ORIGINAL ARTICLE

Knowledge of Home Blood Pressure Monitoring among Medical Students in Malaysia

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ABSTRACT

Introduction: As future healthcare providers, it is vital for medical students to be well-versed in home blood pressure monitoring (HBPM), which plays a crucial role in hypertension management. This study aimed to assess the level of knowledge on HBPM among medical students and factors associated with good knowledge. **Method:** A cross-sectional study was conducted among Year One to Five medical students in a Malaysian public university using universal sampling. Data was gathered via an online questionnaire on HBPM knowledge. The analysis of the data was performed using SPSS v26. Multiple logistic regression identified the determinants of good HBPM knowledge after adjusting for confounding. **Results:** A total of 370 medical students were recruited. The median age was 22 (2) years old, and 73.2% were female. 63.2% of them were from clinical years. The proportion of medical students with good HBPM knowledge was 55.7% (28.7% from preclinical students and 46% from clinical-year students). Multiple logistic regression revealed that clinical-year students were more likely to have good knowledge about HBPM than preclinical-year students. (OR=2.96; 95% CI=1.91-4.58, p<0.001). **Conclusion:** This study showed that preclinical-year students possess a poorer knowledge of HBPM. However, less than half of clinical year students exhibited good knowledge, despite greater patient exposure suggesting current clinical teaching may not impart comprehensive HBPM understanding. Medical schools should strengthen the curriculum by incorporating more practical HBPM learning during clerkships and rotations. This can better equip future physicians to effectively utilize HBPM for diagnosing and managing hypertension.
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INTRODUCTION

Hypertension poses a significant healthcare challenge globally, particularly in Asia, where most of the world's population resides (1, 2). It consistently contributes to premature mortality, with a more pronounced impact in Asia due to low awareness and poor control rates (3). This exacerbates the overall burden of the disease in this region (4, 5). Elevated blood pressure is linked to an increased risk of cardiovascular events, independent of other risk factors (6). Therefore, it is crucial to control blood pressure levels to mitigate the risks of cardiovascular mortality and morbidity. Effective control and monitoring of blood pressure play a pivotal role in the management of hypertension.

In recent times, there has been an increasing recognition of the significance of Home Blood Pressure Monitoring (HBPM) in the diagnosis and management of hypertension (3, 7, 8). HBPM serves as a complement to office or clinic blood pressure measurements, assisting in the attainment of blood pressure control (9). HBPM has also been shown to improve adherence to

antihypertensive medications (10, 11). Additionally, HBPM has demonstrated effectiveness in enhancing adherence to antihypertensive medications (10, 11). Despite numerous international guidelines endorsing the use of HBPM (12-15), its adoption and availability in Asia, unfortunately, remain limited (3).

In China, only 53% of physicians advocated for HBPM (15, 16). Conversely, in Indonesia, HBPM was not commonly practiced due to a shortage of resources and insufficient education on the procedure (17). A study in Japan revealed a surprising finding: fewer than 20% of physicians could accurately specify the recommended blood pressure targets for HBPM (7). Consequently, there exists a considerable disparity between the utilization of HBPM and the recommended guidelines. Bridging this gap may be facilitated through medical education emphasizing the advantages of incorporating HBPM into clinical practice.

With the increasing availability and affordability of HBPM, its adoption is expected to grow, necessitating medical practitioners to be proficient in its application. A target group that should be equipped to advocate for the broader use of HBPM is medical students. Presently, there is a scarcity of studies evaluating the understanding of HBPM among medical students. Hence, our study aimed to assess the level of knowledge among medical students regarding HBPM and identify factors associated with possessing a comprehensive understanding of its usage. These findings may underscore the imperative for a targeted approach in enhancing the training of medical students in utilizing HBPM.

MATERIALS AND METHODS

Study Design and Study Location

This was a cross-sectional study involving medical students enrolled in the Doctor of Medicine Program at Universiti Putra Malaysia, a public university in Serdang, Malaysia. The program spans five years and is structured into three phases. The first phase is dedicated to preclinical training, introducing students to basic medical science with limited clinical exposure. Phases 2 and 3 encompass clinical training, with Phase 2 involving basic clinical practices and Phase 3 providing comprehensive clinical training in preparation for future housemanship training (18).

Study duration and population

The study was conducted over a one-month period, from September to October 2018. Eligible participants included all medical students from Year One to Five, aged 18 years and older.

Sample Size Estimation

The sample size was determined using the Lemeshow formula (19), considering a prevalence range that varied from 60% to 81% of correct responses. This range pertained to participants correctly acknowledging the superiority of HBPM in diagnosing and managing hypertension compared to clinic blood pressure, as reported by Obara et al. (7). After incorporating a non-respondent rate of 20%, aiming for 80% power, and setting a significance level of 0.05, the calculated sample size was 295 (20).

Sampling Method and data recruitment

The study employed a universal sampling method, distributing an invitation link to an online questionnaire via Google Form to all medical students within a one-month period. Prior to responding to the survey, participants were provided with a participation information sheet and an informed consent form. Consent was mandatory for participation, as completion of the consent form was a prerequisite before accessing the questionnaire.

Study instrument

There were 21 items in the questionnaire. The questions were developed by the authors based on the latest version of the local clinical practice guideline on the management of hypertension (21). The development of the questionnaire was conducted in two stages. Stage I involved content validity, and stage II involved face validity and pilot study.

The content validity was performed by 4 experts in which all were Family Medicine Specialists. They were tasked with providing constructive feedback on various aspects of the questionnaires, including the suitability and comprehensiveness of the scale or individual items, the organization of the questions, the time required to complete the survey, and the clarity of the instructions. To assess the content validity of each item in the questionnaire, the experts were asked to rate the importance of each item using a Likert scale that ranged from 1 to 4, where 1 represented “not relevant,” 2 indicated “not important,” 3 signified “relevant,” and 4 denoted “very important.” A CVI value exceeding 0.8 was considered indicative that the items were relevant and should be retained within the questionnaire (22). The S-CVI was 0.91 and the proportion relevance for each expert ranged from 0.80 to 0.85, demonstrating that all the items met the criterion for relevance and were thus retained in the questionnaire (22).

Face validity was conducted among 5 medical students to test the clarity of the questionnaire and they agreed that the questions can measure what they were intended to measure. Prior to the main study, a pilot study was conducted with 30 medical students, who were excluded from final analysis, to evaluate the clarity of the questionnaire items and assess the time needed for completion. During the pilot study, Cronbach’s alpha was measured to determine the reliability of the questionnaire tool. The Cronbach alpha value for home blood pressure questionnaire was 0.688 with moderate

level of internal consistency reliability.

Definition of good knowledge of HBPM

Students answered 'Yes', 'No' or 'I don't know' for each question. Those who answered 'I don't know' are considered incorrect answers. When the respondents provided a correct answer to a question, they were awarded one point. The cutoff point for determining good knowledge was established using the median score, with a total score of 13 or higher on the questionnaire indicating a strong understanding of HBPM.

Data Analysis

The characteristics of the participants were presented using descriptive analysis, which included frequencies, percentages, means, and standard deviations. Chi-square test was used to identify the associations between the categorical data. Multiple logistic regression was used to determine the predictors of good knowledge of HBPM. All variables with the p-value < 0.25 in the univariate analysis were entered into the multiple logistic regression. The dependent variable was the good knowledge of HBPM among medical students. The independent variables were gender, ethnicity, religion and year of study. Statistical Package for Social Sciences (SPSS) version 26.0 was used to analyze the data collected from this survey.

Ethical approval

Ethical approval was obtained from the Ethics Committee for Research Involving Human Subjects, Universiti Putra Malaysia (JKEUPM-2018-295).

RESULTS

Sociodemographic Characteristics

In 2018, the medicine program had 507 medical students enrolled. Out of these, 370 medical students voluntarily participated in the study, giving a response rate of 73%. Table I shows the sociodemographic characteristics of the respondents. The median age of the study respondents was 22 (2) years old with a majority of them being female (73.2%). The most common ethnicity is Malay students (58.6%), followed by Chinese (23.8%) and Indian students (15.7%). The majority of the sample identified themselves as Muslim (60.5%), followed by Buddhists (18.6%) and Hindus (13.2%). In terms of the year of study, there are 136 individuals in the preclinical year (36.8%) and 234 individuals in the clinical year (63.2%).

Level of Knowledge of HBPM

Overall, more than half of the respondents (55.7%) had good HBPM knowledge. However only 28.7% of preclinical year students demonstrated good knowledge (39 out of 136), whereas 46.2% of clinical year students exhibited good knowledge (108 out of 234), indicating a marked difference in knowledge levels between these two groups.

Table I: Sociodemographic Characteristics of Study Respondents (n=370)

Variable		Frequency N (%)	Median (IQR)
Age, years			22 (2)
Gender			
	Male	99 (26.8)	
	Female	271 (73.2)	
Ethnicity			
	Malay	217 (58.6)	
	Chinese	88 (23.8)	
	Indian	58 (15.7)	
	Others	7 (1.9)	
Religion			
	Islam	224 (60.5)	
	Buddhism	69 (18.7)	
	Hindu	49 (13.2)	
	Christianity	25 (6.8)	
	Others	3(0.8)	
Year of Study			
	Preclinical Year	136 (36.8)	
	Clinical Year	234 (63.2)	

Table II showed the percentage of correct and incorrect responses to a series of questions regarding HBPM measurement. Among the statements, the one with the highest percentage of correct responses was "HBPM can optimize blood pressure control in high cardiovascular risk patients and pregnancy" with 90.8% correct responses. The question with the lowest percentage of correct responses was "Home blood pressure measurements should be taken before voiding" with only 21.9% correct responses. Other questions that received high percentages of correct responses include "Home blood pressure measurement is a useful adjunct in the management of hypertension" (90.5%), "HBPM can be used to assess treatment effects" (86.8%), "HBPM can improve compliance with long term treatment" (82.4%), and "Home blood pressure measurements are not supposed to be taken before voiding" (78.1%). Questions that received lower percentages of correct responses include "Home blood pressure measurements can be an alternative to ambulatory blood pressure measurements" (56.5%), "HBPM can be used to diagnose true resistant hypertension" (48.1%), "Home blood pressure measurement is not equivalent to office measurements in diagnosing uncontrolled hypertension" (59.2%), "HBPM can be used to diagnose isolated office hypertension" (59.5%) and "home blood pressure values measured on the first monitoring day should be discarded (23.0%)".

Table II: Distribution of Correct and Incorrect Answers on Home Blood Pressure Monitoring among Medical Students in the Faculty of Medicine and Health Sciences (n=370)

	Questions	Correct N (%)	Incorrect N (%)
1.	Home blood pressure measurement is a useful adjunct in the diagnosis of hypertension.	295 (79.7%)	75 (20.3%)
2.	Home blood pressure measurement is a useful adjunct in the management of hypertension.	335 (90.5%)	35 (9.5%)
3.	Home blood pressure measurement gives good prognostic value.	243 (65.7%)	127 (34.3%)
4.	Home blood pressure measurement is equivalent to office measurements in diagnosing uncontrolled hypertension.	151 (40.8%)	219 (59.2%)
5.	Home blood pressure measurements can be an alternative to ambulatory blood pressure measurements.	209 (56.5%)	161 (43.5%)
6.	Home blood pressure monitoring can be used to diagnose isolated office hypertension.	220 (59.5%)	150 (40.5%)
7.	Home blood pressure monitoring can be used to diagnose masked hypertension.	223 (60.3%)	147 (39.7%)
8.	Home blood pressure monitoring can be used to assess treatment effects.	321 (86.8%)	49 (13.2%)
9.	Home blood pressure monitoring can be used to diagnose true resistant hypertension.	178 (48.1%)	192 (51.9%)
10.	Home blood pressure monitoring can improve compliance with long term treatment.	305 (82.4%)	65 (17.6%)
11.	Home blood pressure monitoring can optimize blood pressure control in high cardiovascular risk patients and pregnancy.	336 (90.8%)	34 (9.2%)
12.	Average blood pressure of at least 12 readings in 3 consecutive days should be used to assess the control home blood pressure measurement.	160 (43.2%)	210 (56.8%)
13.	Blood pressure values measured on the first monitoring day should be discarded.	85 (23.0%)	285 (77.0%)
14.	A mean reading of > 135 and/or >85 mmHg is considered elevated.	309 (83.5%)	61 (16.5%)
15.	Home blood pressure values are not different from clinic blood pressure values in general.	137 (37.0%)	233 (63.0%)
16.	Home blood pressure measurements should be done in the morning only.	235 (63.5%)	135 (36.5%)
17.	Home blood measurements should be done at about the same time for each monitoring day.	277 (74.9%)	93 (25.1%)
18.	Home blood pressure measurements can be taken after meal.	146 (39.5%)	224 (60.5%)
19.	Home blood pressure measurements should be taken before medication intake.	231 (62.4%)	139 (37.6%)
20.	Home blood pressure measurements should be taken before voiding.	81 (21.9%)	289 (78.1%)
21.	Two measurements should be taken 1 minute apart per occasion in home blood pressure monitoring.	154 (41.6%)	216 (58.4%)

Table III reported the factors associated with the level of knowledge of HBPM using bivariate analysis. Table III demonstrated that based on the Chi-Square analysis, there is no association between gender, ethnicity, and religion with the level of knowledge about HBPM. Nonetheless, the level of knowledge was significantly associated with the year of study, whereby clinical year students exhibit better knowledge than preclinical year students on HBPM (p<0.001). Variables with values less than 0.25, including ethnicity, religion, and year of study, were included in the multiple logistic regression.

Table III: Association of Sociodemographic Characteristics of Study Respondents and Level of Knowledge of Home Blood Pressure Monitoring based on Chi-square test (n=370)

Variables	Good Knowledge, n (%), 206 (55.7)	Poor Knowledge, n (%), 164, (44.3)	p-value
Gender			0.79
Male	54 (54.5)	45 (45.5)	
Female	152 (56.1)	119 (43.9)	
Ethnicity			0.10
Malay	115 (52.9)	102 (47.1)	
Chinese	58 (65.9)	30 (34.1)	
Indian	28 (48.3)	30 (51.7)	
Others	5 (71.4)	2 (28.6)	
Religion			0.16
Muslim	119 (53.1)	105 (46.9)	
Buddha	45 (65.2)	24 (34.8)	
Hindu	24 (49.0)	25 (51.0)	
Christianity	15 (60.0)	10 (40.0)	
Others	3 (100.0)	0 (0.0)	
Year of Study			<0.001
Preclinical Years	53 (39.0)	83 (61.0)	
Clinical Years	153 (65.4)	81 (34.6)	

By using the multiple logistic regression analysis, Table IV shows that the year of study is the only predictor of good knowledge of HBPM among medical students. Clinical year students have 2.96 higher adjusted odds of possessing good knowledge of HMBP compared to preclinical year students (95% CI: 1.91-4.58, p<0.001).

DISCUSSION

Our study found that 55.7% of medical students had a good understanding of HBPM. However, there was a significant discrepancy in knowledge between students in the preclinical and clinical years. Multiple logistic regression analysis revealed that students in the clinical years were three times more likely to have a good understanding of HBPM. This finding was expected because the diagnosis, management, and monitoring of hypertension are emphasized in the clinical years of the curriculum, whereas the preclinical years focus mainly on the pathophysiological and pharmacological aspects of hypertension. Medical students on clinical postings have greater exposure to managing hypertensive patients in hospital wards or clinics, which undoubtedly contributed to a better understanding of HBPM.

Our research findings showed that 90.5% of the participants stated that monitoring their patients' blood pressure at home is a valuable addition to hypertension management. This indicates that the level of awareness regarding HBPM for managing hypertension among the participants was commendable and comparable to that reported in a study conducted by Cheng et al. among medical professionals. (23) Cheng et al.

Table IV: Factors associated with good knowledge of home blood pressure monitoring among medical students based on multiple logistic regression (n=370)

Variables	Adjusted OR[1]	95% CI[2] (Lower, upper)	P value
Ethnicity		0.70-2.24	0.45
Malay	1		
Non-Malay	1.25		
Religion		0.24-4.61	0.95
Hindu	1		
Non-Hindu	1.05		
Year of Study		1.91-4.58	<0.001
Pre-clinical Year	1		
Clinical Year	2.96		

Backward logistic regression was used and the model reasonably fits well (Hosmer Lemeshow test: chi-square =1.820; P =0.402); model assumptions were met; no significant interactions and multicollinearity problem; model explained between 6.4% (Cox and Snell R^2) and 8.6% (Nagelkerke R^2) of the variance for good knowledge of home blood pressure monitoring. The model correctly classified 63.8% of cases (95% CI: 61.4%–66.2%, P <0.05) with sensitivity of 25.7%, specificity of 49.4%, positive predictive value of 38.9% and negative predictive value 34.6%. *Statistical significance at P <0.05; OR—odds ratio; CI—confidence interval.

reported that 94% of 138 physicians in the United States acknowledged the usefulness of HBPM in managing hypertensive patients (23).

In our study, it was found that 59.2% of the participants offered an incorrect response to a statement concerning the equivalence of HBPM and office measurements in reporting uncontrolled hypertension. This finding aligns with the research conducted by Obara et al., where over 60% of physicians expressed the belief that HBPM was a superior tool for diagnosing and managing hypertension when compared to clinic blood pressure (7).

Our study found some uncertainty among participants regarding the application of HBPM for diagnosing conditions like isolated office hypertension. Only 59.5% answered this question correctly. In contrast, previous studies in physician populations showed higher awareness - around 80-90% of physicians in Japan (7) and Hungary (24) reported using HBPM to diagnose isolated office hypertension. Similarly, only 48.1% of our respondents correctly answered that HBPM can help diagnose true resistant hypertension, while a study in Hungary found 61% of physicians used it for this purpose (24). The lower rate of correct answers in our medical student sample compared to studies in practicing physician populations was expected given their more limited clinical experience. However, it highlighted the need for expanded education on the appropriate clinical usage of HBPM as a diagnostic aid among trainees. The majority of the students (78.1%) know that blood pressure measurements are not supposed to be taken before voiding as bladder distension can raise blood pressure (25). However, up to 77% of the students would consider including the measurements taken on the first monitoring day. This wrong answer was also important to note as blood pressure levels on the first monitoring day are usually higher than those of the other days and should not be included in the diagnosis and monitoring of hypertension (12). These are important measures to be taken when using HBPM to monitor the accurate blood pressure control. Inaccurate readings resulting from mistakes made during the process could lead to undertreatment or unnecessary over-treatment. Thus, reinforcing the importance of HBPM and improving the quality of education in this area is crucial.

Implication of the study

It is generally acknowledged that HBPM is a valuable addition to hypertension management, however medical students have inadequate knowledge in certain aspects of HBPM. To address this, there is a need to emphasize this topic in the medical curriculum to improve the understanding of medical students as in other countries (26).

Strengths and Limitations

The strength of this study was the fact that the studies examining the knowledge of HBPM among medical students have been limited in the literature. This study can serve as an additional reference and provide guidance for future curriculum development, specifically in aspects of medical education related to the management of hypertension. However, this study had some limitations. Firstly, it was limited to one public university, and therefore may not be representative of medical students nationwide. Secondly, the study employed a cross-sectional design, which can't establish causal relationships. Ideally, face validity should involve 10 experts from the student pool." This clarification is essential for interpreting the results within the context of limitations.

CONCLUSION

In conclusion, this study found a significant gap in knowledge between preclinical and clinical year students regarding HBPM, with only 28.7% of preclinical students demonstrating good knowledge compared to 46% of clinical students. However, the more concerning finding is that less than half of clinical year students exhibited good knowledge, despite greater exposure to hypertensive patients and management. This highlights the need for more emphasis on HBPM education even in the clinical years. Although preclinical students have time to acquire this knowledge later on, the study results suggest current clinical teaching may be insufficient to impart a comprehensive understanding of HBPM. Medical schools should consider strengthening the curriculum by incorporating more practical learning on HBPM during clerkships and clinical rotations. This may better equip future physicians with the knowledge to effectively utilize HBPM for diagnosing and managing hypertension in patients.

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