Hypertension

REVIEW

Evidence-Based, Streamlined Approach to Measure Blood Pressure in Primary Care Settings

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ABSTRACT: The current guideline-recommended clinic blood pressure (BP) measurement procedure takes nearly 10 minutes to complete and may not be feasible to implement in busy clinical practice settings. Additionally, evidence supporting the steps in the current guideline-recommended procedure is of uneven quality. A streamlined, evidence-based approach to clinic BP measurement that still produces accurate and precise BP measurements may facilitate improved hypertension diagnosis and management. We summarized the latest evidence from studies that have quantified the impact of streamlining certain steps in the BP measurement procedure on BP measurement accuracy and precision. We translated this evidence into a practical, streamlined protocol for office BP measurement in usual primary care and potentially other settings. Studies have demonstrated it is possible to reduce the rest period before measurements from 5 to 0 minutes, and the interval between measurements from 60 to 30 seconds, without compromising accuracy. Additionally, analyses of studies with replicate BP measurements performed according to clinical practice guideline recommendations showed that repeating the initial screening measurement only when the first one is ≥130/80 mm Hg optimized accuracy and efficiency. Meanwhile, using the proper cuff size, arm support, and patient positioning are critical for BP measurement accuracy and recommendations for these steps remain unchanged from current guidelines. Broad implementation of a streamlined approach would result in more efficient BP measurement without compromising accuracy or precision, thereby increasing capacity to screen, diagnose, and manage hypertension.

Key Words: arm ■ blood pressure ■ blood pressure determination ■ classification ■ diagnostic techniques ■ overdiagnosis

Globally, ≈1.4 billion people have hypertension, defined as systolic blood pressure (BP) ≥140 mm Hg or diastolic BP ≥90 mm Hg, but only half are aware of their condition, and only 1 in 5 have their BP controlled.[1,2] Reasons for poor awareness of hypertension and BP control include the low rate of hypertension screening worldwide and suboptimal follow-up for confirmatory diagnostic visits and routine treatment.[2] Key to screening, diagnosis, and treatment efforts is accurate BP measurement. Inaccurate measurement, which can be related to nonadherence to recommended BP measurement protocols, contributes to both underdiagnosis, exacerbating the unmet need for hypertension treatment and BP control in some settings, and overdiagnosis, adding risk for medication-related harms without treatment benefit. This crucial initial step—accurate BP measurement—ensures that health care resources are optimally allocated to management of undiagnosed, untreated, or undertreated patients with hypertension.

Intrinsic physiological variability and systematic measurement error both contribute to imprecision in the estimation of BP. A unique BP is generated with each heartbeat and thus varies within individuals over seasons, days, hours, and even seconds.[3] This within-individual variability is 1 reason why clinical practice guidelines recommend that the average of BPs measured on 2 separate occasions (ie, visits) be the basis for diagnosis, rather than 1 measurement or even the average

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of multiple measures taken on the same day.[4] In addition, BP thresholds used in clinical practice guidelines to define hypertension are based on data from research studies which used standardized BP measurements, designed to account for intrinsic BP variability, and followed participants for clinical outcomes. Systematic BP measurement error may occur when there are errors in patient preparation, device, procedure, or observer-related factors, which can occur with nonadherence to BP measurement protocols.[5]

Time constraints, poor training, and suboptimal equipment (inadequate furniture, nonvalidated devices, lack of different cuff sizes) contribute to nonadherence to BP measurement protocols.[6,7] Inaccurate measurements can lead to wasted resources and time spent following individuals who may not have high BP and who may be prescribed inappropriate therapy. Much hypertension screening is performed opportunistically in busy, resource-constrained primary health care clinics when individuals present for nonpreventive care visits. Current guideline-recommended clinic BP measurement protocols for the diagnosis and treatment of hypertension take nearly 10 minutes to complete and may not be feasible to implement in these settings.[8–10] BP measurement protocols must, therefore, strike an acceptable balance between accuracy and efficiency to maximize reach, that is, to increase capacity to screen, diagnose, and manage hypertension in more patients with the same number of clinics and health care workers. Indeed, a 2023 international consensus statement suggested the BP measurement procedure should be pragmatic, efficient, staff- and patient-friendly and focused on steps in the BP measurement procedure that contribute to large measurement error.[11]

Out-of-office BP measurement, which is recommended to detect both white coat and masked hypertension,[10] has been proposed as 1-way to offload the burden of hypertension screening from primary care clinics. However, out-of-office BP measurement for this purpose is currently not practical in many resource-limited settings due to high cost, patient and health worker time commitments, limited access to validated and affordable home and ambulatory BP devices, the need for adequate patient education and training that is required for accurate home BP readings, and difficulty integrating out-of-office BP measurements into the electronic health record. For these reasons, and the fact that many out-of-office BP measurements are arranged based on an initial clinic measurement, clinic BP is likely to continue to play an important role in hypertension management.

The first objective of this review is to summarize the latest evidence evaluating streamlined approaches to BP measurement. The second objective of this review is to translate this evidence into a practical, streamlined protocol for BP measurement in screening settings, including usual primary care.

Clinic BP Measurement: the Current Standard and Supporting Evidence

Standardized approaches to BP measurement are used to obtain accurate and precise BP measurements.[12] There have been numerous reports describing recommended BP measurement procedures, which have been incorporated into clinical practice guidelines for the detection, evaluation, and treatment of hypertension.[10,12–20] Although there have been some updates to recommended BP measurement procedures over time, these have not kept pace with changes in the field of BP measurement and changes in health care delivery systems. For example, important contextual changes have occurred, such as the shift away from auscultatory BP measurement, in part due to concerns about the biohazard risk of mercury-containing BP devices, the position of wall-mounted devices, calibration, as well as human error introduced from manual features of auscultation, in favor of automated, oscillometric BP measurement. Additionally, the demand for BP measurement in primary care has increased due to inclusion of BP as a vital sign collected in almost all ambulatory clinic settings; increases in population size, particularly older-aged persons; changes in BP classification, leading to increased prevalence of hypertension; and the increasing prevalence of conditions associated with hypertension such as obesity, diabetes, and chronic kidney disease.[1,2,21] Further, there are substantial gaps in empirical evidence to support recommended steps in the BP measurement procedure.[5]

Current Recommendations for Office BP Measurement

Contemporary clinical practice guidelines and leading medical societies generally recommend ensuring the patient has an empty bladder and has rested for 3 to 5 minutes before initiating measurement; avoiding exercise, caffeine, and smoking in the 30 minutes before measurement; measuring BP in a quiet place free of distractions; properly positioning the patient to be seated with their feet on the floor, back supported, and arm resting on a desk with the mid-cuff at heart level; using a validated BP measurement device, with periodic maintenance checks; using an appropriate-sized cuff based on the patient's mid-arm circumference; placing the cuff on the patient's bare arm; performing >1 measurement separated by 1 to 2 minutes; and recording the patient's BPs.[16,20,22–28] Clinical practice guidelines recommend repeating BP measurements on ≥2 occasions to diagnose hypertension.

Patient Preparation

Several components of the current guideline-recommended clinic BP measurement procedure are based on limited evidence. A 2016 systematic review

identified only 2 prior studies that evaluated the impact of different rest periods on BP measurement accuracy in clinical settings.[5,29,30] Both studies were conducted only among patients with hypertension; 1 study, which used an automated device, compared a rest period of 5 minutes versus a rest period of 10 minutes, and the other study, which used a mercury device, compared no rest period versus a rest period of 16 minutes.[29,30]

Measurement Technique

Previous research on the impact of cuff size on BP measurement accuracy generally shows using a cuff that is too small overestimates BP, while using a cuff that is too large underestimates BP.[5,31–38] However, these studies had small sample sizes and assessed BP using mercury devices.[5,31–38] Additionally, previous research demonstrated that BP may be overestimated when the arm is unsupported or the mid-cuff is below heart level. However, these studies were limited by small sample sizes and lack of randomization of arm positions, raising concern about confounding due to order effects (ie, a systematic difference in BP based on the order of BP measurements).[39] In addition, some performed evaluations of patients in a supine or standing position, neither of which is one of the recommended positions for hypertension screening and management.[5,40–42] Only 1 clinic-based study examined the impact of back support by comparing measurements taken on an exam table and in a chair with back support, but did not account for other differences between procedures, such as whether the patient's feet were on the floor when seated on the exam table.[43] To our knowledge, no previous trials have examined the impact of ambient noise on BP measurement accuracy until a recent study, detailed below.[5]

Repeat Measurements

Clinical practice guidelines generally recommend obtaining 2 to 3 BP measurements at each encounter for the diagnosis and treatment of hypertension. Studies of repeated BP measurements show BP is often higher on the first reading as compared with subsequent readings, related to phenomena such as accommodation to the measurement and regression to the mean, and 1 prior study of National Health and Nutrition Examination Survey participants whose BP was measured in a mobile examination center demonstrated it may not be necessary to measure BP multiple times in all patients, particularly those with BP below the hypertensive range at the first measurement.[5,44]

Recommendations on the optimal time interval between measurements differ across guidelines and study protocols. Of the few studies that have compared different time intervals between repeat BP measurements, the intervals and number of measurements were also different, thereby limiting inferences related to time intervals.[5,8,45–47]

Updated Evidence and Innovative Approaches to Streamline BP Measurement

A streamlined BP measurement approach is needed in primary care settings, particularly clinics in low- and middle-income countries, to allow for optimal opportunistic screening for hypertension. Primary care clinics around the world are understaffed and increasingly rely on team-based care for hypertension screening and management. Survey data from 17 low- and middle-income countries revealed that the most common tasks completed by nonphysician team members included basic clinical tasks, such as counseling patients, refiling medications, taking medical history, and measuring BP.[48] Nurses and lay health workers can be trained to measure BP according to a standardized protocol, allowing the physician to focus on directing the hypertension care plan and potentially avoiding the white coat effect which can occur when BP is measured by a physician.[12,17,49,50] Streamlined BP measurement protocols may facilitate task sharing across the health care team.

Studies Supporting Streamlined Approaches to BP Measurement

Several recent studies provide evidence to support a streamlined BP measurement approach (Table 1). Two randomized trials have quantified the impact of the antecedent rest period on BP measurement accuracy. In the BestRest trial, resting for 2 minutes or less resulted in BP measurements that were noninferior (<2 mm Hg different) to measurements that were obtained after 5 minutes of rest for those with a systolic BP <140 mm Hg.[9] Although it was necessary to rest for the full 5 minutes for accuracy for those with systolic BP ≥140 mm Hg, these results suggest the majority of patients could be screened without antecedent rest.[9] In the Zero to Five Study, automated office BP (AOBP) readings with 0 minutes rest were closer to mean awake BP based on ambulatory BP measurement (ABPM) than AOBP readings with 5 minutes rest.[51]

Another clinic-based, quality improvement study examined the impact of shortening the interval between measurements from 60 to 30 seconds. In relation to mean awake ABPM, they found that a 30-second interval was as accurate and reliable as a 60-second interval.[8] A subsequent study examined the clinical implications of combining a shorter rest period and interval between measurements in the same protocol. Using AOBP measurement protocols with a rest period of 3 or 5 minutes and a 30- or 60-second interval between measurements (ie, 3/30/30, 3/60/60, 5/30/30, or 5/60/60), Lynn-Green et al[59] found the 3/30/30 and 5/60/60 protocols performed similarly.[59] There were no significant differences in mean SBP or DBP, or the proportion of patients classified as having systolic or diastolic hypertension using the 3/30/30 and 5/60/60 protocols as compared with mean awake ABPM.

Table 1. Summary of Evidence Evaluating Streamlined Approaches to BP Measurement for Hypertension Screening

Measurement Protocol Components	Guideline recommendations	Recommendation for streamlining	Data to support recommendation
Patient preparation	Allow the patient to rest for 3–5 min before initiating BP measurement	Rest period may be reduced or eliminated[9,51]	BP measurements obtained after resting for 0–2 min are < 2 mm Hg different from those obtained after 5 min rest for individuals with SBP <140
	Choose a quiet location	Some noise may not have a clinically meaningful impact on BP[52]	Systolic and diastolic BP measured in a loud public environment are <3 mm Hg different from those measured in a private, quiet office
Measurement technique	Use the correct cuff size such that the bladder encircles 75% to 100% of the arm	Using the correct cuff size is essential for BP measurement accuracy, as under- or overcuffing will under- or overestimate BP, respectively[39]	Using a cuff that is 1 or 2 sizes too small will lead to SBP readings that are almost 5 and 20 mm Hg overestimated, and DBP readings that are almost 2 and 7.5 mm Hg overestimated, respectively. A cuff that is 1 size too small will underestimate SBP by 3.6 and DBP by 1.3 mm Hg.
	Support the patient's arm (eg, resting on a desk) with the middle of the cuff at mid-heart level	Arm support is essential for BP measurement accuracy, as arm placement at the side or in the patient's lap overestimates BP[53,54]	Arms resting on the lap overestimate systolic and diastolic BP by 4 mm Hg and arms resting at the side overestimate SBP by 6.5 mm Hg and DBP by 4.4 mm Hg.
	Position the patient with their back supported and feet flat on the floor	Proper positioning is essential for BP measurement accuracy, as allowing the patient to sit on an exam table overestimates BP[55]	Sitting on an exam table overestimates SBP by 7.0 mm Hg and DBP by 4.5 mm Hg.
Repeat measurements	Take ≥2 measurements	It may not be necessary to repeat the BP measurement for patient's whose first BP reading is <130/80 mmHg[56–58]	Repeating the BP measurement only when the first is ≥130/80 mm Hg reduces the number of BP measurements by ≈50% with limited misclassification (2%–8%)
	Separate repeated measurements by 1–2 min	Reduce interval between measurements from 60–30 seconds[8,59]	A 30 s interval between measurements is as accurate and reliable as a 60 s interval compared with mean awake ABPM; there was also no difference compared with mean awake ABPM for clinic BP measured with 5 min rest and a 60-second interval between measurements or clinic BP measured with 3 min rest and a 30-second interval

BP indicates blood pressure.

The DECIBELs (Determining Change In Blood pressure due to Environment and Loudness) trial examined the impact of measuring BP in a quiet or loud and public or private setting. The study revealed no clinically meaningful difference in BP accuracy or precision obtained in a louder, public space when compared with the reference standard of measuring in a quieter, private office space.[52]

Studies Supporting a Reduced Number of Repeat BP Measurements

Investigations using large data sets containing replicate BP measurements performed according to clinical practice guideline recommendations allowed investigators to explore the relative accuracy and efficiency of BP measurement algorithms that reduce the number of repeat measurements when screening. Analyses of data from a US community-based cohort suggested that repeating the initial screening measurement only when the first 1 is ≥130/80 mm Hg optimized the tradeoff between efficiency and accuracy.[56] This approach led to the fewest number of measurements and had the lowest misclassification: <2% were incorrectly classified as hypertensive, and 8.1% were incorrectly classified as normotensive, with only 27.8% requiring a second BP measurement (versus 100% requiring 3 measurements per current guideline recommendations).[56] Hypertension identified based on the standard and simplified approaches was associated with a higher risk of incident cardiovascular disease.[56] When repeating these analyses in a multicountry data set that included data from Nepal and India, similar misclassification (up to 3.9% over-diagnosed as hypertensive, up to 8.1% under-diagnosed) resulted from this simplified approach.[57] An independent analysis based on a nationally representative household survey from India found that when the initial screening measurement was repeated only when the first 1 was ≥140/90 mm Hg reduced the average number of BP measurements per patient by half, estimated comparable hypertension prevalence (15.5% versus 14.9%), and achieved 85.4% sensitivity and 98.0% specificity for hypertension diagnosis when compared with the research standard.[58]

Studies Supporting the Current Approach to Measure BP

Not all BP measurement steps can be streamlined, as several recent trials have reinforced that some currently recommended practices are indispensable. Specifically, the Cuff(SZ) trial clearly demonstrated that an appropriate cuff size is essential to measurement accuracy.[39] Using 1 cuff for all patients could lead to substantial underestimation (up to 3.5 mm Hg for systolic BP) when the cuff is too large and overestimation (up to 19.5 mm Hg for systolic BP) when the cuff is too small.[39] Additionally, the ARMS (the Arm Rest and Support Study) trial found that allowing the patient's arm to rest in their lap or at their side, instead of on a support with

the middle of the cuff at mid-heart level, caused systolic BP/diastolic BP to be overestimated by 3.9/4.0 mm Hg and 6.5/4.4 mm Hg, respectively.[53] In the SIMPLE-AOBP (Simplifications of the Standardized BP Measurement Procedure and Accuracy) trial, which compared 4 sets of AOBP measurements in a randomized crossover design with mean awake ABPM, AOBP with the patient's arm unsupported overestimated systolic/diastolic BP by 7.7/7.2 mm Hg, respectively.[54] Another randomized crossover study examined the cumulative effect of having the patient's feet flat on the floor, back supported, and arm supported with the BP cuff at mid-heart level by comparing measurements taken in a chair with adjustable positioning options versus on a fixed-height exam table.[55] BP measurements taken on the exam table were 7.0/4.5 mm Hg higher than those taken in the chair.[55]

Taken together, recent high-quality studies support streamlining clinic BP measurement by reducing rest times, decreasing the interval time between replicate measurements, expanding the type of settings used for screening, and reducing the number of repeat measurements. The results from these contemporary studies can improve clinic efficiency without sacrificing measurement accuracy, thereby facilitating the diagnosis and treatment of hypertension in greater numbers of people. Importantly, these studies also highlight important components of the BP measurement procedure that should not be streamlined or simplified, including the selection of the appropriate cuff size and positioning the patient with their arm resting on a table and back supported, and feet on the floor.

Translation of Evidence on Streamlined BP Measurement Approaches Into Primary Care Workflow

Building on the latest evidence reviewed here, we propose a streamlined BP measurement protocol that is acceptably accurate while considerably increasing efficiency (Table 2). Components of the streamlined approach diverging from the standard approach are shown in bold and italics.

By reducing the initial rest period and only repeating the screening BP measurement when the initial BP is ≥130/80 mm Hg, the time to measure BP is considerably shorter as compared with current guideline-recommended procedures. For the majority of patients with no rest, who have an initial BP <130/80 mm Hg, the BP measurement procedure could be completed in ≈1 minute.[9] For those with an initial BP ≥130/80 mm Hg—individuals who would benefit from an initial rest period for maximal measurement accuracy—implementing a 3 to 5 minute rest period before a subsequent measurement would still keep the time to measure BP <5 minutes. Additionally, starting antihypertensive medicines in asymptomatic patients with systolic BP ≥160 mm Hg or diastolic BP ≥100 mm Hg at their first screening visit avoids excess BP measurement in patients who have a low probability of being categorized as normotensive. When a BP measurement protocol with a 5-minute rest period and 3 measurements obtained at a 1-minute interval is used, the BP measurement procedure takes 10 minutes to complete. Over the course of 8 hours, 48 patients could be screened using this protocol. Even when a more efficient protocol based on current guideline recommendations is used, for example, with a rest period of 3 minutes and 2 measurements at a 1-minute interval, the procedure would take 6 minutes, translating into 80 patients screened in an 8-hour period. In contrast, a streamlined approach that includes no rest period with a repeat measurement only among those whose initial measurement is ≥130/80 would dramatically increase screening capacity: if 30% of patients require a repeat measurement, 218 patients could be screened over 8 hours.

The proposed streamlined approach also emphasizes components of the BP measurement protocol that contribute substantially to BP measurement accuracy and must be retained from the current standard approach. Based on the Cuff(SZ) trial findings, it is imperative that a range of cuff sizes are readily available to fit different arm circumferences (ie, a range of cuff sizes should be stored in an accessible location).[39] Busy clinics can use tape measures that are tethered to the BP device and with simplified, color-coded indicators of relevant arm circumference ranges linked to the separate cuff size options. Based on the findings of the ARMS Trial, a desk or table should always be available to ensure proper arm positioning with the middle of the BP cuff at the level of the patient's heart.[53]

World Health Organization HEARTS hypertension control programs have enrolled > 34 million patients with hypertension into treatment across 38 low- and middle-income countries between 2018 and 2024.[60,61] Many of the World Health Organization HEARTS programs have demonstrated the feasibility of implementing streamlined BP measurement protocols in primary care facilities of low- and middle-income countries. For example, the National Heart Foundation of Bangladesh developed a streamlined hypertension screening protocol incorporating elements of the proposed streamlined BP measurement approach; this was integrated into a Non-Communicable Disease Control Program of the Directorate General of Health Services under the Ministry of Health & Family Welfare, World Health Organization HEARTS hypertension program (Figure S1). When nurses or other members of the health care team are empowered to measure BP and guide patients through the measurement protocol steps as part of team-based care, the primary health care providers are then free to concentrate their time on confirming a hypertension diagnosis and managing more complex hypertension cases.

Table 2. Current Versus Streamlined Approach to BP Measurement in Primary Care Settings

Screening step	Current approach	Streamlined approach
Before measurement	Instruct the patient to take 3–5 min of rest before obtaining BP measurement*	No rest period before obtaining BP measurement*
	Select upper arm BP cuff based on mid-upper arm circumference measurement†	Select upper arm BP cuff based on mid-upper arm circumference measurement†
	Position the patient in a standard position, with back supported, feet on the ground, and BP cuff at the level of the heart	Position the patient in a standard position, with back supported, feet on the ground, and BP cuff at the level of the heart
First measurement	All patients: start by taking a single measurement	All patients: start by taking a single measurement
	Record exactly the number displayed on the BP monitor, without rounding or adjusting	Record exactly the number displayed on the BP monitor, without rounding or adjusting
Second measurement	Measure a second BP in all patients using a 1–2-minute interval after cuff deflation	If first SBP <130 and DBP <80 mm Hg, stop here; no second measurement is needed
		Only if first SBP ≥130 or DBP ≥80 mmHg,‡ instruct the patient to take 3–5 min of rest before obtaining another BP measurement. Use the second measurement for decision making

BP indicates blood pressure; DBP, diastolic BP; and SBP, systolic BP.

*Ensure the patient has emptied their bladder and avoided exercise, caffeine, and smoking in the 30 min before measurement. Note patients may benefit from some time to achieve a rested or calm state if the arrival to their visit involved excess activity or stress.

†Circumference ranges for indicated BP cuffs are labeled on the cuffs packaged with most BP measurement devices.

‡The BP threshold to determine whether the measurement is repeated may vary by setting according to the definition of hypertension and BP treatment goals in clinical practice guidelines.

DISCUSSION

The approach to clinic BP measurement recommended by contemporary clinical practice guidelines relies on a limited evidence base and is not likely to be implemented with fidelity for all patients evaluated in today's busy, resource-constrained clinical settings. Recent evidence supports updating these recommendations with a streamlined, patient-centred BP measurement approach that reduces patient rest time and avoids excess BP measurements. In addition to reducing patient burden, the streamlined approach may promote more efficient allocation of health care resources that are increasingly scarce, including human resources (ie, health worker time for measurement, medical decision making, and documentation) and system resources (ie, utilization of clinic appointments, equipment, and space). Overall, streamlined BP measurement increases measurement capacity, which can translate into expanded screening coverage in the population and increased hypertension awareness. At the same time, recent research findings support an emphasis on adhering to aspects of the current approach, specifically individualized BP cuff size selection, arm support and patient positioning.

Typical primary care clinics lack the time, quiet office space, and health worker capacity to support current guideline-recommended BP measurement protocols for all health care encounters.[62,63] Further, the current approach to BP measurement that relies on averaging multiple measurements may not be practical in the field and is prone to error if the device used does not automatically calculate it, limiting opportunities for opportunistic screening. However, it is important that medical records have fields for multiple measurements to understand whether additional measurements are taken when appropriate. Additionally, the ability to program a BP device to perform a second reading if the initial value is above a desired threshold could facilitate implementation of the streamlined protocol. This staged approach to BP screening has already been implemented in several settings, including Bangladesh. In the United States, the Measure Accurately, Act Rapidly, Partner with Patients quality improvement framework developed by the United States American Medical Association uses only 1 measurement in people with initial BP below a set threshold.[28,64]

Another example of a streamlined BP measurement protocol that has been implemented and evaluated is from Project Reducing Disparities and Controlling Hypertension in Primary Care. In the intervention arm of the study, which included a quality improvement program to standardize BP measurements, the BP measurement protocol included a 3-minute delay (rest) between activation of the BP device and cuff inflation, with triplicate measurements taken at 30-second intervals.[65] Implementation of the BP measurement bundle, which included staff training, automated BP devices, and a redesigned clinic workflow, was associated with reduced terminal digit preference, an indicator of BP measurement quality, and less rechecking of BP measurements by primary care providers, which may indicate greater confidence in the measurements and also increases efficiency.[65]

Even when implementing a streamlined BP measurement protocol, primary care facilities must ensure the availability of proper equipment (validated, digital, oscillometric devices, preferably with the capacity to automatically upload results to the health information

system), adequate space and infrastructure (including reliable electric power), adequate health worker staffing and training (including training of nonphysician team-members on how to measure BP and enter BP data), and a robust health information system for recording and tracking BP. Recent research emphasizes that standard BP equipment, even in resource-constrained settings, must include a variety of cuff sizes and that good technique, including use of the proper cuff size, arm support, and patient positioning, remains fundamental.

Technological and health care services innovations may lead to further improvements to BP measurements, serving as hypertension screening in various settings. New BP measurement technologies, such as bluetooth-enabled auto-upload devices, which additionally minimize the potential for recording errors, and improved communications and digital information systems, may become more accessible and affordable, thereby facilitating more patient-centered community- or home-based BP measurement in resource-constrained settings.[66,67] Additionally, innovations in service delivery to measure BP for hypertension screening in community-based settings, for example, could expand the reach of hypertension programs.[68]

Despite the new BP measurement studies reviewed here, further research is needed to empirically evaluate the streamlined approach and identify further opportunities to improve and simplify BP measurement and hypertension screening. First, several of the new studies cited were the first of their kind; replication of findings in additional patients and varied settings (including additional nonresearch settings) would be desirable. Second, other aspects of BP measurement should be critically evaluated.[5] For example, while a 2020 meta-analysis examining the impact of measuring BP with the cuff placed over clothing found small, nonsignificant differences as compared with BP measured on a bare arm, most studies had a high risk of bias.[69] A recent pilot randomized crossover trial did not find significant differences between BP measured over a sweater sleeve and mean awake ABPM.[54] Additional research could inform the impact of measuring BP over clothing. Third, streamlined BP measurement protocols should be field-tested in primary care settings, particularly in low- and middle-income countries, assessing adoption, fidelity to the protocol, and acceptability to patients, health workers, and facility managers. Fourth, there is a need to identify optimal training and re-training modalities and frequency for staff who measure BP.[12,70] Although not explicitly addressed in this review, health care providers should screen for hypertension periodically (eg, annually), regardless of the initial BP measurement value, as recommended by clinical practice guidelines.[22] Such a temporal checkup is critical, given the intrinsic variability and age-related increase in BP observed in many studies.[3,71] Finally, it is important to understand that while streamlined and current guideline-recommended BP measurement protocols may yield comparable BP values in the population, there may be within-individual differences in BP values.[72]

In conclusion, adoption and broad implementation of a streamlined, but still rigorous, approach to BP measurement that does not compromise accuracy will result in more efficient hypertension care.

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