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REVIEW

Role of Ambulatory and Home Blood Pressure Monitoring in Clinical Practice

A Narrative Review

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Hypertension, a common risk factor for cardiovascular disease, is usually diagnosed and treated based on blood pressure readings obtained in the clinic setting. Blood pressure may differ considerably when measured inside versus outside of the clinic setting. Over the past several decades, evidence has accumulated on the following 2 approaches for measuring blood pressure outside of the clinic: ambulatory blood pressure monitoring (ABPM) and home blood pressure monitoring (HBPM). Both of these methods have a stronger association with cardiovascular disease outcomes than clinic blood pressure measurement. Controversy exists about whether ABPM or HBPM is superior for estimating risk for cardiovascular disease and under what circumstances these methods should be used in clinical practice for assessing blood pressure outside of the clinic. This review describes ABPM and HBPM procedures, the blood pressure phenotypic measurements that can be ascertained, and the evidence that supports the use of each approach to measuring blood pressure outside of the clinic. It also describes barriers to the successful implementation of ABPM and HBPM in clinical practice, proposes core competencies for the conduct of these procedures, and highlights important areas for future research.

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Guidelines and scientific statements recommend measuring blood pressure in the clinic setting (1, 2). However, blood pressure measured in the clinic may not accurately reflect levels in the out-of-clinic naturalistic setting (3). Ambulatory blood pressure monitoring (ABPM) and home blood pressure monitoring (HBPM) are 2 well-accepted approaches for measuring blood pressure outside of the clinic (4, 5).

The utility of these methods in guiding patient care has been widely debated (6, 7), and there is controversy about which is better for determining blood pressure outside of the clinic. This review describes ABPM and HBPM procedures, the blood pressure measures that can be obtained by using these methods, and the current evidence base supporting the use of ABPM and HBPM in clinical practice; barriers and clinical competencies that are required for the successful implementation of ABPM and HBPM in practice; and areas of future research.

Methods

We searched MEDLINE through July 2015 using the following key words: *ambulatory blood pressure*, *home blood pressure*, *out of office blood pressure*, *self-measured blood pressure*, and *self-measurement of blood pressure*. We focused on studies that had prospective follow-up for cardiovascular disease (CVD) events or mortality; systematic reviews, meta-analyses, and narrative reviews; and hypertension guidelines, scientific statements, and position papers. A search of PubMed for related articles and a cited reference search through ISI Web of Science were done using identified articles. We also manually searched the reference lists from identified reviews.

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Fundamentals of ABPM and HBPM

Overview of ABPM

In the 1960s, a manually inflated device was introduced that could take blood pressure readings on an ambulatory basis throughout the day (8). Ambulatory monitors are now fully automated, use the oscillometric technique to estimate blood pressure, and are typically used to obtain blood pressure readings for 24 hours (3). Ambulatory monitors are compact, are typically worn on a belt or in a pouch, and are connected to a sphygmomanometer cuff on the upper arm by a tube. The monitors are usually programmed to obtain readings every 15 to 30 minutes throughout the day and night and set so the readings are not displayed to the patient. Although persons go about their normal daily activities during ABPM, they are asked to keep their arm still while the cuff is inflating and to avoid excessive motion, which is associated with unobtainable or artifactual readings. At the end of the recording period, the readings are downloaded into a computer for processing. Persons can fill out a diary during the monitoring period to document any symptoms, awakening and sleeping times, naps, periods of stress, timing of meals, and medication ingestion (4).

Various criteria can be used to determine whether a 24-hour ABPM session is valid, such as requiring that a minimum of 70% or 80% of the planned readings are

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Key Summary Points

Ambulatory blood pressure monitoring (ABPM) assesses blood pressure during routine daily activities (typically during one 24-hour period), whereas home blood pressure monitoring (HBPM) assesses blood pressure at specific times during the day and night over a longer period while the patient is seated and resting.

Blood pressure measures on ABPM and HBPM have a stronger association with cardiovascular disease outcomes than clinic blood pressure.

ABPM and HBPM can quantify mean out-of-clinic blood pressure and can be used to identify white coat hypertension, masked hypertension, blood pressure variability, and hypotension. ABPM can also assess nighttime blood pressure and diurnal blood pressure patterns.

Most guidelines, scientific statements, and position papers recommend that blood pressure monitoring outside of the clinic primarily be done using ABPM to rule out white coat hypertension in persons with elevated clinic blood pressure. HBPM is recommended if ABPM is not available or is poorly tolerated by the patient.

Barriers have limited the implementation of ABPM and HBPM in clinical practice. Core competency requirements may be essential for successful ABPM and HBPM.

There is a need for randomized, controlled trials to test whether treating blood pressure determined by ABPM or HBPM is more advantageous than treating clinic blood pressure on cardiovascular disease outcomes.

obtained (4, 9), at least 14 readings are obtained during the daytime period (10), or at least 10 readings are obtained during the daytime period and at least 5 during the nighttime period (11). None of these criteria is considered to be a gold standard. The daytime and nighttime periods on ABPM can be determined by using the patient's self-report of awakening and sleeping (4), fixed periods (4), and actigraphy (12). Herein, the terms *daytime* and *nighttime* (or *nocturnal*) are used interchangeably with *awake* and *sleep*, respectively. The **Figure** (*top*) shows blood pressure readings obtained from a person in the clinic followed by 24-hour ABPM.

Overview of HBPM

Home blood pressure was initially measured with the auscultatory technique by an observer (13). Most current HBPM devices are automatic, use the oscillometric technique, and are initiated by the patient. Some devices have the ability to store readings for several weeks, which minimizes the need for patients to record the measurements. Devices for HBPM, which measure blood pressure in the brachial artery, are more reliable than other types of devices, such as wrist monitors (13).

Home blood pressure monitoring should be done in a quiet room after 5 minutes of rest in the seated position, with the back and arm supported. A common recommendation for HBPM (2, 5, 14) is that blood pressure be measured by the patient 2 times in the morning and 2 times in the evening. A minimum of 3 consecutive days and a preferred period of 7 consecutive days of HBPM is a reasonable approach for clinical practice (2, 5, 14). For assessment of mean blood pressure, readings obtained on the first day of HBPM are excluded and all subsequent readings are averaged (2, 5, 14). The **Figure** shows blood pressure readings in the same person from ABPM (*top)* followed by HBPM (*bottom*).

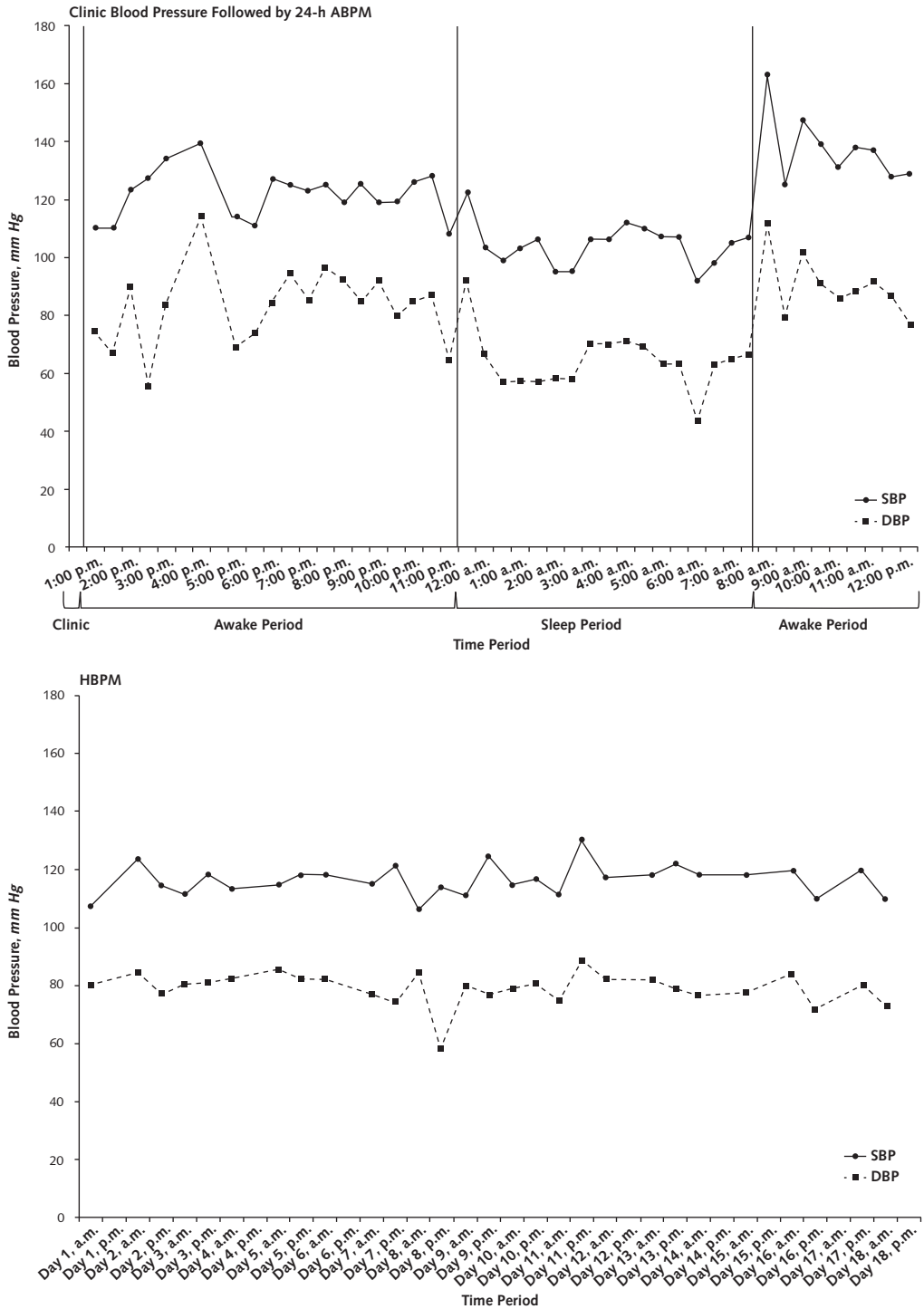
Validated Devices

Only validated devices are recommended for ABPM and HBPM. Validation protocols from the following 3 organizations are widely accepted: the Association for the Advancement of Medical Instrumentation (15), British Hypertension Society (16), and European Society of Hypertension (17). The 2010 European Society of Hypertension International Protocol (17) is the most commonly used. An up-to-date list of validated ambulatory and home blood pressure monitors is available on the dabl Educational Trust Web site (www.dableducational.org) (18) and the British Hypertension Society Web site (www.bhsoc.org/bp-monitors/bp-monitors) (19).

Similarities and Differences in ABPM and HBPM

More measurements are typically obtained with ABPM and HBPM than in the clinic setting. Ambulatory blood pressure monitoring and HBPM can assess average blood pressure outside of the clinic setting, which allows for the identification of white coat hypertension (20, 21) and masked hypertension (22–24); blood pressure variability on ABPM (25) and HBPM (26); and hypotension (2, 4). Because ABPM and HBPM devices use the oscillometric technique, which assesses the amplitude of pressure oscillations during cuff deflation to estimate blood pressure, accurate measurements can be affected by movement (27). The ability to obtain accurate readings is also limited by larger upper arm circumference, arterial stiffness, and variability in heart rate (such as atrial fibrillation) (27). Because ABPM and HBPM devices inflate the blood pressure cuff above estimated systolic blood pressure followed by deflation, persons with severe hypertension may have discomfort or pain with repeated measurements. The main difference between ABPM and HBPM is that ABPM assesses daytime and nighttime blood pressure during routine daily activities (typically during one 24-hour period), whereas HBPM assesses blood pressure at specific times during the day and night over a longer period while the patient is seated and resting. For almost all HBPM devices, blood pressure readings cannot be obtained during sleep.

Figure. Blood pressure data from an untreated healthy person who had clinic blood pressure assessment followed by 24-h ABPM (*top*) and then HBPM (*bottom*).



ABPM = ambulatory blood pressure monitoring; DBP = diastolic blood pressure; HBPM = home blood pressure monitoring; SBP = systolic blood pressure. **Top**. Clinic blood pressure assessment immediately followed by 24-h ABPM. The points for clinic blood pressure represent the average of 3 readings. On ABPM, blood pressure decreases to its lowest level during the night, followed by a surge in the morning hours coinciding with waking up. Average clinic blood pressure was 118/66 mm Hg, and average awake, sleep, and 24-h blood pressure was 129/86 mm Hg, 103/62 mm Hg, and 118/78 mm Hg, respectively. **Bottom**. After the 24-h ABPM assessment, HBPM was then done for 18 d. The points represent the average of 2 morning or 2 evening readings. Because blood pressure readings on HBPM are obtained at fixed times during the day and are measured at rest, the variability of blood pressure over time is less than what is seen on ABPM. Unlike ABPM, HBPM cannot measure blood pressure readings during sleep. Average home blood pressure was 116/79 mm Hg.

Table 1. Blood Pressure Thresholds for ABPM and HBPM Recommended by Different Scientific Societies*

Society Recommendation	Recommended Blood Pressure Thresholds for ABPM		
	Optimal	Normal	Elevated
2005 AHA scientific statement (1)			
Daytime	<130/80	<135/85	>140/90
Nighttime	<115/65	<120/70	>125/75
24 h	<125/75	<130/80	>135/85
2005 ESH practice guidelines (37)			
Daytime	<130/80	<135/85	>140/90
Nighttime	<115/65	<120/70	>125/75
24 h	NR	NR	NR
2008 ASH position paper (38)			
Daytime	NR	NR	≥135/85
Nighttime	NR	NR	≥120/75
24 h	NR	NR	≥130/80
2013 ESH position paper (4)			
Daytime	NR	NR	≥135/85
Nighttime	NR	NR	≥120/70
24 h	NR	NR	≥130/80

	Recommended Blood Pressure Thresholds for HBPM	
	Normal	Elevated
2008 AHA/ASH/PCNA call to action (5)	NR	≥135/85
2008 ASH position paper (38)	NR	≥135/85
2010 ESH guidelines (39)	<130/80	≥135/85
2013 ESH/ESC guidelines (2)	NR	≥135/85

ABPM = ambulatory blood pressure monitoring; AHA = American Heart Association; ASH = American Society of Hypertension; ESC = European Society of Cardiology; ESH = European Society of Hypertension; HBPM = home blood pressure monitoring; NR = not reported; PCNA = Preventive Cardiovascular Nurses Association.
* The different guidelines, position papers, and scientific statements use terms like *abnormal*, *limit*, *threshold*, *goal*, *hypertension*, or *elevated* to designate when a diagnosis of hypertension is made or when the dose of a treatment should be titrated. In this table, we use the term *elevated*. Values are in mm Hg.

CLINICAL SIGNIFICANCE

Elevated Blood Pressure on ABPM and HBPM

Many studies have reported associations of average out-of-clinic blood pressure measured by ABPM, including average 24-hour blood pressure; daytime and nighttime blood pressure; and, separately, average blood pressure on HBPM with CVD and mortality outcomes, independent of mean clinic blood pressure (28–32). Few studies with CVD events or mortality as outcomes have used both ABPM and HBPM in the same sample (33–36), and which method is superior for predicting outcomes remains unclear. Levels that constitute normality and elevated blood pressure status for ABPM and HBPM have been published (1, 2, 4, 5, 37–39) (Table 1); most of the normality data have been derived from studies done in Europe and Japan.

Phenotypes Defined by Clinic and Out-of-Clinic Hypertension Status

Four phenotypes can be defined by cross-classifying clinic and out-of-clinic hypertension status using ABPM or HBPM (Table 2). The following 2 phenotypes represent agreement: sustained normotension (nonelevated clinic and nonelevated out-of-clinic blood pressure) and sustained hypertension (elevated clinic and out-of-clinic blood pressure), which are phenotypes associated with the lowest and highest CVD risk, respectively (40). As originally described by Pickering and colleagues (20), the term *white coat hypertension* refers to untreated persons with elevated clinic blood pressure but not elevated daytime blood pressure on ABPM. The term *masked hypertension* refers to untreated persons who do not have elevated clinic blood pressure but have elevated daytime blood pressure on ABPM (22). In addition to those with daytime hypertension, persons without elevated clinic blood pressure but who have 24-hour hypertension or nighttime hypertension are considered to have masked hypertension (4). Home blood pressure monitoring can also be used to define white coat hypertension and masked hypertension (5).

The terms *white coat hypertension* and *masked hypertension* can be applied to persons receiving antihypertensive medication (23, 41). Treated persons with elevated clinic blood pressure but not elevated out-of-clinic blood pressure have "treated white coat hypertension" or "white coat uncontrolled hypertension." Treated persons with nonelevated clinic blood pressure and elevated out-of-clinic blood pressure have "treated masked hypertension" or "masked uncontrolled hypertension." Ambulatory blood pressure monitoring and HBPM can identify white coat–resistant hypertension (42, 43), which is defined as treatment-resistant hypertension based on clinic blood pressure but controlled out-of-clinic blood pressure. In untreated and treated persons, ABPM and HBPM can assess the white coat effect, defined as having a clinic blood pressure that is greater than the average out-of-clinic blood pressure, and the masked hypertensive effect, defined as having an average out-of-clinic blood pressure that is greater than clinic blood pressure.

White Coat Hypertension

A systematic review done for the U.S. Preventive Services Task Force evaluated the prevalence of white coat hypertension using ABPM and HBPM in untreated populations (28). The prevalence of white coat hypertension ranged from 5% to 65% in 22 studies using ABPM and from 16% to 55% in 6 studies using HBPM. Several (21, 28, 41, 44, 45) but not all (46, 47) studies have reported white coat hypertension not to be associated with a greater risk for CVD outcomes than sustained normotension. Treated white coat hypertension has not been associated with a greater risk for CVD events or death than treated sustained normotension (21, 41, 47).

Masked Hypertension

In a systematic review that identified 5 population-based studies (4 done in Europe and 1 in Japan), the prevalence of masked hypertension ranged from 14% to 30% among participants without elevated clinic blood pressure (23). Three of the studies used ABPM

only (48–50), 1 used HBPM only (51), and 1 used both ABPM and HBPM (46). Four studies included participants receiving antihypertensive medication (46, 49–51). In addition to being associated with subclinical CVD (52), masked hypertension is associated with an increased risk for CVD events. In a meta-analysis of 7 studies (n = 11 502; 5 studies of ABPM and 2 studies of HBPM; 6 studies included participants who received treatment) (53), the multivariable-adjusted hazard ratio for CVD events, comparing masked hypertension with sustained normotension, was 2.00 (95% CI, 1.58 to 2.52). These findings are similar to results from a second meta-analysis of individual-level data from 4 samples of ABPM (n = 7030; 21.8% of participants received antihypertensive medications) (30) and a study of untreated persons who had HBPM (47). Among persons receiving antihypertensive medication, treated masked hypertension on ABPM or HBPM has been associated with a greater risk for CVD events and death than sustained normotension (24, 47).

Other Measures and Phenotypes Captured by ABPM or HBPM

Nondipping Blood Pressure and Nocturnal Hypertension

Many persons have a diurnal pattern of blood pressure (54) that usually decreases to its lowest level during nighttime hours (Figure, *top*). However, some persons do not experience this nocturnal decline, and those whose blood pressure does not decline between daytime and nighttime by 10% or more on ABPM are considered nondippers (2, 4). Persons can have nocturnal hypertension, which is commonly defined as mean nighttime blood pressure of 120/70 mm Hg or greater (55). Several studies have reported that nondipping blood pressure and nocturnal hypertension are associated with increased risk for CVD events and all-cause mortality, independent of clinic and daytime blood pressure (31, 56).

Morning Surge

The morning surge refers to the increase in blood pressure that normally occurs from the nighttime to the early morning (Figure). This period corresponds to an increased incidence of CVD events (57). Some studies have identified an association between an exaggerated morning surge on ABPM and increased stroke risk (57).

Blood Pressure Variability

Blood pressure variability on 24-hour ABPM is generally reported using the 2 following metrics: day–night SD, which captures the variability a patient has around their mean daytime and nighttime blood pressure, and average real variability, which captures variability in blood pressure between successive measurements (58, 59). Although 24-hour blood pressure variability using these metrics was associated with an increased risk for CVD events and death in a meta-analysis (25), the clinical applicability of blood pressure variability may be limited because of its relatively low reproducibility (60) and a modest increase in absolute CVD risk (25). Home blood pressure monitoring can be used to capture long-term (day-to-day) blood pressure variability. In a systematic review (26), higher day-to-day blood pressure variability was associated with an increased risk for CVD events or death.

Table 2. Phenotypes Defined by Clinic and Out-of-Clinic Hypertension Status

Clinic Hypertension	Ambulatory (or Home) Hypertension	
	No	Yes*
No	Sustained normotension	Masked hypertension
Yes†	White coat hypertension	Sustained hypertension

* Commonly, mean daytime (or home) blood pressure ≥135/85 mm Hg based on ambulatory blood pressure monitoring (or home blood pressure monitoring).
† Mean blood pressure ≥140/90 mm Hg based on clinic measurements.

Hypotension

Ambulatory blood pressure monitoring or HBPM can be used to assess postural hypotension, postprandial hypotension, drug-induced hypotension, and hypotension from autonomic dysfunction (4). Either approach can also be used to evaluate syncope, vertigo, or dizziness (61, 62). Although ABPM and HBPM only provide intermittent blood pressure measurements, they offer the ability to obtain measurements at a time when a patient is symptomatic. Ambulatory blood pressure monitoring can be combined with Holter monitoring for simultaneous recording of blood pressure and electrocardiography to evaluate hypotension or symptoms (4).

Clinical Indications for ABPM and HBPM

Guidelines, scientific statements, and position papers most commonly recommend ABPM to exclude white coat hypertension in persons with elevated clinic blood pressure (Appendix Table 1, available at www.annals.org). In a recent draft statement from the U.S. Preventive Services Task Force (63), ABPM was endorsed for confirming hypertension and excluding white coat hypertension, except in patients for whom immediate treatment initiation may be indicated (including those who have blood pressure of 180/110 mm Hg or greater, evidence of end-organ damage, or a diagnosis of secondary hypertension). Other indications for ABPM include the monitoring of antihypertensive medication efficacy in patients with hypertension who received treatment and have elevated clinic blood pressure to determine blood pressure control over the course of the day. Less common recommendations include the assessment of masked hypertension, treated masked hypertension, diurnal blood pressure patterns, 24-hour blood pressure variability, and hypotension. Home blood pressure monitoring is not recommended as often as ABPM (Appendix Table 2, available at www.annals.org) and is most commonly recommended for diagnosing white coat hypertension or assessing treatment-resistant hypertension. The draft statement from the U.S. Preventive Services Task Force (63) did

not officially endorse using HBPM to exclude white coat hypertension but did state that the "confirmation of hypertension using HBPM may be acceptable." For clinical practice, it is reasonable that out-of-clinic blood pressure be monitored primarily with ABPM to rule out white coat hypertension in persons with elevated clinic blood pressure. Home blood pressure monitoring can be done if ABPM is not available or is poorly tolerated by the patient. In the clinic, automatic blood pressure devices are preferred over manual devices because of the closer agreement between clinic and out-of-clinic measurements (64). For patients receiving antihypertensive medication, ABPM and, secondarily, HBPM are sometimes used to assess treated white coat hypertension and the white coat effect and to determine whether out-of-clinic blood pressure is controlled in patients with treatment-resistant hypertension based on clinic blood pressure. Both methods can be used to assess treated masked hypertension and the masked hypertensive effect. Use of ABPM and HBPM in these situations should be weighed in context with the large body of evidence supporting the cardiovascular benefits of antihypertensive treatment that uses clinic blood pressure thresholds to guide therapy (2). The evidence supporting the achievement of blood pressure goals using ABPM or HBPM compared with targeting a clinic blood pressure goal on reducing CVD events and mortality rates is limited.

Challenges in Using ABPM and HBPM in Clinical Practice

Ambulatory blood pressure monitoring is not widely available in primary care settings and is generally offered only in specialized hypertension centers (65, 66). Insurance companies do not commonly reimburse for indications other than white coat hypertension. In addition, the reimbursement for ABPM is low (4, 67). Some patients may have difficulty wearing ABPM devices at night (68). There is also a lack of formal training or certification for ABPM that may make it difficult for physicians to set up these services in their practices.

In contrast to ABPM, HBPM devices are more widely available. Other advantages for using HBPM rather than ABPM include potentially greater patient acceptability and tolerability and better reproducibility of blood pressure phenotypes (5, 13, 39, 69). Home blood pressure monitoring may also be associated with an improvement in antihypertensive medication adherence (70). However, many devices are being sold that have not been validated (71). Further, although HBPM devices are cheaper than ABPM devices, their cost is not commonly reimbursed by insurance companies (5, 72). Therefore, HBPM may be inaccessible to low-income persons. Some devices do not record blood pressure readings, which leads to reliance on the patient to document their measurements (73). Home monitoring requires a long-term commitment from patients for days, weeks, or even longer periods, which may be challenging. Physicians are concerned about the use of nonvalidated HBPM devices; lack of knowledge of where to purchase validated devices; lack of established measurement protocols; and the patient's preoccupation with his or her own blood pressure, which may lead to anxiety (74–78). Additional issues relate to the lack of proper training of the patient in HBPM procedures (75). Patients with hypertension may not have access to adjunctive strategies for HBPM, such as one-on-one counseling, remote telemonitoring, and educational classes, one or more of which may be essential for achieving and maintaining control of blood pressure while using HBPM (72, 79).

Clinical Core Competency Requirements for ABPM and HBPM

Clinical core competency requirements for ABPM and HBPM do not exist in the United States. **Appendix Table 3** (available at www.annals.org) includes proposed clinical core competency requirements for ABPM and HBPM, with an emphasis on increasing medical knowledge and improving patient care and procedural skills. The following 3 areas need further development: structured training in ABPM and HBPM, tests evaluating proof of competence, and requirements for maintenance of competence. Training for the proposed clinical core competency requirements could take place during medical school clerkships, residency or fellowship training for physicians, and professional programs for other practitioners (such as nurses and nurse practitioners). Workshops or conferences on ABPM and HBPM could also play a role in training practicing physicians or other practitioners. Documentation of ABPM and possibly HBPM competence could be achieved by successfully passing an examination and the implementation and interpretation of a minimum number of ABPM and HBPM procedures. Maintenance of competence should require ongoing continuing medical education and conduct of a minimum number of ABPM and HBPM recordings annually.

Important Knowledge Gaps and Future Directions

Many clinically relevant questions remain unanswered. Studies are needed to determine whether using mean blood pressure from ABPM or HBPM to guide antihypertensive medication initiation and titration leads to fewer clinical outcomes than clinic blood pressure alone (80, 81). Information is scarce on whether treating ABPM or HBPM phenotypes (such as nondipping blood pressure) has benefits over and above those provided by mean out-of-clinic blood pressure. There are few data on the mechanisms underlying ABPM and HBPM phenotypes, which may help identify treatment targets. Many newer devices or technologies hold promise for the assessment of out-of-clinic blood pressure but require further evaluation in rigorous studies. Devices worn on the wrist, which are less burdensome to patients, may have broad appeal. These devices are currently not recommended for routine clinical use because some studies indicate the presence of a systematic error when compared with upper

arm measurements (2, 82). However, they may benefit persons with a large arm circumference in whom upper arm devices may be inaccurate (2). Another emerging area is self-measurement devices that are linked to mobile health applications that allow persons to monitor and manage their own blood pressure (83, 84). Validating these methods for assessing out-of-clinic blood pressure is important given the widespread availability of mobile technology.

CONCLUSION

Over the past several decades, evidence that mean out-of-clinic blood pressure measured by ABPM and HBPM maintains a stronger association with CVD and mortality risk than clinic blood pressure has accumulated. Because of the high prevalence of white coat hypertension and its benign prognosis in most observational studies, it may be reasonable to use ABPM and, secondarily, HBPM to identify white coat hypertension in untreated persons with elevated clinic blood pressure. Data on the prognostic value of using ABPM or HBPM compared with clinic blood pressure in guiding antihypertensive medication use and titration are needed. Data on ABPM or HBPM for identifying and treating blood pressure phenotypes other than white coat hypertension are limited. Randomized, controlled trials of ABPM and HBPM on outcomes are needed to address these knowledge gaps. Interventions that address barriers to ABPM and HBPM will also help translate the large body of research on ABPM and HBPM into clinical practice.

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Appendix Table 1. Clinical Indications for Which ABPM Is Recommended in Selected Guidelines Published Since 2011*

Variable	2014 USPSTF (63)	2014 AHA/ACC/CDC (85)†	2014 JNC8 (86)†	2014 ASH/ISH (82)‡	2014 CHEP (87)‡	2013 ADA (88)†	2013 ESH (4)‡	2013 ESH/ESC (2)‡	2012 KDIGO (89)†	2011 ACCF/AHA Task Force (61)‡	2011 NICE (10)
Mean BP											
In untreated persons with:											
Elevated clinic BP											
White coat hypertension	X			X	X		X	X		X	X
White coat effect							X	X		X	
Nonelevated clinic BP											
Masked hypertension							X	X		X	
Masked effect											
Clinic BP that fluctuates considerably over same or different visits								X			
In treated persons with:											
Elevated clinic BP											
White coat hypertension					X		X	X		X	
White coat effect					X		X	X		X	
Resistant hypertension				X	X		X	X			
Nonelevated clinic BP											
Masked hypertension							X			X	
Masked effect											
Clinic BP that fluctuates considerably over same or different visits					X			X			
Diurnal BP patterns											
Morning hypertension							X				
Daytime hypertension							X				
Nighttime hypertension							X	X			
Dipping status					X		X	X			
Morning surge							X				
BP variability (24 h)							X	X			
Hypotension					X		X	X		X	
Discordance between clinic and home BP								X			

ABPM = ambulatory blood pressure monitoring; ACC = American College of Cardiology; ACCF = American College of Cardiology Foundation; ADA = American Diabetes Association; AHA = American Heart Association; ASH = American Society of Hypertension; BP = blood pressure; CDC = Centers for Disease Control and Prevention; CHEP = Canadian Hypertension Education Program; ESC = European Society of Cardiology; ESH = European Society of Hypertension; ISH = International Society of Hypertension; JNC8 = Eighth Joint National Committee; KDIGO = Kidney Disease: Improving Global Outcomes; NICE = National Institute for Health and Care Excellence; USPSTF = U.S. Preventive Services Task Force.

* In persons receiving antihypertensive medications (i.e., treated persons), white coat hypertension is also called treated white coat hypertension or white coat uncontrolled hypertension. Similarly, in treated persons, masked hypertension is also called treated masked hypertension or masked uncontrolled hypertension.

† This report does not make specific recommendations about ABPM.

‡ Levels of evidence for ABPM indications were not graded.

Appendix Table 2. Clinical Indications for Which HBPM Is Recommended in Selected Hypertension Guidelines Since 2011*

Variable	2014 USPSTF (63)†	2014 AHA/ACC/CDC (85)†	2014 JNC8 (86)†	2014 ASH/ISH (82)‡	2014 CHEP (87)‡	2013 ADA (88)†	2013 ESH (4)‡	2013 ESH/ESC (2)‡	2012 KDIGO (89)†	2011 ACCF/AHA Task Force (61)‡	2011 NICE (10)
Mean BP											
In untreated persons with:							As a complement or alternative to ABPM			Discussed but not clear if HBPM is a complement or alternative to ABPM	
Elevated clinic BP											
White coat hypertension				X	X			X			X§
White coat effect								X			
Nonelevated clinic BP											
Masked hypertension								X			
Masked effect											
Clinic BP that fluctuates considerably over same or different visits											
In treated persons with:							As a complement or alternative to ABPM			Discussed but not clear if HBPM is a complement or alternative to ABPM	
Elevated clinic BP											
White coat hypertension					X			X			
White coat effect					X			X			
Resistant hypertension					X			X			
Nonelevated clinic BP											
Masked hypertension					X						
Masked effect											
Clinic BP that fluctuates considerably over same or different visits											
Diurnal BP patterns											
Morning hypertension											
Daytime hypertension											
Nighttime hypertension‖											
BP variability (day-to-day)							X				
Hypotension							X	X			

ABPM = ambulatory blood pressure monitoring; ACC = American College of Cardiology; ACCF = American College of Cardiology Foundation; ADA = American Diabetes Association; AHA = American Heart Association; ASH = American Society of Hypertension; BP = blood pressure; CDC = Centers for Disease Control and Prevention; CHEP = Canadian Hypertension Education Program; ESC = European Society of Cardiology; ESH = European Society of Hypertension; HBPM = home blood pressure monitoring; ISH = International Society of Hypertension; JNC8 = Eighth Joint National Committee; KDIGO = Kidney Disease: Improving Global Outcomes; NICE = National Institute for Health and Care Excellence; USPSTF = U.S. Preventive Services Task Force.

* In persons receiving antihypertensive medications (i.e., treated persons), white coat hypertension is also called treated white coat hypertension or white coat uncontrolled hypertension. Similarly, in treated persons, masked hypertension is also called treated masked hypertension or masked uncontrolled hypertension.

† This report does not make specific recommendations about HBPM.

‡ Level of evidence for HBPM indications was not graded.

§ Suitable alternative if ABPM is not tolerated by patient.

‖ Home blood pressure readings can be taken during the evening before sleep.

Appendix Table 3. Proposed Clinical Core Competency Requirements for ABPM and HBPM

Competency in Medical Knowledge

1. Know the pathophysiology underlying hypertension
2. Know the clinical pharmacology of antihypertensive medications and their effects on BP
3. Know the general methods to measure BP and the strengths and limitations of each method
4. Know the different BP measures and BP phenotypes that can be obtained using ABPM and HBPM
5. Know the strengths and limitations of ABPM and HBPM
6. Know the clinical indications for which the performance of ABPM and HBPM is recommended
7. Know the specialized equipment, techniques, and devices used to conduct ABPM and HBPM
8. Know the measurement protocols for performance of ABPM and HBPM
9. Know the BP device validation protocols endorsed by the Association for the Advancement of Medical Instrumentation, the British Hypertension Society, and the European Society of Hypertension
10. Know which ABPM and HBPM devices have been validated for general patients and special populations
11. Know thresholds to define elevated mean BP on ABPM and HBPM as well as other out-of-clinic BP phenotypes

Competency in Patient Care and Procedural Skills

1. Skills to integrate clinical data in selecting patients for ABPM and HBPM, including the evidence-base including guidelines that make recommendations regarding ABPM and HBPM
2. Skills to perform ABPM and HBPM
3. Skills to prepare patients for ABPM
4. Skills to instruct patients in how to measure their BP using HBPM devices
5. Skills to instruct patients in how to properly interpret their HBPM readings
6. Skills to determine whether an ABPM recording and HBPM readings are valid
7. Skills to interpret readings obtained from ABPM and HBPM
8. Skills to calculate BP phenotypic measures from ABPM and HBPM
9. Skills to instruct patients where to purchase validated HBPM devices
10. Skills to communicate with patient to bring in home BP readings to visits
11. Skills to communicate with patient about when to call the physician's office about elevated HBPM readings

ABPM = ambulatory blood pressure monitoring; BP = blood pressure; HBPM = home blood pressure monitoring.

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