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Using web-based training to improve accuracy of blood pressure measurement among health care professionals: A randomized trial

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Abstract

Accurate blood pressure measurement is crucial for proper screening, diagnosis, and monitoring of high blood pressure. However, providers are not aware of proper blood pressure measurement skills, do not master all the appropriate skills, or miss key steps in the process, leading to inconsistent or inaccurate readings. Training in blood pressure measurement for most providers is usually limited to a one-time brief demonstration during professional education coursework. The American Medical Association and the American Heart Association developed a 30-minute e-Learning module designed to refresh and improve existing blood pressure measurement knowledge and clinical skills among practicing providers. One hundred seventy-seven practicing providers, which included medical assistants, nurses, advanced practice providers, and physicians, participated in a multi-site randomized educational study designed to assess the effect of this e-Learning module on blood pressure measurement knowledge and skills. Participants were randomized 1:1 to either the intervention or control group. The intervention group followed a pre-post assessment approach, and the control group followed a test-retest approach. The initial assessment showed that participants in both the intervention and control groups correctly performed less than half of the 14 skills considered necessary to obtain an accurate blood pressure measurement (mean scores 5.5 and 5.9, respectively). Following the e-Learning module, the intervention group performed on average of 3.4 more skills correctly vs 1.4 in the control group ($P < .01$). Our findings reinforce existing evidence that errors in provider blood pressure measurements are highly prevalent and provide novel evidence that refresher training improves measurement accuracy.

1 | INTRODUCTION

High blood pressure (BP) affects 1.4 billion adults worldwide and is the leading modifiable cause of premature death and disability.[1] Accurate BP measurement is crucial for proper screening, diagnosis, and monitoring of high BP. BP measurement is one of the most common assessments in clinical practice today. If performed incorrectly, BP measurement can result in inadequate or incorrect clinical decision making that can have important clinical implications for the patient. Accurate BP measurement requires mastering several clinical skills and re-training every 6-12 months for skill maintenance.[2–4] The skills a provider is expected to master and maintain include preparing and positioning the patient correctly and identifying and placing the appropriately sized cuff. Too often, providers are not aware of proper BP measurement skills, do not master all the appropriate skills, or miss key steps in the process, leading to inconsistent or inaccurate readings.[5,6] These deficiencies often lead to unnecessary repeated measurement, additional time and resources, or therapeutic inertia.[7] There are also several systemic factors that contribute to inaccurate BP measurements, including limited access to appropriate equipment, inadequate measurement environment, time constraints, and competing priorities.[6]

In June of 2019, the American Medical Association (AMA) and the American Heart Association (AHA) surveyed 2302 health care providers in the United States regarding their experiences being trained to measure BP.[2] Survey respondents included 750 physicians, 750 nurses, 300 physician assistants, 302 pharmacists, and 200 medical assistants. Findings indicated that formal training in BP measurement was usually limited to a one-time brief demonstration during their professional education coursework. Only 45% of physicians surveyed indicated that BP measurement training was revisited or repeated during residency, fellowship, or beyond. Similarly, 47% of the physician assistants surveyed indicated that they never received re-training following the initial experience in professional school.[2] In comparison, 53% of medical assistants received some form of re-training within the last 3 years. Despite the level of training and re-training received, providers indicated 25% to 41% of BP measurements taken across all medical practices are likely to be inaccurate.[2] Respondents further confirmed that they believe inaccuracies are usually due to factors within their control, including a lack of re-training. Most nurses (71%), physician assistants (81%), physicians (66%), and pharmacists (68%) reported that retraining on BP measurements is currently not required but should be going forward.[2] Respondents indicated that levels of motivation would be higher to take part in re-training if a collective, team-based approach was used.

In response to results of this survey and previous research, the AMA and AHA developed a web-based solution to address existing gaps in re-training opportunities for health care providers.[5] We developed a 30-minute e-Learning module that targets all levels of practicing healthcare providers and is designed to refresh and improve existing BP measurement knowledge and clinical skills. The content of the e-Learning module is based on the 2017 ACC/AHA clinical practice guidelines and includes an overview of the complete BP measurement process, proper technique, and suggestions for avoiding common errors.[2] The purpose of the current study was to evaluate the effectiveness of the e-Learning module in changing BP measurement knowledge and clinical skills.

2 | METHODS

2.1 | Blood pressure measurement e-learning module development

The 30-minute e-Learning module, developed in collaboration with the AMA and AHA, provides an innovative and comprehensive approach to re-training providers on how to measure BP accurately. We selected a web-based solution due to substantial popularity of this type of post-graduate training approach in the health care field. Traditional face-to-face forms of professional development training for health professionals are rapidly being supplemented or replaced with e-Learning options using web-based technologies.[9] Web-based solutions tend to be low-cost, flexible, and convenient for learners.[10]

The content development process was led by subject matter experts from the AMA and AHA. It involved reviewing existing literature including the 2017 ACC/AHA clinical practice guidelines and leveraging the findings from the 2019 AMA/AHA survey.[2,10] The module targets all practicing healthcare providers, including physicians, nurses, physician assistants, pharmacists, and medical assistants. It is divided into three micromodules and covers the epidemiology of hypertension and relevant clinical guidelines, best practices for taking accurate measurements on manual, semi-automated, and automated devices, and tips on how to partner with patients to prioritize BP control. Throughout the module, users engage in brief knowledge check questions and interactivities. At the end of the module, users complete a 20-question quiz to earn a certificate of completion and continuing education credit.

Prior to evaluating the effectiveness of the module, 16 users from four health care organizations, representing all members of the target audience, volunteered to participate in user testing of the module. Testing sessions were approximately 1 hour long and were administered over the phone or in-person. Users provided feedback on the content and functionality of the module and, where possible, AMA and AHA incorporated feedback into the final module. The final module titled Achieving Accuracy: BP Measurement can be accessed on the AHA Shop CPR website.

2.2 | Study participants

Four health care organizations were recruited as study sites: Advocate Aurora Health Care, University of Pennsylvania Health System, University of Alabama at Birmingham Health Care, and CVS Minute-Clinic. Physicians, nurses, physician assistants, and medical assistants with previous training in BP measurement and currently practicing in an ambulatory setting where BP was routinely measured were eligible to participate. Each organization sent a recruitment email to eligible participants and the first 50 invitees to respond at each site were enrolled

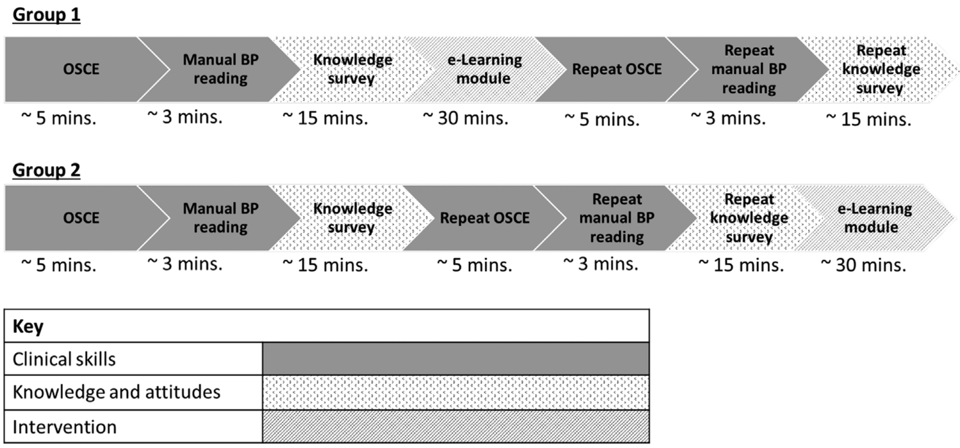

FIGURE 1 Sequence of study activities

in the study. Study participation was voluntary and did not impact their employment status. Individual performance on study-related BP measurement assessments was not reported to the health care organization. Participants received modest remuneration for their time.

2.3 | Study design

Using a standardized patient setting, we employed a multisite randomized study design aimed to assess knowledge and skills related to BP measurement before and after completion of the online e-Learning module. The study began in September 2019 and was completed by January 2020. Participant knowledge and attitudes were assessed using an online knowledge survey that included 12 questions related to correct BP measurement processes, classification of BP measurements, and processes for confirmation of elevated BP readings. Clinical skills were assessed before and after e-Learning module completion with two data collection activities: (1) Assessment of patient preparation, positioning, and cuff application using an objective structured clinical examination (OSCE) with a trained standardized patient (SP); and (2) Assessment of manual BP accuracy using a simulated BP training arm (Laerdal, Wappingers Falls, New York, USA). The University of Illinois at Chicago's Institutional Review Board (IRB), the local review board for the AMA (Protocol 2019-0827), and each participating site's IRB approved the study protocol.

Participants were randomized 1:1 to one of two groups (Group 1: Intervention or Group 2: Control). Randomization involved sequentially alternating participants between Group 1 and Group 2 based on next available time to begin the protocol. Participants chose the time they were available and were randomly assigned to either Group 1 or Group 2, making sure to keep the overall 1:1 assignment. The likelihood of being assigned to group 1 or group 2 did not depend on the time block. Assignment ensured that each participant did not have the same SP for the OSCE in the pre-period as in the post-period, while ensuring that each SP was used at the same rate as the other simulated patients. Both groups completed the same seven activities: two OSCEs, two simulated arm BP readings, two online surveys, and the e-Learning module; but in a different sequence. Group 1 participants were assigned to a typical pre-post assessment approach and Group 2 to a test-retest approach and represented a control group. The sequence of study activities for Groups 1 and 2 is depicted in Figure 1.

2.4 | OSCE

For the OSCE portion of the study, a patient case was developed, and 10 experienced SPs were recruited and trained to portray the role of the patient. The case focused on capturing the participant's ability to prepare, position, and apply a cuff for an accurate BP reading using an automated device according to the AHA Scientific Statement on BP Measurement in Humans.[2,9] The case emulated a previously published BP measurement case.[5] Participants were instructed to consider the SP as a new patient to their practice and take all the necessary steps required to attain an accurate BP assessment using an automated device. Participants were allocated 5 minutes to complete the encounter and did not need to take any additional vital signs. Once the BP assessment was complete, participants were instructed to verbally communicate the reading to the patient and end the visit.

SPs were trained to assess whether study participants correctly prepared and positioned them, selected and positioned the appropriate cuff, and measured BP in both arms. The exam room set up included a table; two chairs; an automated BP machine which included a small, regular, and large sized cuff; and a measuring tape. SPs were trained to prepare and position themselves incorrectly until the participant instructed them otherwise. This included engaging in conversations during the measurement, interacting with their mobile device, and sitting on the table with their feet dangling prior to the participant entering the room. At the end of each OSCE, the SP completed an online grading rubric that captured whether the participant accurately completed all 14 steps associated with measuring BP accurately. The OSCE score consisted of 14 items with each item graded as completed/not completed. Each item was weighted equally, and the reported OSCE score represents the number of skills performed correctly. See Standardized Patient Rubric in the Supplemental Materials section.

2.5 | Manual BP measurement

Participants' ability to obtain an accurate manual BP measurement was assessed using a simulated arm with a preprogrammed BP. Simulated arm BP values ranged from 120 to 150 mmHg for systolic BP and from 70 to 98 mmHg for diastolic BP. Participants were not informed of the range of values used for programming. A measurement was considered accurate if the participant listed both the systolic BP and the diastolic BP within ±4 mmHg of the programmed value. Participants' scores were recorded as accurate or inaccurate and group scores represent the proportion that measured both systolic BP and diastolic BP accurately.

2.6 | Knowledge survey

Pre- and post- surveys assessed participants' knowledge of the BP measurement process and attitudes toward their own measurement accuracy. Both surveys consisted of 12 knowledge questions that assessed a participant's understanding of hypertension categories and BP measurement techniques. See Online Survey in the Supplemental Materials section. Questions were weighted equally, and the knowledge score represented the number of questions answered correctly. The survey also included one additional attitudinal question on participants' self-perceived accuracy of taking BP measurements and four questions on participants' current confidence level in ability to perform different skills needed to correctly perform BP measurement. The accuracy of BP measurement was rated on a 10-point scale, while the four ability questions were measured on a 5-point Likert scale.

2.7 | Outcomes

The primary outcome was to determine the change in clinical skills via change in OSCE score. Secondary outcomes were changes in knowledge score and accurate manual BP assessment.

2.8 | Statistical analysis

Means and standard deviations were used to provide descriptive measures of continuous data and relative frequencies were used for categorical data. Differences between groups were compared using the two-sample *t* test, the paired *t* test for comparisons of the magnitude of change in pre- and post- assessments between the control and intervention groups, and the chi-square test for differences in categorical parameters. To account for the possibility of improvements in performance due solely to participating in the OSCE, knowledge survey, and simulated arm readings, we used paired *t* tests to compare the difference between the pre- and post- scores in the control group to the difference between pre- and post- scores of the intervention group. Results were considered statistically significant with a $P < .05$. All statistical tests were planned a priori and did not constitute overlapping hypotheses.[11] We conducted a sample size estimation for our primary hypothesis based on the a priori assumption that we would observe a two-question, or 14%, improvement, in the OSCE score between experimental and control groups. Based on these numbers, a trial with power of 80% and an alpha of 0.05 would require a total sample size of 30 or 15 participants in each group. All analyses were performed using SAS 9.4.

3 | RESULTS

A total of 177 practicing providers participated in the study. Of the 177 participants, seven were not included in the analysis. These seven participants did not complete the study in the correct order or missed steps leading to incomplete data. Of the seven, three participants were assigned to Group 1 and the other four were assigned to group 2. The remaining 170 participants are represented in Table 1; 88 (52%) were in the intervention group (Group 1) and 82 (48%) were in the control group (Group 2). Medical assistants or certified nursing assistants (n = 52) and nurse practitioners or advanced practice nurses (n = 52) comprised most of the participants (61.2% combined). Registered nurses (n = 33, 19.4%) were the next largest group of participants, followed by physicians (n = 17, 10%) and others, including physician assistants, licensed practice nurses, licensed vocational nurses, and health educators (n = 16, 9.4%). There were no statistically significant differences between the intervention group and the control group in terms of provider type ($P = .80$). Participant baseline attitudes toward accuracies in BP measurement are described in Table 2.

Table 3 contains the results of the OSCE score, knowledge assessments, and skills in obtaining the correct BP measurement at baseline and the change observed upon repeat assessment. For the initial assessments, participants in both the intervention and control groups correctly performed fewer than half of the 14 necessary components in the OSCE (mean scores 5.5 and 5.9, respectively), correctly answered fewer than 65% of the knowledge items (mean scores 7.6 and 7.7), and accurately obtained the BP on the simulation arm less than half of the time (38.6% and 48.8%). There were no statistically significant differences between the groups in any of the three assessments at baseline. Following the e-Learning module, Group 1, the intervention group, performed on average 3.4 more OSCE items correctly vs 1.4 in Group 2 ($P < .01$) and answered 1.7 more knowledge questions correctly vs 0.5 in Group 2 ($P < .01$). The percentage of participants in Group 1 that obtained an accurate systolic and diastolic BP measurement increased by 17.1 percentage points compared with a decline by 6.1 percentage points in Group 2 ($P = .01$). This table does not include the data from the seven participants who did not complete the study. An analysis that included these seven participants and treated their missing BP measurement accuracy data as inaccurate did not meaningfully change the results.

Regarding the 12 knowledge questions, the greatest improvement in scores was in the question related to identifying the advantages of using a fully automated BP measurement device instead of a

TABLE 1 Site and study participant characteristics

Location	Intervention No.	Intervention %	Control No.	Control %	Chi-square	P
					0.47	0.93
Site 1	22	25.0%	18	22.0%		
Site 2	24	27.3%	24	29.3%		
Site 3	23	26.1%	24	29.3%		
Site 4	19	21.6%	16	19.5%		
Profession					1.66	0.80
Nurse Practitioner or Advanced Practice Nurse	27	30.7%	25	30.5%		
Medical Assistant or Certified Nursing Assistant	26	29.6%	26	31.7%		
Registered Nurse	20	22.7%	13	15.9%		
Medical Doctor or Doctor of Osteopathic Medicine	8	9.1%	9	11.0%		
Other	7	8.0%	9	11.0%		
Years of experience					6.36	0.27
Fewer than 5 years	22	25.0%	19	23.2%		
5 to 9 years	21	23.9%	18	22.0%		
10 to 14 years	17	19.3%	22	26.8%		
15 to 19 years	12	13.6%	4	4.9%		
20 or more years	15	17.1%	19	23.2%		
Prefer not to answer	1	1.1%	0	0.0%		

TABLE 2 Attitudes related to BP measurement in intervention and control groups at baseline

Attitude survey items	Intervention	Control	P
How accurate are the BP measurements that you typically take?[a]	8.7 ± 1.35	8.5 ± 1.00	.26
How confident are you that you can do the following?			
Properly prepare and position the patient prior to measuring BP[b]	0.99	0.98	.52
Choose the correct BP cuff size[b]	0.94	0.99	.12
Accurately measure BP using manual methods[b]	0.95	0.95	.92
Accurately measure BP using automated methods[b]	0.95	0.93	.45

[a]Values shown are mean ± standard deviation for each group. Answer options were presented to participants on a scale from 1 to 10.
[b] Proportion of respondents selecting either Mostly Confident or Very Confident on 5-point Likert scale. *P*-values from pooled *t* tests.

semi-automated or manual device, with a net 25-percentage point improvement in correct responses; a 20-percentage point increase in Group 1 compared to a 5-percentage point decrease in Group 2, with the next greatest improvement coming in the question related to the minimum number of minutes a patient should rest quietly before taking a BP measurement, with a net 20-percentage point improvement. Regarding the OSCE components, the greatest improvement occurred in correctly identifying and documenting which arm to use for future BP readings, with a net 33-percentage point improvement in correct responses; a 33-percentage point increase in Group 1 compared to no change in Group 2. The next greatest improvement occurred in checking the BP in both arms, with a net 32-percentage point improvement.

4 | DISCUSSION

This multisite randomized controlled study with data collected from four health care organizations shows that an e-Learning module designed to retrain providers on BP measurement can help improve provider knowledge and skills. Participants included a diverse group of providers from various health care settings with a broad range of training levels. Across all four sites, participants in the intervention group demonstrated significant improvement in both their knowledge and skills after completing the 30-minute e-Learning module. At baseline, the average gaps in clinical skills were greater than the average gaps in knowledge, highlighting the need for re-training that addresses hands-on BP measurement skills. Participants in the

TABLE 3 Knowledge survey and OSCE scores at baseline and follow-up

Assessment	Intervention (No. = 88)	Control (No. = 82)	P[*]
Baseline			
OSCE Score (mean ± SD)[a]	5.5 ± 2.26	5.9 ± 2.39	.36
Knowledge Score (mean ± SD)[b]	7.6 ± 1.69	7.7 ± 1.71	.70
Accurate manual measurement ±4 mmHg (no., %)	34, 38.6%	40, 48.8%	.18
Follow-up			
OSCE Score (mean ± SD)	8.9 ± 2.09	7.2 ± 2.21	<.01
Knowledge Score (mean ± SD)	9.3 ± 1.63	8.2 ± 1.86	<.01
Accurate manual measurement ±4 mmHg (n, %)	49, 55.7%	35, 42.7%	.09
Change from baseline to follow-up			P2[**]
OSCE Score Change (mean ± SD)	3.4 ± 2.18	1.4 ± 2.3	<.01
Knowledge Score Change (mean ± SD)	1.7 ± 1.66	0.5 ± 1.79	<.01
Accurate manual measurement ± 4 mmHg Change (no., %)	15, 17.1%	−5, −6.1%	.01

OSCE, objective structured clinical examination.
[a]Maximum score for OSCE = 14.
[b]Maximal score for knowledge assessment = 12.
*Values from pooled *t* test.
**Values from paired *t* test.

intervention group demonstrated a correspondingly larger improvement in their clinical skills than knowledge after completing the e-Learning module.

Our findings reinforce existing evidence that errors in provider techniques are highly prevalent and that there is a benefit to recurrent refresher training to improve BP accuracy across all practicing providers.[2,12] Assuming the providers' initial training was adequate, our baseline assessments suggest that BP measurement knowledge and clinical skills decay over time, resulting in technical errors and inaccurate readings. The baseline assessments showed that the average provider failed to perform more than half of the clinical skills correctly. When providers were asked to rate their own level of accuracy, on a scale of 1 to 10, the average rating was 8.7 across all providers. These findings, paired with provider perceptions, further emphasize the importance for healthcare organizations to invest in retraining efforts. The disconnect between providers' perceived accuracy and their actual performance demonstrates a classic Dunning-Kruger effect,[13] an overestimation of baseline knowledge and skills, and is consistent with previous research on this topic.[5] The e-Learning module used in the current trial suggests immediate improvement in BP measurement performance is feasible, but more research is needed to fully understand the long-term impact and durability of the refresher training. Addressing providers' perceptions toward the importance of their own accurate readings may require changes at the organizational level.

Previous research has shown that while provider knowledge and skills play a significant role in obtaining accurate BP measurements, provider ability is not the only factor contributing to inaccuracies.[12] System factors like workflow limitations, sub-optimal equipment, time constraints, and competing priorities at the organizational level are often cited as barriers to accurate readings. Accurate BP measurement requires a patient to rest for 5 minutes beforehand, and data have shown that providers often feel rushed and are unable to meet this guideline recommendation without disrupting their daily workflow.[12] Our findings suggest that several of the key skill and knowledge gaps among providers are closely tied to systems issues. From a knowledge standpoint, the greatest improvement was related to advantages and disadvantages of manual vs automated devices and knowing that patients require a 5-minute rest prior to measuring their BP. From a clinical skills standpoint, the greatest improvement was related to knowing that a first-time patient requires checking BP on both arms and the need to identify and record the arm with the higher reading for future visits. Previous research shows that performance on these two skills tend to be the lowest among the measurement skills.[5] While it is encouraging to observe that providers' knowledge and skills improved after the e-Learning intervention, provider re-training will have a limited impact if organizations do not address the systems-level barriers that influence inaccuracies. In particular, organizations need to address the common issues of insufficient access to appropriately calibrated and/or validated devices[14,15] and inadequate time to perform all of the necessary steps of accurate BP measurement.[16–18] Health care organizations need to revisit their current BP measurement practices and provide the structure and resources necessary to apply guideline recommended BP measurement procedures.

The authors also recognize that knowledge and skills gaps continued to exist post-intervention. This maybe due to the complexity of the subject. BP measurement requires mastering several skills and an eLearning module alone may not be sufficient. Research has shown that while eLearning is continuing to gain momentum with clinical skills training, a blended approach should be considered in the future.[19]

Strengths of the current study include generalizability to a broad range of health care settings (academic and private health systems) and clinicians at all levels of training, from medical assistants to attending physicians. Additionally, to our knowledge, this is the first randomized study assessing the effectiveness of a web-based retraining program for BP measurement knowledge and clinical skills. We are aware of only one other online training program for BP measurement developed by the Pan American Health Organization in collaboration with Resolve to Save Lives, the World Hypertension League, Lancet Commission on Hypertension Group, and Hypertension Canada, which has not been tested in a randomized trial.[20]

Limitations of this study include the short follow-up time for assessing knowledge and skills. Similar follow up testing at 3- or 6-month intervals would better determine whether the improvements have a lasting impact over time. Follow-up testing can also help health care organizations establish how often their providers need this type of refresher training; current guidelines recommend re-training every 6-12 months.[3,4] Assessing the impact of provider BP measurement re-training on BP control rates was outside of the scope of this study but would further inform the value of BP measurement re-training. Results of this study show that refresher training can improve accuracy in a standardized setting. Our study does not determine whether this type of training translates to practice level changes where other environmental factors come into play. Lastly, we recognize that provider training can be more difficult in time constrained and low-resource settings, but the brief e-Learning format should make this module an attractive re-training opportunity in these and other practice settings.

5 | CONCLUSIONS

Our results confirm the need for BP measurement re-training and the ability to improve providers' knowledge and skills with a brief 30-minute e-Learning module. Further research can help clarify the frequency at which re-training is best implemented. Re-training alone, without addressing systems-level barriers to accurate BP measurement, is likely inadequate to address this performance gap. However, BP measurement re-training should be a cornerstone of any health care organization's quality improvement program.

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CONFLICTS OF INTEREST

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REFERENCES

1. Stanaway JD, Afshin A, Gakidou E, et al. Global, regional, and national comparative risk assessment of 84 behavioural, environmental and occupational, and metabolic risks or clusters of risks for 195 countries and territories, 1990–2017: a systematic analysis for the Global Burden of Disease Study 2017. *Lancet*. 2018;392(10159):1923-1994. https://doi.org/10.1016/s0140-6736(18)32225-6
2. Rabbia F, Testa E, Rabbia S, et al. Effectiveness of blood pressure educational and evaluation program for the improvement of measurement accuracy among nurses. *High Blood Press Cardiovasc Prev*. 2013;20:77-80.
3. Muntner P, Shimbo D, Carey RM, et al. Measurement of blood pressure in humans: A scientific statement from the American Heart Association. *Hypertension*. 2019.
4. Muntner P, Einhorn PT, Cushman WC, et al. Blood pressure assessment in adults in clinical practice and clinic-based research: JACC scientific expert panel. *J Am Coll Cardiol*. 2019;73:317-335.
5. Rakotz MK, Townsend RR, Yang J, Alpert BS, Heneghan KA, Wynia M, Wozniak GD Medical students and measuring blood pressure: Results from the American Medical Association Blood Pressure Check Challenge. *J Clin Hypertens* (Greenwich). 2017;19:614-619.
6. Kallioinen N, Hill A, Horswill MS, Ward HE, Watson MO Sources of inaccuracy in the measurement of adult patients' resting blood pressure in clinical settings: a systematic review. *J Hypertens*. 2017;35:421-441.
7. Egan BM, Sutherland SE, Rakotz M, Yang J, Hanlin RB, Davis RA, Wozniak G Improving hypertension control in primary care with the Measure Accurately, Act Rapidly, and Partner with Patients Protocol. *Hypertension*. 2018;72:1320-1327.
8. Blood Pressure Measurement Training Research Report. Prepared by Decision Analyst. https://www.ama-assn.org/system/files/2019-11/market-research-survey-bp-measurement.pdf. 2020.
9. Lawn S, Zhi X, Morello A An integrative review of e-learning in the delivery of self-management support training for health professionals. *BMC Med Educ*. 2017;17:183.
10. Walsh K. Cost and value in e-learning: the perspective of the learner. *BMJ Simul Technol Enhanced Learn*. 2018;4(4):201-202.
11. Armstrong RA When to use the Bonferroni correction. *Ophthalmic Physiol Opt*. 2014;34:502-8.

12. Hwang KO, Aigbe A, Ju H-H, Jackson VC, Sedlock EW Barriers to accurate blood pressure measurement in the medical office. *J Prim Care Community Health*. 2018;9:2150132718816929.
13. Kruger J, Dunning D. Unskilled and unaware of it: how difficulties in recognizing one's own incompetence lead to inflated self-assessments. *J Pers Soc Psychol*. 1999;77:1121-34.
14. Sharman JE, O'brien E, Alpert B, et al. Lancet Commission on Hypertension group position statement on the global improvement of accuracy standards for devices that measure blood pressure. *J Hypertens*. 2020;38:21-29.
15. Cohen JB, Padwal RS, Gutkin M, et al. History and justification of a national blood pressure measurement validated device listing. *Hypertension*. 2019;73:258-264.
16. Linzer M Working conditions in primary care: physician reactions and care quality. *Ann Intern Med*. 2009;151:28-36, W6-9.
17. Sinnott C, Georgiadis A, Park J, Dixon-Woods M. Impacts of operational failures on primary care physicians' work: A critical interpretive synthesis of the literature. *Ann Fam Med*. 2020;18:159-168.
18. Prasad K, Poplau S, Brown R, et al. and Healthy Work Place I. Time pressure during primary care office visits: a prospective evaluation of data from the Healthy Work Place Study. *J Gen Intern Med*. 2020;35:465-472.
19. Mcdonald EW, Boulton JL, Davis JL E-learning and nursing assessment skills and knowledge - An integrative review. *Nurse Educ Today*. 2018;66:166-174.
20. Campbell NRC, Khalsa T, Ordunez P, et al. Brief online certification course for measuring blood pressure with an automated blood pressure device. A free new resource to support World Hypertension Day. *J Clin Hypertens (Greenwich)*. 2020;22:1754-1756.

SUPPORTING INFORMATION

Additional supporting information may be found in the online version of the article at the publisher's website.

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