Original Article

Knowledge and Practices of Blood Pressure Measurement among Final Year Students, House Officers, and Resident Dental Surgeons in a Dental Hospital, South West Nigeria

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Abstract

Objectives: To assess the knowledge and practices of blood pressure measurement (BPM) among final year students, house officers, and resident dental surgeons. **Materials and Methods:** A cross-sectional study consisting of a convenience sample of all final year students, house officers, and resident dental surgeons in a dental hospital in South West Nigeria was conducted. All participants were requested to complete a 16-item questionnaire about their knowledge of accurate BPM. After completing the questionnaire, the participants were observed by a single research associate as they measured the blood pressure (BP) of patients using a checklist prepared according to the World Health Organization and the American Heart Association (AHA) guidelines for measuring BP. The performance score was based on a 25-element skillset on BP measurement. Data were entered into Statistical Package for the Social Sciences (SPSS) Version 22. Frequencies and means were generated and independent Student's t-tests and Pearson's Chi-square tests were used to test the association between continuous and categorical variables, respectively at P value < 0.05. **Results:** In total, 139 questionnaires were returned by 59 final year dental nursing students, 29 final year dental students, 14 house officers, 18 registrars, and 19 senior registrars. Overall, 46.0% of the participants had poor knowledge of accurate BPM. The mean [standard deviation (SD)] BPM knowledge score was 5.8 (2.0), dental nursing students had the least 4.8 (1.5) score, and dental students had the highest 6.9 (2.0) score (P < 0.0001). Overall, the mean (SD) BPM knowledge scores for students and dentists were 5.5 (1.9) and 6.4 (1.9), respectively (P = 0.01). One-hundred and thirty-seven (98.6%) participants performed BPM inaccurately. There was a weak positive non-statistically significant correlation between knowledge and performance scores (r = 0.03; P = 0.75). **Conclusions:** Overall, 46.0% of participants had poor knowledge of accurate BPM while 98.6% performed BPM inadequately. These findings suggest the need for curriculum review on accurate BPM.

Keywords: *Blood pressure measurement, dental hospital, Nigeria*

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Introduction

Cardiovascular diseases are as prevalent in many developing countries as it is in developed countries and are increasingly common health issue worldwide.[1,2] They are a major cause of morbidity and mortality in sub-Saharan Africa. Out

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of the 17 million premature deaths (under the age of 70 years) due to non-communicable diseases in 2015, 82% are in low- and middle-income countries and 37% were caused by cardiovascular diseases.[2] Over two decades ago, the high burden of mortality from cardiovascular causes in developing countries is estimated at 9 million and this is expected to increase to 19 million by 2020.[3] Cardiovascular disease is a major risk factor for heart attack, stroke, and renal failure.[4] Heart failure is a growing problem worldwide with serious consequences in sub-Saharan Africa where there are limited resources.[5,6] Almost all unexpected deaths of medical origin in Nigeria are due to cardiovascular causes.[7] Hypertension is a common cardiovascular disease that does not have specific clinical manifestations until the development of target organ damage.[8] In developing countries, the detection of hypertension is often missed and failure to identify it is largely due to limited attention paid to the procedures necessary to obtain accurate blood pressure (BP) readings and a general lack of trained manpower and limited training of personnel.[9] In addition, faulty or unreliable BP measuring equipment as regularly witnessed in most centers in developing countries is also a major factor in adequate blood pressure measurement (BPM).[9]

Correct measurement of BP is critical for making proper decisions in management of hypertension to decrease cardiovascular risk and prevent organ damage. Inaccurate BPM could lead to a patient being falsely classified as hypertensive or falsely classified as having high normal or normal BP as well as lead to faulty clinical decisions regarding patient progression in an exercise program.[10,11] Screening of patients to detect hypertension early and initiate treatment before the onset of target organ damage is highly cost-effective.[8] The American Heart Association (AHA) recognizes three sources of error in BPM namely observer bias, faulty equipment, and failure to standardize the technique of measurement.[12] There seems to be a large interobserver variation both among nursing staffs and physicians despite clear guidelines because they do not follow the international society guidelines.[13] Studies have shown that teaching, training, and knowledge about BPM among healthcare professionals are suboptimal.[14,15] This study was undertaken to assess the knowledge and practices of BPM among final year students, house officers, and resident dental surgeons in a dental hospital in South West Nigeria. These participants areearly and middle-level manpower trainees who need to develop clinical skills and competencies in BPM required in the early diagnosis of hypertension and prompt referrrals to appropriate specialists. The BPM gives cardiovascular status of the patient to dental health professionals and guides them for dental treatment. Findings from this study are required to inform policy and practice in BPM thereby strengthening both undergraduate and postgraduate dental programs.

Materials and Methods

A cross-sectional study on BPM was undertaken among all final year dental nursing students, final year dental students, house officers, and resident dental surgeons at the Dental Center University College Hospital, a tertiary hospital in Ibadan, South West Nigeria. Participants were informed that their participation was voluntary and confidential and that the data obtained will only be used for research. Identifying information such as names were not collected. After this, written consent was obtained from them. The study was undertaken in strict compliance with principles of the Declaration of Helsinki on studies involving human subjects. A self-administered, semi-structured, and pre-tested questionnaire containing information on sociodemographic characteristics and various aspects of correct BPM (16 questions) as suggested by WHO and AHA (11) guidelines was completed by the participants in a room. The knowledge score of correct BPM was graded based on correct answers given as excellent (11-16 correct answers), good (6-10 correct answers), and poor (1-5 correct answers). After the questionnaire was completed, a patient who provided written informed consent was invited into the room for BPM.

Direct observation of a study participant measuring the BP of the simulated patient was used to assess their BP measuring skills.[15] The case simulation assessed BPM skills centered around rest, body positioning, cuff selection, cuff placement, use of the BP measuring device, BP in both arms and readings. The participants used the auscultatory method with a manual sphygmomanometer to ensure that all skills required to obtain an accurate BPM are performed.

A participant was invited to an examination room where a simulated patient was seated on a stool with no arm, back, or foot support, and with legs crossed. Next to the stool was an empty chair and an adjacently placed table. The chair had a back and arm support and a mercury sphygmomanometer; small, medium, large, and extra-large cuffs were placed on the table. The simulated patients were adults who had all received an identical script with detailed instructions to follow during each simulated encounter. They were instructed not to speak

unless spoken to during the procedure and to comply with any instructions given to them by the participants during the testing.

The participants were all given the same brief written clinical vignette stating that the patient in front of them was a 50-year-old who require a tooth extraction, new to their practice, and had not seen their physician in several years indicating a need for BP to be measured.[16] The participants were also told to measure the patient's BP and write down the results. In addition, they were told that they will be scored on the use of the BP measuring device. A single research associate used a scorecard to record the participant's performance on the case simulation. The participants were observed by the research associate as they measured the BP of patients using a checklist prepared according to the WHO and AHA (11) guidelines for measuring BP. The performance score was based on 25 skills: (1) time between entering the room and first reading; (2) total number of readings; (3) time between first and second reading; (4) removal of clothes; (5) arm support given; (6) zeroing of BP meter; (7) accurate cuff size; (8) inflation rate; (9) asked history of coffee/tea/cigarette intake or exercise; (10) both arms used; (11) tubing checked for leakage; (12) placement of stethoscope; (13) repeat reading taken; (14) position of arm; (15) deflate rate; (16) position of arm; (17) last digit reading; (18) patients back supported; (19) both patient's feet flat; (20) patient told to relax and not talking; (21) cuff positioned over brachial artery; (22) patient helping to elevate upper limb; (23) inflation of cuff above radial pulse; (24) arm used for BPM documented; and (25) patient position documented. Participants received correct or incorrect scores for each of the 25 skills tested. Performance score was graded based on the number of correct scores into accurate performanc (>13 correct scores) and inaccurate performance (< = 13 correct scores).

Random visits by the principal/co-investigators during questionnaire completion and BPM were conducted to ensure that data collection and completeness as planned.

Data were entered into Statistical Package for the Social Sciences (SPSS) Version 22. Sociodemographic characteristics were described using percentages, means, and standard deviations (SD). The percentages of participants who correctly performed skills and answered questions on various aspects of correct BPM were reported. The mean (SD) total scores of performance (25 skills) and knowledge (16 questions) of correct BPM were also reported. The differences by professional cadre, age group, and gender were presented in contingency tables and tested using independent samples Student's t-tests or Pearson's Chi-square test at P value < 0.05.

Results

Table 1 shows that the mean (SD) age of the study participants was 26.3 (5.9) years. Of 139, 94 (67.6%) participants were females. Of all the participants, 59 (42.4%) were dental nursing students, 29 (20.9%) were dental students, 14 (10.1%) were house officers, 18 (12.9%) were registrars, and 19 (13.7%) were senior registrars, respectively.,

Table 2 shows knowledge of accurate BPM among study participants. Overall, more than 50% of participants reported each of the following items correctly: knowledge of most appropriate BPM devices, the position of the patient while taking BPM, true reading when readings from the two arms are different and what determines systolic or diastolic BP. No participant knew that the BP of elderly or diabetic patients could be measured when the patient is standing. Few participants 10 (7.2%) and 14 (10.1%) knew the accurate number of BPM on a visit and the pressure, cuff should be inflated above radial pulse disappearance. The mean (SD) BPM knowledge score was 5.8 (2.0), with dental nursing students having the least 4.8 (1.5) and dental students having the highest 6.9 (2.0) mean (SD) scores, respectively (P < 0.0001) [Table 3]. Overall, the mean (SD) BPM knowledge score for students and dentists were 5.5 (1.9) and 6.4 (1.9), respectively (P = 0.01). Sixty-four (46.0%) participants had poor knowledge score of BPM while only 1 (0.8%) had an excellent knowledge score. Good knowledge of BPM was observed among 8 (57.1%) house officers, 12 (66.7%) registrars, 22 (75.9%) dental students, and 15 (78.9%) senior registrars, respectively. On the contrary, the majority of dental nursing students 42 (71.2%) had poor knowledge of BPM.

Out of the 25 BPM techniques that were observed, seven techniques were performed by more than 50% of participants accurately [Table 4]. Only 1 (0.7%) participant (senior registrar) documented arm used for BPM. Also, only 1 (0.7%) participant documented a patient's position for BPM. The mean (SD) BPM performance score was 8.7 (2.6), with dental students having the least 8.0 (3.0) and senior registrars having the highest 9.4 (2.7) scores (P = 0.43), respectively [Table 5]. Overall, the mean (SD) BPM performance score of students and dentists were 8.5 (2.7) and 9.0 (2.5) (P = 0.34), respectively. Overall, 137 (98.6%) participants performed BPM

Table 1: Sociodemographic characteristics

Sociodemographic characteristics	Overall *n*=139 No. (%)	Dental Nursing Students *n*=59 No. (%)	Dental Students *n*=29 No. (%)	House Officers *n*=14 No. (%)	Registrars *n*=18 No. (%)	Senior Registrars *n*=19 No. (%)
Age (years)						
– 25	45 (32.4)	48 (81.4)	25 (86.2)	13 (92.9)	2 (11.1)	0 (0)
>25	94 (67.6)	11 (18.6)	4 (13.8)	1 (7.1)	16 (88.9)	19 (100.0)
Mean (SD)	26.3 (5.9)	23.5 (3.1)	23.9 (2.1)	25.6 (2.9)	34.6 (4.9)	36.4 (4.2)
Gender						
Male	45 (32.4)	5 (8.5)	11 (37.9)	7 (50.0)	10 (55.6)	12 (63.2)
Female	94 (67.6)	54 (91.5)	18 (62.1)	7 (50.0)	8 (44.4)	7 (36.8)

Table 2: Knowledge of accurate blood pressure measurement among study participants

Accurate knowledge	Overall *n*=139 No. (%)	Dental nursing Students *n*=59 No. (%)	Dental Students *n*=29 No. (%)	House Officers *n*=14 No. (%)	Registrars *n*=18 No. (%)	Senior Registrar *n*=19 No. (%)
Most appropriate BP measuring device	96 (66.2)	43 (72.9)	11 (37.9)	10 (71.4)	16 (88.9)	12 (63.2)
Frequency of calibration	39 (28.1)	15 (25.4)	13 (44.8)	4 (28.6)	7 (38.9)	0 (0)
Number of BPM on first visit	10 (7.2)	3 (5.1)	2 (6.9)	1 (7.1)	1 (5.6)	3 (15.8)
Arm used for BPM	15 (10.8)	5 (8.5)	4 (13.8)	1 (7.1)	3 (16.7)	2 (10.5)
Position BPM should be taken	133 (95.7)	59 (100.0)	27 (93.1)	12 (85.7)	16 (88.9)	19 (100.0)
Standing position for BPM in elderly or diabetic patients	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
Korotkoff sound Systolic Blood Pressure	94 (67.6)	47 (79.7)	19 (65.5)	5 (35.7)	10 (55.6)	13 (68.4)
Korotkoff sound Diastolic Blood Pressure	103 (74.1)	45 (76.3)	22 (75.9)	11 (78.6)	10 (55.6)	15 (78.9)
Recorded higher or lower reading	73 (52.5)	18 (30.5)	22 (75.9)	11 (78.6)	11 (61.1)	11 (57.9)
Arm position for BPM	25 (18.0)	2 (3.4)	9 (31.0)	3 (21.4)	4 (22.2)	7 (36.8)
Part of stethoscope to hear low pitched sounds	54 (38.8)	16 (27.1)	11 (37.9)	8 (57.1)	7 (38.9)	12 (63.2)
Position of center of bladder of cuff on arm	64 (46.0)	13 (22.0)	21 (72.4)	7 (50.0)	10 (55.6)	13 (68.4)
Inflation of cuff above radial pressure	14 (10.1)	3 (5.1)	4 (13.8)	4 (28.6)	1 (5.6)	2 (10.5)
Rate of deflation of cuff	58 (41.7)	18 (30.5)	18 (62.1)	4 (28.6)	9 (50.0)	9 (47.4)
Rest before BPM	34 (24.5)	9 (15.3)	6 (20.7)	6 (42.9)	6 (33.3)	7 (36.8)
Cuff size	56 (40.3)	10 (16.9)	20 (69.0)	8 (57.1)	8 (44.4)	10 (52.6)

Table 3: Knowledge score of accurate blood pressure measurement among study participants

Knowledge score	Overall *n*=139	Dental Nursing Students *n*=59	Dental Students *n*=29	House Officers *n*=14	Registrars *n*=18	Senior Registrars *n*=19	*F*	*p*	Post-hoc
Excellent (No. (%))	1 (0.8)	0 (0.0)	1 (3.4)	0 (0.0)	0 (0.0)	0 (0.0)	-	-	-
Good (No. (%))	74 (53.2)	17 (28.8)	22 (75.9)	8 (57.1)	12 (66.7)	15 (78.9)			
Poor (No. (%))	64 (46.0)	42 (71.2)	6 (20.1)	6 (42.9)	6 (33.3)	4 (21.1)			
Mean (SD)	5.8 (2.0)	4.8 (1.5)	6.9 (2.0)	6.2 (2.0)	6.2 (1.8)	6.7 (2.0)	8.6	<0.0001	DNS vs DS*
									DNS vs Reg**
									DNS vs SR***

Note: DNS – Dental Nursing Students; DS – Dental Students; Reg – Registrars; SR – Senior Registrars. *-p<0.0001; **-p=0.001; ***-p=0.04

inaccurately while 2 (1.4%) participants comprising a dental student and senior registrar performed BPM accurately.

There was a weak positive correlation between knowledge and performance scores of BPM but this was not statistically significant (r = 0.03; P = 0.75).

Table 4: Performance of accurate blood pressure measurement among study participants

Accurate Performance	Overall *n*=139 No. (%)	Dental nursing students *n*=59 No. (%)	Dental students *n*=29 No. (%)	House officers *n*=14 No. (%)	Registrars *n*=18 No. (%)	Senior Registrar *n*=19 No. (%)
Time between entry in clinic and first reading	13 (9.4)	6 (10.2)	4 (13.8)	0 (0)	1 (5.6)	2 (10.5)
Total number of readings	15 (10.8)	11 (18.6)	1 (3.4)	0 (0)	2 (11.1)	1 (5.3)
Time between 1st and 2nd reading	13 (9.4)	10 (16.9)	1 (3.4)	0 (0)	2 (11.1)	0 (0)
Removal of clothes	102 (73.4)	35 (59.3)	22 (75.9)	14 (100.0)	16 (88.9)	15 (78.9)
Arm support given	63 (45.3)	10 (16.9)	18 (62.1)	8 (57.1)	12 (66.7)	15 (78.9)
Zeroing of BP Meter	47 (33.8)	38 (64.4)	5 (17.2)	0 (0)	2 (11.1)	2 (10.5)
Accurate cuff size	137 (98.6)	58 (98.3)	28 (96.6)	14 (100.0)	18 (100.0)	19 (100.0)
Inflation rate	8 (5.8)	5 (8.5)	1 (3.4)	1 (7.1)	0 (0)	1 (5.3)
Asked history of coffee or tea or cigarette intake or exercise	128 (92.1)	53 (89.8)	26 (89.7)	13 (92.9)	18 (100.0)	18 (94.7)
Both arms used	5 (3.6)	3 (5.1)	0 (0)	0 (0)	1 (5.6)	1 (5.3)
Tubing checked for leakage	8 (5.8)	1 (4.5)	2 (6.9)	0 (0)	4 (22.2)	1 (5.3)
Placement of stethoscope	118 (84.9)	51 (86.4)	24 (82.8)	12 (85.7)	16 (88.9)	15 (78.9)
Repeat reading taken	34 (24.5)	31 (52.5)	1 (3.4)	0 (0)	1 (5.6)	1 (5.3)
Position of arm	104 (74.8)	42 (71.2)	17 (58.6)	11 (78.6)	16 (88.9)	18 (94.7)
Deflate rate	20 (14.4)	5 (8.5)	6 (20.7)	4 (28.6)	3 (16.7)	2 (10.5)
Position of arm	42 (30.2)	30 (50.8)	2 (6.9)	3 (21.4)	1 (5.6)	6 (31.6)
Last digit reading	46 (33.1)	6 (10.2)	19 (65.5)	6 (42.9)	6 (33.3)	9 (47.4)
Patients back supported	36 (25.9)	15 (25.4)	7 (24.1)	4 (28.6)	4 (22.2)	6 (31.6)
Both patient's feet flat	19 (13.7)	12 (20.3)	4 (13.8)	1 (7.1)	1 (5.6)	1 (5.3)
Patient told to relax and not talking	20 (14.4)	6 (10.2)	4 (13.8)	1 (7.1)	3 (16.7)	6 (31.6)
Cuff positioned over brachial artery	91 (65.5)	42 (71.2)	15 (51.7)	9 (64.3)	13 (72.2)	12 (63.2)
Patient helping to elevate upper limb	104 (74.8)	42 (71.2)	17 (58.6)	8 (57.1)	12 (66.7)	15 (78.9)
Inflation of cuff above radial pulse	49 (35.3)	38 (64.4)	14 (48.3)	11 (78.6)	11 (61.1)	12 (63.2)
Arm used for BPM documented	1 (0.7)	0 (0)	0 (0)	0 (0)	0 (0)	1 (5.3)
Patient position documented	1 (0.7)	0 (0)	0 (0)	1 (7.1)	0 (0)	0 (0)

Table 5: Performance score of accurate blood pressure measurement among study participants

Performance score	Overall *n*=139	Dental Nursing Students *n*=59	Dental Students *n*=29	House Officers *n*=14	Registrars *n*=18	Senior Registrars *n*=19	*F*	*p*
Accurate (No. (%))	2 (1.4)	0 (0.0)	1 (3.4)	0 (0.0)	0 (0.0)	1 (5.3)	-	-
Inaccurate (No. (%))	137 (98.6)	59 (100.0)	28 (96.6)	14 (100.0)	18 (100.0)	18 (94.7)		
Mean (SD)	8.7 (2.6)	8.8 (3.0)	8.0 (3.0)	8.4 (2.6)	9.1 (2.2)	9.4 (2.7)	1.0	0.43

Discussion

American Heart Association (AHA) guidelines have shown the inaccuracies of BPM and possible sources of errors.[17] In this study, we have demonstrated inadequate knowledge and practice of BPM among final year students, house officers, and resident dental surgeons in a dental hospital in South West Nigeria.

In agreement with findings from other studies,[18,19] the majority (67.6%) of participants in this study were females. The higher preponderance of females seen among hospital staff based researches may be due to the female gender-based nature of some medical professions like nursing and possibly dentistry. It could also be a reflection of the gender gap closure that is being witnessed in most medical fields.[20] In this study, dental nursing students constituted the largest group (42.4%) of the participants.

The background knowledge of BPM possessed by hospital staff is important in achieving accurate BPM.[21] The mean BPM knowledge score of the 16 questions on accurate knowledge of BPM in this study was 5.8 indicating that the knowledge of the technique among the participants was inadequate. For example, it was only in four items that more than 50% of the participants were accurate. Overall, over 40% of the participants had poor knowledge of accurate BPM, this falls within 22.3% to 87.1% reported in other previous studies.[22,23] The importance of accurate BPM in clinical practice cannot be overemphasized. Unfortunately, several reports have shown abysmal knowledge of accurate BPM among nursing students, medical students, nurses,

and doctors.[24,25] The poor knowledge of accurate BPM might be due to the lack of formal training in BPM at both undergraduate and postgraduate levels since BPM is assumed to be a basic clinical skill acquired through apprenticeship. In addition, for doctors and dentists, it might be due to reliance on nurses for BPM keeping them out of touch with the accurate knowledge and possible practice of the technique.

Manual measurement using a mercury sphygmomanometer and a stethoscope remains a gold standard for BPM.[26] In this study, the majority of the participants knew that the mercury spygnomanometer is the most appropriate BP measuring device in agreement with other previous studies.[27] Conversely, for a frequency of calibration of BP devices, slightly above a quarter (28.1%) of participants indicated the appropriate calibration interval of 6 months. AHA recommends that during BPM, patients should sit comfortably with their arms supported.[28] In line with this recommendation, over 95.7% of participants knew that patients should sit comfortably on a chair with their arms supported to get an accurate reading. Measuring the patient's BP at a sitting level will ensure that the center of the cuff bladder is at the heart level. If the position of the center of the bladder is above or below the heart level, BP may be recorded falsely high or low for every 10 cm above or below the heart level, respectively[29] and if the arm is not supported the systolic BP (SBP) and diastolic BP (DBP) might increase.[30]

In this study, over 65% of the participants knew that the first and fifth Korotkoff sounds determine the SBP and DBP, respectively. It is well acknowledged that the predictive power of multiple BP recordings is much greater than a single office recording.[31] A minimum of three recordings should be taken at an interval of at least 5 minutes and an average of the last two recordings should be used to represent the patient's BP.[32] Some guidelines recommended measuring BP in both arms at the initial visit and therefore in the arm with the highest BP to prevent missed diagnosis.[33,34] In this study, only 7.2% of participants knew that two recordings have to be taken on the first visit to a health facility and slightly above one-tenth (10.8%) knew that the recordings should be done in both arms. Similarly, slightly more than half (52.5%) of the participants knew that when you have two different recordings on both arms, a third recording should be taken on the arm with the higher recording. El Bagir and Ahmed in Saudi Arabia also reported that less than 50% of the nurses and less than 30% of the doctors in their study knew that BPM should be done in both arms on the first visit.[25] Conversely, most of the participants demonstrated inadequate knowledge of other variables that influence BPM in agreement with previous studies.[35,36] This can result in inaccurate BPM.

It is interesting to observe that no participant knew that BP of elderly or diabetic patients could be taken while patients are standing so as to diagnose postural hypotension. BPM guidelines recommend that before BPM, the patient should rest undisturbed in a quiet comfortable setting at room temperature for at least 5 minutes. Contrary to findings in previous studies[21,36] where over 75% indicated that patients must rest for at least 5 minutes before BPM, in this study less than a quarter (24.5%) of participants reported that a patient should rest for at least 5 minutes before BPM. As a matter of concern, less than half (41.7%) of the participants as in a previous study[21] indicated the ideal deflation rate of 2 mmHg per second. This inadequacy in accurate BPM among the majority of participants may affect BPM because an inflation rate that is too fast will underestimate the SBP and overestimate the DBP. In relation to the selection of cuff size, placement of the center of the bladder of cuff and part of the stethoscope head used to hear low pitched Korotkoff sounds; more than 50% of the participants lack the appropriate knowledge. Pickering *et al*.[12] reported that the ideal cuff should have a bladder length of 80% and a width of at least 40% of arm circumference (a length-to-width ratio of 2:1). When placing the center of the bladder of cuff and stethoscope, first palpate the brachial artery in the antecubital fossa and place the midline of the bladder of the cuff (commonly marked on the cuff by the manufacturer) so that it is over the arterial pulsation over the patient's bare upper arm. The lowermost edge of the cuff should be at least 1 inch (2.5 cm) above the antecubital crease so that the bell (preferred) or the diaphragm of stethoscope can be placed over the point of the strongest palpable brachial artery pulse in the antecubital fossa without encroaching beneath the cuff.[37] The key to good measurement is the use of a high-quality stethoscope with short tubing because inexpensive models may lack good tonal transmission properties required for accurate auscultatory measurement.[12] For the selection of cuff sizes, the lack of different cuff sizes in most clinics and wards in Nigeria may partly contribute to the inadequate knowledge demonstrated by the participants. Therefore, different cuff sizes should be procured when health facilities buy cuffs.

In this study, dental nursing students had the least 4.8 mean knowledge score when compared to dental students (6.9), house officers (6.2), registrars (6.2), and senior registrars (6.7). This finding is similar to findings from a previous study[21] on knowledge of BPM among doctors and nurses where the mean knowledge

score of doctors was significantly higher than the mean knowledge score of nurses. These observations may be due to differences in the extent of training undergone by doctors and nurses. It was surprising to note that dental students had a better knowledge of BPM than dentists, which could be due to a decline in knowledge base over time, therefore underscoring the importance of continuing dental education in BPM. However, overall, the mean knowledge score of students (5.5) was lower than the mean knowledge score of oral health professionals (6.4).

Accurate performance of the 25 skills required to measure BP accurately was disappointing. The average participant failed to perform more than 70% of the skills accurately. Very poor performance was observed in several skills including documenting arm used and position of BPM; checking BP in both arms; deflating cuff at 2 mmHg/sec; checking tubing for leakage; at least 5 minutes rest prior to BPM; taking more than one reading and allowing at least 5 minutes between first and second readings. The result can be interpreted to show that the current dental school curriculum for teaching BPM needs to be evaluated and redesigned. As with nurses and doctors, competency testing of dentists should be ongoing. The inaccurate performance by the majority of students in this study is consistent with findings from other studies where medical,[38] nursing,[24] chiropractic,[23] and pharmacy[39] students demonstrated poor performance of BPM. This probably demonstrates that the poor performance of BPM among students is an international problem that requires a solution. Several strategies have been initiated to mitigate the loss of competence of BPM in some countries. For example, in Turkey,[40] refresher training in the third year of medical school after initial training in the second year has been successful. Previous publications have reviewed and emphasized the consequences of the poor performance of BPM.[12,41] Most errors in the BPM technique results in higher values of BP. For example, a 5 to 10 mmHg error can result in an inaccurate categorization of BP from prehypertension to stage 1 hypertension resulting in unnecessary and potentially harmful therapy for a significant number of patients.[37] Potential harmful effects on patients can result from an inappropriate escalation of therapy when hypertension that is controlled appears uncontrolled due to poor technique.[16] Dental health professionals need to master BPM skills since accurate BP recordings will improve BP management because they will identify hypertensive patients that will require referral to an appropriate health facility. For dentists to attain and maintain this critical skill, dental schools must improve methods used to teach students how to master BPM skills accurately. In addition, it is critical that a system is put in place to ensure that oral health professionals maintain mastery throughout their careers. Studies have shown that when periodic training of clinical staff in accurate BPM using videos as well as written and in-person competency testing were undertaken, the staff were able to maintain their ability to measure BP accurately.[12,42] The use of automated devices that are now recommended for measuring BP could potentially reduce the need for retraining[12] because these devices have an advantage of reducing observer errors and the white-coat effect and providing multiple measurements.[34,43] So far, automated devices are not commonplace in the training of both undergraduate and postgraduate dental students especially in developing countries like Nigeria.

In this study, the mean BPM performance score of dental students was the least while that of the senior registrars was the highest. This may be because senior registrars are more experienced in BPM arising from their years of experience and more contact with patients. This may also be the reason why overall the mean BPM performance score of dentists was higher than the students. In addition, the curriculum is not clear on the training of students in BPM while resident dental surgeons are trained in BPM during oral medicine and oral and maxillofacial surgery training. BPM is part of the schedule of duties of dental nurses and during such measurement, dental nursing students are routinely trained on how to measure BP accurately. This might be the reason why dental nursing students had a higher BPM performance score than dental students. There was no linear relationship between accurate knowledge and performance of BPM.

A limitation of the study is that the convenience sample of final year students, house officers, and resident dental surgeons comprise only study participants who agreed to participate may signal their self-perceived knowledge and performance of BPM skills or the level of confidence in those skills. The results suggest that there is little if any bias in knowledge and performance due to these factors.

In conclusion, there was a wide variation in knowledge of accurate BPM among the four population groups studied. The knowledge of the basic principles of BPM was inadequate. Overall, 46.0% of participants had poor knowledge of accurate BPM while 98.6% performed BPM inadequately. The reason for this inadequate knowledge and performance of BPM might be because oral health practitioners hardly use the BPM skills in their daily practice. Students and dentists working in dental hospitals need to improve their knowledge and practice about BPM and teaching programs on BPM

should be developed as part of undergraduate and postgraduate programs as well as continuing dental education.

Declaration of patient consent

The authors certify that they have obtained all appropriate patient consent forms. In the form, the patient(s) has/have given his/her/their consent for his/her/their images and other clinical information to be reported in the journal. The patients understand that their names and initials will not be published and due efforts will be made to conceal their identity.

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Conflicts of interest

Each author has no financial obligation or other relationships with any organization, therefore, there is no conflict of interest.

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