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Blood Pressure Monitoring Variation in Routine Antiretroviral Therapy Clinic Visits: A Cross-Sectional study

Sody M. Munsaka[1*], Benson M. Hamooya[2], Malan Malumani[3], Brian Chanda Chiluba[4], Sepiso K. Masenga[1]

[1]University of Zambia, School of Health Sciences, Department of Biomedical Sciences, Lusaka, Zambia, [2]Mulungushi University, School of medicine and Health Sciences, Livingstone, Zambia, [3]Livingstone University Teaching Hospital, Livingstone, Zambia, [4]Department of Physiotherapy, School of Health Sciences, University of Zambia

*Corresponding author: s.munsaka@unza.zm

Abstract

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Background:
In the time of COVID-19, various strategies are initiated by the Ministry of Health to ensure that accessibility to the way blood pressure is measured can result in inaccurate readings with huge clinical implications for management. Although several studies exist that report blood pressure variations due to measurement errors, data is lacking from sub-Saharan Africa on the proportion of inaccurate blood pressure readings. The main aim of this study was to explore the blood pressure measurement variations between routine blood pressure measurement and measurement that follows standard guidelines.

Methods and Materials:
We conducted an analytical cross-sectional study at Livingstone University Teaching, in Zambia and enrolled 226 persons living with HIV. Routine blood pressure measurements were repeated using standard guidelines. Descriptive and inferential statistics were used to describe and determine blood pressure differences between routine and standard measurements.

Results:
The median age (interquartile range) in the study was 44 (35-52) years with 149 female participants representing a female preponderance of 65.9%. Systolic and Diastolic BP were significantly different between routine and standard measurements ($p<0.0001$). About 23 (10%) and 59 (26%) of the participants had systolic and diastolic BP exceeding 20 mmHg and 10 mmHg, respectively. Systolic and Diastolic differences between routine and standard measurements ranged from -37 to 55 and -26 to 40, respectively.

Conclusion: Our study confirms the presence of BP inaccuracy in clinical settings from a sub-Saharan African country. Knowledge and training that limits BP monitoring errors are required for health personnel attending to vulnerable groups such as PLHV where the burden of hypertension is higher than the general population. Our study highlights the need for better integration of hypertension care to HIV in clinical settings.

Keywords: *Blood pressure measurement variation, routine blood pressure measurement, standard blood pressure measurement*

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INTRODUCTION

Hypertension is a risk factor for cardiovascular disease, stroke, and death and is more common in people living with HIV (PLHV) [1–3]. Accuracy of blood pressure (BP) measurements to diagnose hypertension or monitor hypertensive individuals on antihypertensive medication is therefore crucial. Misdiagnosis of hypertension has a huge impact on the health and social life of patients [4]. Some of the common factors associated with inaccurate BP measurement include but are not limited to bladder distention, rest period, leg position, unsupported back, unsupported arm, talking during measurement, and several measurements [4,5]. However, data on BP measurement accuracy is lacking in sub-Sahara Africa (SSA). We, therefore, set out to explore the BP measurement variations between routine BP measurement and standard measurement that follows the American Heart Association/American College of Cardiology (AHA/ACC) guidelines where the patient is allowed to rest for 5-10 minutes, with their bladder emptied, sitting with their feet flat on the floor and their back supported, and BP measured at heart level.

METHODS AND MATERIALS

Study Design and Setting

Data were entered into the Statistical Package for Social Science version 16 (IBM, Armonk, NY, USA) for analysis. We conducted an analytical cross-sectional study at Livingstone University Teaching Hospital (LUTH), the largest referral hospital (and hosting the largest ART clinic) in the Southern Province of Zambia. The antiretroviral therapy (ART) clinic offers ART and general medical services to the community, with approximately 20 - 30 patients per day.

Participants

Participants were enrolled from the ART clinic during their regular attendance. We compared BP measurements for 226 participants.

Eligibility criteria

We included all adults aged 18 years and above living with HIV. Study participants were only recruited after verbally consenting and signing a consent form. We excluded patients seeking healthcare due to an acute illness rather than routine ART clinic reviews.

BP measurements

Routine BP readings were obtained by one measurement taken by the attending nurse. The patient was then sent to the research room where three BP readings were taken. Both the nurses and the researchers used the WGNBPA 730 (USA) BP monitors for measurements and the BP machines were calibrated before they were used. For standard measurements, we adapted the new AHA/ACC guidelines [6]: The patients had not been exercising, smoking, or drinking caffeine, their bladders were empty, and they were seated for more than 5 minutes before measurements were taken in a still position. The limb used to measure BP was supported ensuring that the BP cuff was at heart level. During the measurements, the participants were asked to sit upright, back straight, with feet flat on the floor without legs crossing each other. Three readings were taken and the last two averaged. The average BP was used to reflect the person's BP. Routine BPs taken by attending nurses did not take into account the consideration explained above. The personnel conducting the routine and standard measurements were blinded to the study's aims and objectives.

Hypertension diagnosis was based on the history of antihypertensive drugs (for hypertensive patients that did not take antihypertensive drugs for $\geqslant$ 2 weeks to satisfy the eligibility criteria). Social demographic characteristics such as age, gender, marital status, and employment status were obtained. We also obtained body mass index (BMI), waist circumference, duration on ART, CD4 counts, HIV RNA viral load, and fasting blood glucose (FBG).

Data analysis

Due to skewness in our data, we described our data using medians and interquartile range (IQR) and proportions for categorical variables. To compare routine BP measurements taken by attending nurses and standard BP measurements, we used Wilcoxon matched-pairs signed-rank test and Spearman correlation coefficient to assess the strength of association. We also reported median differences and their confidence limits (95%). P-values less than 0.05 were considered significant and are shown in bold.

RESULTS

General characteristics of participants

The study was composed of 226 PLHV with a median age of 44 years (Table 1). The median duration of antiretroviral therapy was 96 months. The majority were females (65.9%), self-employed (33.2%), married (44.7%), and virally suppressed (88.1%). The median BMI, FBS, waist circumference, and CD4 count was 22.3, 5.1 mmol/l, 80.0 cm and 467 cell/µl, respectively.

Table 1: Demographic and clinical characteristics of study participants

Variable	Group	Median (IQR) or n (%)
Age *years*		44 (35, 52)
BMI *kg/m²*		22.3 (19.7, 26.9)
FBS *mmol/l*		5.1 (4.7, 5.6)
Duration on ART, months		96 (48, 132)
Waist circumference, *cm*		80.0 (72.0, 89.0)
Gender	*Male*	77 (34.1)
	Female	149 (65.9)
Employment	*Formal employment*	58 (25.7)
	Unemployed	73 (32.3)
	Retired	20 (8.8)
	Self-employed	75 (33.2)
Marital status	*Married*	101 (44.7)
	Single	49 (21.7)
	Divorced/separated	13 (5.8)
	Widowed	63 (27.9)
Hypertension status	*Normotensive*	191 (85.5)
	Hypertension	35 (15.5)
CD4, cells/μL		467 (360, 643)
Viral load suppressed *(<1000 copies/ml)*	Yes	199 (88.1)
	No	27 (11.9)

SD=standard deviation, BMI=body mass index, FBS=fasting blood sugar, SBP=systolic blood pressure, DBP=diastolic blood pressure

Comparison of routine versus standard BP measurements

The median routine SBP, DBP and pulse were 128 mmHg, 83 mmHg and 78 beats per minute (bpm), respectively whereas the median standard SBP, DBP and pulse rate were 124 mmHg, 80 mmHg and 72 bpm, respectively. Routine BP readings were significantly different when compared to standard measurements. Routine SBP, DBP and pulse rate were significantly higher than standard measurements (Figure 1, $p<0.0001$), with a strong positive correlation (Table 2).

We then categorized routine minus standard BP differences based on clinically significant differences of 20 mmHg and 10 mmHg for both SBP and DBP, respectively. We found that about 34 (15%) had SBP and DBP differences between 11-20 mmHg (Table 3). Then about 19 (8%) and 14 (6.2) had SBP and DBP differences greater than 20 mmHg, respectively. An estimated 10% and 26% of participants had inaccurate SBP and DBP, respectively. The maximum differences between routine and standard measurement ranged from -37 to 55 mmHg for SBP and -26 to 40 for DBP.

Table 2. Routine BP measurements versus standard BP measurements

Variable	Routine measurement Median (IQR)	Standard measurement Median (IQR)	Median of difference 95% CI	rho	p-value
Systolic Blood pressure, *mmHg*	128 (115,144)	124 (113,141)	3 (1,5)	0.8	**<0.0001**
Diastolic blood pressure, *mmHg*	83 (75, 94)	80 (71, 89)	3 (1, 5)	0.7	**<0.0001**
Pulse, *beats per minute*	78 (69, 86)	72 (62, 80)	4 (2, 4)	0.7	**<0.0001**

Rho, nonparametric Spearman correlation coefficient; CI, confidence interval

Systolic blood pressure (A, D), diastolic blood pressure (B, E) and pulse (C, E) were significantly different by measurement method. In all cases, routine blood pressure and pulse were higher than that measured following standard guidelines, systolic blood pressure. DBP, diastolic blood pressure.

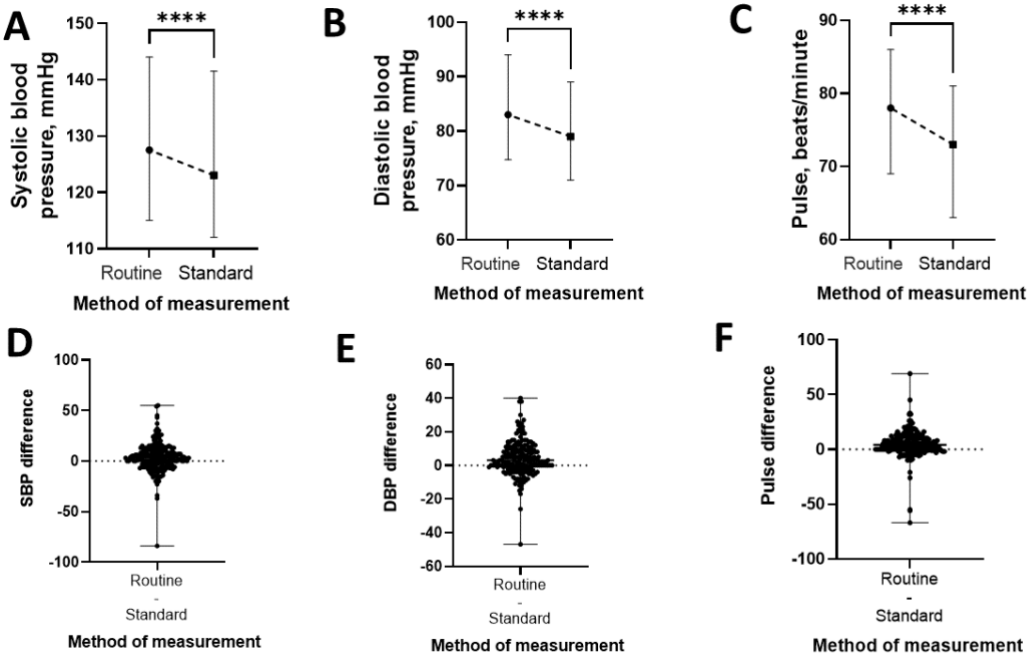

Table 3. The proportion of inaccurate blood pressure category

Blood pressure difference	Systolic Blood pressure, mmHg n (%)	Diastolic blood pressure, mmHg n (%)
Routine *minus* standard		
Less than or equal to 0	104 (46.0)	102 (45.1)
1 to 10 mmHg	69 (30.5)	76 (33.6)
11 to 20 mmHg	34 (15.0)	34 (15.0)
Greater than 20 mmHg	19 (8.4)	14 (6.2)
Minimum to maximum difference between routine and standard measurements, *mmHg*	-37 to 55	-26 to 40
Acceptable BP difference *≤ ±20 mmHg SBP or ≤ ±10 mmHg DBP*	203 (89.8)	167 (73.9)
Inaccurate BP difference *> ±20 mmHg SBP or > ±10 mmHg DBP*	23 (10.2)	59 (26.1)

Figure 1: Routine versus standard blood pressure differences

DISCUSSION

In this cross-sectional study of a population of 226 PLHV, we explored blood pressure monitoring variation in routine antiretroviral therapy clinic visits at LUTH. Our study found that routine BP readings were significantly different compared to standard measurements. Routine SBP, DBP and pulse rate were significantly higher than standard measurements.

BP is measured for diagnosis, monitoring, prognosis, and screening of hypertension-related conditions and management. Inaccurate measurements have implications for post-management sequelae. PLWH have a high pill burden that is reflected on by non-adherence to ART. A hypertensive diagnosis adds to the pill burden. Therefore, accurate BP measurements are critical in this regard. In this analytical study, we found that about 10% to 26% of PLWH had an inaccurate SBP and DBP reading, respectively. The difference between routine and standard BP measurement for this inaccuracy was greater than 20 mmHg and 10 mmHg for SBP and DBP, respectively. The maximum difference ranged from -37 to 55 mmHg for SBP and -26 to 40 for DBP and this was higher than previous reports (reviewed in [4]).

Several studies have found inaccuracies in BP monitoring that has significant implications on clinical management (reviewed in [4]). SBP varies more than DBP [7] and the normal intraindividual variation for SBP and DBP can range from 0 - 14 mmHg and 0 - 8 mmHg, respectively [7,8]. Several factors affect BP variation that impacts accuracy. Broadly, these factors include human error, intraindividual factors, medication, posture, type of BP monitoring device and measurement protocols [9,10]. Several factors can be eliminated by following standard guidelines to minimize errors and improve accuracy. In this study, we used the same BP monitoring device, validated protocol, and there was no hypertensive participant currently on medication. This ensured an accurate comparison between the routine and standard measurements. Although we did not identify specific factors associated with the BP irregularities, our data suggest that the routine monitoring of BP in the HIV clinic requires attention to minimize erroneous BP measurements. Health personnel responsible for BP monitoring must be trained to follow standard guidelines and protocols to ensure accurate BP readings.

Clinical implications

Findings from our study indicate that BP readings for a significant number of patients may be inaccurate. This has the potential to mislead the management of these patients.

CONCLUSION

A significant proportion of individuals had differences in BP between routine and standard measurements higher than 20 mmHg and 10 mmHg for SBP and DBP, respectively. This suggests the presence of BP inaccuracy in clinical settings from a sub-Saharan African country. Knowledge and training that limits BP monitoring errors are required for health personnel attending to vulnerable groups such as PLHV where the burden of hypertension is higher than the general population. In this population, accurate BP monitoring can accurately identify those requiring additional attention.

WHAT IS ALREADY KNOWN

1. BP inaccuracies are present in most clinic set-ups but data is scarce from sub-Sahara Africa
2. SBP variation is greater than DBP

WHAT THIS STUDY ADDS

1. A significant proportion of SBP and DBP inaccuracy readings are present in routine HIV clinics among PLWH.
2. A significant proportion of individuals had differences in BP between routine and standard measurements higher than 20 mmHg and 10 mmHg for SBP and DBP, respectively.
3. The maximum differences ranged between -37 to 55 mmHg for SBP and -26 to 40 for DBP, one of the highest variational differences known to us

DECLARATION

Competing interests There were no competing interests from all authors in this study.

Author contributions SKM and SMM conceived the study. SKM, BMH, MM, BCC and SMM contributed to the writing of the manuscript. SMM is the principal investigator. SKM is the senior author and guarantor. All authors read, provided feedback, and approved the final manuscript.

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Ethics approval and consent to participate Ethical approval was obtained from the University of Zambia Biomedical Research Ethics Committee (UNZABREC) (Assurance No. FWA00000338 IRB00001131 of IORG0000774) on 24th May 2017. Permission to conduct

the study was granted by the Livingstone University Teaching Hospital Administration. All participants were asked to consent by signing an informed consent form before being included in the study. All data collected were de-identified and used for research purposes only.

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