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Accuracy Of Home Blood Pressure Monitoring Devices In Use Among Adults In Aba, Southeast Nigeria

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Abstract: ***Blood pressure related conditions such as hypertension compose a major health problem globally. Accurate blood pressure measurement is essential for early diagnosis of hypertension. The aim of this study was to assess the accuracy of digital home blood pressure monitoring devices in use among adults in Aba, southeast Nigeria. A clinic based retrospective chart review was conducted using digital upper arm home blood pressure monitoring device validation records done between June 2017 to February 2018. A sample size of 210 records was used. Computer-mediated random sampling technique was used to enrol participant records. A checklist designed by the research team was instrument for data collection. Descriptive statistics, Chi square, Fischer exact test and two tailed t-test was used for data analysis. Level of significance was set at P < 0.05. Results revealed a significant difference in diastolic readings between digital device and manual mercury sphygmomanometer (t = -3.412, P = 0.001). 79.5% of the digital devices were inaccurate at 5mmHg allowance. 41.4% of the devices were inaccurate at 10mmHg allowance. At 10mmHg allowance, there was significant association between accuracy status and brand of digital device (χ^2 = 12.516, P = 0.002). In Conclusion, more than half (79.5%) of digital upper arm home blood pressure devices are inacurate by more than 5mmHg. There is need for frequent validation of digital upper arm blood pressure devices by a trained healthcare worker if digital home blood pressure measurements are to be depended upon for health care related decisions.***

Keywords: Hypertension, Accuracy, sphygmomanometer, Nigeria.

I. INTRODUCTION

Blood pressure (BP) related conditions such as hypertension are among the world's leading health-related factors that bring about premature death (Bancej, Campbell, Mckay, Nichol, Walker & Kaczorowski, 2010). Globally, hypertension affects an estimated 1 billion people (Akinlua, Meakin, Umar, & Freemantle, 2015). The risk from hypertension is likely to continue on the rise with increase in global population. The African continent appears to be the most affected region in the world, with Nigeria contributing a substantial portion to Africa's total hypertension burden (Akinlua, et al., 2015).

Hypertension imposes considerable socio-economic and health costs on individuals, families and health care systems (Bancej, et al., 2010). To minimize the costs imposed by hypertension on society, early diagnosis and treatment is regarded as essential. On the one hand, clinical mercury sphygmomanometer BP measurements have been the basis for hypertension diagnosis (Ruzicka, Akbari, Bruketa, Kayibanda, Baril, & Hiremath, 2016). On the other hand, home blood pressure (HBP) measurements have in recent times become very important in monitoring of BP during treatment of

hypertension (Shin, et al., 2015). The American Heart Association recommends that individuals diagnosed of hypertension should monitor their blood pressure at home.

HBP monitoring can be used to validate a diagnosis of hypertension, recognize and trim down the need for medication in individuals with white coat and masked hypertension, improve compliance with medication, and aid in the management of BP in individuals with diabetes and chronic renal disease (Bancej, et al., 2010). HBP monitoring is known to be cost-effective and more accurate at predicting cardiovascular outcomes in hypertensive patients (Shin, et al., 2015). Based on the last sentence, propositions for enhanced assessment of BP status include greater reliance on home blood pressure monitoring (Myers, et al., 2011).

Digital HBP monitoring devices may provide a clinician with valuable information about one's BP. From the nurse's perspective, digital HBP monitoring devices offer ample advantage over mecury sphygmomanometer as it ensures greater patient involvement or participation in hypertension management. The Canadian Hypertension Education Program guidelines offer resources to support the greater use of digital HBP monitoring devices especially in hypertension management (Bancej, et al., 2010).

There are different kinds of digital HBP monitoring devices such as upper arm, wrist and finger models. Of all available types, the digital HBP monitoring device with upper arm cuff is recommended by the American Heart Association and Korean Society of Hypertension (Shin, et al., 2015).

Digital HBP monitoring devices are becoming increasingly popular. The worldwide use of digital HBP devices varies from 30-70% (Ruzicka, et al., 2016). Unreliable data from Africa and anecdotal reports from Nigeria seems to suggest an extensive use of digital HBP monitoring devices among adults above the age of 45 years. Despite the widespread use of digital HBP monitoring devices, there is dearth of information on the accuracy of the HBP monitoring devices in use (Ruzicka, et al., 2016).

Accurate digital HBP measurements is the vital cornerstone to quality diagnosis and management of hypertension (Ringrose, Polley, McLean, Thompson, Morales, & Padwal, 2017). In order to ensure sustained accuracy of digital HBP monitoring devices, formal validation for accuracy by trained health personnel was recommended by standard international protocols developed by British Hypertension Society, European Society of Hypertension and the Association for the Advancement of Medical Instrumentation (Ruzicka, et al., 2016).

Many digital HBP monitoring devices are sold without formal validation of accuracy (Ringrose, et al., 2017). This may hint a potential problem for individuals monitoring their BP for clinical reasons. To determine the extent at which digital HBP monitoring devices are supposedly serving individuals in ways they were designed to do, an evidence-based assessment of digital HBP monitoring devices in use by adults would be needed.

Limited recent studies have been done with regard to assessing the accuracy of automated BP devices. Findings from previous studies were equivocal. Odili, Abdullahi, Nwankwo, Asayama and Staessen (2015) found that digital HBP readings were significantly higher than clinic-based BP measurements. In additionally, Nelson, Kennedy, Regnerus and Schweinle (2008) found a significant difference between upper arm digital HBP readings compared to standard analogue mercury BP measurements among individuals of all ages. Furthermore, Ringrose et al (2017) found that digital HBP readings were about 69% of the times different from mercury sphygmomanometer BP measurements by at least 5mmHg. In contrast, Ruzicka et al (2016) found that digital HBP readings were about 30% of the times different from mercury sphygmomanometer BP measurements by at least 5mmHg. The mild equivocallity of empirical findings between Ringrose et al and Ruzicka et al justified a need for further investigation into the accuracy of digital BP monitoring devices. Furthermore, previous empirical studies concentrated on the accuracy status of digital HBP devices but little attention was given to the potential assosiation between accuracy of device and age of the device. This is what this unique study hopes to add. In addition, at the time of writing this report, there was paucity of empirical studies carried out in Africa on this subject.

Accurate BP values from digital HBP monitoring devices are expected to help individuals and clinicians in early diagnosis of hypertension, monitor response to treatment, encourage better control over one's blood pressure and cut health care costs. Digital BP monitoring devices are likely to be bought by older individuals who may have cardiovascular comorbidities, and other predisposing factors for aterial stiffness and wide pulse pressure (Ringrose, et al., 2017; Ruzicka, et al., 2016). Aterial stiffness and wide pulse pressure are theoretically presumed to unfavorablely influence the accuracy of BP measurments. Under or over-estimating BP by 5mmHg could have an effect on treatment choices for individuals (Nelson, et al., 2008).

Up to 47% of Nigerians are hypertensive, and about half of this population could be using digital upper arm HBP monitoring devices (Akinlua, et al, 2015). Despite the widespread use of digital HBP monitoring devices and its identified limitations, very little data exists on the accuracy of the digital HBP devices in use by adults in Nigeria. The paucity of emprical evidence to the accuracy of digital HBP monitoring devices in use in Nigeria motivated the research team to carry out a study of this nature.

The aim of this study was to examine the accuracy of digital upper arm HBP monitoring devices in use among adults in Aba, southeast Nigeria.

Potential findings from this study may point healthcare providers, towards the need for ingenious guidelines on the regulation and validation of digital HBP monitoring devices, especially in Africa.

II. METHODS AND MATERIAL

Study Area: Aba is a semi-urban town located in south-east Nigeria. It is the commerce nerve centre of Abia State. The town has a land area of approximately 75 km^2. It is inhabited majorly by the Igbo and partly English Speaking Nigerians. Aba has an estimated population of 1,500,000. There is one public out-patient nurse-led clinic in Aba where individuals can be taught proper HBP measuring techniques,

get recommendations on appropriate client-specific BP cuff size and have their HBP monitoring device evaluated for accuracy. This clinic was set up by a private-public partnership with the Local Government authority and started services on 19th June 2017. The clinic is led by a Doctorate degree nurse-cardiologist with eleven years clinical experience, who had undergone special training on hypertension management guidelines developed by the Korean Society of Hypertension, and had been certified by the American Heart Association (AHA) on Advanced Cardiac Life Support (2016). The Clinic was designed to serve an estimated 30,000 individuals (2% of the current estimated resident population). At the time of this study, the clinic had attended to 860 individuals and validated 524 digital upper arm HBP monitoring devices. The last sentence makes this nurse-led out-patient clinic suitable for a study of this nature.

Study Design: A retrospective chart review design was adopted for this study. This design involved the analysis of data collected from a sample of clinic based records (Polit & Beck, 2012).

Population: The target population for the study was adults who own and use an upper arm digital HBP monitoring device and had brought them for validation from 19th June 2017 to 19th February 2018. 524 participant's digital upper arm HBP monitoring device validation records were available.

Sample size calculation: A sample size of 210 participant records was determined using Cohen's sample size formula for cross-sectional studies involving single population proportion: $n = \frac{Z^2 x\ S.D^2}{d^2}$ (Charan & Biswas, 2013). Where Z^2 (Standard normal variate) = 1.96; S.D (Standard Deviation of variable) = 36mmHg (Five folds of the systolic standard deviation between upper arm digital HBP monitoring devices and clinical mercury sphygmomanometer reported in Ringrose et al); d (Absolute error) = 5mmHg. A minimum sample size of 199 was computed. To ensure a more robust statistical validity, the minimum sample size was increased by 5% to reach a final sample size of 210. The final sample size amounted to 40% of the target population.

Sampling Technique: 210 participant's digital upper arm HBP monitoring device validation record was used for the study. The records were randomly selected with the aid of computer mediated random numbers generated using Microsoft Excel 2007 computer application.

Inclusion and Exclusion Criteria: To ensure objectiveness, the criteria for inclusion of participant records included availability of data from the first visit; age of upper arm digital HBP monitoring device less than 90 days from day of purchase; and appropriate cuff-to-arm size. The exclusion criteria included multiple validation records for the same device.

Instrument for data Collection: The instrument for data collection was a checklist which had spaces for documented readings from a calibrated and validated manual mercury column manual sphygmomanometer (control) and each participant's own digital upper arm HBP monitoring device. The checklist was divided into five sections (sections A-E). Section A elicited participant's socio-demographic information. Section B extracted digital upper arm HBP monitoring device characteristics. Section C elucidated the reference BP value by averaging three documented manual mercury column sphygmomanometer readings. Section D extracted the digital upper arm HBP device reading by averaging values from three documented upper arm HBP device readings. Section E commented on accuracy status at 5mmHg allowance and at 10mmHg allowance. The instrument was worded in English.

Validity of the Instrument: To establish face validity, the instrument was submitted to three research experts from Disease Surveillance and Notification Unit, World Health Organization, Abia State, Nigeria. They verified that the checklist items were in line with the operational variables of interest.

Reliability of the Instrument: To test the intra-rater reliability of the instrument, a test of equivalence was done using test-retest method. Twelve pilot test records from University of Nigeria Medical Clinic Enugu, were used. One member of the research team examined the twelve pilot records using the checklist on two separate occasions at an interval of 14days between the two examinations. The two sets of data were subjected to Pearson Correlation analysis to determine similarity in results. An intra-rater reliability index > 0.9 was obtained (0.999 for systolic readings, and 0.998 for diastolic readings). A reliability index of r > 0.7 would imply good reliability of the instrument (Polit & Beck, 2012).

Ethical Consideration: This study was ethically approved by The Health Research and Ethics Committee Federal Medical Center Umuahia, Nigeria (approval number FMC/QEH/G.596/Vol.10/306). Administrative permission was obtained from authorities managing the selected nurse-led out-patient clinic before accessing participants' records. Informed consent was waived since the study is a retrospective chart review. To maintain the principle of anonymity all participants' records were de-identified prior to data collection.

Procedure for Data Collection: Before collecting data, the researcher examined the participants' records for adequacy. Adequacy would mean that the following specific guidelines were followed during validation of device process. The specific guidelines include: BP taken after 10 minutes of resting; Patient's arm circumference was measured to identify appropriate cuff; Digital upper arm HBP device was examined to be appropriate; Manual mercury sphygmomanometer was first used; Digital upper arm HBP device and manual mercury sphygmomanometer were alternately used in measuring blood pressure on the left arm at 5 minutes intervals; at least six sequential measurements were recorded; All measurements were taken with the patient sitting upright on a straight-backed chair, feet not crossed and flat on the floor, arm supported on a flat table surface at the level of the heart. If participant's records were found to be adequate for data collection, then the researcher examined participant's records for relevant documented information with regard to socio-demographic and device characteristics, reference BP readings and digital HBP device readings, then extracted the required data to fill into the instrument for data collection.

Operational Definition of Variables: *Accuracy* was measured in terms mean difference in measurement reading between an averaged three mercury sphygmomanometer measurements (control) and three digital HBP device readings taken five minutes apart. *Accuracy at 5mmHg allowance* was

classified as "accurate" (mean difference ≤ 5mmHg) and "Inaccurate" (mean difference > 5mmHg). *Accuracy at 10mmHg allowance* was classified as "accurate" (mean difference ≤ 10mmHg) and "Inaccurate" (mean difference > 10mmHg).

Method of Data Analysis: The instrument of data collection generated both continuous and categorical data. Three recorded systolic and diastolic readings were averaged to obtain the mean BP reading for both the mercury sphygmomanometer and the digital upper arm device. At first instance, if the difference between the mean readings of the mercury sphygmomanometer and the digital upper arm HBP device was more than 5mmHg, the digital upper arm device was classified as inaccurate; if not, it was classified as accurate. At second instance, if the difference between the mean readings of the mercury sphygmomanometer and the digital upper arm HBP device was more than 10mmHg, the digital upper arm HBP device was classified as inaccurate; if not, it was classified as accurate. Collated data was subjected to descriptive statistics. Two tailed t-test Chi square and Fischer exact test statistics were used for test of hypotheses. Level of significance was set at $P < 0.05$. Results were presented in tables. All statistical analysis was done with the aid of Statistical Package for Social Sciences (SPSS) version 21.

III. RESULTS

In all, 210 participant records were included in the study. The mean age of the participants was 52.4±11.2 years old, and majority 85 (40.5%) of them were aged between 50 – 59 years old. More than half 129 (61.4%) of the participants were females. Nearly half 97 (46.2%) of the participants declared no prior underlying cardiovascular disease condition. Among the participants, majority 86 (41%) had "Answer Acc." brand of digital HBP monitoring device. The mean age of digital HBP monitoring device from point of purchase was 21.3±20.2 days. Majority 109 (51.9%) of the digital devices had an age of 1 – 14 days from point of purchase. The socio-demographic and digital device characteristics were summarized in Table 1.

N = 210

Variables	Details	Mean±SD	f	%
Age (in years)	Mean age	52.4±11.2		
	20 - 29		6	2.9
	30 - 39		23	11.0
	40 – 49		42	20.0
	50 - 59		85	40.5
	60 - 69		35	16.7
	70 - 79		19	9.0
Gender	Male		81	38.6
	Female		129	61.4
Co-morbidity	Hypertension		80	38.1
	Diabetes		33	15.7
	None declared		97	46.2
Brand of digital HBP	Comfort		78	37.1
	Answer Acc.		86	41.0
	Sein		46	21.9
Age of HBP device from point of purchase (in days)	Mean age	21.3±20.2		
	1 - 14		109	51.9
	15 – 28		50	23.8
	29 – 42		14	6.7
	43 - 56		18	8.6
	57 - 70		13	6.2
	71 - 84		5	2.4
	85 - 98		1	0.5

Table 1: Characteristics of participants and digital device

Table 2 showed a comparison between mean readings of digital HBP device and manual mercury sphygmomanometer (auscultation method). With regard to Systolic readings, there was no significant difference in readings between digital HBP device and manual mercury sphygmomanometer (*t = -1.838, P = 0.068*). Nonetheless, there was significant difference in readings between digital HBP device and manual mercury sphygmomanometer with regard to diastolic readings *(t = -3.412, P = 0.001)*.

N = 210

Parameter	Apparatus	N	Min	Max	Mean	SD	df	t-test	P value	Sig. (2 tailed)
Systolic	Device	210	86	230	150.0	24.57	209	-1.838	0.068	Not significant
	Auscultation	210	91	250	151.6	26.42				
Diastolic	Device	210	46	151	89.1	14.48	209	-3.412	0.001	Significant
	Auscultation	210	52	132	90.9	13.36				

Decision Rule: P < 0.05 is significant

Table 2: Comparison between HBP device and auscultation readings

N = 210

Criteria	Parameter	Accuracy status	f	%
At 5mmHg allowance	Systolic	Accurate	88	41.9
		Inaccurate	122	58.1
	Diastolic	Accurate	112	53.3
		Inaccurate	98	46.7
	Absolute accuracy	Accurate	43	20.5
		Inaccurate	167	79.5
At 10mmHg allowance	Systolic	Accurate	144	68.6
		Inaccurate	66	31.4
	Diastolic	Accurate	181	86.2
		Inaccurate	29	13.8
	Absolute accuracy	Accurate	123	58.6
		Inaccurate	87	41.4

Table 3: Accuracy status of digital HBP devices

Table 3 summarized the accuracy status of the digital HBP devices. At 5mmHg, more than half 122 (58.1%) of the digital HBP devices were inaccurate on systolic readings, while nearly half 98 (46.7%) of them were inaccurate for diastolic readings. Considering absolute accuracy (accurate in both systolic and diastolic readings), more than half 167 (79.5%) of the devices were inaccurate at 5mmHg allowance. On the other hand, 66 (31.4%) of the devices were inaccurate for systolic and 29 (13.8%) were inaccurate for diastolic readings at 10mmHg. With regard to absolute accuracy at

10mmHg, nearly half 87 (41.4%) of the devices were inaccurate.

Table 4 showed that there was significant association between accuracy status of digital HBP device and the brand of digital device ($\chi^2 = 12.516$, $P = 0.002$) at 10mmHg allowance; however this was not found to be true at 5mmHg. Furthermore, no significant association was found between accuracy status of digital device and age of the device from point of purchase at 5mmHg and 10mmHg.

N = 210

		Absolute accuracy					
Characteristic	**Details**	**Accurate**	**Inaccurate**	χ^2	**Fischer**	**P value**	**Sig.**
At 5mmHg allowance							
Age of device from point of purchase (in days)	1 - 14	27	82		5.196	0.519	Not significant
	15 – 28	9	41				
	29 – 42	3	11				
	43 - 56	3	15				
	57 - 70	0	13				
	71 - 84	1	4				
	85 - 98	0	1				
Brand of device	Comfort	13	65	5.172		0.075	Not significant
	Answer Acc.	24	62				
	Sein	6	40				
At 10mmHg allowance							
Age of device from point of purchase (in days)	1 - 14	72	37		10.869	0.093	Not significant
	15 – 28	27	23				
	29 – 42	6	8				
	43 - 56	6	12				
	57 - 70	7	6				
	71 - 84	4	1				
	85 - 98	1	0				
Brand of device	Comfort	47	31	12.516		0.002	Significant
	Answer Acc.	59	27				
	Sein	17	29				

Decision Rule: P < 0.05 is significant

Table 4: Association between accuracy status and characteristics of device

IV. DISCUSSION

Blood pressure measurements are the guide for the diagnosis and management of hypertension (Ruzicka, et al., 2016). The result of this study showed that there was significant difference in diastolic readings between digital HBP devices and standard manual mercury sphygmomanometer ($P = 0.001$) but not for systolic readings. Moreover, the digital upper arm HBP devices significantly underestimated the diastolic BP readings. This finding would indicate poor reliability upper arm digital HBP devices since diastolic readings are essential in the diagnosis of hypertension. This finding was supported by Myers et al (2011) who found that routine manual office BP readings were significantly higher than digital automated office BP readings ($P < 0.001$). However, this finding was not in agreement with Nelson et al (2008) who found that for all age groups upper arm digital BP device readings were significantly higher than those of standardized manual mecury sphygmomanometer ($P < 0.05$). The divergence in findings could be due to differences in the age profile of participants used in the diferent studies since the reliability of digital wrist and arm measures are lowest for individual above 50 years of age (Nelson, et al., 2008). Nelson et al (2008) utilized a sample composed by 26.5% of individuals above 50 years, while this study utilized a sample composed of 66.2% of individuals above 50 years. The suggested explanation is further supported by Shin et al (2013) who noted that age is a more important determining factor for BP readings than gender for individuals aged more than 60 years.

This study revealed that 58.1% and 46.7% of digital upper arm HBP devices were inaccurate by more than 5mmHg on systolic and diastolic measures respectively. 79.5% and 41.4% of the digital upper arm HBP devices had absolute accuracy at 5mmHg and 10mmHg allowance respectively. The proportion of inaccurate digital upper arm HBP devices found in this study was higher than 69% documented in Ringrose et al (2017). Based on the idea that participants with poor blood sugar control are 1.65 times more likely to have uncontrolled BP, the reliability of digital devices may be further reduced by cardivascular comorbidities (Muleta, et al., 2017). The discrepancy in findings may be due to participants' co-morbidities. Ringrose et al (2017) utilized a sample which had 78% hypertensives and 20% diabetes mellitus participants among others. In this study, a sample having 80% hypertensives and 33% diabetes mellitus participants was used.

Accuracy status of digital HBP device was found to be significantly associated with the brand of digital HBP device at 10mmHg ($P < 0.05$) but not true at 5mmHg. Meanwhile, no significant association was found between accuracy status of digital HBP device and age of the device from point of purchase at 5mmHg and 10mmHg. The finding in this study was not in conformity with Ringrose et al (2017) and Ruzicka et al (2016), who found no significant association whatsoever between accuracy status and brand of digital HBP device in their respective studies. The divergence in findings may be linked to variations in proprietary characteristics of the HBP devices. Based on the idea that different brands of digital HBP devices are fitted with proprietary algorithms used to determine BP oscillometric measurements, it may be possible that the sensitivity of the algorithms differ from brand to brand (Ringrose, et al., 2017). Based on the last sentence, specific proprietary HBP device characteristics may over or under estimate blood pressure (Ruzicka, et al., 2016). In Ringrose et al (2017) and Ruzicka et al (2016), majority of the devices studied was the "Omron" brand, whereas in this study majority of the devices studies was of the "Answer Acc." brand.

Strenghts: Compared to previous studies, this study took into consideration the age of the instrument from point of purchase. This was done because the team of researchers could not track the age of device from time of production.

Limitations: Some of the limitations of the study would include the fact that one nurse-cardiologist measured the reference mecury BP. She was not blinded to readings of both the digital HBP device and mecury sphygmomanometer.

Furthermore, the sample for the study was drawn from individuals who were willing to carry their digital HBP device to the clinic for validation.

V. CONCLUSION

In summary, about 79.5% of digital upper arm HBP monitors are innacurate by more than 5mmHg. The validation of the accuracy of the digital upper arm HBP device by a trained healthcare worker immediately after purchase may be needful before depending on digital HBP measurements for health care related decisions.

REFERENCES

[1] Akinlua, J., Meakin, R., Umar, A., & Freemantle, N. (2015). Current Prevalence Pattern of Hypertension in Nigeria: A Systematic Review. PLOS ONE, 10(10): e0140021.https://doi.org/10.1371/journal.pone.0140021.

[2] Bancej, C., Campbell, N., Mckay, D., Nichol, M., Walker, R., & Kaczorowski, J. (2010). Home Blood Pressure Monitoring Among Canadian Adults With Hypertension: Results from the 2009 Survey on Living with Chronic Disease in Canada. Can J Cardiol, 26(5), e152-e157.https://www.ncbi.nlm.nih.gov/pmc/articles/PMC2886560.

[3] Charan, J., & Biswas, T. (2013). How to calculate sample size for different study designs in medical research. Indian J Psychol Med., 35(2), 121-126. http://doi.10.4103/0253-7176.116232.

[4] Muleta, S., Melaku, T., Chelkeba, L., & Assefa, D. (2017). Blood Pressure Control and Its Determinants Among Diabetes Mellitus Co-morbid Hypertensive Patientss at Jimma University Medical Center, South West Ethiopia. Clinical Hypertension, 2-9. doi: 10.1186/s40885-017-0085-x.

[5] Myers, M., Godwin, M., Dawes, M., Kiss, A., Tobe, S., Grant, F., et al. (2011). Conventional Versus Automated Measurement of Blood Pressure in Primary Care Patients with Systolic Hypertention: Randomised Parallel Design Controlled Trial. BMJ, 342, d286. https://doi.org/10.1136/bmj.d286.

[6] Nelson, D., Kennedy, B., Regnerus, C., & Schweinle, A. (2008). Accuracy of Automated Blood Pressure Monitors. Journal of Dental Hygiene, 82(4), 1-17.

[7] Odili, A., Abdullahi, B., Nwankwo, A., Asayama, K., & Staessen, J. (2015). Characteristics of Self-measured Home Blood Pressure in a Nigerian Urban Community: the NIPREGH Study. Blood Press Monit., 20(5), 260-265. doi:10.1097/MBP.0000000000000136

[8] Polit, F., & Beck, C. (2012). Nursing Research: Generating and Assessing Evidence For Nursing Practice. Philadelphia: Lippincott Williams & Wilkins.

[9] Ringrose, J., Polley, G., McLean, D., Thompson, A., Morales, F., & Padwal, R. (2017). An Assessment of the Accuracy of Home Blood Pressure Monitors When Used in Device Owners. American Journal of Hypertension, 30(7), 683. doi:10.1093/ajh/hpx041.

[10] Ruzicka, M., Akbari, A., Bruketa, E., Kayibanda, J., Baril, C., & Hiremath, S. (2016). How Accurate Are Home Blood Pressure Devices in Use? A Cross-Sectional Study. PLoS One, 11(6), e0155677. doi:10.1371/journal.pone.0155677

[11] Shin, J., Park, J., Kim, K., Yang, D., Pyun, W., Kim, Y., et al. (2015). 2013 Korean Society of Hypertension Guidelines for the Management of Hypertension: Part I - Epidemiology and Diagnosis of Hypertension. Clinical Hypertension, 21, 1. doi:10.1186/s40885-014-0012-3