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## Assessment of blood pressure skills and belief in clinical readings<sup>☆,☆☆</sup>

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### ABSTRACT

**Background:** Accurate blood pressure (BP) measurement is essential for the diagnosis and management of hypertension. In clinical practice, BP is estimated using noninvasive methods with significant variability of application of guidelines in clinical practice, impacting the accuracy and certainty of BP measurements.

**Objective:** We sought to assess how BP is measured in clinical practice.

**Methods:** A survey was administered through professional societies that included predominantly cardiologists. Assessment of adherence to guideline recommendations for BP assessment was measured and compared to the level of confidence in clinic BP measurement.

**Results:** There were 571 surveys completed. The majority of respondents were cardiologists (61.1%), with 47 preventive cardiologists. BP was routinely checked in both arms by 53% at the initial visit, 48% check BP once each visit, and 64% wait 5 min before initial BP assessment. Automated BP assessment is used by 58% respondents. The majority (83%) trust their BP readings, and those who trust their BP readings are more likely to perform the initial BP assessment themselves, compared to those who do not trust the clinic BP readings (30.2% vs. 13.6%,  $P = 0.009$ ). Accurate BP measurement is performed by 23% of cardiologists, and more likely performed accurately by a preventive cardiologist (38.3%) compared with other cardiologists (20.0%,  $P = 0.007$ ). Accurate BP measurement is more likely for those who perform the initial BP themselves rather than any other staff (36.8% vs. 17.9%;  $P < 0.001$ ); and for those who repeat BP manually (80% vs. 54%;  $P < 0.001$ ), compared to those who do not measure BP accurately. Despite the inaccuracy of BP measurement, there is a high level of confidence in the BP readings.

**Conclusions:** Accurate BP assessment continues to remain suboptimal in clinical practice. Reliability of BP assessment requires education, identifying barriers to implementation of recommendations and engagement of the entire team to improve BP assessment.

Hypertension remains the leading risk factor globally for deaths and quantitatively is the most important noncommunicable disease given its impact on cardiovascular, neurologic and renal disease. It affects over 1 billion people worldwide and it is estimated that less than 1 in 5 people are adequately controlled, contributing to over 10 million deaths per year [1]. Accurate measurement of blood pressure (BP) is essential to the diagnosis of hypertension and also for its management. BP assessment is the most important and commonly performed measurement in clinical medicine. Inaccuracies in BP measurement in a population, even if small, can have considerable consequences. Overestimation can result in inappropriate treatment, just as underestimation can lead to increased adverse cardiovascular outcomes. Overestimating true BP by 5 mm Hg in the population could result in inappropriate treatment with antihypertensives in approximately 30 million Americans, exposing them unnecessarily to adverse side effects of the medications and unnecessary

costs [2]. Underestimations of the same 5 mm Hg can miss over 20 million Americans when extracted on a population level, with a potential 25% increase in fatal strokes and myocardial infarction [3].

Nonetheless, accurate BP measurement in the clinic is highly undervalued and often performed inaccurately. For some clinicians, this results in clinical inertia with the awareness that BP is often inaccurate in their clinical setting, resulting in a hesitation to treat an elevated BP, given the lack of confidence they have in their BP readings. In others, there is simply lack of awareness of how to accurately assess BP, and hence, the clinicians will respond and initiate treatment to inaccurate readings. Current recommendations for BP measurement in the outpatient setting vary amongst different organizations across the world. This has led to ambiguity and a lack of standardization in clinical practice. The 2017 American College of Cardiology (ACC)/American Heart Association (AHA) guidelines recommend two separate BP readings 1–

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3 min apart taken after the patient has been sitting for at least 5 min [4]. Guidelines published in 2018 by European Society of Cardiology (ESC)/European Society of Hypertension (ESH) describe a similar protocol but at least three BP measurements [5]. Both recommend ambulatory and home BP monitoring to confirm diagnosis outside the clinic setting. In addition, the European guidelines also emphasize unattended automated (AOBP) measurements to reduce or even eliminate white coat hypertension. By automating this process, it inherently creates a standardized process that minimizes interruption and variation between patients. In the BP assessment algorithm published by Hypertension Canada, all initial AOBP measurements are performed unattended [6]. General consensus amongst guidelines favors automated over manual BP readings; however, there is delay in uptake in clinical practice.

To date, there is limited information regarding how cardiologists assess BP clinically, particularly since the 2017 Guideline for the Prevention, Detection, Evaluation, and Management of High Blood Pressure in Adults were released. We sought to determine how BP is assessed in clinical practice by cardiologists, to determine both the accuracy of BP assessment and trust cardiologists had in their BP measurements.

## 1. Methods

This study was approved by the internal review board of the University of Arizona. The survey (**Appendix 1**) was distributed to three professional societies, which were chosen due to their focus on cardiovascular disease prevention and hypertension. It was also shared on twitter which resulted in additional responses. Although the target populations intended was cardiologists, others in healthcare could also respond. Only those who completed the entire survey were included in the analysis

### 1.1. Study design

The survey was distributed by e-mail by three professional societies that include predominantly cardiologists or clinicians that specialize in hypertension and cardiovascular disease prevention. This included the American Society for Preventive Cardiology, The Society for Cardiovascular Computed Tomography, and the High Blood Pressure Research Council of Australia. The survey was open for 30 days on SurveyMonkey™, and allowed only a single response from respondents. The survey was shared on social media in the last 2 weeks of the data collection but represented only 22% of the total respondents.

### 1.2. Accurate BP assessment

We defined “Accurate BP Assessment” if the respondents reported the following: routinely checking BP in both arms; checking BP two or more times per visit; and waiting 5 min before checking BP. Although respondents were asked if they used an automated BP monitor versus a manual monitor, this was not included in the definition of accurate BP assessment.

### 1.3. Statistics

We performed a descriptive analysis of variables of interest, presenting categorical variables as percentages. We performed unadjusted comparisons of the characteristics of those persons checking BP accurately compared to those who do not in our cohort by using  $\chi^2$  tests. All p values were 2-tailed, and the level of significance was set at  $\alpha = 0.05$ . Data were analyzed using STATA 16.0 (StataCorp, College Station, TX).

## 2. Results

There were 612 respondents in the 30 days of sending the request to complete our survey. A total of 571 persons responded to all questions, which was a 93.3% completion rate. The majority of respondents

**Table 1**  
Respondent characteristics.

		N = 571 (%)
Clinical Role	Preventive Cardiologists	47 (8.2)
	Cardiologist	302 (52.9)
	Physician (other)	127 (22.3)
	Other Healthcare Professional	95 (16.6)
Country of Practice	USA	317 (55.5)
	Canada	38 (6.7)
	Mexico	54 (9.5)
	Europe	63 (11.0)
	Australia/New Zealand	34 (6.0)
	South America	46 (8.0)
	Asia	11 (1.9)
Africa	8 (1.4)	

were cardiologists: 349 (61.1%), with 47 of them identified as preventive cardiologists (**Table 1**). The remaining respondents were: 127 (22.2%) physicians of other types 40 (7.0%), nurse practitioners, 11 (1.9%) nurses, 5 (0.9%) medical assistants, and 39 (6.8%) other healthcare professionals. Those who completed the entire survey are included in this analysis, with most of the respondents (55.5%) from the United States (**Table 1**).

### 2.1. Clinic blood pressure assessment

The majority of the people responding to this survey reported that they did not routinely check BP in both arms at the initial clinic visit (55.5%) or check BP more than once at each clinic visit (51.0%). Most reported waiting 5 min before checking BP (64.3%). (**Fig. 1**) In most cases, from everyone completing the survey only 25.9% assessed the blood pressure themselves. Nonetheless, 57.6% (276) repeated the BP manually, and 61.3% (214) cardiologists performed a manual BP measurement themselves. (**Table 2**)

Automated BP monitors for BP assessment in clinic were not used in 39% of those surveyed. In those who do use automated BP monitors in their clinics, 24% don't give any instructions to the person taking the BP measurement about talking during the procedure, while 28.9% instruct the person taking the BP to not talk to the patient. Only 19.6% have the person measuring the BP to leave the patient's room while the automated cuff is inflating. (**Table 2**)

### 2.2. Use of ambulatory and home blood pressure monitoring

The majority (52.2%) of respondents use ambulatory BP monitoring to assess for white coat hypertension or Masked hypertension or confirm a diagnosis of hypertension, although 26.1% do not use ambulatory BP monitoring (**Table 2**). The remainder use ambulatory BP monitoring for a single specific reason but not for all indications. From those surveyed, 52.7% recommend the use of home BP monitoring in all patients with HTN, and 32.2% recommend it only when BP appears uncontrolled and new medications started. Interestingly, only 2.3% reported that most of their patients cannot afford a home BP monitor.

### 2.3. Trust in BP readings

The majority of those surveyed trusted their BP measurement (83.9%), despite most of those surveyed perform it inaccurately, with no difference in those who trusted or did not trust the clinic BP assessment ( $P = 0.13$ ) (**Fig. 1**). Those who trusted their clinic BP assessments were more likely to routinely check BP in both arms at initial visit, when compared with those who did not trust their BP (47.4% vs 32.6%;  $P = 0.009$ ). They were also more likely to perform the initial BP assessment themselves when compared with those who did not trust their BP (28.7% vs 13%;  $P = 0.002$ ). Performance of a manual repeat BP did not differ between those who trusted or did not trust their clinic BP measures. There

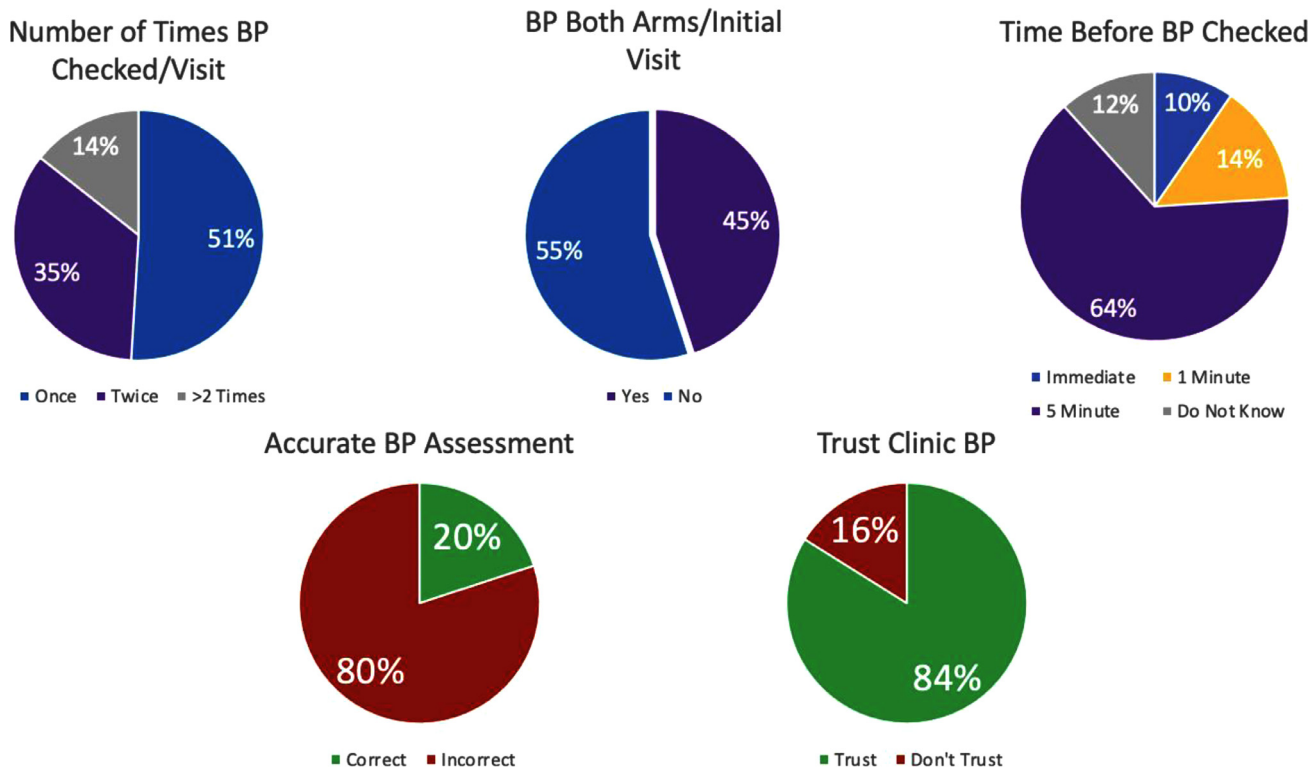


Fig. 1. Accuracy of blood pressure assessment.

Table 2  
Clinical blood pressure assessment.

		N = 571(%)
At the initial visit do you routinely check BP in both arms?	Yes	247 (45.0)
	No	314 (55.0)
How many times in a clinic visit do you check BP?	Once	291 (51.0)
	Twice	198 (34.7)
	More than 2X	82 (14.3)
How many minutes do you wait before the initial BP measurement?	Immediate/1 min	55 (9.6)
	5 Min	82 (14.4)
	Do Not Know	367 (64.3)
	Medical Assistant	67 (11.7)
Who Checks the Initial BP in Your Clinic?	Physician Assistant	264 (46.2)
	Nurse	7 (1.2)
	Nurse Practitioner	130 (22.8)
	Myself	17 (3.0)
	Other/Missing	148(25.9)
Do You Trust Your Clinic BP?	Yes	5 (0.9)
Do you check BP using an automated BP monitor?	No	479 (83.9)
	Yes	92 (16.1)
If you use an automated BP monitor, does anyone from your staff remain in the room?	Yes	348 (61.0)
	No	233 (39.0)
	Yes & No instructions About Talking	137 (24.0)
	Yes & Instructed to Not Talk to The Patient	165 (28.9)
When do you order a 24-hour ambulatory BP monitor in your practice?	No staff remains in the room	112 (19.6)
	I don't use an automated BP monitor	157 (27.5)
	To diagnose or rule out White Coat HTN	71 (12.4)
	To diagnose or rule out Masked HTN	18 (3.2)
	To confirm a diagnosis of HTN based on clinical assessment	35 (6.1)
	To diagnose or rule out either White Coat HTN or Masked HTN or confirm a diagnosis of HTN	298 (52.2)
	I don't use an ambulatory BP monitor	149 (26.1)
How often do you recommend Home BP monitoring?	In all patients with HTN	301 (52.7)
	In newly diagnosed HTN	36 (6.3)
	When blood pressure appears uncontrolled and new medications started	184 (32.2)
	I don't recommend home BP assessment	34 (6.0)
	Most of my patients cannot afford a home BP monitor	16 (2.8)

BP= Blood Pressure, HTN = Hypertension.

**Table 3**  
Confidence in blood pressure assessment.

ALL PARTICIPANTS	Trust BP N = 479	Do Not Trust BP N = 92	P-value
Routinely Check BP in Both Arms at Initial Visit	227 (47.4)	30 (32.6)	0.009
Initial BP assessed by:			0.002
Myself	136 (28.7)	12 (13.0)	
Other	338 (71.3)	80 (87.0)	
Manually repeat BP in clinic	276 (57.6)	56 (60.9)	0.56
How many times in a clinic visit do you check BP?			0.065
Once	240 (50.1)	51 (55.4)	
Twice	163 (34.0)	35 (38.0)	
Greater than Two Times	76 (15.9)	6 (6.5)	
How many times in a clinic visit do you check BP?			0.35
Once	240 (50.1)	41 (44.6)	
Twice or Greater	239 (49.9)		
Accurate Use of Automated BP Monitor (No Staff in Room)	96 (20.0)	16 (17.3)	0.56
Yes	383 (80.0)	76 (82.6)	
No			
Accuracy of BP Assessment	101 (21.1)	13 (14.1)	0.13
Accurate	378 (78.9)	79 (85.9)	
Inaccurate			
CARDIOLOGISTS ONLY	N = 290	N = 59	
Participants	255 (97.9)	47 (79.7)	0.090
Cardiologists	35 (12.1)	12 (20.3)	
Preventive Cardiologists			
Initial BP assessed by:	87 (30.2)	8 (13.6)	0.009
Myself	201 (69.8)	51 (86.4)	
Other			
Do You Manually repeat BP in clinic?	175 (60.3)	39 (66.1)	0.41
Yes	115 (39.7)	20 (33.9)	
No			
How many times in a clinic visit do you check BP?			0.33
Once	138 (47.6)	30 (50.8)	
Twice	112 (38.6)	25 (42.4)	
Greater than twice	40 (13.8)	4 (6.8)	
Use of Automated BP Monitor/No Staff in Room	58 (20.0)	7 (11.9)	0.14
Yes	232 (80.0)	52 (88.1)	
No			
Accuracy of BP Assessment	69 (23.8)	11 (18.9)	0.391
Accurate	221 (76.2)	48 (81.4)	
Inaccurate			

BP= Blood Pressure.

was also no difference in terms of the number of times that the BP was checked or use of an automated BP monitor, if that was used. (Table 3)

#### 2.4. Accuracy of bp measurement

Using the definition of accurate BP in this study, only 114 persons (20.0%) accurately measured BP, yet 479 (83.9%) trusted their BP assessments in their clinics (Fig. 1). Although accurate BP measurement was infrequently performed, it was more likely to be done accurately by preventive cardiology respondents, over other group (38.3% vs 18.3%;  $P < 0.001$ ) (Fig. 2), and this was true even when comparing preventive cardiologists to all cardiologists (38.3% vs. 20.5%;  $P = 0.007$ ). An accurate BP assessment was more likely when performed by the person being surveyed than any other person in the clinic. In those who performed the BP accurately, 79.8% performed a manual reading in their clinic compared with 52.7% in the group where BP assessment was inaccurate ( $P < 0.001$ ). Regardless of accuracy of BP measurement, there was no difference in the level of trust in their clinic BP readings which was high: 88.6% in those who performed BP accurately vs 82.7% who performed BP inaccurately ( $P = 0.13$ ). (Table 4)

#### 2.5. Importance of blood pressure assessment

There was almost universal agreement that accurate BP assessment was a skill that was essential for medical assistants, nurses and doctors; with >99% who agree or strongly agree on this and consider accurate BP

**Table 4**  
Accuracy of blood pressure measurement.

ALL PARTICIPANTS	Accurate BP Measurement N = 114	Inaccurate BP Measurement N = 457	P-value
Participants	18 (15.8)	29 (6.4)	0.001
Preventive Cardiologists	96 (84.2)	428 (93.7)	
All Others			
Initial BP assessed by:			
MA/PA/RN/NP	67 (58.8)	356 (77.9)	<0.0001
Myself	47 (41.2)	101 (22.1)	
Manually repeat BP in clinic	91 (79.8%)	241 (52.7%)	<0.0001
Trust Clinic's BP Measurement	101 (88.6%)	378 (82.7%)	0.13
CARDIOLOGISTS ONLY	N = 80	N = 269	
Participants	62 (20.5)	240 (79.5)	0.007
Cardiologists	18 (38.3)	29 (1.7)	
Preventive Cardiologists			
Initial BP assessed by:	45 (17.9)	207 (82.1)	<0.0001
MA/PA/RN/NP	35 (36.8)	60 (63.2)	
Myself			
Manually repeat BP in clinic	64 (80.0%)	150 (55.8%)	<0.0001

BP= Blood Pressure.

assessment as an important part of the physical exam. In terms of opinions regarding the need and frequency of practice of taking BP, there was wide variability: 14.5% responded that no practice of BP measurement skills were needed, 25.9% selected that skills needed practice every 2

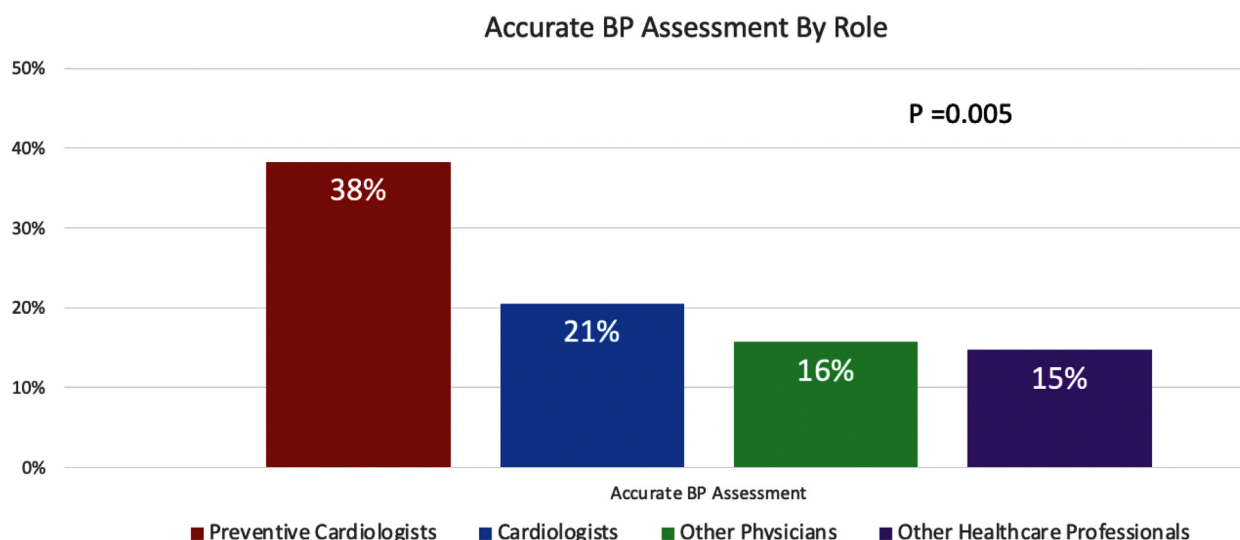


Fig. 2. Accurate blood pressure assessment by role.

weeks, while 31.9% selected every 6 months and 27.7% responded annual practice of skills was needed. (Fig. 3)

### 2.6. Knowledge of blood pressure equipment accuracy

The knowledge of those surveyed regarding the reliability of the equipment they use to measure BP was quite variable. Most reported that they know they are using an accurate BP monitor when it was validated against an accurate gage (42.0%), while 25.4% felt that they did not need to check their equipment and their facility provided reliable equipment. Further 22.8% responded they would measure the BP with another monitor and compare, 7.8% would measure the BP in the opposite arm to assess accuracy and 1.8% ask their colleagues to determine the accuracy of their BP monitor (Fig. 4).

## 3. Discussion

Our study demonstrates that the knowledge of blood pressure measurement skills remains deficient amongst all healthcare professions, with only 1 in 5 persons accurately assessing BP. Despite BP measurement being the most commonly performed procedure in the healthcare setting, there remains significant room for improvement. The assessment of BP provides essential information to aid in the diagnosis and monitoring of hypertension, with a timely response and appropriate treatment. Nonetheless, it is dependent on an accurate measurement and our findings demonstrate lack of awareness of the optimal assessment of BP.

The awareness of the effect of inaccurate BP measurement has been well-described but appears to remain unknown to many in clinical practice, as demonstrated in our survey. The effect of active listening when BP is assessed can increase the systolic BP by up to 10 mm Hg [7]. If a patient needs to urinate, the systolic BP can increase even higher than 10 mm Hg [8]. Crossed legs and lack of any back support can raise BP as well [9, 10]. Taking blood pressure over any clothing can create artifacts in BP assessment although alone does not raise blood pressure [11]. Nonetheless, rolling up sleeves has the potential to create a tourniquet effect that can raise BP up to 50 mm Hg [12]. Using a cuff that is too big or too small can lower or raise BP, respectively [13]. Lack of arm support, [14] or having the arm not at the level of the heart can also raise BP [15]. Additionally there are preferences for the terminal digit to end with zero, estimated to occur in 60–80% of readings which ultimately affects BP accuracy, [16] as well as treatment with antihypertensive medication, especially for women [17]. Reliance on a single

read, not measuring BP in both arms at the initial visit, and auscultation rather than automated BP readings can also reduce the accuracy of a clinical BP assessment. Inter-arm differences in systolic blood pressure >5 mmHg are associated with increased cardiovascular mortality for those with elevated cardiovascular disease (CVD) risk [18] as well as people free of pre-existing CVD [19]. Our definition of “accurate BP” was quite liberal and did not include all of these details that are important to accuracy. We assessed if: (1) BP was measured in both arms; (2) time before the initial BP was taken; and (3) the number of times BP was taken. With just these three measures of accuracy, we saw dismally low rates of accurate BP assessment.

While the reliance of BP measurement in the clinic setting continues to guide the diagnosis and management of hypertension, the use of automated BP monitoring is increasingly recommended by guidelines and adopted to reduce these potential sources of errors. Our findings reveal that despite the majority of respondents using automated devices (61%), only one BP measurement was preferred by most (51%) respondents, with a high level of trust in their measurement. In addition, our survey shows that there was great variability in knowledge regarding the reliability of the equipment they use to measure BP, with only 42% reporting the they know they are using an accurate BP monitor when it was validated against an accurate gage. Hence reliable BP measures require not only further training to improve knowledge and compliance with recommended procedures, but also understanding to the barriers for implementation as well as monitoring of assessment procedures [20].

Despite high rates of inaccurate BP assessment, almost all of those surveyed understand the importance of BP assessment and see it as a skill that is essential for medical assistants, nurses and physicians, as well as an essential part of the physical exam. Although only a small proportion of those surveyed felt that BP skills did not need to be practiced, it is clear that most medical professions may not receive proper initial instruction of BP measuring skills and may not receive any additional training or regular reassessment of their BP skills, [21] given the majority of respondents (84%) trusted their BP assessment in the clinic.

### 3.1. Strengths and limitations

Limitations of this study include use of self-reporting via electronic survey rather than skills assessment, although the findings are supported by previous reports of the known BP measurement challenges. Using electronic survey has many advantages such as being rapid and also allow control of order in which questions are answered to prevent respon-

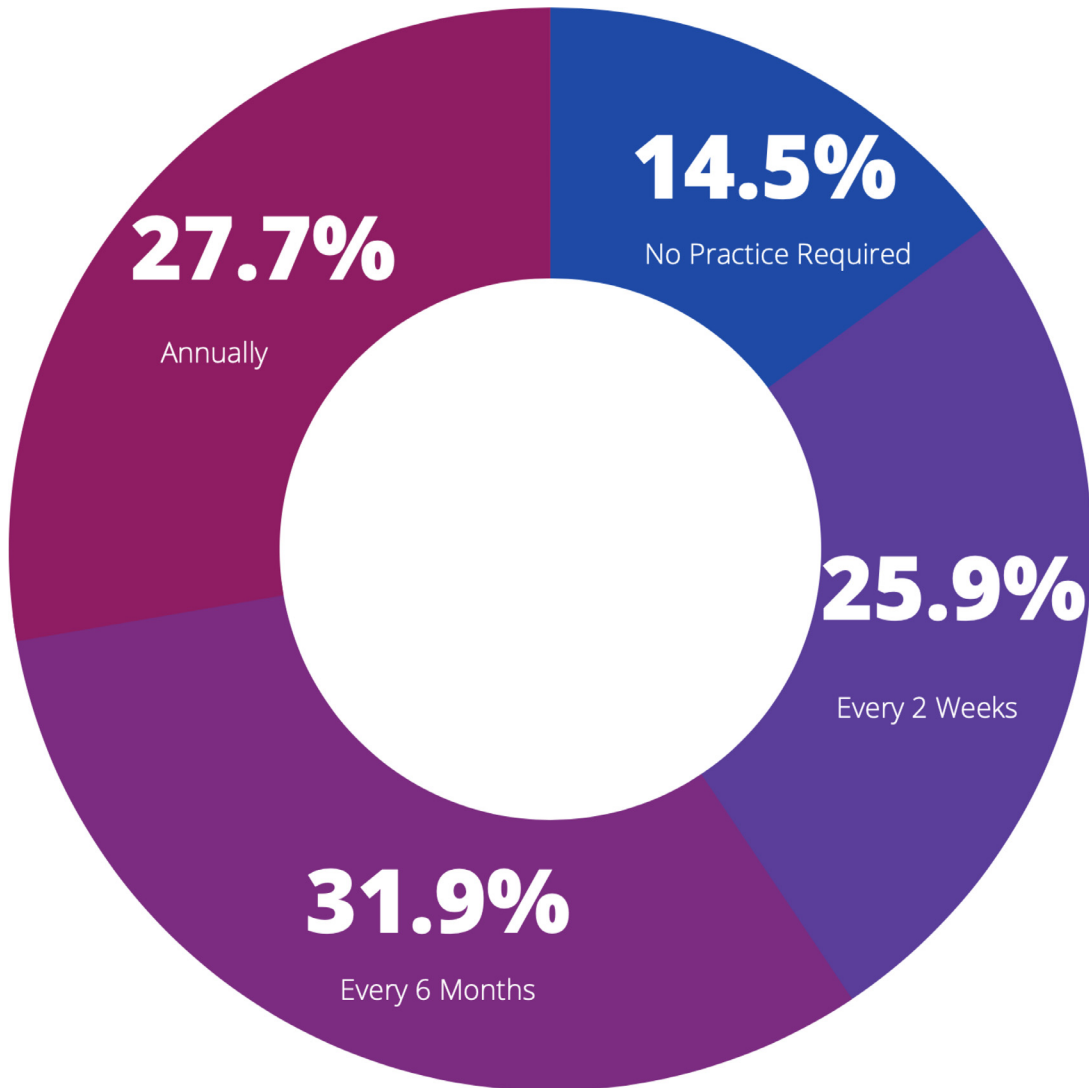


Fig. 3. Blood pressure skills  
How often should blood pressure skills be assessed?.

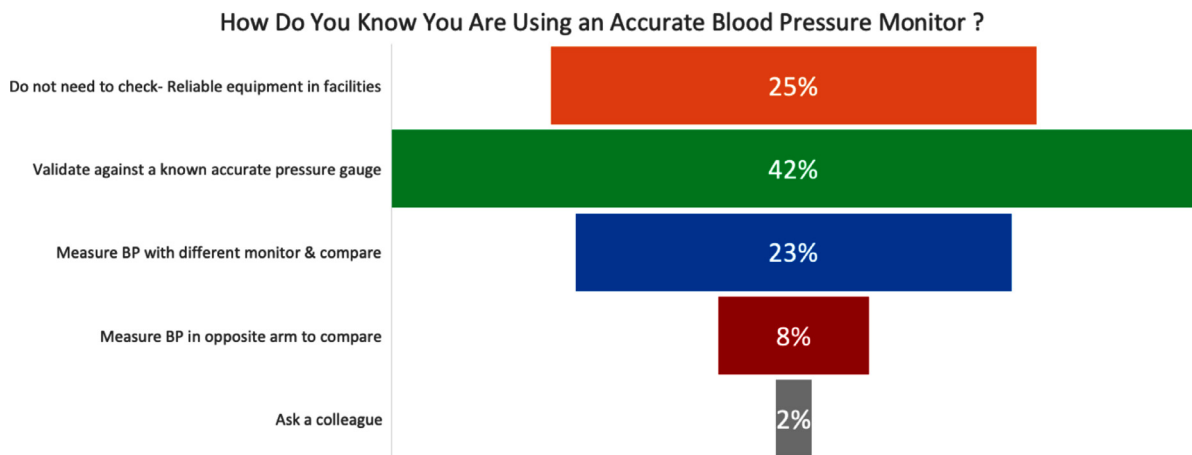


Fig. 4. Knowledge of accuracy of equipment.

dents returning to change answers [22]. Our findings provide further support for the awareness-to-adherence model used by Heneghan et al. [23], in which recommendations or practices may not be adopted despite awareness. Another limitation includes responder bias, since those who voluntarily completed the survey may be interested in hypertension assessment, in contrast with those that did not. This respondent bias would likely underestimate the true inaccuracy in BP assessment. Additionally, we did not collect data on gender of respondents or years in practice, that may influence BP measurement skills. We also did not identify whether respondents accessed the survey via their professional society or via social media. We were also unable to estimate the response rate and have no true denominator. Lastly, our definition of accurate BP assessment does not encompass all the variables that can affect the accuracy of BP measurement, but as noted, was a very liberal assessment of clinical skills. Even with this, it is apparent that BP assessment skills need refinement in clinical practice.

#### 4. Conclusion

The results of this study demonstrate that accurate BP assessment continues to remain suboptimal in clinical practice, including by cardiologists and preventive cardiologists. The potential impact on our patients is difficult to estimate but given the importance of the diagnosis and treatment of hypertension on reducing cardiovascular disease and kidney disease, the importance of these simple skills cannot be overstated. Reliability of BP assessment in clinic requires continued education, identifying the barriers to implementation of recommendations and engagement of the entire team to improve BP assessment, which will lead to improved cardiovascular outcomes for our patients.

#### Declaration of interests

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

#### CRedit authorship contribution statement

**Martha Gulati:** Conceptualization, Data curation, Formal analysis, Investigation, Methodology, Project administration, Resources, Software, Validation, Visualization, Writing – original draft. **Lori-Ann Peterson:** Data curation, Project administration, Writing – review & editing. **Anastasia Mihailidou:** Conceptualization, Investigation, Methodology, Supervision, Writing – review & editing.

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#### Supplementary materials

Supplementary material associated with this article can be found, in the online version, at [doi:10.1016/j.ajpc.2021.100280](https://doi.org/10.1016/j.ajpc.2021.100280).

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