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Human Errors in Automated Office Blood Pressure Measurement

Merrill F. Elias

Amanda L. Goodell

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REVIEW

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Still Room for Improvement

Merrill F. Elias, Amanda L. Goodell

ABSTRACT: In this review of the literature and commentary, we examine the literature on automated blood pressure (BP) measurements in the office and clinic. Our purpose is to revisit issues as to the pros and cons of automated BP measurement published in *Hypertension* in June 2020 and to identify areas needing additional research. Despite initial reservations about automated BP, it is here to stay. A number of experts suggest that human error will be reduced when we move from the more complex skills required by aneroid sphygmomanometer measurement to the fewer skills and steps required by automated BP measurement. Our review indicates there is still need for reduction in errors in automated BP assessment, for example, retraining programs and monitoring of assessment procedures. We need more research on the following questions: (1) which classes of health care providers are least likely to measure BP accurately, usually by ignoring necessary steps; (2) how accurate is BP assessment by affiliated health care providers for example the dental office, the optometrist; and (3) why do some dedicated and well-informed health care professionals fail to follow simple directions for automated BP measurement? We offer additional solutions for improving automated BP assessment in the office and clinic.

Key Words: accuracy ■ blood pressure ■ hypertension ■ screening ■ sphygmomanometer

Our first goal in this review and commentary was to provide an updated literature review of the pro and con debate on automated blood pressure measurement published in the October 20, 2019 issue of *Hypertension*.[1,2] In the short time since this landmark article has been published, there have been additional articles that speak to the specific points made by the authors of the pro and con opinions.

Our reading of this debate, and the articles that followed, convinced us that the accuracy of blood pressure (BP) measurement in the office and clinic was an important topic for further review and discussion. Thus, our second goal was to review the literature pertaining to human errors in BP measurement in the office and clinic setting. Data Supplement 1 summarizes the procedures employed to conduct the review.

Inaccuracy in office and clinic BP assessment can be defined as the deviation from what is considered a BP value obtained gold standard measurement procedure (eg, invasive direct measurement at the aorta), deviation from BP values obtained by an expert at BP assessment, or deviation from the patient's typical day-time BP. We agree with these definitions, but we focus primarily on inaccuracy in BP measurement resulting from human errors in following the prescribed and approved procedures for BP assessment.

Based on our observation that measurement error is still present despite the use of automated devices, our third goal was to review existing practices and advance new suggestions for improving BP measurement by health care professionals.

Myers et al[3–5] published extensive reviews of the history of automated BP measurement, including its advantages with regard to improving the diagnostic process and reducing errors in measurement. Automated office BP measurement (AOBPM) was defined as follows:

Correspondence to: Merrill F. Elias, Department of Psychology, University of Maine. 5742 Little Hall Orono, ME, 04469. Email mfelias@maine.edu

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Nonstandard Abbreviation and Acronyms

AOBPM	automated office BP measurement
BP	blood pressure
SPRINT	Systolic Blood Pressure Intervention Trial
STRIDE	Science and Technology for Regional Innovation and Development in Europe

measurement with a fully automated device in the office by physicians, nurses, and other trained medical personnel (office medical staff); measurement with an automated device by the patient in a quiet room separate from office staff. Our review is constrained to the first part of the definition, measurement with a fully automated device in the office by physicians, nurses, and other trained medical personnel (office medical staff), for 2 reasons: (1) we wish to focus on the direct interaction between physicians, nurses, and other medical staff with the patient; and (2) the literature on patient self-measurement is too extensive to deal with in a single review. Consequently, this review does not include office measurement by the patient in a quiet room, 24-hour ambulatory BP measurement, nor does it include white coat hypertension. These are important topics but go beyond our focus on AOBPM in the clinic. Articles by Myers and et al,[3–5] among others, provide comprehensive reviews of these topics. The pro and con arguments for AOBPM in all contexts, provides an important historic context for our comments and further review of AOBPM as we more narrowly define it. In summary, we are using AOBPM as an abbreviation of automated office blood pressure measurement (an acronym). We are simply abbreviating automated office blood pressure measurement and making it clear that AOBPM in this article is not synonymous with AOBPM as defined by Myers et al, but simply as a generic abbreviation for AOBPM.

HISTORIC OVERVIEW: THE PROS AND CONS OF AUTOMATED BP MEASUREMENT

In October 2019, *Hypertension* published 2 articles presenting pro[1] and con[2] positions on the implementing of AOBPM in medical practice. At this time, AOBPM was gaining popularity. For example, the fully automated oscillometric sphygmomanometer was used in the SPRINT (Systolic Blood Pressure Intervention Trial),[6–8] and AOBPM for BP assessment in Candida[9] was accepted.

The Pro Side by Jones

In general, positive features of automated BP assessment include its use for BP measurement at home, thus avoiding higher BP values related to white coat hypertension and also allowing the time needed for multiple BP assessments on one occasion and multiple assessments at multiple occasions.[1]

Jones[1] raised an important question: why do we give so much attention to accuracy of BP measurement when we spend considerably less time discussing accuracy in the measurement of other risk factors such as cholesterol values or fasting glucose? He offers 2 reasons: (1) there are moment-to-moment variations in BP, that is, it is fluid; and (2) BP is measured indirectly. These observations are of fundamental importance because it is absolutely essential, given fluidity of BP, to sample several BP measurements on one occasion and, ideally, on 2 successive days, before the diagnosis of hypertension.[10–12] We note that this goal can be achieved in the office and clinic, but it may be more easily achieved with automated BP assessment at home if the patient is properly educated in measurement methods and invests the time and effort to take these measurements.

We agree with Jones[1] that ease of obtaining BP measurement with automated devices, as compared with manual aneroid sphygmomanometer measurement, is a compelling reason for encouraging AOBPM. BP measurement with the aneroid sphygmomanometer involves sequential sets of activities and decisions that require human judgment, motor and perceptual skills, including keen hearing. Thus, AOBPM is less demanding on human skills than measurement with the aneroid sphygmomanometer. However, we note that AOBPM does not exempt the examiner from demands on attention, knowledge, ability to follow proper directions, and the proper execution of sequential activities. Consequently, human error has not been entirely removed from the measurement process by the adoption of AOBPM devices.

The Con Side of the AOBPM by Zhang

Zhang et al[2] do not object to AOBPM. Rather, they raise a fundamental concern that the prognostic accuracy of AOBPM (as compared to manual BP measurement) has not been established. We concur, but note that there have been several studies indicating that automated BP assessment in the home and the office predicts intermediate measures of target organ damage, for example, an index of global target organ damage including retinal and renal parameters,[13] left ventricular hypertrophy and carotid intima-medial thickness.[14–17] In the study by Myers et al[16] with 3627 community dwelling residents (>65 years of age), 10 mm Hg increments in systolic and diastolic BP (defined by AOBPM) were associated with increased risk of nonfatal or fatal cardiovascular events over a follow-up period of 4.9 years for subjects free from antihypertensive drugs at baseline. The number of studies of AOBPM in relation to cardiovascular outcomes may be expected to continue to grow, and it is a

matter of time until we have additional data with bearing on the prognostic value of AOBPM.

A second concern by Zhang et al[2] is the potential increased time and office space required by the need to obtain multiple AOPBM. In agreement with Vongpatanasin,[18] we argue that multiple BP measurements are essential to capture the variability described by Jones and to adequately diagnose hypertension. Among others, Figueiredo et al[19] has recommended that BP measurements be taken on at least 2 office visits in clinical practice and 2 separate occasions in research. The very basic importance of accurate BP measurement in patient care dictates that we take the time to measure it correctly.

A third concern by Zhang et al[2] is the frequent use of inadequately calibrated automated BP devices. This concern is strongly supported by the literature.[17] However, the problem is not unique to AOBPM. Cohen et al[20] have traced the evolution of BP measurement devices from what they describe as the very accurate mercury sphygmomanometer that is no longer in use due to concerns about mercury exposure. They note that the aneroid sphygmomanometer loses calibration just as do AOBPM devices. They provide an overview of the procedures for device calibration and sources for identifying valid devices.

Calibration is clearly an important aspect of accuracy of BP assessment. Ogedegbe and Pickering[21] describe United States, British, and European associations engaged in BP device validation and improved BP measurement. An international group[22] of experts in BP measurement has created a nonprofit organization, STRIDE (Science and Technology for Regional Innovation and Development in Europe), to further the effort of lowering BP worldwide through the correct diagnosis and management of hypertension (https://stridebp.org/index.php). Even well-calibrated devices may be used incorrectly if measurement is not conducted properly by the user (human error).

Stergiou et al,[23] on behalf of the Association for the Advancement of Medical Instrumentation (The European Society of Hypertension) provide a comprehensive history of the efforts to obtain standardization and validation of BP measuring devices. They list the many associations involved in the task of standardization and validation. These investigators conclude that this organization will provide universal standards for validation of BP measuring devices.[23]

Failure to calibrate one's BP measuring device or being unaware of the need to calibrate is among the errors in human BP measurement. The wrist-cuff device has been a special concern with regard to validation. Questions have been raised as to its accuracy[21,24–28] and solutions suggested for improving accuracy, including arm-heart positioning sensors, have been advanced.[24] In summary, the consensus of opinion from the literature is that, for patients without physical disabilities or with circumstances preventing its use, the arm-cuff is to be preferred in the clinic and for opportunistic screening.

AOBP RELATED TO SPECIFIC PATIENT NEEDS

Use of the wrong device is a human error in BP monitoring. Melville et al[29] have discussed the fact that the wrist-cuff device may cause discomfort in patients who are fragile or obese or for various reasons cannot obtain the correct posture necessary for measurement with the arm-cuff. Moreover, there is a literature indicating that automated BP monitoring is inaccurate in patients with atrial fibrillation because of the high variability of heart rate and stroke volume.[30] Pagonas et al,[30] employing intraarterial BP measurement, reported that atrial fibrillation slightly increased the intraindividual variability of oscillometric measurement; however, this phenomenon did not impair the accuracy of oscillatory devices after 3 consecutive measurements. Following a review and meta-analysis of this literature, Stergiou et al[31] concluded the AOBPM monitors are accurate in measuring systolic BP but not diastolic BP in patients with atrial fibrillation.

Human Error in BP Assessment: A Fundamental Problem

Errors in AOBPM follow in the wake of concern for errors associated with manual BP assessment. One of the most recent manuals dealing with the proper measurement of BP includes a section on AOBPM[32] and the American Heart Association has published an advisory piece on how to measure BP with the AOBPM device.[33,34] Thus, concerns about automated BP assessment are essentially concerns about BP measurement in the office and clinic in general, including manual BP measurement. Vongpatanasin[18] characterizes current BP measurement practices in general as sloppy and attributes this phenomenon to bad habits learned early in medical training. Vongpatanasin's[18] opinion was based on a now classic article by Rakotz et al,[35] in which these investigators describe their study on a simulated patient encounter for BP assessment. Rakotz et al[35] sampled BP measurement skills in 159 first-to fourth-year medical students attending a meeting of the American Medical Association. Only one of the 159 students met all of 11 criteria for the proper measurement of BP. The mean number of skills performed properly out of the 11 examined was 4.1. Importantly, Rakotz et al[35] reported their unrelenting efforts to teach the proper methods of manual BP measurement in medical school, and his concern that good techniques were often replaced by bad techniques learned from practicing physicians, as well as internship and practicum experiences. We note that in many countries practical training in medicine begins earlier than in

the United States, thus allowing more time for good and bad habits to be learned and reinforced.

The failure to adhere to proper BP measurement protocol is well documented in research by Woolsey et al.[36] These investigators examined hypertension diagnosis practices in Utah primary health clinics using United States Preventive Task Force recommendations for the accurate diagnosis of hypertension. They employed a survey sent by internet to 321 primary care clinics. Thirty-eight percent of the clinics completed the questionnaires. Estimated adherence to the recommendation for proper BP measurement methods ranged from 57.5% to 93.5%. Percentages of accuracy for each BP measurement technique are shown in Table 1. The overall recommendation was that BP measurement could be improved by the use of automated devices.

Does AOBPM Eliminate Errors?

Myers'[37] work indicates that AOBPM performed properly reduces errors in measurement compared with manual BP assessment. This finding makes good logical sense because more skill and sensory and psychomotor abilities are needed for proper measurement with the manual aneroid sphygmomanometer. In a comprehensive meta-analysis, Roerecke et al[38] found that AOBPM was more accurate than other methods of BP assessment typically employed in the office and recommend that AOBPM be the preferred method of measuring BP in clinical practice. We do not disagree with this conclusion. Our argument, based on our review of the literature that follows, is that AOBPM has not entirely eliminated measurement error.

Table 2 lists the most common mistakes made with AOBPM devices as described in a study by Hwang et al.[39] The authors employed data from 54 unique patient encounters at 6 adult primary care centers located in and around Houston, Texas.[39] All revealed common errors.[32] The Hwang et al[39] study involved an important feature: the investigators asked health care providers why they reported (self-report) failure to follow instructions. We paraphrase and summarize the major responses to the questionnaires in Table 3. It is clear that a number of these issues relate to work loads, time constraints, and the right equipment being available at the right time.

Table 1. Accuracy of BP Measurement Techniques Used in Study by Woolsey[36]

Technique	% Performed correctly
Written policy for training patients to self-measure BP	27.7
Instructions for ABPM available	36
Training time provided	48.8
Rest period of 5 min before measurement	57.7
2 or more BPs taken per patient	58.5
Patient's arm at heart level	84.6

ABPM indicates automated office blood pressure measurement; and BP, blood pressure.

Table 2. Most Frequent BP Assessment Errors in 6 Clinics[39]

Error	Description
Feet	Both feet were not planted firmly on the floor.
No rest given	Patient did not rest 5 min before measurements.
Posture	Patient did not sit upright with back supported.
Talking	Patient talked during BP readings.
Arm	Patient's arm was not elevated nor palm lying face up.
Cuff location	Cuff was not placed directly on the skin when taking BP.
Only one reading	Only obtaining one reading, although the original reading was above 140/90 mm Hg (older BP diagnostic criteria used).
Movement	Patient was moving during BP reading.
Cuff size	Incorrect cuff size as determined by cuff markers.

BP indicates blood pressure.

Who Makes Errors in BP Assessment?

If we could identify classes of health care professionals who are more likely to err in AOBPM, we would have a step up in designing remedies. For example, do we focus on physicians and nurses or other medical specialists who are called into service for BP assessment? Our review of this potential literature revealed more opinion by experts than actual data.

There is indirect evidence relative to nurses and physicians and other medical specialists which must be viewed with caution but may be helpful in hypothesis generation. Nurses obtain lower BP values than doctors in general, regardless of the measurement procedure.[40,41] This phenomenon is often attributed to less white coat reactivity to the nurse, but could also be related to factors such as taking more time to do it correctly and better educational programs for nurses.[42] At least one study indicates that BP values obtained by nurses are better predictors of hypertension-related target damage[41]; thus providing indirect support for the hypothesis that nurses are measuring BP more accurately than physicians. Nursing associations are acutely aware of the errors in measurement made by nurses, and a number of studies of educational interventions have been successful in reducing error in measurement.[43]

It is clear that persons at the highest professional levels, physicians, and nurses, err in BP assessment. It is estimated that up to 27 of 29 potential sources of error in BP have been identified in the measurement of BP by trained clinicians,[44] but these studies do not further classify trained clinicians by job specialty. We very much need more data on this topic. This may be a difficult task because there are many classifications of nurses and physicians in terms of education and job responsibilities.

Table 3. Seven of the Most Common Reasons for Deviation From BP Measurement Criteria[39]

Reason	Description
Lack of training	After starting in the clinic there were no consistent processes for proficiency checks and training.
Time 1	Challenge of working in a realistic, chaotic environment related to lack of time due to multitasking.
Time 2	Perceived lack of time to allow 5 minutes of rest.
Time 3	Necessity of dealing with patient behaviors inconsistent with measurement, for example, patient is talking.
Absence of equipment	Absence of equipment in the right place at the right time, for example, chairs and rolling stands allowing proper support of the arm when available.
Poor environment	Poor quality of the environment at the clinic site, for example, noise and crowding.
Unique patient issues	Difficulty measuring BP in patients in wheelchairs and on stretchers.

BP indicates blood pressure.

OPPORTUNISTIC SCREENING OUTSIDE OF THE MEDICAL CLINIC

Hot Spots for Inaccurate Measurement

The emphasis on opportunistic screening for hypertension has created a class of BP examiners employed in health affiliated practices, for example, dentists, optometrists, ophthalmologists, and podiatrists. Elias and Goodell[45] argue that it is very possible that measurement with AOBPM devices is done less well in these contexts, but emphasize that more data are needed to confirm this hypothesis. There is much in the way of anecdotal data from patients suggesting that issues such as lack of awareness of directions, use of a wrist-cuff device and ignoring of posture, including legs crossed and feet off the floor (eg, measurement in the dental chair) are recurring issues. We very much need data to confirm these reports of poor measurement practices.

Cost of Poor Measurement to the Patient

With the lowering of systolic and diastolic BP values (mm Hg) for the diagnosis of hypertension[11] and the use of AOBPM in clinical trials,[8,32,46] the demand for accuracy in BP assessment has increased, albeit has always been important to the patient. Woolsey et al[36] point out that a false positive diagnosis of hypertension exposes the patient to unnecessary costs of medication, side effects from medication administered unnecessarily or prematurely, and adverse psychological effects of being diagnosed as hypertensive. These adverse psychological phenomena related to being labeled as hypertensive include anxiety, depression, and adopting a sick role.[47,48] Clearly the person with hypertension has to be informed and treated, but it is important to get it right on the diagnosis and that information needs to be conveyed in a manner that avoids unnecessary stress to the patient.[49]

Elias and Goodell[45] argue that a false diagnosis of hypertension can precipitate further false diagnoses if the patient becomes sensitized to the BP assessment procedure. They describe a scenario in which the patient, via classical conditioning (an elementary form of learning), may develop a learned BP elevation, so that one sees a higher than normal BP in the presence of the cuff, the examiner, and the examining room. Regrettably, we could find no studies on the proportion of patients who consult their physicians with the suspicion that they have been given a false diagnosis of hypertension or how many health affiliates doing screening actually follow-up with the patient or the patient's physician.

FROM LAMENT TO ACTION

Despite its promise, measurement of BP with the AOBPM devices does not seem to yet live up to its potential for better measurement. Initial training appears to be offset by the learning of poor BP measurement practices on the job. We see a literature characterized by years of lamenting poor BP measurement practices, including traditional measurement with the manual aneroid sphygmomanometer, but little evidence of success in remediation of the issues. Thus, in the following section, we recommend several approaches to alleviate this problem.

BUNDLING (MULTI-MODAL APPROACHES)

One promising response to the recognition of poor BP measuring practices is referred to as bundling. Boonyasai et al[50] uses it to describe programs that use AOBPM in the context of a redesign of the office workflow by using human factors and ergonomics principles. The approach can be applied to the health care practitioners' reasons for not measuring BP accurately as discussed earlier in this article, that is, not enough time, unsuitable equipment, multitasking, etc. Rather than attempt to address these issues separately, bundling approaches them all in a systematic way and is sometimes referred to as a multidimensional approach.

Umscheid and Townsend[51] have reviewed the literature indicating that bundling has been employed successfully in the treatment of infections, and they argue that it could be used to elicit better BP assessment with automated devices.

The study of bundling by Boonyasai et al[50] provides an illustration of the application of the bundling approach to the assessment of BP. The study was designed to improve BP measurement at 6 primary care centers over a 6-month period. It was conducted as part of Project Reducing Disparities and Controlling

Hypertension in Primary Care at Johns Hopkins Hospital. The study sample was representative of racial and economic diversity. The components of the program are shown in Table 4. Adherence to correct BP assessment protocol was evaluated by unannounced audits and electronic medical records.

Overall adherence (percent of staff adhering) to the proper BP protocol at the 6 sites was 71.6%, varying from 84.6% at the best site to 19.6% at the least adherent site, with a median of 74.4%. The investigative team described the response to the program as robust, but imperfect.

Unannounced audits indicated that 5 of the 6 clinics used the automated devices and followed the rules at least 75% of the time. The need to repeat measurements by primary care personnel who received the reports decreased by 15.5% by the end of the program.

The investigators did not provide estimates as to the total cost of the bundling program. The costs of the devices (Omron HEM-907XL) used in the program can be estimated at a minimum of $530 per each from the cost data provided. This amount did not include the cost of multiple machines, follow-up training or support for the clinics involved.

The study team reached 3 major conclusions: (1) bundling improves BP assessment in the real world clinic setting; (2) improvement in the workflow was a critical intervention; and (3) isolated interventions are likely to have little value in the clinic setting.

Table 4. Components of the ReDCHiP Improvement in BP Measurement Program[50]

General component	Specific points
How to use the BP device Omron HEM-907XL	Mounted; baskets with cuffs of different sizes and rolling stands easily available
	Programmed; for timed rest period and to obtain 3 consecutive measurements from the patient
	Role-specific training was included for PCPs and CMAs. Proper BP measurement technique was demonstrated and stressed.
BP measurement protocol	Seat in chair with back support
	Proper cuff size and placement
	Patient's arm is supported at heart level
	Patient's feet are supported by the floor or a step stool
	Patient's legs are not crossed
	Patient rests quietly for the duration of all 3 measurements
	Three consecutive measures obtained
Follow-up	Weekly follow-up with clinic staff
	Discuss barriers in implementing the program
	Facilitate finding solutions to barriers
	Discussion of solutions at other clinics. Data used from all 6 clinics involved in the program

BP indicates blood pressure; and ReDCHiP, Reducing Disparities and Controlling Hypertension in Primary Care.

Bundling is a logical and arguably successful approach to improving BP assessment. Below, we suggest some obvious micro-solutions that are very likely more appropriate for the small office or clinic setting.

Posting Instructions in the Examining Room

Hyman,[52] in a news article, points out that medical devices used in clinics and hospitals must come with an instruction manual called instructions for use, but that instructions for use are not routinely read and may not even get to the intended recipient, that is, the health care provider who is using the device. Our expertise, albeit anecdotal, is consistent with this argument. However, we could find no formal studies addressing this hypothesis. Instructions posted in the examining room serve as a reminder of appropriate measurement methods but also serve as a basis for patients to become aware of proper measurement steps and procedures. Straightforward instructions on Monitoring Your Blood Pressure at Home have been provided by the American Heart Association[32] and can be adapted for this purpose.

Proper Furniture in the Examining Room

Automated BP measurement requires a suitable chair with an armrest or a suitable table and chair. The drawing shown in Figure 1 is representative of the illustrations used in AOBPM manufacturer instruction manuals. We have not been able to find a literature in which the presence of these simple, but essential, equipment items are mentioned and no relevant surveys. However, the medical architecture literature does indicate a significant concern with improving the ergonomic design of the clinic and the examining room.[53] None of the elaborate plans in the Freihoefer et al[53] publication deal with proper furniture to measure BP. It is clear from Figure 1 (and almost all illustrations of how to measure AOBPM properly), that it requires a table and chair or a chair with armrest. These need not be high-tech furniture items. A high-end examination chair and kiosks designed for BP measurement are available, but at considerable cost.[54] However, proper measurement methods can be accomplished far more economically. Proper furniture for BP measurements should permit the patient to sit erect, with back and arm support, with the instrument cuff at the level of the heart, and there must be allowance for an adjustment of chair height so that the other criteria can be met (eg, feet flat on the floor).

Improved Oversight: Contributions From the Patient

Improvement in BP measurement is not likely to result from monitoring by outside regulatory forces, for example, government or state agencies, because people

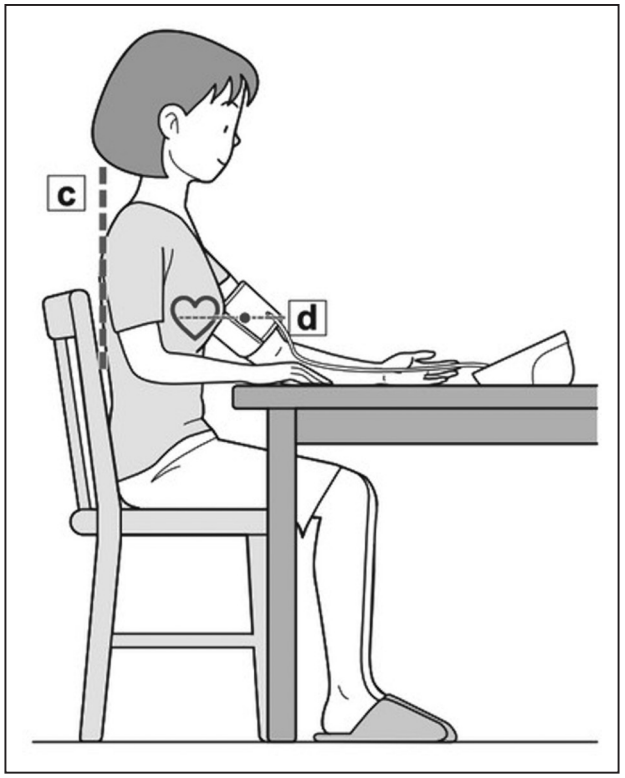

Figure. Image of best practices for automated office blood pressure measurement.
Drawing reprinted with permission courtesy of OMRON Healthcare, Inc.

change their behavior when they are observed. But the first line of observation is the patient and it seems evident that health care providers do not change their behavior despite being observed by patients.

One would expect behavior in a positive direction to be affected by the fact that the patient is the captive observer of BP measurement methods. Patients complain via blog exchanges[55] that they are ignored when they question measurement procedures and these complaints are consistent with our own personal experience. Unfortunately, we could find no formal data speaking to health care providers' responses to patient complaints or the prevalence of such complaints. This leads to a further question. Do health care providers presume that their patients are not competent or are not entitled to raise questions about the measurement procedure? This is a reasonable question, but once more, we could find no studies that speak to this issue in the context of BP measurement.

There is a literature indicating that patients fear speaking up because they will be labeled uncooperative[56] and beyond this concern, it is obviously awkward if not embarrassing to confront an expert with criticism of a manifestation of their expertise, that is, properly measuring BP.

The issue of patient empowerment to speak up was addressed by Lastinger et al[57] in the hand washing study. This investigation was conducted to determine the best ways to get patients to speak up and to evaluate health care providers' reactions to patient speaking up behavior. Hospitalized children's parents and adult patients were study participants (N=222). Anonymous email surveys were administered to the parents, residents, and attending physicians in the Departments of Internal Medicine, Pediatrics, and Family Medicine. Patients were provided the opportunity to use signs instead of confronting the patient care person with words. Both the patient participants and their health care providers preferred direct verbal communication to signs. Speaking up resulted in improvement in hand washing behavior. By virtue of the element of patient empowerment to speak up, this study may be a model for studies in relation to speaking up with regard to proper steps in BP assessment. We learned several important things: (1) speaking up helps; (2) health care providers do not like it; and (3) providers prefer to be spoken to directly with concerns.

This patient empowerment approach could possibly work if we can assume that there are informed patients. BP measurement at home, with premeasurement and follow-up training, has very likely contributed to an informed patient. Moreover, health care providers and researchers are themselves patients and are thus not lacking in training as to BP assessment. In general, we need to encourage policies and procedures that allow the patient to express concerns about BP measurement procedures. No patient should leave the clinic or office without the opportunity to comment on the BP measurement process, and commentary should be encouraged. We do not presume that patients are always or even mostly correct; our call is for an opportunity for the patients to express concerns and begin an important dialogue.

To our knowledge, no studies have been done to support the micro-approaches we suggest, nor have there been cost estimates investigated. These are suggested as possibilities for implementation and research as to their effectiveness in reducing errors in AOBPM.

LIMITS OF THE REVIEW

We do not include patient-measured BP or ambulatory BP assessment in this review. We do cite reviews by Myer et al[3–5] on this topic. We also do not discuss home BP assessment or the role of telemetry in home BP assessment given our focus on BP assessment in the office and clinic by health care professionals. See reviews of these topics by Niiranen et al,[58] Parati et al,[59] and Zullig et al,[60] among others.

NEED FOR FUNDAMENTAL RESEARCH

Aside from the various descriptive studies, it comes to a fundamental question: Why do health care providers

who are devoted to their profession, their work and their patients (and sometimes perform complex procedures routinely), ignore the relatively simple directions for AOBPM? Neither the social psychological literature nor the behavioral medicine literature offers the most commonly reported popular explanation, that is, the instructions are unnecessary, irrelevant, or take too much time. It would seem that following the instructions is relevant and necessary to reliable AOBPM.

SUMMARY

Despite initial concerns about AOBPM it is likely to be here to stay. The assumption, or hope, that the introduction of automated BP monitoring devices eliminates human error in BP measurement is not supported by the literature. In this review, we illuminate errors in measurement and argue that we need more data on which health care professionals are most likely to make errors in BP assessment and thus benefit from retraining; and we summarize studies that have evaluated accuracy of automated BP measurement in the office and clinic and offer some straightforward and potentially inexpensive approaches to facilitate better measurement practices with automated BP measurements devices.

CONCLUSIONS AND PERSPECTIVES

BP measurement with the automated device is here to stay in routine clinical practice[3,37,61,62] and in observational studies and clinical trials.[6,8] It holds promise for reducing human error in BP assessment, but this promise has not yet been fulfilled. Two major conclusions from our review are that AOBPM does not solve the problems of inaccuracy of BP assessment by health care providers, and that while there is general agreement that obvious errors in BP measurement are made, we have very limited data as to which health care providers are most likely to make errors. We do suspect that poor BP assessment is more likely in the context of screening programs offered by affiliate health care providers, for example, dentists and optometrists, than in the medical office or clinic. However, we have no substantial body of evidence confirming or refuting this hypothesis. This is an important future research topic because poor measurement defeats the positive goal of screening for hypertension outside the medical clinic or office, just as it defeats the goal of accurately diagnosing hypertension in the clinic, the office and research studies where accurate diagnosis is critical.

While multidimensional approaches have shown some success in improving BP assessment, we advance 3 simple suggestions, among others, where cost is a consideration: (1) make sure the health care provider gets the manufacturer's instructions and that these instructions are posted; (2) provide the simple furniture required for AOBPM in the examining room; and (3) create a patient advocacy or empowerment system in the office and clinic so that informed patients can make a positive contribution to the supervision of AOBPM techniques.

If we assume that we have the issue of unreliable BP measurement solved by virtue of using AOBPM, we will experience what American icon and baseball catcher Yogi Berra described as deja vu all over again. We need to get it right this time.

ARTICLE INFORMATION

Affiliations

Department of Psychology (M.F.E., A.L.G.) and Graduate School of Biomedical Science and Engineering (M.F.E.), The University of Maine, Orono.

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