Ability and accuracy of patient-performed blood pressure monitoring among pregnant women in urban Ghana

Check for updates

Emma R. Lawrence, MD; Titus K. Beyuo, MD, PhD; Noah Newman, MPH; Makafui Aku Klutse, MD; Joshua Kafui Asempa, MD; Andrea Pangori, MS; Cheryl A. Moyer, PhD; Jody R. Lori, PhD; Samuel A. Oppong, MD

BACKGROUND: Patient-performed blood pressure monitoring in pregnancy is rarely performed in low- and middle-income country settings, including Ghana. The clinical efficacy of home blood pressure monitoring relies on a pregnant patient being able to independently execute the correct steps to position and use a blood pressure monitor and to achieve accurate blood pressure measurements.

OBJECTIVE: This study aimed to (1) assess whether pregnant women can correctly use an automatic blood pressure monitor to check their blood pressure before and after a brief training and (2) determine whether blood pressure values measured by pregnant women using an automatic monitor are similar to values measured by a healthcare provider using a standard clinic monitor.

STUDY DESIGN: This was a cross-sectional study conducted at the Korle Bu Teaching Hospital, a tertiary hospital in Accra, Ghana. Participants were adult pregnant women presenting for their first prenatal care visit. Data collection was performed by 2 Ghanaian physicians. Information on demographics, obstetrical history, and past medical history was collected. A brief training was provided on the correct use of the blood pressure monitor, including a verbal script, annotated photographs, and a hands-on demonstration. Pre- and posttraining assessments using a 9-item checklist of correct preparation, position, and use of an automatic blood pressure monitor were performed. Following a modified British Hypertension Society protocol, a series of 4 blood pressure measurements were taken, alternating between provider performed using a clinic monitor and patient performed using an automatic monitor intended for individual use and validated in pregnancy.

RESULTS: Among 176 participants, the mean age was 31.5 years (±5.6), and 130 (73.9%) were multiparous. Regarding socioeconomic characteristics, 128 (72.7%) were married, 171 (97.2%) had public insurance, and 87 (49.7%) had completed ≤9 years of formal education. Regarding clinical blood pressure issues, 19 (10.9%) had a history of a hypertensive disorder in a previous pregnancy, and 6 (3.4%) had chronic hypertension. Before receiving any training, 21 participants (12.1%) performed all 9 steps correctly to prepare, position, and use the automatic blood pressure monitor. Comparing pretraining vs posttraining ability, statistically significant increases were seen in the correct performance of each step and the mean number of steps performed correctly (6.1±1.8 vs 9.0±0.2, respectively; $P<.001$) and proportion performing all 9 steps correctly (12.1% vs 96.6%, respectively; $P<.001$). The mean difference between doctor-performed and patient-performed blood pressure measurements was 5.6±4.8 mm Hg for systolic blood pressure values and 3.4±3.08 mm Hg for diastolic blood pressure values, with most differences within 5 mm Hg for both systolic blood pressure values (102/176 [58.0%]) and diastolic blood pressure values (141/176 [80.1%]).

CONCLUSION: After a brief training, pregnant women in Ghana demonstrated that they are able to use an automatic blood pressure monitor to check their blood pressure correctly and accurately.

Key words: antenatal monitoring, eclampsia, home blood pressure monitoring, high blood pressure in pregnancy, home monitoring, hypertensive disorders of pregnancy, low- and middle-income countries, patient monitoring, preeclampsia, pregnancy, sub-Saharan Africa

From the Department of Obstetrics and Gynecology, University of Michigan, Ann Arbor, MI (Dr Lawrence, Ms Pangori, and Dr Moyer); Department of Obstetrics and Gynecology, University of Ghana Medical School, Korle Bu, Accra, Ghana (Drs Beyuo and Oppong); Department of Obstetrics and Gynecology, Korle Bu Teaching Hospital, Korle Bu, Accra, Ghana (Drs Beyuo, Klutse, Asempa, and Oppong); University of Michigan Medical School, Ann Arbor, MI (Mr Newman); University of Michigan School of Nursing, Ann Arbor, MI (Dr Lori)

The authors report no conflict of interest.

Patient consent is not required because no personal information or detail is included.

Research reported in this publication was supported by the Fogarty International Center of the National Institutes of Health (NIH) under grant number D43 TW009345 awarded to the Northern Pacific Global Health Fellows Program and under award number K01 TW012166. The content is solely the responsibility of the authors and does not necessarily represent the official views of the NIH. Funding sources had no involvement in the research design, preparation of the manuscript, or decision to submit the article for publication.

Cite this article as: Lawrence ER, Beyuo TK, Newman N, et al. Ability and accuracy of patient-performed blood pressure monitoring among pregnant women in urban Ghana. Am J Obstet Gynecol Glob Rep 2023;XX:x.ex–x.ex.

Corresponding author: Samuel A. Oppong, MD. saoppong@ug.edu.gh

2666-5778/$36.00

© 2023 The Authors. Published by Elsevier Inc. This is an open access article under the CC BY-NC-ND license (http://creativecommons.org/licenses/by-nc-nd/4.0/)

http://dx.doi.org/10.1016/j.xagr.2023.100243

AJOG Global Reports at a Glance

Why was this study conducted?

Patient-performed blood pressure (BP) monitoring in pregnancy is rarely performed in low- and middle-income country settings, including Ghana.

Key findings

Before any instruction, the ability to correctly perform all steps to prepare, position, and use an automatic BP monitor is low among pregnant women in Ghana. After a brief multimodal and multilanguage training, statistically significant increases in ability were measured, with almost all participants performing all steps correctly, across a wide range of formal education levels. The accuracy of clinic-performed vs patient-performed BP measurements is overall very good; however, a minority do demonstrate clinically significant differences.

What does this add to what is known?

After a brief training, pregnant women in Ghana can use an automatic BP monitor to check their BP correctly and accurately.

Introduction

Hypertensive disorders of pregnancy (HDPs), which include preeclampsia and eclampsia, are a leading cause of global maternal morbidity and mortality.[1,2] The rates of HDPs are significantly higher in low- and middle-income countries (LMICs),[3] where associated adverse maternal and neonatal outcomes are common.[3−5]

Approaches to the prevention of HDPs include risk stratification, initiation of aspirin in high-risk pregnancies,[6] and consideration of calcium supplementation in calcium-deficient diets.[7] However, given the wide range of risk factors and limited efficacy of prevention strategies, hypertensive disorders remain common complications of pregnancy. The clinical management of HDPs depends on gestational age and clinical presentation. In addition to antihypertensive medications and consideration of seizure prophylaxis, management often involves inpatient admission with close monitoring and delivery.[8] Overall, prompt diagnosis of HDPs is essential to identify and manage affected pregnancies before the development or progression of maternal and neonatal complications.[1]

The cornerstone of the diagnosis of HDPs is the measurement of new or worsening blood pressure (BP) elevations. Although a subsequent assessment of clinical symptoms and laboratory values are essential to make an exact diagnosis, BP remains the crucial warning sign.[7] An important function of prenatal care, especially during frequent visits in the third trimester of pregnancy, is repeated BP measurements by a healthcare provider. However, even in patients who attend all recommended prenatal visits, 1 to 4 weeks may pass among scheduled visits.[9,10]

Patient-performed BP monitoring, which involves a pregnant person monitoring their BP outside of a clinical setting, has been increasingly used in high-income countries with demonstrated patient accuracy and adherence.[11−14] However, patient-performed BP monitoring in pregnancy is rarely performed in LMIC settings, including Ghana. Pregnant patients in LMICs may face additional challenges to engaging in home monitoring, including lower health literacy and less formal education. The clinical efficacy of home BP monitoring relies on a pregnant patient being able to independently execute the correct steps to position and use a BP monitor and to achieve accurate BP measurements. This study aimed to evaluate the ability and accuracy of patient-performed BP monitoring among pregnant women in urban Ghana.

Materials and Methods

This was a cross-sectional study evaluating patient-performed BP monitoring by pregnant women in Ghana. The study aimed to (1) assess whether pregnant women can correctly use an automatic BP monitor to check their BP before and after a brief training and (2) determine whether BP values measured by pregnant women using an automatic monitor are similar to values measured by a healthcare provider using a standard clinic monitor.

The study was conducted at the Korle Bu Teaching Hospital (KBTH), Ghana's largest and oldest tertiary care institution that manages a diverse patient population across southern Ghana. KBTH provides the full spectrum of obstetrical care, including outpatient prenatal clinic visits, ultrasonography, inpatient labor and delivery, and postpartum care. HDPs are a major cause of maternal morbidity at KBTH[15] and have surpassed postpartum hemorrhage as the leading cause of maternal mortality.[16] Patient-performed home BP monitoring is rarely performed in this setting.

Participants were pregnant women receiving their prenatal care at KBTH. The inclusion criteria were current pregnancy at any gestational age; presentation for their first prenatal visit at KBTH; age ≥18 years; fluency in English, Twi, or Ga (the 3 most common languages spoken among prenatal attendants); and upper arm circumference measuring between 22 and 44 cm (appropriate for BP cuff size). Women facing an immediate health crisis were excluded from recruitment.

Recruitment was performed at KBTH's "booking clinic" where initial prenatal visits are performed. Recruitment was performed daily during open hours of the clinic, over a 2-week period, from February 2022 to March 2022.

Data collection and training were performed by 2 junior Ghanaian physicians working as research assistants. All data collection and training procedures were verbally administered in the participants' choice of English, Twi, or Ga. First, information on sociodemographics, obstetrical history, and past medical history was collected. Before any instruction, participants were given an assembled automatic BP monitor and asked to check their BP. A 9-item checklist, developed by the American Heart Association and corroborated with the American College of Obstetrics and Gynecology (ACOG) and manufacturer guidelines,[17–20] was used to objectively evaluate whether the participant followed each step to correctly prepare, position, and check their BP ("pretraining"). Subsequently, a brief training was administered by the research assistant. The training lasted approximately 10 minutes and reviewed the correct use of the BP monitor. The training included a verbal script, annotated photographs, and a hands-on demonstration with the actual monitor (Appendix A). To assess the participants' ability to perform self-monitoring, a posttraining assessment of correct preparation, position, and use was performed, using the same 9-item checklist ("posttraining attempt number 1"). Following this first attempt, additional individualized instruction was provided by the research assistant, and the participant again demonstrated how to check their BP ("posttraining attempt number 2").

To assess the accuracy of patient-performing BP monitoring, a modified British Hypertension Society protocol was used.[21,22] After training was performed, a series of 4 BP measurements were taken, alternating between a doctor-performed measurement using the clinic monitor and patient-performed measurement using a patient monitor. The clinic monitor used by the doctor was an automatic model intended for hospital use. The monitor used by the patient was an automatic model intended for individual use and validated in pregnancy and preeclampsia,[21] which was selected given its relative availability and affordability in Ghana. Before initiating any measurements, the participant sat quietly for 5 minutes. Measurements were all taken on the participants' left arm, with 1 minute between measurements.

Written informed consent was obtained from all participants. Ethical approval was granted by the institutional review boards at KBTH (approval number: KBTH-IRB 00098/2021) and the University of Michigan (approval number: HUM00200589).

Sociodemographic variables were described with means and standard deviations for continuous data and frequencies and proportions for categorical data. Body mass index (BMI) was calculated from weight at the first prenatal visit and height. Risk factors for preeclampsia were described using the ACOG guidelines.[6] Ability to perform each step of the checklist was described (yes vs no), and the mean number of correct steps and the proportion of participants with all 9 steps correct were calculated at 3 time points: pretraining, posttraining attempt number 1, and posttraining attempt number 2. The Wilcoxon rank-sum test, Pearson chi-square test, and Fisher exact test were used to compare the proportion of each step correct, mean number of correct steps, and proportion with all 9 steps correct between pretraining and posttraining attempt number 2.

The accuracy of self-monitoring was evaluated by taking the mean of differences between the mean of the 2 researcher-measured values and the mean of the 2 participant-measured values—performed separately for systolic BP (SBP) and diastolic BP (DBP) measurements. Finally, mean SBP differences and mean DBP differences were categorized by <5.0, 5.1 to 10.0, 10.1 to 15.0, and >15.0 mm Hg, which the researchers considered clinically significant categories. Of note, 2-sided statistical tests at the alpha level of .05 were used for inferential data. Data were entered into the Research Electronic Data Capture for storage and organization, and all data management and statistical analyses were performed in R (version 4.2.2).

Results

Demographics

Of 209 patients presenting to the KBTH booking clinic during the recruitment period, 176 (84.2%) agreed to participate and were enrolled in the study. Participants had a mean age of 31.5 years (±5.6) and a mean BMI of 29.3 kg/m^2 (±5.6), with 74 participants (44.1%) categorized as obese (Table 1). Most participants were married (128/176 [72.7%]) and enrolled in Ghana's public National Health Insurance Scheme (171/176 [97.2%]). There was a wide range of formal education, with approximately half of the participants (87/175 [49.7%]) having completed ≤9 years of formal education. Most participants (130/176 [73.9%]) were multiparous, and 169 of 176 participants (96.0%) had a singleton pregnancy.

Regarding previous experience with clinical BP issues, 19 of 175 participants (10.9%) had a previous pregnancy complicated by a hypertensive disorder, and 6 of 175 participants (3.4%) had chronic hypertension. Using the ACOG clinical risk assessment for preeclampsia, 68 of 166 participants (41.0%) had at least 1 high-risk factor and/or 2 moderate-risk factors and, thus, were considered at overall high risk of developing preeclampsia in their current pregnancy (Appendix B).

Participants' ability to correctly self-measure blood pressure

Before receiving any instruction, 21 of 176 participants (12.1%) performed all 9 steps correctly to prepare, position, and use the automatic BP monitor (Figure). The mean number of pretraining steps performed correctly was 6.1±1.8 of 9.0, with a range of 1 to 9 total steps correct. Individual step correctness ranged from 51 of 176 participants (29.0%) properly aligning the artery mark and hose to 167 of 176 participants (95.4%) having a bare upper arm. Following the brief training, 158 of 176 participants (90.8%) performed all 9 steps correctly on their first attempt, and 169 of 176 participants (96.6%) performed all 9 steps correctly on their second attempt. Comparing pretraining vs posttraining ability, statistically significant increases were seen in the correct performance of each step and the mean number of steps performed correctly (6.1±1.8 vs 9.0±0.2, respectively; $P<.001$) and proportion performing all 9 steps correctly (12.1% vs 96.6%, respectively; $P<.001$).

Accuracy of self-measured blood pressure

Regarding the accuracy of patient-performed monitoring, the mean difference between doctor-performed and patient-performed BP measurements was 5.6± 4.8 mm Hg for SBP values and 3.4±

TABLE 1
Participant demographics (N=176)

Characteristic	n (%) or mean±SD
Age (y)	31.5±5.6
Marital status	
Married	128 (72.7)
Not married (cohabitating, single, divorced, or widowed)	48 (27.3)
Highest level of education completed (n=175)	
None	15 (8.6)
Primary school	15 (8.6)
Junior high school	57 (32.6)
Senior high school	44 (25.1)
Tertiary	44 (25.1)
Insurance status	
No insurance	2 (1.1)
Public insurance (NHIS)	171 (97.2)
Private insurance	3 (1.7)
Parity	1.6±1.4
Nulliparous	46 (26.1)
Multiparous	130 (73.9)
Number of gestation of current pregnancy	
Singleton	169 (96.0)
Twins	7 (4.0)
Triplets	0 (0)
BMI at first antenatal visit (kg/m^2) (n=168)	29.4±5.6
Underweight (<18.5)	2 (1.2)
Normal (18.5–24.0)	37 (22.0)
Overweight (25.0–29.0)	55 (32.7)
Obese (±30.0)	74 (44.1)
Hypertensive disorder in a previous pregnancy (n=175)	
No	156 (89.1)
Yes	19 (10.9)
Chronic hypertension	
No	170 (96.6)
Yes	6 (3.4)

BMI, body mass index; *NHIS*, National Health Insurance Scheme; *SD*, standard deviation.

Lawrence. Ability and accuracy of patient-performed blood pressure. Am J Obstet Gynecol Glob Rep 2023.

3.1 mm Hg for DBP values (Table 2). Most doctor-performed vs patient-performed differences were within 5 mm Hg for both SBP values (102/176 [58.0%]) and DBP values (141/176 [80.1%]). However, a notable minority of participants had differences of >10 mm Hg SBP (23/176 [13.1%]) or 10 mm Hg DBP (9/176 [5.1%]).

Discussion

Principal findings

Before any instruction, the ability to correctly perform all steps to prepare, position, and use an automatic BP monitor was low among pregnant women in Ghana. After a brief multimodal and multilanguage training, ability was very high, with almost all participants performing all steps correctly, across a wide range of formal education levels. The accuracy of clinic-performed vs patient-performed BP measurements was overall very good, with most differences within 5 mm Hg for both SBP and DBP values. However, a minority did demonstrate clinically significant differences.

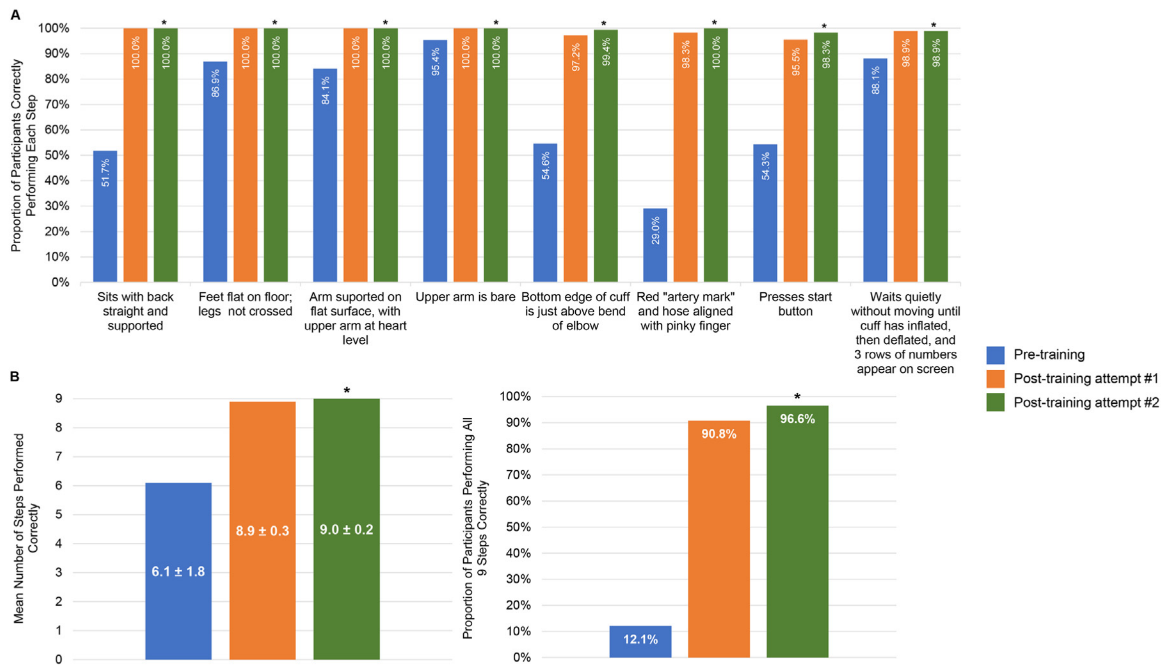
Results in the context of what is known

In 2020, the World Health Organization reasserted that an automatic BP monitor is the recommended approach for clinical monitoring.[23] A shift toward using automatic BP monitors at the study site reflects that recommendation. Unlike earlier studies that used manual sphygmomanometry as the standard of care,[22] this shift supports our decision in this study to use the typical clinic automatic BP monitor as our standard comparator. Importantly, our study is not intended as a full validation study but rather an evaluation of the usability of a validated monitor in a unique LMIC population. Delayed diagnoses of HDPs in LMIC settings may result in eclampsia and adverse maternal and fetal outcomes; this underscores the importance of studying methods of earlier detection, such as patient-performed BP monitoring, in these at-risk populations.

The literature is clear that using a standardized, recommended approach to BP monitoring is important in every setting.[17,23] However, no previous research can be found assessing participants' ability to correctly use a BP monitor. Although a training component is referenced in several home BP monitoring studies,[11,24,25] assessment of post-training ability to use the device correctly is lacking. This may be due to these studies being conducted in high-income countries, with high assumed health literacy levels, and the expectation that participants can read the monitors' instructions if needed.

FIGURE

Training assessment of steps performed (N=176)



A, Pre- vs posttraining assessment of each step to correctly check blood pressure (n=176). **B,** Pre- vs posttraining assessment of all steps correct and mean steps correct. Asterisk indicates statistically significant difference between the pretraining attempt and posttraining attempt number 2. *P* values are all <.005 and were computed using the Pearson chi-square and Fisher exact tests at the alpha level of .05.

Lawrence. Ability and accuracy of patient-performed blood pressure. Am J Obstet Gynecol Glob Rep 2023.

Regarding accuracy, many commonly used BP devices have not been formally validated in pregnant populations. A systematic review evaluating the accuracy of 28 automatic BP monitors concluded that 61% were successfully validated among pregnant women.[21] Focusing specifically on BP devices used for home monitoring, an Australian study[22] found that among all devices, 69% had an SBP difference of ≤5.0 mm Hg, 27% had an SBP difference between 5.1 and 10.0 mm Hg, 2% had an SBP difference between 10.1 and 15.0 mm Hg, and 2% had an SBP difference of ≥15 mm Hg; these are comparable to our study findings. No significant difference was seen in the SBP or DBP accuracy of validated vs nonvalidated devices.[22] Going 1 step further, a systematic review[26] compared differences between clinic and self-monitoring BPs, also considering potential changes in accuracy throughout a pregnancy. Although they found very high overall

TABLE 2

Differences in BP values between patient-performed and doctor-performed (N=176)

Value	n (%) or mean±SD
Mean SBP difference	5.55±4.80
Mean DBP difference	3.41±3.08
Categorical SBP differences	
≤5.0	102 (58.0)
5.1–10.0	51 (29.0)
10.1–15.0	14 (8.0)
>15.0	9 (5.1)
Categorical DBP differences	
≤5.0	141 (80.1)
5.1–10.0	26 (14.8)
10.1–15.0	8 (4.5)
>15.0	1 (0.6)

BP, blood pressure; *DBP*, diastolic blood pressure; *SBP*, systolic blood pressure; *SD*, standard deviation.

Lawrence. Ability and accuracy of patient-performed blood pressure. Am J Obstet Gynecol Glob Rep 2023.

accuracy, with mean self vs clinic differences of 1.5 to 2.2 mm Hg SBP and 0.7 to 1.5 mm Hg DBP, they did note significant heterogeneity among studies.[26] Agreement continued to be high regardless of SBP or DBP levels, but the agreement did decrease at later gestational ages. All studies included in the systematic review were conducted in high-income countries in Europe, North America, or Japan.[26]

Clinical and research implications

This study highlights the importance of providing education to patients before they engage in home BP monitoring. Before the provided training, the participants' ability to correctly complete all steps to use an automatic BP monitor was low, especially regarding the correct placement of the cuff, artery mark, and hose. This is particularly important in LMIC populations with less formal education and lower health literacy. However, sufficient health literacy to correctly use a BP monitor should not be assumed in any population. Reproductive-aged patients in all settings are typically young and healthy, with pregnancy often being their first encounter with the healthcare system; thus, exposure to and knowledge of BP monitoring may be low.

Here, the training was brief—lasting approximately ≤10 minutes—and was effective across a diverse population, including many participants with low formal education. Given a range of formal education and literacy, the training was intentionally multimodal and involved verbal administration of instructions, review of photographs, and a hands-on component. Language was another important consideration, with the training offered in English and the 2 widely spoken local languages in the study setting. In settings where clinical encounters are very short, and even a brief training could be time prohibitive, options to consider include group training and video-based training. Additional research is needed to explore the patient perspective and feedback on training approaches to continue to optimize training strategies for at-risk populations.

Even with most participants correctly following all steps to check their BP, some provider-measured vs patient-measured BP differences were large enough to be clinically significant. This supports the importance of performing repeated BP measurements, both in clinical settings and in patient-performed settings, especially if abnormal values are detected. In addition, BP monitors intended for home use should be compared with clinic monitors for reasonable clinical agreement before a patient uses them at home. This is supported by the literature, which suggests that validated devices may not be more accurate than nonvalidated devices for home monitoring[22] and that there may be marked individual differences between home and clinic monitors—even with devices that are commonly used for home monitoring.[27] Finally, these differences highlight that patient-performed monitoring can be an important screening tool to detect new or worsening BP elevations; however, elevated BPs detected at home should always prompt rapid follow-up with a healthcare provider to confirm elevations and initiate further evaluation.

Strengths and limitations

The limitations of the study include a single study setting at a tertiary institution in a large urban center. Thus, findings may not be applicable to other low-resource areas, including rural settings. Importantly, the study setting was selected because it provides care for a diverse patient population and the study cohort did include a wide range of formal education levels, including many participants with low educational attainment. In addition, conclusions about the success of a brief training may be limited by the short time between the training and the assessment, with participants benefiting from immediate recall. This may overestimate the pregnant patients' ability to remember the correct steps when they take the monitors home and use them across an entire pregnancy. However, additional time, practice, and repetition at home may improve some patients' ability to use the monitors correctly. Thus, additional research is needed to determine longer-term retention of correct patient-performed monitoring. Finally, this study was unable to statistically determine sociodemographic and clinical history factors associated with the small group of participants who did not perform all steps correctly on their final posttraining attempt. Given the very high proportion of participants who performed all steps correctly, comparisons with the small group of lower performers would be underpowered. This minority subgroup may be a focus of additional research to determine strategies for tailored training.

Conclusions

Overall, among pregnant women in urban Ghana, we demonstrated a high posttraining ability to correctly prepare, position, and use an automatic BP monitor. The accuracy of clinic vs patient-performed measurements was overall very good; however, a minority did have clinically significant differences. Study findings highlight the importance of providing patient education before home BP monitoring, the need to confirm reasonable clinical agreement before the use of a monitor at home, and the necessity that home BP elevations are confirmed in clinical settings. This study suggests that patient-performed BP monitoring could be u by pregnant women in LMICs, even among populations with lower health literacy or less formal education. ■

Supplementary materials

Supplementary material associated with this article can be found in the online version at doi:10.1016/j.xagr.2023.100243.

REFERENCES

1. Gestational hypertension and preeclampsia: ACOG Practice Bulletin, Number 222. Obstet Gynecol 2020;135:e237–60.

2. Abalos E, Cuesta C, Grosso AL, Chou D, Say L. Global and regional estimates of preeclampsia and eclampsia: a systematic review. Eur J Obstet Gynecol Reprod Biol 2013;170:1–7.

3. Abalos E, Cuesta C, Carroli G, et al. Pre-eclampsia, eclampsia and adverse maternal and perinatal outcomes: a secondary analysis

of the World Health Organization Multicountry Survey on Maternal and newborn Health. BJOG 2014;121(Suppl1):14–24.

4. Lawrence ER, Beyuo TK, Kobernik EK, Moyer CA, Oppong SA. A comparative analysis of neonatal outcomes in pregnancies complicated by preeclampsia and eclampsia in Ghana. AJOG Glob Rep 2022;2:100061.

5. Duley L. The global impact of pre-eclampsia and eclampsia. Semin Perinatol 2009;33:130–7.

6. Low-dose aspirin use during pregnancy. Available at: https://www.acog.org/clinical/clinical-guidance/committee-opinion/articles/2018/07/low-dose-aspirin-use-during-pregnancy. Accessed January 25, 2023.

7. Chappell LC, Cluver CA, Kingdom J, Tong S. Pre-eclampsia. Lancet 2021;398:341–54.

8. Goldenberg RL, McClure EM. It takes a system: magnesium sulfate for prevention of eclampsia in a resource-limited community setting. Glob Health Sci Pract 2019;7:340–3.

9. Adedokun ST, Yaya S. Correlates of antenatal care utilization among women of reproductive age in sub-Saharan Africa: evidence from multinomial analysis of demographic and health surveys (2010-2018) from 31 countries. Arch Public Health 2020;78:134.

10. Ameyaw EK, Dickson KS, Adde KS. Are Ghanaian women meeting the WHO recommended maternal healthcare (MCH) utilisation? Evidence from a national survey. BMC Pregnancy Childbirth 2021;21:161.

11. Tucker KL, Taylor KS, Crawford C, et al. Blood pressure self-monitoring in pregnancy: examining feasibility in a prospective cohort study. BMC Pregnancy Childbirth 2017;17:442.

12. Hinton L, Tucker KL, Greenfield SM, et al. Blood pressure self-monitoring in pregnancy (BuMP) feasibility study; a qualitative analysis of women's experiences of self-monitoring. BMC Pregnancy Childbirth 2017;17:427.

13. Kalafat E, Benlioglu C, Thilaganathan B, Khalil A. Home blood pressure monitoring in the antenatal and postpartum period: a systematic review meta-analysis. Pregnancy Hypertens 2020;19:44–51.

14. Butler Tobah YS, LeBlanc A, Branda ME, et al. Randomized comparison of a reduced-visit prenatal care model enhanced with remote monitoring. Am J Obstet Gynecol 2019;221:638.e1–8.

15. Beyuo TK, Lawrence ER, Kobernik EK, Oppong SA. Clinical presentation and predictors of eclampsia among women with hypertensive disorders of pregnancy in Ghana. Pregnancy Hypertens 2022;30:171–6.

16. Adu-Bonsaffoh K, Oppong SA, Binlinla G, Obed SA. Maternal deaths attributable to hypertensive disorders in a tertiary hospital in Ghana. Int J Gynaecol Obstet 2013;123:110–3.

17. American Medical Association. How to measure your blood pressure at home. 2021. Available at: https://www.ama-assn.org/system/files/2020-11/smbp-infographic.pdf. Accessed January 25, 2023.

18. American Medical Association. Helping patients achieve and maintain blood pressure goals.American Medical Association publication; 2020. Available at: https://www.ama-assn.org/system/files/2020-06/7-step-smbp-quick-guide.pdf. Accessed January 25, 2023.

19. Hypertension in pregnancy: executive summary. Obstet Gynecol 2013;122:1122–31.

20. Focus Information Technology. What position should a pregnant woman be in to measure her blood pressure? Perinatology. Available at: https://perinatology.com/Q&A/Blood%20pressure%20measurement.htm. Accessed January 25, 2023.

21. Bello NA, Woolley JJ, Cleary KL, et al. Accuracy of blood pressure measurement devices in pregnancy: a systematic review of validation studies. Hypertension 2018;71:326–35.

22. Tremonti C, Beddoe J, Brown MA. Reliability of home blood pressure monitoring devices in pregnancy. Pregnancy Hypertens 2017;8:9–14.

23. John O, Campbell NRC, Brady TM, et al. The 2020 "WHO Technical Specifications for Automated Non-Invasive Blood Pressure Measuring Devices With Cuff". Hypertension 2021;77:806–12.

24. van den Heuvel JFM, Kariman SS, van Solinge WW, Franx A, Lely AT, Bekker MN. SAFE@-HOME - Feasibility study of a telemonitoring platform combining blood pressure and preeclampsia symptoms in pregnancy care. Eur J Obstet Gynecol Reprod Biol 2019;240:226–31.

25. Pealing LM, Tucker KL, Mackillop LH, et al. A randomised controlled trial of blood pressure self-monitoring in the management of hypertensive pregnancy. OPTIMUM-BP: a feasibility trial. Pregnancy Hypertens 2019;18:141–9.

26. Tucker KL, Bankhead C, Hodgkinson J, et al. How do home and clinic blood pressure readings compare in pregnancy? Hypertension 2018;72:686–94.

27. Lo C, Taylor RS, Gamble G, McCowan L, North RA. Use of automated home blood pressure monitoring in pregnancy: is it safe? Am J Obstet Gynecol 2002;187:1321–8.