Gender: Male ( ) Female ( )

2. Age: 19- 25 ( ) 26-35 ( ) 36 –45 ( ) 46 –55 ( ) >56 ( )

3. Please complete table as appropriate

Please state your Professional qualifications or indicate if you are a student midwife	Number of years qualified or Date of qualification (if student year of study)	Number of years performed Blood Pressure measurements.

4. How often should the manometers be calibrated?

Timing of calibration	Mercury	Aneroid	Electronic /Digital
Every month			
Every 6 months			
Every 12 months			
Never			
Whenever it fails			
Don't know			

5. What position should you have the pregnant woman in when measuring her blood pressure?

a. Semi-recumbent ( )
b. Lying flat on her back ( )
c. Lying down on her side ( )
d. Sitting ( )
e. Standing ( )

6. What method should be used to estimate the systolic blood pressure?

a. Palpation of the radial pulse ( )
b. Identifying the first Korotkoff sound ( )
(the first appearance of clear sounds)
c. Another method ( )

please state _____

7. What method should be used to identify the diastolic blood pressure?

a. Identifying the fourth Korotkoff sound (that is the muffling of sound heard through the stethoscope during cuff deflation) ( )

b. Identifying the fifth Korotkoff sound (that is the final disappearance of sound heard through the stethoscope during cuff deflation) ( )

c. Another method please state_____ ( )

8. How much of the arm circumference should the bladder cuff cover ?

a. 100 % ( )
b. 80 % ( )
c. 50 % ( )
e. 20% ( )
f. Don't know ( )

9. At what rate should you deflate the cuff?

a. In time with the woman's heart beat ( )
b. Quite fast I don't measure the rate ( )
c. 2-3mmHg per second ( )
d. 5-10mmHg per second ( )

10. How long should the woman rest before having her blood pressure measured?

a. Yes for 5 minutes ( )
b. Yes for 1 minute ( )
c. No, it does not matter ( )
d. No, there is no time available ( )
e. Only after taking a high reading and before Rechecking the reading ( )

11. Before taking a blood pressure measurement how much time should be allowed to elapse after the woman has

a. smoked a cigarette _____

b. eaten a meal _____

c. exercised _____

d. drunk a cup of coffee _____

e. Don't know ( )

12. The measurements should be taken to the nearest

a. to the nearest 5mmHg ( )
b. to the nearest 10mmHg ( )
c. to the nearest 2mmHg ( )
d. to the nearest 1mmHg ( )
e. to the nearest 0mmHg ( )

13 Which arm can you take a blood pressure reading from?

a. right arm ( )
b. left arm ( )
c. either arm ( )

14. Regarding arm position, which is correct?

a. If the arm is raised, blood pressure increases ( )
b. If the arm is lowered blood pressure decreases ( )
c. If the arm is raised, blood pressure decreases ( )
d.The arm position does not affect blood pressure readings ( )

15. Can you list any other factors that can affect the accuracy of a blood pressure measurement.

Thank you for your co-operation in completing the questionnaire. If you have any comments you would like to make please feel free to add them below. Your contribution to the survey is greatly appreciated and valued.

APPENDIX 18

Follow up letter for non-respondents

Knowledge Questionnaire 2

Dear

A few weeks ago you should have received a questionnaire from me, just in case you did not, or have misplaced it, or have forgotten, or you may feel you have left it too late to reply, I am sending you another one in the hope that you could spare 5 minutes to complete and return it to me in the enclosed envelope. I have received some replies but not enough to make a true evaluation of the project. I do need more people to complete this questionnaire in order for the study to be evaluated properly and the findings can then be used to inform practice. I do hope you will be able to help me and I appreciate you have many calls upon your time. Your contribution so far has been very valuable to the research project and I would like to thank you for your help so far and hope you will be able to contribute to this stage of the project.

Confidentiality is assured. The envelope is coded to enable me to follow up any not returned. Your questionnaire response is totally anonymous and whatever information is given will have no effect on your employment.

Thank you for your help in completing this.

With best wishes

Jacqui Gibson

APPENDIX 19

PARTICIPANT FEEDBACK QUESTIONNAIRE and

COVERING LETTER

Dear

It is now several weeks since you attended the update session on blood pressure measurement. Having had some time to reflect on the session and its relevance to your clinical practice, I would be grateful if you could spare me the time to complete the enclosed evaluation questions and return to me in the envelope provided within the next two weeks.

The information you will provide, forms an important aspect of the final stages of the research project and therefore, it is essential as many people as possible reply. Your contribution has been very valuable to the research and the completion of this questionnaire will ensure that the study can be completed and the findings will help to inform practice.

Thank you for your help in completing this.

With best wishes

Jacqui Gibson

1. Prior to attending the update session have you ever undertaken or had any update on blood pressure measurement

NO

YES If yes what form did this take

Self directed study on the topic i.e. books, journals, internet

Attendance at a specified teaching session on blood pressure

Other please identify

2. Did you find the update session on blood pressure useful?

YES

NO

PARTLY

3. Was the session length

About the right length

Too long

Too short

4. What did you like best about the session

5. What did you like the least about the session

6. Since attending the session have you changed any aspects of your clinical practice ?

NO (please expand with some comments)

YES (please expand to describe what aspects you have changed or introduced into your practice and WHY)

APPENDIX 20

Proforma for assessing competency in

Blood pressure measurement with a manual device

BLOOD PRESSURE MEASUREMENT - MANUAL EQUIPMENT

Competency Statement

On completion of this assessment the participant will be able to demonstrate the clinical and theoretical safety aspects of the practical use of a manual blood pressure monitor.

Performance Criteria

By the end of the assessment the practitioner will be able to:	Attained	Referred
1. State the clinical application of the device.		
2. Explain the safety checks and precautions to be observed prior to use		
3. Identify appropriate equipment needed for use with the device		
4. Check the condition of the equipment		
5. Demonstrate understanding of the action required in event of equipment fault		
6. Access client history		
7. Demonstrate correct position of client		
8. Demonstrate how to assess cuff size required		
9. Demonstrate how to apply cuff properly		

Attained Referred

10. Demonstrate how to estimate systolic pressure

11. Demonstrate how to conduct a Blood Pressure measurement according to current guidelines

12. Identify factors that can affect accurate measurement

13. Demonstrate knowledge of professional and vicarious liability

Assessment Completed By: …… (Sign & Print Name – Trainer)

Practitioner: …….. (Sign & Print Name – Mentee)

Date of Assessment ……. Location …… Review Date……

If referred -date of Re-Assessment ……..

APPENDIX 21

Proforma for assessing competency in

Blood pressure measurement with an electronic device

BLOOD PRESSURE MEASUREMENT – ELECTRONIC EQUIPMENT

Competency Statement
On completion of this assessment the participant will be able to demonstrate the clinical and theoretical safety aspects of the practical use of an electronic blood pressure monitor.

Performance Criteria
By the end of the assessment the practitioner will be able to: Attained Referred

1. State the clinical application of the device.
2. Explain the safety checks and precautions to be observed prior to use
3. Identify appropriate equipment needed for use with the device
4. Check the condition of the equipment
5. Demonstrate understanding of the action required in event of equipment fault
6. Access client history
7. Demonstrate correct position of client
8. Demonstrate how to assess cuff size required
9. Demonstrate how to apply cuff properly

Attained Referred

10. Demonstrate how switch machine on and the function of all keys
11. Demonstrate how start a blood pressure reading
12. Demonstrate how to set machine to conduct repeated reading at intervals
13. Explain information displayed on front of machine
14. Demonstrate how to switch machine off
15. Identify factors that can affect accurate measurement
16. Demonstrate knowledge of professional and vicarious liability

Assessment Completed By: …… (Sign & Print Name – Trainer)

Practitioner: …… (Sign & Print Name – Mentee)

Date of Assessment ……. Location …… Review Date…….

If referred -date of Re-Assessment ……..