



Inter-observer reproducibility of blood pressure measurements in the clinic in a tertiary hospital in Nigeria by nurses and physicians: A cross-sectional study

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Abstract

Accuracy of blood pressure measurement is critical to management of hypertension and stratification of patients. We observed marked variations in blood pressure readings obtained by the nurses and those obtained by the physicians at the time of the consultation.

Objective: To assess inter-observer reproducibility of blood pressure measurements in the clinics by nurses and physicians.

Method: This was a cross-sectional study. Blood pressure recordings of patients attending the cardiology clinics were obtained using validated electronic devices by the nurses and again by the attending physicians during consultation. The results obtained were analysed and coefficient of variation (COV) in percentage, inter-class correlation coefficient with 95% confidence interval (ICC), Bland-Altman limits of agreement of 95% and prevalence-adjusted and bias-adjusted kappa (PABAK) were used to determine inter-observer variability of the blood pressure measurements.

Results: Majority of the participants were aged between 51-70 years (44.2%) and females (53.8%). The mean systolic BP obtained by the nurses was 131.86 ± 23.20 and 126.70 ± 21.94 for those by the physicians while diastolic were 78.40 ± 14.48 and 75.97 ± 12.67 for the nurses and physicians respectively with overall significant p values. When subjected to test of COV (SBP 16.40, DBP 15.83), Bland Altman analysis (SBP 5.16, DBP 2.43) and PABAK (SBP 0.031, DBP 0.040), there was poor reproducibility of BP measurements by nurses and physicians.

Conclusion: There was poor reproducibility of blood pressure measurements taken by nurses and physicians in this study. Adherence to standardized guidelines for blood pressure measurement may improve blood pressure reproducibility among health care workers.

Key words: Blood Pressure, Inter-observer, Nurses, Physicians, Reproducibility.

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Introduction

Hypertension is recognized as the most significant modifiable risk factor for mortality and disability worldwide, affecting approximately 1.4 billion adults and contributing to over 10 million deaths annually.^{1,2}

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The global prevalence of hypertension is estimated to be around 31%, with elevated blood pressure being the primary risk factor for various diseases, particularly stroke, heart failure, and chronic kidney disease.^{2,3} Individuals with normal blood pressure by the age of 55 who live up to 80 years are believed to have a 90% lifetime risk of developing hypertension.⁴

This highlights the critical public health significance of hypertension and the necessity for accurate diagnosis and timely intervention to mitigate its complications.

Blood pressure (BP) measurement is among the most frequently performed screening tests in medicine, and its simplicity has facilitated widespread home monitoring.⁵ However, BP levels fluctuate in response to both internal and external factors, making it challenging to determine an individual's optimal blood pressure.⁶ To enhance measurement consistency, it is essential to adhere to established guidelines for BP assessment.

Accurate BP measurement is crucial for diagnosing, classifying, and managing hypertension. Research indicates that a 5-mmHg variation in systolic blood pressure (SBP) can result in a 6% absolute and 30% relative difference in hypertension prevalence.⁷ Given a global prevalence of 1.4 billion individuals with hypertension,² an error of 5 mmHg in BP assessment could lead to the misclassification of hypertension status in approximately 84 million people worldwide.

Errors in office and clinic BP measurements occur when there is a discrepancy between the recorded BP and values obtained through gold standard techniques (e.g., invasive direct aortic measurement), expert evaluation, or the patient's typical daytime BP.⁸ Values obtained following BP measurements are influenced by patient characteristics, attending physician/nurse and the sphygmomanometer used.

Although clear guidelines exist for maximizing accuracy in BP measurements, inter-observer variability still exists among physicians and nurses and between the two groups. This could be due to poor adherence to these guidelines, as found in a study that assessed self-reported practices of doctors and nurses in BP measurements.⁹

In our facility, patients attending the clinics were more often than not noted to be worried about the marked variations in blood pressure readings obtained by the nurses before their consult with the physicians and those obtained by the physicians at the time of the consult. This concern aroused our curiosity and the aim of this study was to assess the reproducibility of blood pressure measurements done by the nurses and physicians.

Materials and methods

This study employed a cross-sectional design and was conducted among adult hypertensive patients

receiving care at the cardiology outpatient clinic of Alex Ekwueme Federal University Teaching Hospital, Abakaliki, Ebonyi State, Nigeria. Participants were recruited consecutively. Blood pressure measurements were taken from 197 patients using validated electronic devices, initially by nurses and subsequently by attending physicians during consultations. An appropriately sized cuff was used for each patient. Before measurement, patients were seated comfortably for five minutes with their backs supported, arms positioned at heart level, feet flat on the floor, and legs uncrossed. Data analysis was performed using IBM SPSS version 23. Inter-observer variability in blood pressure measurements was assessed using the coefficient of variation (COV) in percentage, the inter-class correlation coefficient (ICC) with a 95% confidence interval, Bland-Altman limits of agreement at 95%, and the prevalence-adjusted and bias-adjusted kappa (PABAK).

Ethical clearance was obtained from the Alex Ekwueme Federal University Teaching Hospital Health Research Ethics committee (NHREC/16/05/22/450). Participants signed informed consent but were free to withdraw from participation without affecting their medical care in the clinic. None of the screening carried out during study was invasive. To ensure confidentiality, information obtained from patients in the course of the study, were depersonalized.

Results

A total of 197 patients between 18 and 90 years were examined. The modal age group was 51-70 years, accounting for 44.2% of the participants. About 53.8% were female. The mean systolic blood pressure readings by the nurses and doctors varied significantly for males and females with p-values of <0.001 and 0.003 respectively. While there was no significant variation in the diastolic BP for females (p-value 0.219), those for the males were

Table 1: Sociodemographic Characteristics of the Participants

Characteristics	Frequency	Percentage
Age group		
<30 yrs	12	6.1
31 – 50 yrs	59	29.9
51 – 70 yrs	87	44.2
71 – 90 yrs	39	19.8
Sex		
Female	106	53.8
Male	91	46.2

Table 2: Comparison of the Means and standard deviations of blood pressure parameters obtained by Nurses (A) and Doctors (B) by Male and female participants

Variable	Nurse (A) Mean ± SD	Doctor (B) Mean ± SD	t	P-Value
Systolic BP				
Male	133.58±26.96	126.59±24.31	4.358	<0.001
Female	130.39±19.42	126.79±19.8	3.029	0.003
Over All	131.86±23.2	126.7±21.94	5.423	<0.001
Diastolic BP				
Male	79.21±15.53	75.74±14.57	2.375	0.019
Female	77.71±13.55	76.17±10.84	1.240	0.219
Over All	78.40±14.48	75.97±12.67	2.853	0.005

Table 3: Comparison of the Means and standard deviations of blood pressure parameters obtained by Nurses (A) and Doctors (B) by age group of participants

Group	Age Group (Years)				Total Mean±SD	F	P
	≤30 Mean±SD	31-50 Mean±SD	51-70 Mean±SD	71-90 Mean±SD			
Sys. BP							
Nurse	119±23.11	134.63±25.11	133.9±23.38	127.1±18.05	131.86±23.2	2.325	0.076
Doctor	111.08±14.46	130.69±23.82	126.9±22.12	125.03±18.57	126.7±21.94	2.834	0.039
Dia. BP							
Nurse	73.08±13.73	84.24±15.28	76.89±13.27	74.59±13.78	78.4±14.48	5.277	0.002
Doctor	71.17±11.56	79.68±14.97	75.25±11.52	73.44±10.49	75.97±12.67	2.961	0.033

Table 4: Inter-observer agreement

Variable	ICC (95% IC)	BA 95% LOA	COV	PABAK
Systolic BP	0.87 (0.82 to 0.90)	5.16 (-25.23 to 35.55)	16.40	0.031
Diastolic BP	0.76 (0.68 to 0.82)	2.43 (-21.02 to 25.88)	15.83	0.040

Abbreviations: BA = Bland-Altman limits of agreement of 95%; BP = Blood Pressure; COV = coefficient of variation in percentage; ICC = intra-class correlation coefficient with 95% confidence interval; PABAK = prevalence-adjusted and bias-adjusted kappa;

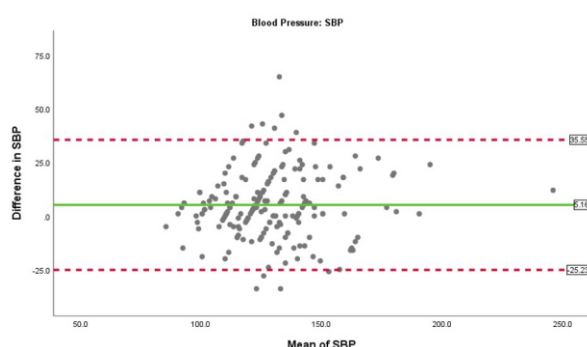


Figure 1: Variations in systolic blood pressure readings recorded by nurses (A) and doctors (B) are plotted on the y-axis, while the x-axis represents the average of both measurements. The solid green line denotes the mean difference between the two sets of readings, whereas the dashed red lines correspond to the mean difference plus or minus two standard deviations.

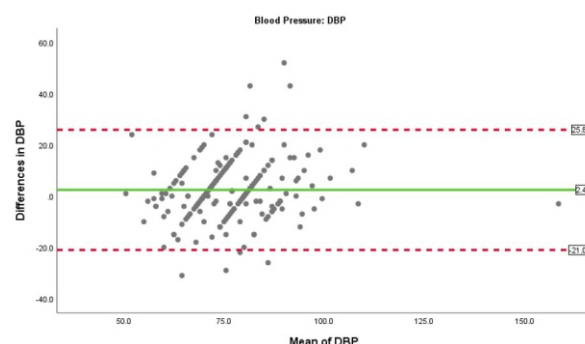


Figure 2: Variations in Diastolic Blood Pressure measurements recorded by Nurses (A) and Doctors (B) are plotted on the y-axis, while the x-axis represents the average of both measurements. The solid green line denotes the mean difference between the two sets of readings, whereas the dashed red lines indicate the mean plus or minus two standard deviations.

significant (p-value 0.019). Overall diastolic BP readings varied significantly for doctors and nurses with a p-value of 0.005. Notable variations were also seen among the various age groups assessed.

Reproducibility of the measurements when assessed with inter class correlation coefficient was [TS1.1] found to be better for systolic BP measurements compared to diastolic BP measurements. However, further analysis with COV, PABAK and Bland Altman plots showed poor reproducibility overall of blood pressure measurements by nurses and doctors.

Discussion

This study showed that the systolic and diastolic measurements obtained by nurses and doctors were not reproducible and doctors obtained significantly lower blood pressure values than nurses. In addition, the variations were greater among males when compared to females. This is in contrast to some existing studies that showed measurements gotten by nurses to be significantly lower than those of doctors and also noted more variations among females than males.^{10,11,12}

Variations in blood pressure measurements are often due to patients' characteristics, observer's technique/expertise and device used for the measurement. Readings tend to fluctuate drastically depending on the patient's physical and mental state.

Thus, for reproducible readings to be obtained, the patient has to be in the same physical and emotional state as in the previous reading.¹³ In addition, a cold atmosphere, as well as having a full bladder at the time of measurement could also lead to higher than normal blood pressure readings.¹³

The observer also significantly impacts blood pressure readings. Traditionally, the white coat effect has been described as being significantly more with doctors than nurses¹⁴. This has led to some authors suggesting that physicians should not be involved in the measurement of blood pressure but should rather work with the readings obtained by the nurses or other trained personnel.¹⁵ This however does not hold true for our study as the physicians obtained significantly lower readings than the nurses. Furthermore, observer practices like failing to give a five minute rest period before measuring the blood pressure, failing to take multiple readings (at least 3) or use of an inappropriate cuff size could also impact blood pressure readings.^{16,17} Time constraint is also an important factor as a casual reading takes just about 2 minutes to complete, compared with the 8 minutes required for standardized blood pressure measurements.^{16,18} A study that assessed self-reported practices by doctors and nurses found that both groups failed to adhere to the proper techniques for measuring blood pressure and this could account for the poor reproducibility of blood pressure measurements.⁹ A more conducive and relaxed environment in the doctor's consulting room could contribute to the lower readings gotten by the doctors when compared to the reading gotten by the nurses at the hall. The nurses' station is usually crowded and often poorly controlled compared to the doctor's consulting room which is usually more private and conducive.

The device used also plays a role in the determining how reproducible blood pressure measurements are. Poorly calibrated devices are likely to generate spurious readings and affect both accuracy and reproducibility of measurements. Therefore, all devices for blood pressure measurement should be adequately validated before use and regularly maintained and recalibrated in order to reduce the device related error margins.¹⁹

It is equally important to consider the intrinsic variability of blood pressure itself as this could also affect the results obtained. This variability likely underscores the need for 24hr ambulatory blood pressure monitoring for accurate first-time diagnosis

of hypertension as well as cardiovascular risk stratification as is recommended by several guidelines.²⁰

Conclusion

There was poor reproducibility of blood pressure measurements by doctors and nurses in this study with physicians having lower measurements than nurses. This study highlights the need for Cardiology clinics to audit and standardise BP measurements for proper patient management. However, this study did not address the reasons for the poor reproducibility of BP measurements among doctors and nurses. Future studies should be powered to investigate the factors underlying BP variability among health workers in a clinic setting as well as compare them to more standardised measures such as the ambulatory and home BP measurements as a means of improving reliability of office BP measurements.

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List of abbreviations

BA- Bland-Altman

BP- Blood pressure

DBP- Diastolic Blood pressure

COV- Coefficient of variation

ICC- Inter-class correlation coefficient

PABAK- Prevalence-adjusted kappa

References

1. Global Burden of Disease Risk Factor Collaborators. Global, regional, and national comparative risk assessment of 84 behavioural, environmental and occupational, and metabolic risks or clusters of risks for 195 countries and territories, 1990-2017: a systematic analysis for the Global Burden of Disease Study, 2017. *Lancet* 2018; 392:1923–1994.
2. Mills KT, Bundy JD, Kelly TN, Reed JE, Kearney PM, Reynolds K, et al. Global disparities of hypertension prevalence and control: a systematic analysis of population-based studies from 90 countries. *Circulation* 2016; 134:441–450.
3. Benjamin EJ, Virani SS, Callaway CW, Chamberlain AM, Chang AR, Cheng S, et al. American Heart Association Council on Epidemiology and Prevention Statistics

- Committee and Stroke Statistics Subcommittee. Heart disease and stroke statistics - 2018 update: a report from the American Heart Association. *Circulation* 2018; 137:e67–e492.
4. The Seventh Report of the Joint National Committee on Prevention, Detection, Evaluation, and Treatment of High Blood Pressure – The JNC 7 Report. *JAMA*. 2003, 289: 2560-2572. 10.1001/jama.289.19.2560.
 5. Pater, C. Beyond the Evidence of the New Hypertension Guidelines. Blood pressure measurement – is it good enough for accurate diagnosis of hypertension? Time might be in, for a paradigm shift (I). *Trials* 6, 6 (2005). <https://doi.org/10.1186/1468-6708-6-6>
 6. Raven PB, Chapleau MW. Blood pressure regulation XI: overview and future research directions. *Eur J Appl Physiol* 2014; 114:579–586.
 7. Joffres MR, Campbell NRC, Manns B, Tu K. Estimate of the benefits of a population-based reduction in dietary sodium additives on hypertension and its related healthcare costs in Canada. *Can J Cardiol* 2007; 23:437–443.
 8. A Elias, Merrill F. A Goodell, Amanda L. Human Errors in Automated Office Blood Pressure Measurement. *J Hypertension* 2021 P 6-15 V 77 N 1 R doi:10.1161/HYPERTENSIONAHA.120.1616. <https://www.ahajournals.org/doi/abs/10.1161/HYPERTENSIONAHA.120.16164>
 9. Kirhan, İdrisa; Kir, Seherb; Dilek, Meldac. Self-reported practices of doctors and nurses for the measurement of blood pressure. *Blood Pressure Monitoring* 26(1):p 8-13, February 2021. | DOI: 10.1097/MBP.0000000000000482
 10. Clark C; Horvath I; Taylor R; and Campbell J. Doctors record higher blood pressures than nurses: Systematic review and meta-analysis. *The British journal of general practice: the journal of the Royal College of General Practitioners*. 2014; 64. e223-32. 10.3399/bjgp14X677851.
 11. Mancia G, Bertinieri G, Grassi G, Parati G, Pomidossi G, Ferrari A et al. Effects of blood-pressure measurement by the doctor on patient's blood pressure and heart rate. *Lancet* 1983; 322(8352): 695–698.
 12. La Batide-Alanore A, Chatellier G, Bobrie, G, Fofol, I, Plouin, PF. Comparison of nurse- and physician-determined clinic blood pressure levels in patients referred to a hypertension clinic: implications for subsequent management. *Journal of Hypertension* April 2000; 18(4):p 391-398.
 13. Frohlich ED, Grim C, Labarthe DR, Maxwell MH, Perloff D, Weidman WH. Recommendations for human blood pressure determination by sphygmomanometers. Report of a special task force appointed by the Steering committee, American Heart Association. *Hypertension* 1988; 11:210a-221a.
 14. Labinson PT, Giacco S, Gift H, et al. The importance of the clinical observer in the development of a white-coat effect in African-American patients with hypertension. *Blood Press Monit* 2008; 13(3): 139–142.
 15. Graves JW, Sheps SG. Does evidence-based medicine suggest that physicians should not be measuring blood pressure in the hypertensive patient? *Am J Hypertens*. 2004 Apr; 17(4):354-60. doi: 10.1016/j.amjhyper.2003.12.007. PMID: 15062890.
 16. Ray GM, Nawarskas JJ, Anderson JR. Blood pressure monitoring technique impacts hypertension treatment. *J Gen Intern Med* 2011; 27:623–629
 17. Minor DS, Butler KR Jr, Artman KL, Adair C, Wang W, McNair V, et al. Evaluation of blood pressure measurement and agreement in an academic health sciences center. *J Clin Hypertens (Greenwich)* 2012; 14:222–227.
 18. Stergiou GS, Kyriakoulis KG, Kollias A. Office blood pressure measurement types: different methodology-different clinical conclusions. *J Clin Hypertens (Greenwich)* 2018; 20:1683–1685.
 19. Jan van Egmond, Jacques W.M. Lenders, Erna Weernink, Theo Thien, Accuracy and Reproducibility of 30 Devices for Self-Measurement of Arterial Blood Pressure, *Am J Hypertens*, 1993 oct. 6,(10): 873–879, <https://doi.org/10.1093/ajh/6.10.873>
 20. Mancia G, Zanchetti A, Agabiti-Rosei E: Ambulatory blood pressure is superior to clinic blood pressure in predicting treatment-induced regression of left ventricular hypertrophy. AMPLE Study Group. Study on ambulatory Monitoring of Blood Pressure and Lisinopril Evaluation. *Circulation*. 1997, 95: 1464-70.