Analysing the technique of blood pressure measurement in primary care: a single centre pilot study

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Declaration

I, **Dr. Etonu Joseph**, hereby declare that the work on which this thesis is based is my original work (except where acknowledgements indicate otherwise) and that neither the whole work nor any part of it has been, is being, or is to be submitted for another degree in this or any other university. I authorise the University to reproduce for the purpose of research either the whole or any portion of the contents in any manner whatsoever. I further declare the following:

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Abstract

Analysing the technique of blood pressure measurement in primary care: a single centre pilot study

Background: Accurate blood pressure (BP) measurement is essential for the diagnosis and management of hypertension. However, BP measurement technique is often suboptimal in primary healthcare facilities, potentially leading to misdiagnosis and inappropriate management.

Objective: To assess the quality of BP measurement technique in a primary healthcare facility in the Western Cape, South Africa, and to identify factors that may affect the accuracy of BP recordings.

Methods: A cross-sectional study was conducted using a questionnaire and clinical point of care audit to assess the knowledge and skills of healthcare workers involved in BP measurement. Digital BP machines were also audited for calibration and cuff size appropriateness. BP measurements were observed for 102 patients to audit the technique of BP measurement and compared to measurements obtained by the research team using a pre-validated, standardised technique.

Results: Knowledge of BP measurement was adequate (>60% on knowledge quiz) amongst 72% of doctors, and inadequate (<60% on knowledge quiz) amongst 81% of nurses. We found widespread use of improper BP cuff sizes and non-calibrated digital BP machines. The use of digital BP machines produced significantly higher systolic BP readings than manual readings (145.0 vs 141.1; p=0.031), with non-significant differences in diastolic and mean arterial pressures.

Conclusion: This study successfully piloted a novel method of assessing BP measurement technique, and identified several factors that could influence measurement outcomes, potentially impacting on clinical care. Recommendations for further research and targeted staff training are suggested.

Publication-ready manuscript

Title: Analysing the technique of blood pressure measurement in primary care: a single centre pilot study

Introduction and literature review

Hypertension is a significant contributor to ill health, causing an estimated 9.4 million deaths globally each year and being responsible for more than half of the 17% deaths attributable to cardiovascular disease.[1] In the United States in 2018, hypertension was a primary or contributing cause of 494,837 deaths,[2] with an estimated cost of 131 billion dollars annually. Approximately 30% of the adult population in South Africa have hypertension, posing a significant burden to patients' families, the healthcare system, and the economy [3].

Accurate measurement of blood pressure (BP) is crucial for hypertension assessment and management. However, BP measured only once in a clinical setting may not accurately represent a patient's BP over 24 hours. Despite this limitation, office BP readings are still the primary driver of hypertension management decisions in primary care.[4] Given the high patient burden in primary care and the time-pressure that staff operate under, it is important to ensure that BP measurement at the clinic level is accurate .

The prevalence of non-communicable diseases (NCDs) including hypertension, cardiovascular disease, chronic respiratory disease, and cancers is on the rise globally. Raised BP remains the leading cause of death worldwide, accounting for 9.4 million deaths per year from 1990-2010, and it is estimated that currently up to 1.39 billion people were hypertensive in 2010. Over the past four decades, the highest levels of hypertension worldwide have shifted from high-income countries to middle- and lower-income countries.[2] The African region has the highest prevalence of hypertension, with approximately 46% of adults aged 25 years and older being hypertensive. South Africa has the highest prevalence of hypertension in sub-Saharan Africa, with an overall prevalence of 30%.[5] The morbidity and mortality of hypertension are due to target organ damage and subsequent neurovascular, cardiovascular, and renal disease. Optimal management of patients with hypertension is dependent on accurate measurement of blood pressure together with overall risk assessment and effectively managing co-morbid conditions [6].

In most South African primary health care facilities, the method used to measure blood pressure is the office blood pressure measurement (OBPM). OBPM mainly uses two devices, the automated electronic digital BP device and the manual blood pressure device (aneroid or mercury sphygmomanometers). Manual BP measurements are mainly used in the clinician's office to confirm abnormal BP readings, while nurse-run preparation rooms usually use digital devices [7]. OBPM has strict guidelines, [89] with several factors needing consideration, such as white coat hypertension, measuring while talking, and measuring BP of the patient with a full bladder. Ambulatory hypertension is known to have worse long-term outcomes than white coat hypertension because it is difficult to detect. These kinds of patients present with normal office BPs but have elevated BP elsewhere, resulting in under-treatment of their hypertension. They are known to have a higher risk of target organ damage than truly normotensive patients.[10]

In addition to the patient-related factors of white-coat and ambulatory hypertension, BP measurements are also confounded by the knowledge levels of BP measurement technique, actual measurement practice and equipment used by primary care practitioners (PCPs). A study by Du Toit, in a South African private hospital, found out that there was a deficit in the knowledge of the nurses that were involved in the blood pressure management.[11] A similar finding is reported in Spanish (43% of healthcare workers had adequate knowledge of BP measurement technique) and Nigerian (26.3% had adequate knowledge of technique) studies.[12] [13] These findings might be attributed to some healthcare professionals lack of knowledge in BP measurement techniques.

Proper calibration of blood pressure equipment is crucial for accurate measurements. A study conducted in the United States found that only 45% of blood pressure cuffs used in primary care clinics were calibrated correctly.[14] The Nigerian study cited above found that only 16.8% of blood pressure cuffs used in primary care settings were regularly calibrated. These findings suggest that there is a need for regular equipment calibration in primary care settings to ensure accurate blood pressure measurements. A study conducted in South Africa which investigated the use of automated blood pressure monitors in primary healthcare settings, found that while automated monitors were available in some clinics, they were not always used correctly,

noting that proper training on the use of these monitors and regular calibration is necessary for accurate blood pressure measurement.[15] It is also suggested that automated monitors tend to overestimate blood pressure compared to mercury sphygmomanometers.[13] Choice of BP measuring device and correct care of this device is therefore another essential component of high quality BP measurement technique.

When using mercury sphygmomanometers in primary healthcare settings, a Tanzanian study found that only 26% of healthcare professionals had received training on the proper use of the equipment, and that the majority did not follow the recommended technique for blood pressure measurement.[16] Hence, the author recommended for training and regular calibration of equipment in order to improve the accuracy of blood pressure measurements. The above studies clearly indicated the value of utilizing proper training and regular calibration of blood pressure equipment in primary healthcare settings in order to ensure accurate measurements.

The frequency of blood pressure measurement in primary care settings can vary widely. For example, in a study conducted in USA, found that the average number of blood pressure measurements per patient visit was 2 [17]. On the other hand, the study done by Okaka et al in Nigeria found that only 27.7% of patients had their blood pressure measured during a routine clinic visit.[18]

Regular monitoring of blood pressure is important in the management of hypertension, as it provides information on BP control and response to therapy. According to Harris et al., the frequency of BP measurement in primary healthcare facilities varies depending on the facility, patient population, and healthcare provider practices.[19] In Nigeria, it was found that the majority of hypertensive patients did not have their BP measured at the recommended intervals, with only 37.9% having their recorded measurements during a six month period.[13] This lack of regular BP monitoring was due to a lack of awareness of the importance of regular monitoring and the cost of accessing healthcare services. It has been shown that patients who had their blood pressure checked at least four times a year were more likely to have their blood pressure controlled than those who had their blood pressure checked less frequently.[20] Yet in primary care, providers measured blood pressure only once per year in 82% of patients with hypertension.[21]

The American Heart Association (AHA) recommends that blood pressure should be measured at least once every six months for individuals with a systolic blood pressure of less than 120 mmHg and a diastolic blood pressure of less than 80 mmHg.[22] For individuals with a systolic blood pressure of 120-129 mmHg or a diastolic blood pressure of 80-89 mmHg, blood pressure should be measured at least once every three to six months, while those with a systolic blood pressure of 130 mmHg or higher or a diastolic blood pressure of 90 mmHg or higher should have their blood pressure measured at least once every month until it is controlled.[22]

In a South African study, it was found that BP was checked at least once a year in 84% of patients attending primary healthcare clinics.[23] The recommended frequency of BP measurement in patients with hypertension is at least once every six months. It is therefore important for the primary healthcare facility in Western Cape to adhere to the frequency of blood pressure measurement as this will help in identifying potential gaps in the management of hypertension[17].

The American Heart Association and the European Society of Hypertension have published guidelines for accurate BP measurement techniques[2425]. However, some studies have shown that those guidelines are not always followed in clinical practice. For example, in a study done in Spain, reported that only 29% of healthcare professionals adhered to the recommended guidelines for blood pressure measurement[12]. In a separate study conducted in Nigeria, reported that only 32.6% of healthcare professionals used the correct technique for blood pressure measurement,[13] with similar findings in Ghana[26] and India[27]. Common problems identified in these studies were inappropriate cuff size, failure to measure blood pressure in both arms, and failure to use a standardized protocol. Other factors such as anxiety and stress can also lead to inaccurate blood pressure measurements.[5]A South African study found that the lack of training and inadequate resources were contributing factors to inaccurate blood pressure measurement in primary healthcare facilities. [5] The study suggests a need for further research to examine the factors that contribute to inaccurate blood pressure measurement in primary health care facilities.

Given the high prevalence of hypertension in primary care and the concomitant burden of disease of complicated hypertension, the relative paucity in the literature on BP measurement technique in primary care, and the need to develop targeted quality improvement interventions, this study was conceptualised as a pilot

study using a novel methodology to quantify the quality of BP measurement in primary care. The primary outcome describes the knowledge of PCP's (Primary Care workers, the Doctors and nurses) proper blood pressure (BP) measurement techniques in the primary care setting, which will help in identifying potential gaps and develop targeted quality improvement interventions to enhance BP measurement practices in primary care. To achieve this aim, the following objectives were set:

AIMS AND OBJECTIVES

1. To assess the knowledge of PCPs in performing accurate blood pressure measurement as per the current guidelines.
2. To evaluate the equipment used for blood pressure measurement and its calibration status.
3. To audit the current practice of blood pressure measurement by PCPs in the selected primary care facility.
4. To compare the standard blood pressure measurements with those taken by the research team to determine the accuracy of blood pressure measurement performed by PCPs.

Research Methods

This study was conceptualized as a descriptive, cross sectional, single center study with an audit component. The primary health facility selected for the study whose name was withheld for confidential purposes, is strategically located in the Cape Town Metro. The choice of this particular facility was based on several key factors that ensure the feasibility and relevance of the research, some of which included its presence in the Cape Metro, its being a Community Primary Health care facility, the availability of patients being managed for hypertension as further explained below.

The Cape Metro has a substantial population of approximately 4.2 million people,[28] with a significant proportion (about 75-80%) lacking medical insurance. Consequently, these individuals rely on free access public health facilities for their healthcare needs. By conducting the study in a primary health facility catering to this demographic, we aim to investigate and assess blood pressure (BP) measurement practices in a population that faces unique challenges in accessing medical care.

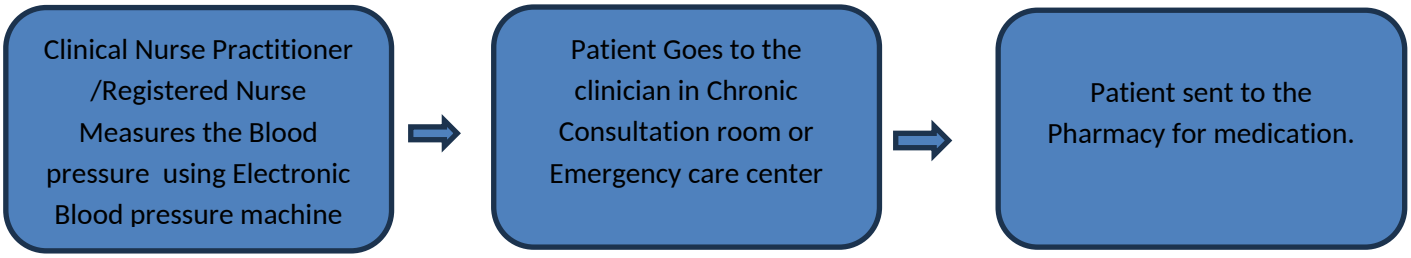
Furthermore, the study site offers the advantage of a variable number of patients visiting daily. Despite this variability, all patients follow similar patient flow pathways when requiring BP measurements. This uniformity allows us to observe and evaluate BP measurement techniques under consistent conditions, enhancing the internal validity of our findings.

While we acknowledge that conveniently selecting the study site may have limitations in terms of generalizability, the practicality and accessibility of this primary health facility makes it an ideal setting for investigating the research questions and achieving the study's objectives effectively.

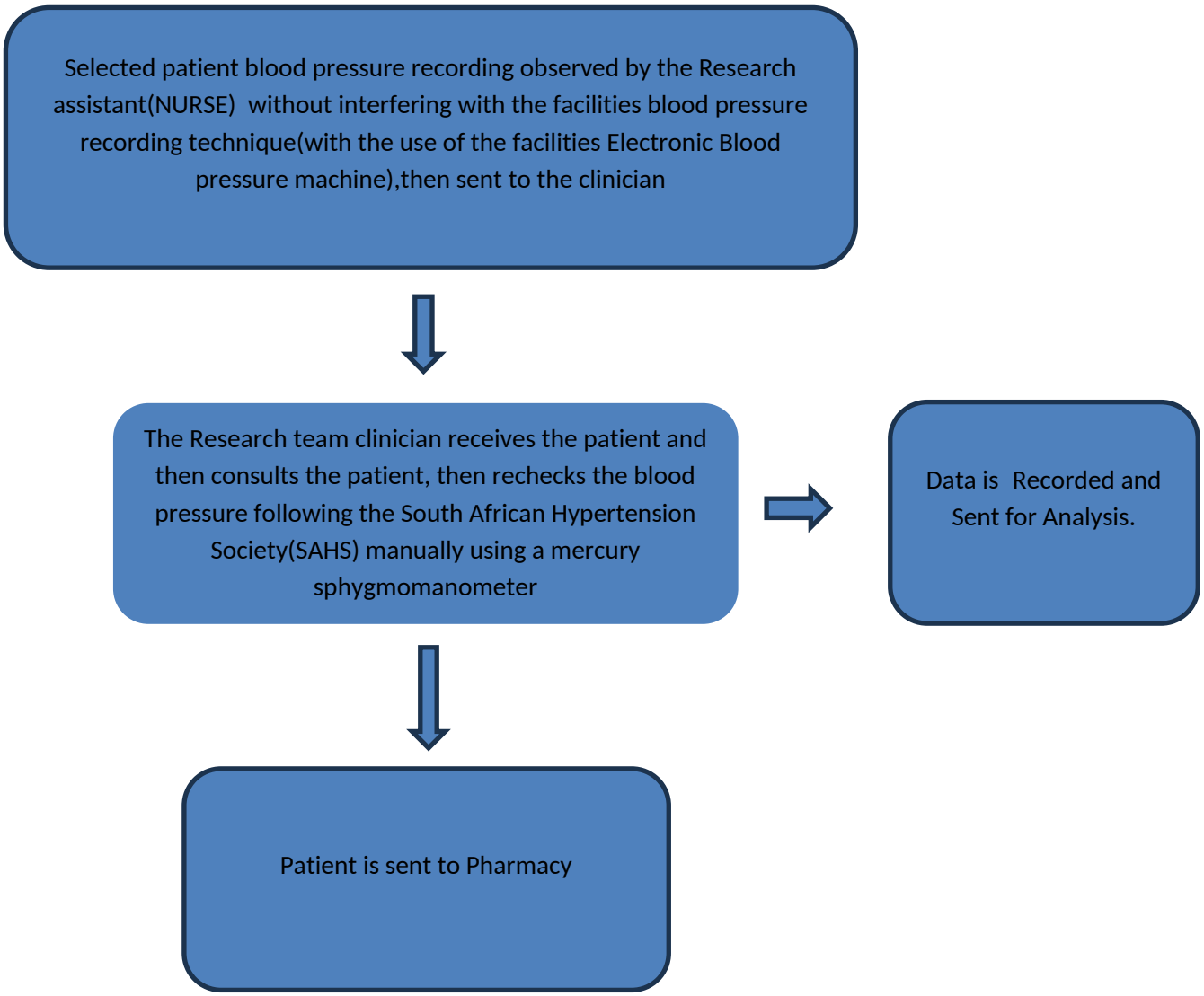
The current practice in BP measurement at this facility involves a qualified nurse, specifically a Registered Nurse (RN), who is responsible for measuring the vital signs (heart rate, blood pressure, respiratory rate, temperature) in addition to other concomitant important presenting signs and point-of-care tests. These tests may include electrocardiograph (ECG) recordings, urinalysis, and finger prick hemoglobin or glucose recordings. All of these assessments are conducted in a designated area commonly referred to as the 'preparation room'. Once these measurements and tests are completed, the patient proceeds to the prescribing clinician located in the chronic disease area or the emergency care area, who is either a doctor or a clinical nurse practitioner (CNP). The prescribing clinician interprets the gathered data and proceeds with appropriate actions based on the findings.

For this audit, the team composed of the nurse at the Prep room who selected the patients, that fitted the criteria of the study and completed the process of recording the blood pressure using an electronic blood pressure monitor and the patients were then sent to the research medical officer (as previously described) who measured the blood pressure in a standardized manner, using a mercury sphygmomanometer, in a private consultation room. The decision to use a mercury sphygmomanometer was used on the basis that it still remains the most accurate way of blood pressure measurement when the proper technique is used. [313]

Facility flow of patients observed and conceptual framework.



The research team flow of patients.



Study Population and Sampling

The study population comprised two cohorts: the health care workers involved in measuring, interpreting and responding to BP readings (registered nurses, nurse practitioners and doctors); and patients living with hypertension.

The facility from which the patients were selected treats up to 17500 patients per month.[30] according to facility data,[30] for the years of 2019 and 2020, the number of hypertensive patients seen were 2578 and 2564 respectively.

Inclusion criteria:

1. All health workers (doctors and nurses) directly involved in BP measurement, interpretation and prescription.
2. All hypertensive patients who attended the clinic for BP recording on the days of data collection.

Exclusion criteria:

1. Staff who refuse to consent.
2. Staff who are absent on the day of data collection
3. Patients with HPT refusing to be part of the study.
4. Patients unable to give informed consent due to cognitive impairment

Sampling

Staff were recruited using a purposive sampling technique, ensuring that individuals meeting the specified criteria were deliberately chosen to participate in the research.

Regarding patient recruitment for the audit component of the study, a systematic random sampling technique was used, wherein the first patient was randomly chosen, and then every third patient thereafter was included in the sample. Patients selected were all hypertensive patients of all age ranges who came to the facility for care as described before.

The day of the week for data collection was conveniently chosen based on the availability of the research team.

Sample Size

The full cohort of staff meeting the inclusion criteria was included in the study. It was estimated that a sample of twenty-five (n=25) staff members who utilise the blood pressure machines and use the readings, would be a realistic sample. This was based on the manager's estimate of the number of staff available on any given day.

A sample size of one hundred patients (n=100) was determined for the audit component of the study.[31] We determined this sample size from a pre-calculated table describing the number of observations required at a single service point to make a reliable observation about the activity. To provide a reliability co-efficient of 0.95 (95%) and estimating a co-efficient of 0.3 with one observation, a sample size forty-four (n=44) observations would be needed. We opted for a much larger sample size to ensure that we (at least) met this level of reliability. This is appropriate for audit methodology, as the intention is not to generate a representative sample of hypertensive patients, but rather to reflect the practice of the clinical staff at a particular point in the clinic.

Confounders Considered:

Several potential confounders were identified during the study, which could influence the BP measurements and the outcomes of interest. These confounders were carefully considered to minimize their impact on the study results, and they included:

White Coat Effect: To mitigate this, the research team implemented measures to create a calm and supportive environment during data collection. Patients were reassured, and measurements were taken in a quiet area to reduce anxiety.

Cuff Size: The use of an incorrectly sized BP cuff can lead to inaccurate readings. To address this, both the research team and the clinic staff were trained and provided with appropriate-sized cuffs based on patients' arm circumferences.

Patient Position: The position of the patient during BP measurement can affect the readings. The research team and the clinic staff were instructed to follow the guidelines and ensure that patients were in a seated position with their feet flat on the floor, their back supported during

measurements and the arm supported at the level of the heart.

Data Collection and Analysis

A set of study tools were developed which are detailed below. Face and content validity was established by using the Southern African Hypertension Society (SAHS) guideline[3] and the American Heart Association (AHA) hypertension guidelines[32] as the base documents, and thereafter scrutinised by a panel of five family physicians experienced in primary care. Additionally, a pilot study was conducted to test the construct of the tools. There were no suggested modifications to the study tools after the pilot study. Pilot data was not included in the main study.

1. A tool (Appendix A) was used, which consisted of a self-administered, paper-based multiple-choice question (MCQ) quiz designed to measure knowledge related to BP measurement with most of the questions derived from the SAHS and AHA guidelines. Prior to administering the questionnaires, it was validated by an expert panel of five consultant family physicians for accuracy and consistency. On the day of administration of the MCQ, the researcher explained to participants what the study was about and how they would benefit from the results after interpretation. Participants then answered the quiz in hardcopy and were given an unlimited amount of time to complete it. The average time taken was twenty-five minutes.

   A total of 27 questionnaires, was given to available 27 staff members available at the staff meetings, N=11(eleven doctors) and N=16(sixteen Nurses). The completed questionnaires were cross-checked immediately after filling for completeness by the researcher. All questionnaires received unique study codes, and identifying characteristics were removed before entering the data onto a Microsoft Excel spreadsheet. Results were analysed descriptively and presented as percentages of the total possible score. Scores were reported for individuals, per staff category (nurses or doctors) and as a whole group. Scores of less than 60% were deemed inadequate, 60-75% were considered acceptable, and scores greater than 75% were deemed good.
2. An audit tool (Appendix B) to assess the services using a Donabedian approach as follows:

a. Structural indicators: the availability of the equipment, a quiet prep room and standard operating procedures; documentation on calibration and maintenance of the equipment.
b. Process indicators: BP measuring technique using an observation tool validated against the SAHS guideline.

3. Outcome indicators: The clinic-measured BP of participating patients was compared to measurements recorded by the research team using a mercury sphygmomanometer and strict application of the technique recommended by the SAHS guideline (Appendix C). The technique of the doctor performing this measurement was validated by two independent family physician consultants who were unrelated to this study. All BP values were entered into a Microsoft excel sheet and subsequently analysed by a statistician to produce descriptive data, including means with confidence intervals and proportion tables. Additionally, analysis of variance (ANOVA) was conducted, with $p<0.05$ indicating statistical significance.

Ethical considerations

Ethics approval to conduct the study was granted by the UCT Human Research Ethics Committee (HREC REF: 353/2022). Permission and access to conduct the study in the Cape Metropolitan area were obtained from relevant managers via the national health research database [33]. The study was in alignment with the Declaration of Helsinki. Each participant agreed voluntarily to participate and signed an informed consent form before being enrolled in the study and were assured of a no-risk right to exit at any time. Data collected was anonymised before being recorded in digital format. All hardcopies were stored in a locked cupboard that is placed in an office with access-control.

This study will provide a baseline for a quality improvement project for the pilot facility, and all findings have already been shared anonymously with the relevant clinicians.

RESULTS AND FIDINGS

Knowledge Scores

Twenty-seven (N=27) staff members participated in this phase of the study. Eleven were doctors (N=11) and sixteen were nurses (N=16). The MCQ, detailed in Table 1, produced an average score of 55.5% for the total cohort. Doctors had an average score of 66%, while nurses had an average score of 48% (Figure A). As per the pre-defined categories (>75%=good; >60%=adequate; <60%=inadequate), the score of doctors was deemed adequate and the nurses inadequate. Among the nursing staff, none scored a mark higher than 75%, and 81% of them scored an inadequate mark (<60%). One doctor scored above 75%, while most of the doctors (8/11) scored above 60%, with 2/11 scoring less than 60%. Table 1 as indicated below, provides further details on individual question scores, and a comparison between the nursing and doctor cohorts.

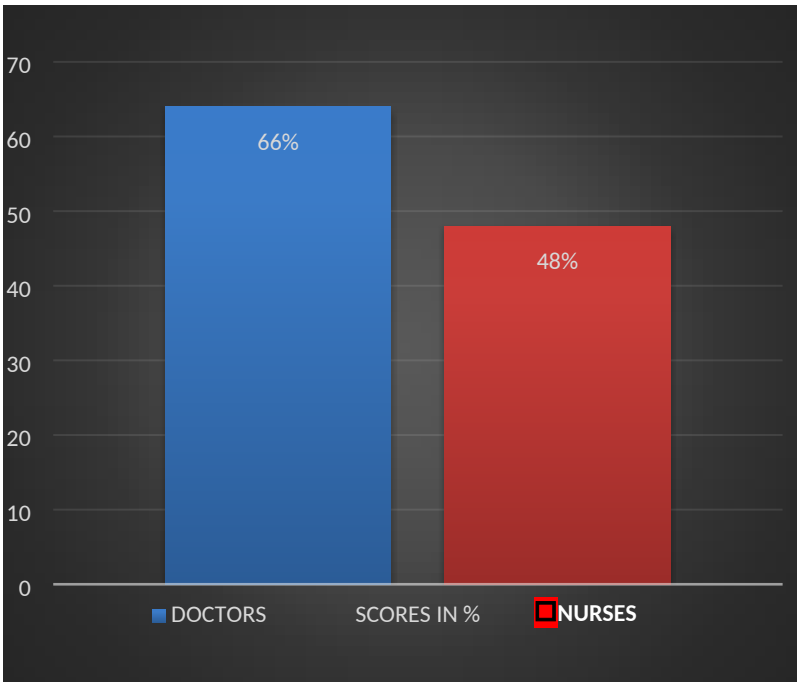


Figure A. Average Test Score of both Nurses and Doctors.

Table 1. Knowledge Scores among Doctors and Nurses

		Total (N=27)		Doctors (n = 11)		Nurses (n = 16)	
	Overall scores		***55.5***		***66***		***48***
1	Which do you think is the most accurate manometer?	23	*85.2*	10	*90.9*	13	*81.3*
2	How often should the digital manometer be calibrated?	13	*48*	5	*45.5*	8	*50*
3	How many times should blood pressure be measured on the first visit?	13	*48*	7	*63.6*	6	*37.5*
4	What arm should be used to take blood pressure?	16	*59*	7	*63.6*	10	*62.5*
5	In what position should blood pressure be taken?	24	*89*	11	*100*	13	*81.3*
6	What determines systolic blood pressure?	23	*85*	10	*90.9*	13	*81.3*
7	What determines diastolic blood pressure?	22	*81*	9	*81.8*	13	*81.3*
8	If a standard adult cuff (12-cm) is used in a very obese adult patient, you would expect the blood pressure results to be:	21	*78*	10	*90.9*	11	*68.8*
9	The main reason why the radial pulse (systolic palpable pressure) should be measured is	6	*22*	5	*45.5*	1	*6.3*
10	Regarding arm position, which is correct?	8	*30*	7	*63.6*	0	*0*
11	Before taking the Blood pressure, the patient should be allowed to sit for;	6	*22*	2	*18.2*	1	*6.3*
12	At initial consultation it is advised to measure the blood pressure in both arms if discrepant	4	*15*	1	*9.1*	1	*6.3*
13	When measuring the blood pressure which one of the following actions is most likely going to affect the blood pressure readings.	20	*74*	7	*63.6*	9	*56.3*
14	When measuring the blood pressure, it is important that	14	*52*	8	*72.7*	6	*37.5*
15	When measuring the blood pressure of an elderly patient (over 65yrs) it is important to	11	*41*	7	*63.6*	3	*18.8*

The structural and process components of the audit revealed significant deficiencies in various clinical areas (Table 2). Regarding structural indicators, notable issues were the absence of a guideline in the clinical space, lack of calibration of the digital BP devices, absence of functional manual BP machines and the unavailability of a quiet area for BP measurements. The chronic care area, servicing the largest number of hypertensive patients, did not have an appropriately sized arm cuff for obese patients.

In terms of process indicators, there was generally poor compliance with key elements of the measurement technique. The chronic care unit satisfied one of the six indicators, while the maternity unit was most compliant. Overall, the chronic care unit was least compliant with the guidelines (10%), followed by the emergency unit (30%) and the maternity unit (78%).

Table 2: Structural and process indicators of BP measurement

	CHRONIC CLINIC	**EMERGENCY UNIT**	**MATERNITY UNIT**
STRUCTURAL INDICATORS			
BP Guideline available	0	0	1
BP machine calibrated	0	0	0
Different cuff sizes available	0	1	1
Quiet area	0	0	0
Availability of functional manual blood pressure machines	0	0	1
PROCESS INDICATORS			
Patient emptied bladder	0	1	1
Correct cuff size used	0	0	1
Back supported	1	1	1
Arm supported	0	0	1
Age >65yrs, BP sitting and standing	0	0	N/A
Opposite arm also measured	0	0	1
Compliance with guideline	1/10 (10%)	3/10 (30%)	7/9 (78%)
Key: Observed = 1; Not observed = 0; N/A = not applicable			

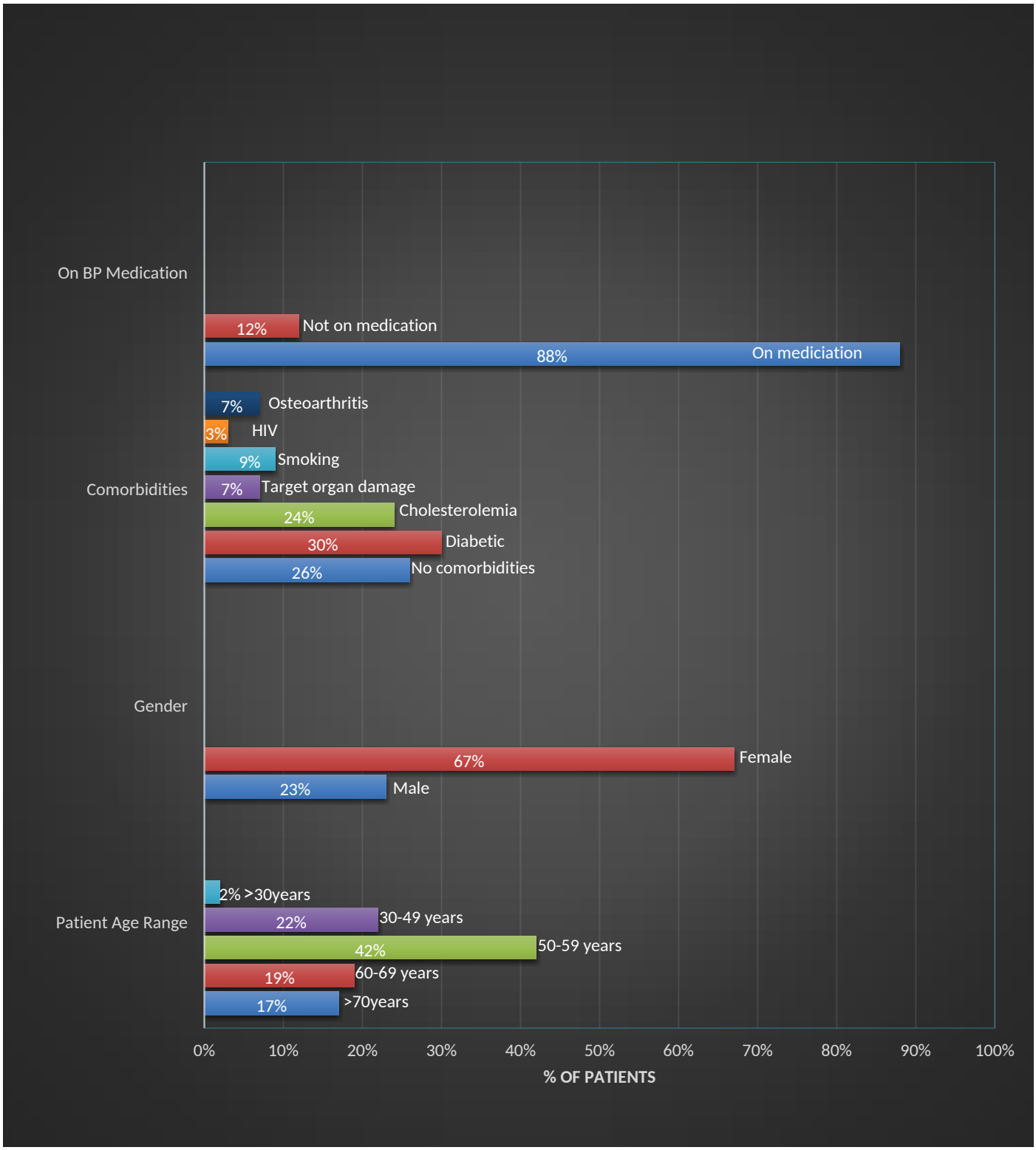


Figure B: Demographic Data of The Patients That Participated in The Study

One hundred and two patients (N=102) were recruited into the study, exceeding the targeted sample by two. Blood pressure recordings were taken from all of these 102 participants. The age distribution of this cohort showed that 19% fell into the 60-69 years category, followed by 42% in the 50-59 years category, 17% >70years, 22% were aged 30-49 years, and 1% <30 years. Patients were on average 56.6 years old (SD = 12.6 years), ranging from 21 to 86 years of age. Sixty seven percent (67%) were female, and twenty three percent were male (23%). 74% of patients had comorbidities (30% were Diabetic; 24% had increased cholesterol; 7% had Osteoarthritis; 9% were smokers; 3% had HIV; and 7% had target organ damage) Figure B. Eighty eight percent (88%) of patients were on some form of medication for their hypertension. Using the classification in the SAHS guidelines [3], the distribution of participants' BP recordings was as follows: 41% had normal BP (<140/90), 42% were classified as having Grade 1-Grade 2 BP (SBP >140-179 and/or DBP 90-99), 17% had recordings in the Grade 3 range (SBP 180-199 and/or DBP >110).

As indicated below in Table 3, systolic blood pressure readings were higher with routine facility measurement as compared to standardised measurement by the research team (p = 0.031). There were no statistical differences in diastolic blood pressure or mean arterial pressures (MAP) readings.

Table 3. Blood Pressure Reading with Facility Digital and Mercury/Aneroid

	Facility Digital BP Recording (SD)	**Mercury/Aneroid BP Recording (SD)**	***p***
Systolic	145.11 (30.72)	141.00 (29.71)	0.031*
Diastolic	86.15 (14.74)	84.93 (15.34)	0.144
MAP	87.92 (14.86)	86.63 (15.22)	0.135

Discussion

The key findings indicated adequate levels of knowledge amongst doctors, and inadequate knowledge amongst nurses. There was a lack of compliance with the structural and process indicators in respect to current

best practice guidelines, especially in the chronic and emergency care units. Of note is that a statistically significant difference was found between the measurement of systolic BPs between the clinic and research teams.

Participants scored fairly in the knowledge assessment. While the doctors scored higher than the nurses in some regards, there seemed to be an overall paucity in knowledge on some important technical aspects of measuring BP. This is consistent with previously cited literature, which similarly indicated low levels of basic knowledge about the mechanics and technique of BP measurements in Ghana,Nigeria,South Africa and Spain.[11,12,13,] It is noteworthy that the least-answered questions by both doctors and nurses were related to how long a patient needed to sit before their blood pressure could be recorded. This may be explained by the time-pressured manner that this facility operates under. While we did not assess knowledge levels against years since graduating, this finding raises questions about the retention of knowledge since graduation, the attention to detail about a common medical procedure, and highlights the importance of regular review of tasks performed commonly in primary care.

The exploration of structural indicators revealed deficiencies, especially in the chronic and emergency units. The lack of clinical guidelines in the clinical space implies that staff are either very well-versed with the guidelines and have no need for a reference text or are simply practising from memory. None of the digital BP machines had any record of ever being calibrated, representing a serious issue in terms of the reliability of their measurements. It is also important to note that while the electronic blood pressures done in the prep room were screening blood pressures, the consultation rooms of most doctors did not have functional manual blood pressure machines as seen in the table 2, which meant the clinicians are mostly dependant on the electronic blood pressure recordings, which would affect the blood pressure readings and the management overall. It is also well known that using inappropriately sized cuffs results in inaccurate recording of BP. Each of these factors is considered an important confounder in measuring BP, and their cumulative effect on BP measurement accuracy is not yet fully understood. It is worth noting that similar structural deficiencies were reported in African, European, and North American studies [3,25,26]. Addressing these structural issues requires

health facility managers to pay closer attention to ensuring that clinical spaces are fit-for-purpose and adequately resourced based on the burden of disease of the services provided.

On the other hand, process deficiencies were observed in relation to several of the process indicators. These measurements took place in a crowded, busy and loud health facility. As previously cited [3], it has been shown that when BP is measured while the patient is excited, animated, or agitated, the systolic BP can be raised by up to 10mmHg.[34] Additionally, elderly and obese patients' Blood pressures had been inaccurately measured given the deficient practices in relation to these patients (3). In a busy, overcrowded primary care environment, clinicians and their managers face an ongoing challenge of maintaining best practice while working in a context that mitigates against this.

While a statistically significant difference was found for systolic BPs between the control and the facility measurements, there were no major differences between the mean of the diastolic BP recordings and the mean arterial BP. A difference of 4.1 mmHg could influence a prescribing clinician to change or initiate a patient’s medication. However, determining whether this difference was due to the structural and process deficiencies in measurement technique, due to normal physiological fluctuations, or due to some other environmental confounders was beyond the remit of this study, and would require a suitably powered randomised controlled trial. However, what remains true is that prescribing clinicians in this facility cannot rely on the screening BP measurements of digital devices to make accurate decisions about management changes for hypertensive patients.

Study Limitations

This was a single-centre, pilot study whose findings are not representative of the patient population of this facility, or of the broader patient population. Additionally, the audit methodology does not cater for the measurement of correlation between structural and process indicators, and clinical outcomes, which would require a much larger sample size.

In relation to the knowledge component, data on the background, length of time since graduation, participation in formal postgraduate training and special interests of the healthcare workers was not collected. We are thus not able to make any clear pronouncements on the profile of worker who is likely to have higher/lower knowledge than their peers.

Recommendations

In respect to this study, the data and results have been shared with the facility involved as a baseline of a quality improvement project. Several recommendations were made:

- Clinicians should re-measure BP when the screening BP is abnormal with calibrated aneroid or mercury sphygmomanometers, especially when a change in the chronic prescription is considered. This could be included as an SOP in the different points of care.
- Nurse managers should implement checklists to ensure that all structural elements are adhered to, including establishing scheduled calibration and maintenance for digital machines.
- Nurses working in the chronic disease and emergency unit should be re-trained on correct technique of BP measurement.

CONCLUSION

Applying a novel methodology, this study was able to answer the research question relating to the quality of BP measurements, while additionally identifying specific areas of improvement for the clinical services. Some light was shone on the multiple variables that can impact the quality of these measurements. Suggestions for future research include scaling this study to a larger cohort of facilities, exploring prescriber behaviour in making critical decisions about patient care in hypertension, and clinical care pathways for hypertensive patients that are responsive to overcrowded and under-resourced primary care facilities.

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APPENDIX A: KNOWLEDGE QUESTIONNAIRE.

1. **Which do you think is the most accurate manometer?**	
a. Mercury	☑
b. Aneroid	
c. Electronic or digital	
2. **How often should the digital manometer be calibrated?**	
a. Every month	
b. Every 6 months	☑
c. Never	
d. Whenever it fails	
3. **How many times should blood pressure be measured on the first visit?**	
a. 1	
b. 2	☑
c. 3	
d. Until you get an accurate reading	
4. **What arm should be used to take blood pressure (not injured patients)?**	
a. Right	
b. Left	
c. Both	☑
d. Either arm	
5. In what position should blood pressure be taken? (mark all that apply)	
a. Standing	
b. Supine	
c. Sitting	☑
d. All the above	
a. Standing	
6. What determines systolic blood pressure?	

a. The first sound heard	☑
b. Change of intensity	
c. High-pitched sound	
7. **What determines diastolic blood pressure?**	
a. The last audible sound	☑
b. Change of intensity	
c. Low-pitched sound	
8. If a standard adult cuff (12-cm) is used in a very obese adult patient, you would expect the blood pressure results to be:	
a. Falsely high	☑
b. Falsely low	
c. True	
a. Falsely high	
9. The main reason why the radial pulse (systolic palpable pressure) should be measured is (mark all that apply):	
a. To avoid the auscultatory gap	☑
b. It is the best indication of systolic blood pressure	
c. It avoids disturbing the patient more than necessary, due to the inflation of the cuff bladder	
d. It is the best indication of diastolic blood pressure	
10. Regarding arm position, which is correct?	
a. If the arm is raised, blood pressure increases. vf	
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	
11.Before taking the Blood pressure, the patient should be allowed to sit for;	
a. 1 minute	
b.10 minutes	
c.20 seconds	

d.3-5 minutes	☑
e.2 minutes	
12. At initial consultation it is advised to measure the blood pressure in both arms if discrepant;	
a. Use the lower blood pressure of the two	
b. Use the higher blood pressure of the two	☑
c. Measure a 3rd Blood pressure reading	
13.When measuring the blood pressure which one of the following actions is most likely going to affect the blood pressure readings.	
a. Smoking before blood pressure recording	
b. Drinking coffee before blood pressure recording	
c. Eating food in the previous 30 minutes before recording	
d. a, b and c	☑
e. None of the above	
14. When measuring the blood pressure, it is important that	
a. That the patient should be seated	
b. The back should be supported	
c. Arm bared and arm supported at the level of the heart	
d. a, b, and c	☑
e. a and c only	
15.When measuring the blood pressure of an elderly patient (over 65yrs) it is important to	
a. Measure it while standing	
b. Measure it while sitting down	
c. Measure it while lying in supine position	
d. a and b	☑

APPENDIX B: CHECKLIST FOR THE RESEARCH PAPER ON BLOOD PRESSURE MEASUREMENT TECHNIQUE.

NAME of point Care (Chronic clinic, Acute Care, Maternity):

1. Availability of Blood pressure guidelines in the triage room and charts on How to correctly take blood pressure readings.

2. The blood pressure machine should clearly be calibrated with a marking or label on it for at least 6 months.

3. Are there different calf sizes, a standard cuff (12 cm) for a normal arm and a larger cuff for an arm with a mid-upper arm circumference >33cm

4. When measuring the blood pressure particularly patients with a raised BMI, the bladder of the cuff should encircle 80% of the arm

5. The blood pressure of the patients should be taken while the

    I. Patients Back is supported
    II. Arm is supported
    III. Legs not crossed
    IV. Not talking
    V. Seated and standing for the elderly
    VI. The room should be quiet with minimal noise or destructions

6. When the blood pressure is recorded another recording should be taken on the opposite arm atleast 1-2 minutes apart

7. If there is a 5mmhg discrepancy in the systolic blood pressure, a third blood pressure recording should be done.

APPENDIX C: DATA COLLECTION TOOL FOR THE PATIENTS OF MANUAL BLOOD PRESSURE VS THE ELECTRONIC ONE.

PATIENT FOLDER NUMBER	**DIGITAL MACHINE (CURRENT FACILITY MACHINE)**			**MERCURY MACHINE/ANEROID MACHINE (MANUAL MACHINE)**			**Comorbidities**	**Medications Taken**	**Substances used and smocking**	**Target Organ Damage**
	Systolic	Diastolic	MAP	Systolic	Diastolic	MAP				

APPENDIX D: DATA COLLECTION FOR THE MCQS DOCTORS AND NURSES AS PER THE QUESTIONNAIRE.

	Q1	Q2	Q3	Q4	Q5	Q6	Q7	Q8	Q9	Q10	Q11	Q12	Q13	Q14	Q15	Q16	Q17	Q18
DOCTORS																		
RIGHT																		
WRONG																		
NURSES																		
RIGHT																		
WRONG																		

APPENDIX E: CONSENT FORM.

Consent Form

For Participants

You are invited to participate in a study of analysing blood pressure measurement technique in selected western cape primary health care facilities.

We hope to learn from this research for a way to improve service provision as regards the blood pressure control is required. You were selected as a possible participant in this study because Known with hypertension and receive medication from this facility.

If you decide to participate, we will (Describe the procedures to be followed, including their purposes, how long they will take, and their frequency. Describe the discomforts and inconveniences reasonably to be expected, and estimate the total time required. Describe the risks reasonably to be expected, any benefits reasonably to be expected, as well as any incentives for participation.

Any information obtained in connection with this study that can be identified with you will remain confidential and will be disclosed only with your permission. In any written reports or publications, no one will be identified, or identifiable and only aggregate data will be presented.

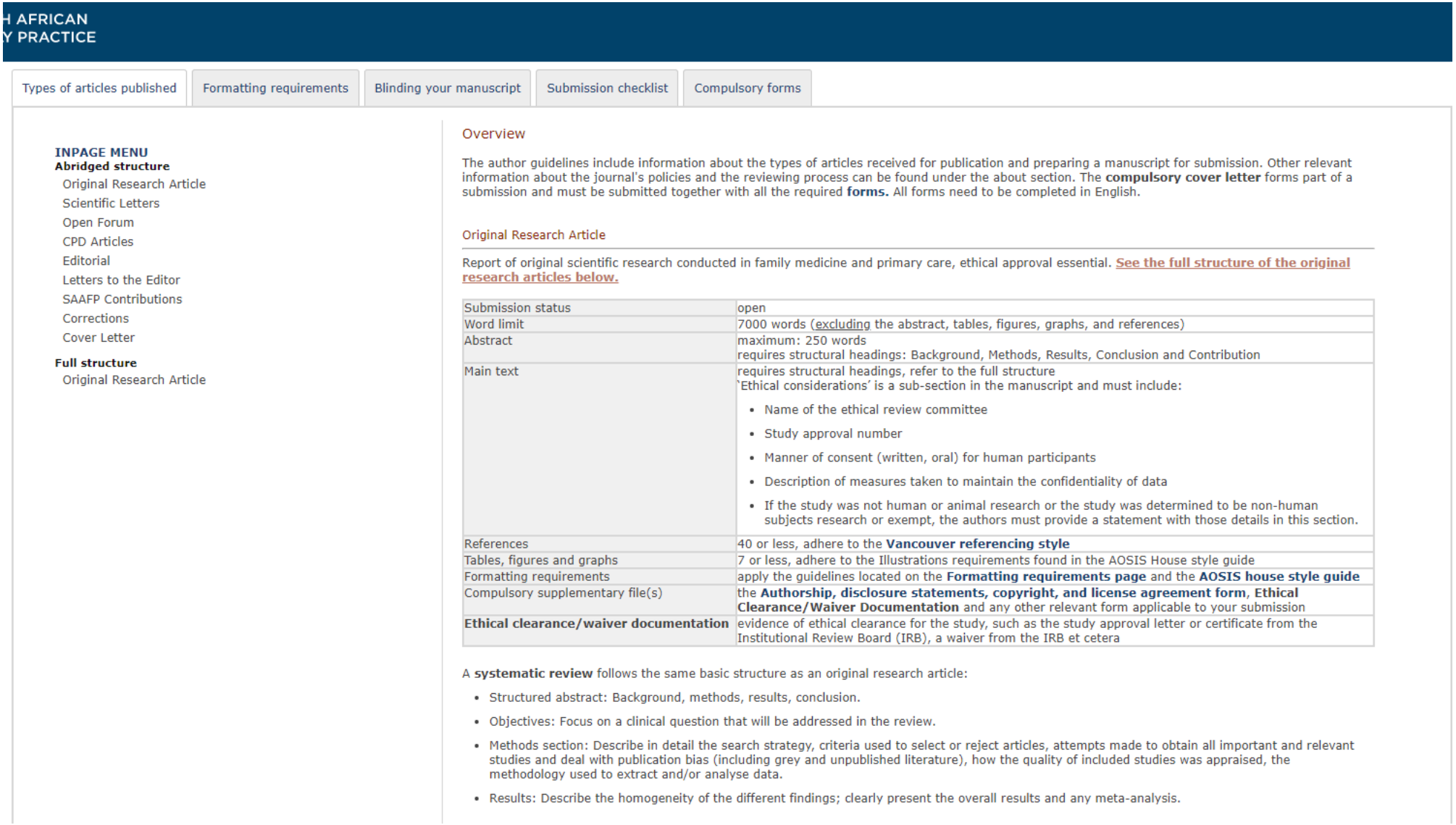
Your decision whether or not to participate will not affect your future relations with Retreat Day Hospital in any way. If you decide to participate, you are free to discontinue participation at any time without affecting such relationships.

This research project has been reviewed and approved in accordance Levels of Review for Research with Humans. If you have any questions about the research and/or research participants' rights or wish to report a research related injury, please inform the research team immediately.

A copy of this form will be kept for further use.

You are making a decision whether or not to participate. Your signature indicates that you have read the information provided above and have decided to participate. You may withdraw at any time without prejudice after signing this form should you choose to discontinue participation in this study.

X	X
Signature	**Date**
X	X
Signature of witness(if appropriate)	**Signature of investigator**



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21 June 2022

HREC REF: 353/2022

Dr L Ras
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Dear Dr Ras

PROJECT TITLE: ANALYSING THE TECHNIQUE OF BLOOD PRESSURE MEASUREMENT IN PRIMARY CARE: A SINGLE CENTRE PILOT STUDY-
(MASTERS CANDIDATE-DR JOSEPH ETONU)

Thank you for submitting your study to the Faculty of Health Sciences Human Research Ethics Committee (HREC) for review.

Before formal approval can be given, please address or respond to the following comments:
1. Please provide the information consent document for this study.

Please note that no research may occur without formal written HREC approval.

Please quote the HREC REF 353/2022 in all your correspondence.

Yours sincerely

PROFESSOR M BLOCKMAN
CHAIRPERSON, FACULTY OF HEALTH SCIENCES HUMAN RESEARCH ETHICS COMMITTEE

HREC APPROVAL