

Medical students and measuring blood pressure: Results from the American Medical Association Blood Pressure Check Challenge

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Blood pressure (BP) measurement is the most common procedure performed in clinical practice. Accurate BP measurement is critical if patient care is to be delivered with the highest quality, as stressed in published guidelines. Physician training in BP measurement is often limited to a brief demonstration during medical school without retraining in residency, fellowship, or clinical practice to maintain skills. One hundred fifty-nine students from medical schools in 37 states attending the American Medical Association's House of Delegates Meeting in June 2015 were assessed on an 11-element skillset on BP measurement. Only one student demonstrated proficiency on all 11 skills. The mean number of elements performed properly was 4.1. The findings suggest that changes in medical school curriculum emphasizing BP measurement are needed for medical students to become, and remain, proficient in BP measurement. Measuring BP correctly should be taught and reinforced throughout medical school, residency, and the entire career of clinicians.

1 | INTRODUCTION

Thomas Frieden, MD,¹ Director of the Centers for Disease Control and Prevention, stated in the 2015 Shattuck lecture that improving blood pressure (BP) control could save more lives than any other single clinical intervention. A critical component in achieving improved BP control is having healthcare professionals measuring BP accurately, as demonstrated by Kaiser Permanente Northern California in their highly successful hypertension control efforts.² For the purpose of this paper, the term "BP measurement" refers to noninvasive techniques that estimate BP. Measuring BP is the most commonly performed medical procedure in clinical practice.³ It is a complex procedure requiring the mastery of multiple skills performed simultaneously to yield an accurate measurement. In the United States, multiple protocols for obtaining accurate BPs exist.³ Unfortunately, however, they are rarely followed in daily clinical practice.^{4,5}

A properly trained observer, the person taking the measurement, is the most critical component of accurate BP measurement.³ In addition to having the patient rest for at least 5 minutes and be correctly positioned prior to taking the first BP reading, the observer must also choose the appropriate size cuff and suitably position the cuff on the patient.³ Additional skills are required when measuring BP with a manual sphygmomanometer using the auscultatory method, which is technically more challenging than measuring BP with an automated device. The observer must possess adequate hand-eye coordination, hearing, and visual acuity; be able to interpret the Korotkoff sounds correctly; inflate and deflate the cuff properly; and record the BP as measured, without terminal digit preference, rounding the BP up or down so that the documented value ends in a zero or five.⁴

Medical students in the United States are taught to measure BP during the first year of medical school using the auscultatory method with a manual sphygmomanometer. We spoke to faculty members who teach BP measurement from US medical schools and confirmed that formal BP measurement training occurs only in the first year of medical

*The findings and conclusions in this report are those of the author and do not necessarily represent the views of the American Medical Association.

school, and therefore is generally the only formal training physicians are ever likely to receive. In comparison, nurses and medical assistants are more likely to have their skills tested every 6 months throughout their careers as recommended in American Heart Association guidelines.³ It is, therefore, critical that medical students attain mastery of this procedure during medical school, when they are initially taught how to perform it. However, studies from many countries have demonstrated that medical, nursing, chiropractic, and pharmacy students do not obtain mastery of the skills needed to measure BP competently while in school.⁶⁻¹¹ We are not aware of any published studies assessing US medical students' BP measurement technique. The purpose of this study was to test students from US medical schools on their ability to measure BP properly.

2 | METHODS

To make the assessment of the medical students' skills as realistic as possible, we chose direct observation of a simulated patient encounter for testing. We relied on a convenience sample derived from the approximately 600 first- through fourth-year medical student members of the American Medical Association (AMA) who attended the AMA's House of Delegates Annual Meeting on June 4 and 5, 2015, in Chicago, Illinois. We informed the attendees of the Blood Pressure Check Challenge (BP Challenge) at the beginning of each session, and positioned placards in the meeting venue with the times and room locations of the event. Over the 2 days, 159 medical students volunteered to participate in the BP Challenge. To be eligible to participate in the challenge, all participants confirmed that they had previous training in BP measurement. Participants received verbal and written information indicating that their participation was voluntary and confidential, and that the data obtained may be used for research. We did not collect identifying information. Those who completed the challenge were eligible to win a gift card. The institutional review board at the University of Illinois at Chicago approved this study.

2.1 | Case simulation

Physicians and staff from the AMA, the University of Pennsylvania, and the University of Tennessee Health Science Center developed the BP Challenge case simulation. The case simulation assessed BP measurement skills centered around rest, body positioning, cuff selection and placement, environment, and measuring BP in both arms. The testing process incorporated automated BP devices so that the student's ability to use the auscultatory method correctly was removed from the testing process. This was done to reduce the number of skills required for the students to perform during testing, making it easier to assess their ability to demonstrate mastery in a simulated clinical setting. It was also a practical concession to the recent US and international guidelines for the management of hypertension, which recommend the use of automated devices, when available, to measure BP.¹²⁻¹⁴ The use of automated BP devices reduces human error and bias when compared with the auscultatory method with a manual

sphygmomanometer.¹⁵ In other words, it is easier to perform the skills needed to obtain an accurate BP measurement using automated devices. The use of an automated device, however, does not ensure that all skills required to obtain an accurate BP measurement will be performed.

Participants were taken individually to one of four identical mock examination rooms for testing. At the start of each simulated encounter, a patient actor was sitting on an elevated stool with no arm, back, or foot support and with his/her legs crossed. Next to the elevated stool was an empty chair with built-in back and arms for support. Adjacent to the stool was a table at the appropriate height to support an arm, which also contained an automated BP monitor; small, medium, large, and extra-large BP cuffs; and a measuring tape. The patient actors were adults who had all received an identical script with detailed instructions to follow during each simulated patient encounter. Each patient actor was instructed to arrive prior to the start of the BP Challenge to rehearse his or her role in order to standardize the simulated patient case.

The medical students were all given the same brief written clinical vignette stating that the patient in front of them was 50 years old, new to their practice, and had not seen a doctor in several years, indicating a need for BP to be measured in both arms.⁴ The students were also told to measure the patient's BP and write down the results. It was explained to them that they would not be scored on familiarity or use of the BP monitor, and a physician or nurse would assist in operating the machine if asked to do so by the student. Participants completed a paper-administered questionnaire prior to the case simulation to collect demographic characteristics including year in school, age, sex, state where their school was located, and medical specialty they planned to pursue. We used a random identifier to link participant demographic information to the scorecard used to record participant performance on the case simulation. The patient actors were instructed not to speak unless spoken to during the procedure and to start using their mobile phones just prior to the BP measurement (by texting, reading, or browsing the internet). They were also to comply with any instructions given to them by the medical students during testing, for example, "please refrain from using your mobile phone during the procedure."

We observed student BP measurement skills and assessed their performance based on evidence-based techniques from the most commonly used textbook¹⁶ and guideline⁴ currently in use in medical schools in the United States. The performance score was based on 11 skills: (1) resting the patient for 5 minutes prior to the measurement or expressing intent to do so; (2) legs uncrossed; (3) feet on floor; (4) arm supported; (5) correct cuff size; (6) cuff placed over bare arm; (7) no talking; (8) no mobile phone use or reading; (9) BP measurement taken in both arms; (10) correctly identifying BP from the arm with the higher reading as being clinically more important when asked; (11) correctly identifying which arm to use for future readings (the arm with higher BP). Participants received pass or fail scores for each of the 11 skills tested. These scores were combined into an overall performance score.

A team of registered nurses and primary care physicians, who were trained and then observed while scoring several students to qualify as

raters, scored participants. Raters were checked for inter-rater concordance on a small sample of seven students prior to initiating the study by having two or three raters simultaneously assess performance on each skill and comparing the results. The concordance rate was 97.5% (197 of 202); for three students there were no disagreements among raters, while raters scored one or two skills differently for four students. The raters then reconvened to review and reconcile the scoring differences in an effort to minimize potential disagreement among raters across all 11 skills during the BP Challenge.

2.2 | Statistical analysis

Demographic characteristics are described using percentages, means, and standard deviations. The percentage of participants correctly performing skills and mean total scores (11 skills) are reported. The differences by medical education group, age group, sex, and planned specialty group were examined in contingency tables and tested using independent samples *t* tests or Pearson's chi-square test. Analyses were performed in SAS version 9.4 (SAS Institute, Cary NC, USA).

3 | RESULTS

Demographic characteristics of participants are presented in Table 1. Over 2 days, 159 students participated, representing medical schools in 37 states. The mean age of participants was 25 years and the majority (65.4%) were between the ages of 20 and 25 years. First-year students made up 61.6% of the participants. Among those who had a planned specialty, 26.4% were planning on primary care as their specialty. Over one third (35.2%) were undecided on their planned specialty.

TABLE 1 Characteristics of medical students in the Blood Pressure Check Challenge

Variables	
Mean age (SD), y	25.0 (2.9)
Age 20–25 y, %	65.4
Age 26–29 y, %	26.4
Age 30–36 y, %	6.3
Age 40+ y, %	0.6
Male, %	54.1
First-year medical student, %	61.6
Second-year medical student, %	14.5
Third-year medical student, %	17.6
Fourth-year medical student, %	4.4
Planned specialty, %	
PC	26.4
EM	10.7
Surgery	13.8
Other	13.8
Undecided	35.2
States represented, No.	37

The overall performance on the 11 skills required to measure BP accurately was poor (Table 2). Only one student among 159 scored 100%. On average, the students performed just over four (4.1) of the 11 skills correctly. Six of the 11 specific skills were performed correctly by <20% of the students. The least frequently correct skill performed was the 5-minute rest in the chair (6.9%) followed by indicating which arm should be used for future readings (13.2%). Of the other five skills, roughly half of participants performed three of them correctly: legs uncrossed (52.2%); no talking during the measurement (57.2%); and arm supported (61.0%). Students performed best on selecting the correct cuff size (73.6%) and ensuring the cuff was placed over a bare arm (83.0%).

In terms of overall performance, medical students in the second or later years scored higher than students in their first year (4.9 vs 3.7; $P < .01$). No association was found between overall performance and either age ($P = .12$), sex ($P = .92$), or planned specialty ($P = .49$). Students in the second through fourth year of medical school scored higher in the 5-minute rest in chair (12.1% vs 3.1%; $P < .05$), feet on floor (24.1% vs 9.2%; $P < .05$), BP checked in both arms (31.0% vs 10.2%; $P < .01$), noting BP from arm with higher reading (25.9 vs 9.2; $P < .05$), and indicating which arm to use for future readings (22.4 vs 8.2; $P < .01$). Only slight differences were found in performance on specific skills by the participant age, sex, or planned specialty. Compared with younger participants, older participants tended to perform better on positioning feet on floor (24.5% vs 10.6%; $P < .05$). Female students performed better on ensuring legs were in the uncrossed position compared with male students (62.9% vs 44.2%; $P < .05$). Finally, variation was found in the performance on the patient not talking among the planned specialty of participants ($P < .01$).

4 | DISCUSSION

Medical student performance on the BP Challenge, which assessed 11 skills required to measure BP accurately, was disappointing. Given these students represented schools in 37 states, the results suggest it is unlikely that current US medical students are able to perform reliably the skills necessary to measure BP accurately. Student demographic characteristics and planned specialty had little impact on overall performance. The average student failed to perform more than one half of the skills correctly. Very poor performance occurred in several skills, including rest prior to measurement, ensuring the patients' feet were flat on the floor, ensuring the patient was not actively using a cell phone during measurement, and checking BP in both arms for a new patient visit.

The results suggest that the current medical school curriculum for teaching BP measurement needs to be evaluated and redesigned. As with nursing and other nonphysician healthcare professionals, we believe strongly that competency testing of physicians should be ongoing as well. Our findings are consistent with existing studies performed outside the United States in medical, nursing, chiropractic, and pharmacy students, making it likely that this is an international problem in need of a solution and not only a domestic one.^{6–11} One successful

TABLE 2 Percentage of participants correctly performing skills to measure blood pressure accurately, and mean performance score

	Medical education			Age, y		Sex		Planned specialty		
	All (n=159)	1st year (n=98)	2nd to 4th year (n=58)	20-25 (n=104)	≥26 (n=53)	Male (n=86)	Female (n=70)	PC (n=42)	EM (n=17)	Other (n=22)
Rest 5 min in chair prior to measurement, %	6.9	3.1	12.1 ^a	5.8	9.4	9.3	2.9	7.1	0	18.2
Legs uncrossed, %	52.2	50.0	55.2	51.0	54.7	44.2	62.9 ^a	52.4	58.8	45.5
Feet on floor, %	15.1	9.2	24.1 ^a	10.6	24.5 ^a	15.1	14.3	16.7	29.4	22.7
Arm supported, %	61.0	57.1	69.0	55.8	71.7	58.1	62.9	64.3	52.9	63.6
Correct cuff size, %	73.6	71.4	77.6	72.1	77.4	76.7	70.0	78.6	58.8	81.8
Cuff over bare arm, %	83.0	87.8	79.3	84.6	81.1	82.6	84.3	76.2	88.2	90.9
No talking, %	57.2	53.1	65.5	54.8	62.3	55.8	58.6	54.8	47.1	45.5
No mobile phone use/reading, %	17.0	13.3	24.1	17.3	15.1	18.6	15.7	16.7	17.6	13.6
Checked in both arms, %	18.2	10.2	31.0 ^b	17.3	20.8	20.9	15.7	19	11.8	22.7
Noted arm with higher reading, %	15.1	9.2	25.9 ^b	14.4	17.0	17.4	12.9	16.7	11.8	22.7
Correctly answered which arm to be used to measure in future, %	13.2	8.2	22.4 ^a	11.5	17.0	16.3	10.0	7.1	11.8	22.7
Mean performance score	4.1	3.7	4.9 ^b	4.0	4.5	4.2	4.1	4.1	3.9	4.5

Abbreviations: EM, emergency medicine; PC, primary care.

^ap<.05.

^bp<.01.

strategy for mitigating the loss of competence of BP measurement skills after initial training among medical students in Turkey included refresher training in the third year followed by performing BP measurements on real patients.⁹

It is unlikely that physician-measured BPs will disappear anytime soon, in spite of evidence that they are the least likely to be accurate.¹⁷ This consequence of poor technique has been reviewed and emphasized in past publications.^{4,15} Each error in technique typically gives higher values for BP, and the errors tend to compound one another. A 5- to 10-mm Hg error can result in an incorrect upclassification of BP category from prehypertension to stage 1 hypertension, resulting in unnecessary and potentially harmful therapy for a significant number of patients.¹⁸ Poor technique can also cause patients with hypertension that is controlled to appear uncontrolled, which can lead to inappropriate escalation of therapy, also leading to potential harm to the patient. Assuming that physicians will continue to measure BPs in clinical practice, the future physician workforce will need to master the skills required to measure BP accurately. Without accurate BP readings, improving BP control is unlikely because physicians would not reliably know which patients need to be more aggressively treated and which do not. For physicians to attain and maintain this critical skill, medical schools must improve methods used to teach students how to master skills required to measure BP accurately during medical school. In addition, it is critical that a system must be put in place to ensure that physicians maintain mastery throughout their careers.

Fully automated BP devices are now recommended for measuring BP in the office because of their advantage of reducing observer errors and the white-coat effect and providing multiple measurements.¹³⁻¹⁵ In theory, the use of automated devices could potentially reduce the need for retraining.⁴ To the best of our knowledge, automated devices are not commonplace in the initial training of medical students. Studies have shown that when a combination of periodic training videos along with written and in-person competency testing are used, clinical staff are able to maintain their ability to measure BP accurately.^{4,19} Even after retraining, however, there is evidence that physicians in practice do not measure BP accurately.²⁰

4.1 | Limitations

A limitation of the study is that the convenience sample of medical students comprised only students attending the AMA annual meeting who volunteered to participate. These students are AMA members and not necessarily a representative sample of US medical students. However, we are not aware of any evidence suggesting that students who are members of the AMA would be more or less competent in BP measurement skills than medical students who are not AMA members. Also, students self-selecting into the study may signal their self-perceived knowledge of BP measurement skills or the level of confidence in those skills. The results suggest there is little if any upward bias in performance due to these factors. While the majority of participants were first-year students, it is those students whom are closest to their formal training in BP measurement skills. Finally, we

did not test the students' ability to measure BP using the auscultatory method, which is currently how many physicians measure BP. The ability to successfully use this method is more difficult and requires additional skills than those we tested. Hence, by excluding auscultatory assessment, we would expect performance to improve, not worsen.

5 | CONCLUSIONS

The analysis shows that medical students do not attain mastery of the skills required to measure BP accurately. We believe the use of automated devices will reduce some common errors in measuring BP, but our study confirms that automated device use alone will not eliminate many common errors in BP measurement. If physicians continue to measure BP, as we expect they will, then medical school training in these skills should be revised and studied to ensure it is effective. We also expect that physicians, after achieving mastery in these skills, should undergo competency testing at similar intervals, a minimum of every 6 months throughout their careers, as is recommended for other healthcare professionals.⁴

AUTHOR CONTRIBUTIONS

Dr Wozniak had full access to all of the data in this study and takes responsibility for the integrity of the data and the accuracy of the data analysis. Study concept and design: Rakotz, Townsend, Alpert, and Wynia; acquisition of data: Rakotz, Heneghan, and Wynia; analysis and interpretation of data: Yang and Wozniak; drafting of the manuscript: all; critical revision of the manuscript for important intellectual content: Rakotz, Townsend, Alpert, Wynia, and Wozniak; statistical analysis: Yang and Wozniak; study supervision: Rakotz.

CONFLICT OF INTEREST DISCLOSURES

Bruce Alpert is a consultant with Cordex.

ACKNOWLEDGMENTS

The authors acknowledge the contributions from Sara Alafogianas, Meredith Belber, Vikas Bhala, Shahid Choudhry, Donna Daniel, Melissa Hash, Delane Heldt, Namratha Kandula, Katherine Kirley, Asha Krishnan, Wendell Meyer, Linda Murakami, Annalynn Skipper, Patricia Tucker, and Aiden Wynia.

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How to cite this article: Rakotz MK, Townsend RR, Yang J, et al. Medical students and measuring blood pressure: Results from the American Medical Association Blood Pressure Check Challenge. *J Clin Hypertens.* 2017;19:614–619. <https://doi.org/10.1111/jch.13018>