Brief Review

OPEN

Emergence of Home Blood Pressure-Guided Management of Hypertension Based on Global Evidence

Kazuomi Kario, Daichi Shimbo, Satoshi Hoshide, Ji-Guang Wang, Kei Asayama, Takayoshi Ohkubo, Yutaka Imai, Richard J. McManus, Anastasios Kollias, Teemu J. Niiranen, Gianfranco Parati, Bryan Williams, Michael A. Weber, Wanpen Vongpatanasin, Paul Muntner, George S. Stergiou

Recent guidelines for the management of hypertension from the 2018 European Society of Cardiology/European Society of Hypertension and the 2017 American College of Cardiology (ACC)/American Heart Association (AHA)[1,2] have stressed the importance of out-of-office blood pressure (BP) measurement for hypertension management. There has been a similar emphasis on out-of-office BP monitoring for the management of hypertension in the United Kingdom, Canada, Japan, and other Asian countries.[3–6] Ambulatory BP monitoring (ABPM) and home BP monitoring (HBPM) are 2 well-validated approaches for measuring out-of-office BP. In the published literature, HBPM is a term that has commonly referred to the self-measurement of BP at home, although in some studies, HBPM has been used to describe a provider or research assistant measuring an individual's BP in his/her home. ABPM and HBPM can identify white coat hypertension (diagnostic disagreement between office and out-of-office BP in untreated subjects) and white coat uncontrolled hypertension (diagnostic disagreement in treated subjects).[1–8] Although ABPM has been the preferred method for out-of-office measurement, the 2017 ACC/AHA BP guideline considered HBPM to be a more practical approach in clinical practice than ABPM, particularly for individuals taking antihypertensive medication. The 2014 Japanese Society of Hypertension Guidelines for the Management of Hypertension proposed HBPM as the most effective and practical for guiding antihypertensive medication initiation and titration in clinical care, while waiting for intervention trials demonstrating better cardiovascular outcomes in patients managed based on out-of-office BP levels.[3,9,10]

Home BP Threshold of 135/85 mm Hg

A commonly recommended HBPM monitoring schedule consists of performing morning and evening BP measurements twice on each occasion over a minimum of 3 days with a preferred period of 7 days.[1,11] Traditionally, out-of-office BP thresholds have been determined by using the regression and outcome-derived approaches[12] with data from observational studies. The threshold for high out-of-office BP corresponding to an office BP threshold of 140/90 mm Hg has been determined to be 135/85 mm Hg for both home and daytime BP on ABPM.[1,3–8]

Associations of Home BP With Cardiovascular Disease Outcomes

Previous prospective studies have demonstrated that individuals who have higher home BP levels have an increased risk of cardiovascular disease (CVD) (Table 1). This includes several observational studies conducted among community-based and clinic-based populations.[13–26]

Community-Based Studies

The Ohasama study was the first to demonstrate that home BP measurement had a stronger predictive value for mortality than screening office BP measurement in a general population (Table 1).[13] Based on initial follow-up data from the Ohasama study in 1997, the outcome-derived reference value for hypertension based on home BP was proposed as 137/84 mm Hg, which supported the aforementioned threshold of 135/85 mm Hg.[27] In another population-based

From the Division of Cardiovascular Medicine, Department of Medicine, Jichi Medical University School of Medicine, Tochigi, Japan (K.K., S.H.); Hypertension Cardiovascular Outcome Prevention and Evidence in Asia (HOPE Asia) Network Tokyo, Japan (K.K., S.H., J.-G.W.); The Hypertension Center, Columbia University Medical Center, New York, NY (D.S.); Department of Hypertension, Centre for Epidemiological Studies and Clinical Trials, The Shanghai Institute of Hypertension, Shanghai Key Laboratory of Hypertension, Ruijin Hospital, Shanghai Jiaotong University School of Medicine, China (J.-G.W.); Department of Hygiene and Public Health, Teikyo University School of Medicine, Tokyo, Japan (K.A., T.O.); Tohoku Institute for Management of Blood Pressure, Sendai, Japan (Y.I.); Nuffield Department of Primary Care Health Sciences, University of Oxford, United Kingdom (R.J.M.); Hypertension Center STRIDE-7, School of Medicine, Third Department of Medicine, Sotiria Hospital, National and Kapodistrian University of Athens, Greece (A.K., G.S.S.); National Institute for Health and Welfare, and Department of Medicine, University of Turku and Turku University Hospital, Finland (T.J.N.); Department of Medicine and Surgery, University of Milano-Bicocca, Milan, Italy (G.P.); Istituto Auxologico Italiano, IRCCS, Cardiology Unit and Department of Cardiovascular, Neural and Metabolic Sciences, S. Luca Hospital, Milano, Italy (G.P.); UCL Institute of Cardiovascular Sciences, University College London, United Kingdom (B.W.); Division of Cardiovascular Medicine, State University of New York, Downstate College of Medicine, Brooklyn (M.A.W.); Hypertension Section, Department of Internal Medicine, University of Texas Southwestern Medical Center, Dallas (W.V.); and Department of Epidemiology, University of Alabama at Birmingham (P.M.).

This paper was sent to Daniel W. Jones, Guest Editor, for review by expert referees, editorial decision, and final disposition.

Correspondence to Kazuomi Kario, Division of Cardiovascular Medicine, Department of Medicine, Jichi Medical University School of Medicine, 3311-1, Yakushiji, Shimotsuke, Tochigi 329-0498, Japan. Email kkario@jichi.ac.jp

(*Hypertension*. 2019;74:229-236. DOI: 10.1161/HYPERTENSIONAHA.119.12630.)

Table 1. Prospective Studies of Home BP Monitoring and Cardiovascular Events

		Measurement Period	Outcomes
Community-based study			
Ohkubo et al[13], Ohasama study	Japan (N=1789; age ≥40 y; mean follow-up, 6.6 y)	28-d HBPM (28 readings)	Relative HR of cardiovascular mortality with a BP increase of 1 mm Hg was 1.021 (95% CI, 1.001–1.041; *P*<0.05).
Okumiya et al[26], Kahoku study	Japan (N=1186; age, 73.5 y; follow-up, 4 y)	5-d HBPM (20 readings)	Adjusted HRs for cardiovascular mortality of each HSBP ≥135–144 mm Hg, ≥145 mm Hg compared to HSBP 125–134 mm Hg (as reference) were 2.3 (95% CI, 1.0–5.6; *P*<0.05), 2.1 (0.9–5.0; *P*<0.1), respectively.
Sega et al[14], PAMELA study†	Italy (N=2051; age, 25–74 y; mean follow-up, 131 mo)	1-d HBPM (2 readings)	HR of cardiovascular mortality with a BP increase of 1 mm Hg was 1.05 (95% CI, 1.04–1.06; *P*<0.0001).*
Hänninen et al[15], Finn-Home study	Finland (N=2046; age, 44–74 y; follow-up, 7.5 y)	7-d HBPM (28 readings)	Adjusted HR of MH for cardiovascular events compared to normotension was 1.62 (95% CI, 0.96–2.71; *P*=0.07).
Tientcheu et al[16], Dallas Heart study	United States (N=3027; age, 18–65 y; median follow-up, 9 y)	2 d in-home visit BP measurements (not by the self-measurement, but by trained research personnel; 10 readings)	Adjusted HR of MH for composite cardiovascular events compared to normotension was 2.03 (95% CI, 1.36–3.03; *P*=0.0005).
Ntineri et al[17], Didima study	Greece (N=665; mean age, 54 y; follow-up, 19 y)	3-d HBPM (12 readings)	Adjusted HR of cardiovascular morbidity and mortality with an SBP increase of 10 mm Hg was 1.04 (95% CI, 0.94–1.15; *P*=0.45).
Clinic-based study			
Bobrie et al[18], SHEAF study‡	France (4939 treated hypertensive patients; mean age, 70 y; mean follow-up, 3.2 y)	4-d HBPM (baseline HBP; 24 readings)	Adjusted HR of fatal or nonfatal cardiovascular events with a BP increase of 1 mm Hg was 1.02 (95% CI, 1.01–1.02; *P*<0.001).
Fagard et al[19]	Belgium (391 older outpatients; mean age, 71 y; follow-up, 10.9 y)	1-d HBPM (baseline HBP; 3 readings; not by self-measurement, by a physician or assist physician with mercury device)	Adjusted relative HR of cardiovascular events with a home BP increase of 1 SD (22.9 mm Hg) was 1.32 (95% CI, 1.06–1.64; *P*=0.01).
Asayama et al[20], HOMED-BP§	Japan (3518 hypertensive patients; mean age, 59.6 y; median follow-up, 5.3 y)	5-d HBPM (follow-up HBP; 5 readings)	Adjusted HR of fatal or nonfatal cardiovascular events with a home BP increase of 1 SD (13.2 mm Hg) was 1.47 (95% CI, 1.23–1.75; *P*<0.0001).
Kario et al[21], HONEST study‖	Japan (21 591 hypertensive patients; mean age, 64.9 y; mean follow-up, 2.02 y)	2-d HBPM (follow-up HBP; 8 readings)	HR of incidence of cardiovascular events for morning HSBP ≥145 mm Hg and CSBP ≥150 mm Hg compared to morning HSBP 125 mm Hg and OSBP <130 mm Hg was 3.92 (95% CI, 2.22–6.92).
Hoshide et al[23], J-HOP study¶	Japan (4310 patients with a history of and risk factors for cardiovascular disease; mean age, 65 y; mean follow-up, 4 y)	14-d HBPM (baseline HBP; 84 readings)	Adjusted HR of stroke events with a home BP increase of 10 mm Hg was 1.36 (95% CI, 1.19–1.56; *P*<0.001).

BP indicates blood pressure; HBPM, home blood pressure monitoring; HR, hazard ratio; HSBP, home systolic BP; MH, masked hypertension; OSBP, office systolic BP and SBP, systolic BP.

*Calculated from presented data of β coefficient and SE in this study. †Pressioni Arteriose Monitorate e Loro Associazioni (PAMELA) study; ‡Self-Measurement of Blood Pressure at Home in the Elderly: Assessment and Follow-up (SHEAF) study; §Hypertension Objective Treatment Based on Measurement by Electrical Devices of Blood Pressure (HOMED-BP); ‖Home Blood Pressure Measurement With Olmesartan Naive Patients to Establish Standard Target Blood Pressure (HONEST) study; ¶Japan Morning Surge-Home Blood Pressure (J-HOP) study.

study of 1186 community-dwelling elderly residents of a rural Japanese town, systolic home BP ≥135 mm Hg versus 125 to 134 mm Hg was associated with an almost 4× higher risk of mortality. Systolic home BP <125 mm Hg was also associated with an increased risk of mortality. The population-based PAMELA study (Pressioni Arteriose Monitorate E Loro Associazioni) demonstrated that the risk of death was progressively higher according to increasing home or ambulatory BP level compared to office BP level, despite only 2 home BP readings being obtained for each participant.[14] In the Finn-Home Study, masked hypertension, defined as office BP <140/90 mm Hg with home BP ≥135/85 mm Hg, was associated with a statistically significantly higher age-adjusted risk of CVD events and a higher risk of all-cause mortality after adjustment for age, sex, and office BP compared with normotension (adjusted hazard ratios, 1.64; [95% CI, 1.01–2.67]; and 2.09 [95% CI, 1.17–1.34]).[15] In the Dallas Heart Study, both white coat hypertension (adjusted hazard ratio, 2.09 [95% CI, 1.05–4.05]) and masked hypertension (adjusted hazard ratio, 2.03 [95% CI, 1.36–3.03]), defined using an

office BP threshold of 140/90 mm Hg and home BP threshold of 135/85 mm Hg, were each associated with higher incidence of CVD events compared with normotension, even after adjustment for traditional cardiovascular risk factors.[16] However, in the Dallas Heart Study, home BP readings were not self-measured but were obtained by research staff on 2 occasions at the individual's home. The Didima study, which had the longest follow-up (mean 19 years), demonstrated that compared to normotension, sustained hypertension (hypertension both in the office and in the out-of-office setting), masked hypertension, and white coat hypertension were each associated with an increased risk of death and CVD. In adjusted models, the risk of death remained statistically significantly higher for sustained hypertension, masked hypertension, and white coat hypertension, whereas the risk for CVD remained statistically significant only for white coat hypertension.[17]

Clinic-Based Studies Exploring the Role of Office and Out-of-Office BP in Patients Treated for Hypertension

A prospective study conducted among older French adults taking antihypertensive medication reported that those with masked uncontrolled hypertension, defined as office BP <140/90 mm Hg and home BP ≥135/85 mm Hg, had a statistically significantly higher risk of CVD events (hazard ratio, 2.06 [95% CI, 1.22–3.47]) compared to participants who had controlled hypertension, defined as office BP <140/90 mm Hg and home BP <135/85 mm Hg (Table 1). The risk of CVD events associated with masked uncontrolled hypertension was similar to that of uncontrolled hypertension (hazard ratio, 1.96 [95% CI, 1.27–3.02]), defined as office BP ≥140/90 mm Hg and home BP ≥135/85 mm Hg.[18] In a registry consisting of older adults, aged ≥60 years, the prognostic value of home BP was superior to that of office BP, and was similar to or better than daytime systolic BP (SBP) and daytime diastolic BP, respectively.[19] The multicenter HOMED BP (Hypertension Objective Treatment Based on Measurement by Electrical Devices of Blood Pressure) demonstrated that the 5-year risk of CVD events was low (≤1%) if on-treatment home SBP was <131.6 mm Hg.[20] The HONEST (Home Blood Pressure Measurement With Olmesartan Naive Patients to Establish Standard Target Blood Pressure) Study, the largest prospective study (n=21 591) of home BP conducted to date, demonstrated that higher on-treatment morning home BP was associated with a statistically significant increased risk for CVD events. In this study, cardiovascular risk was increased in participants with morning home SBP ≥145 mm Hg and office SBP <130 mm Hg (hazard ratio, 2.47 [95% CI, 1.20–5.08]) compared with morning home SBP <125 mm Hg and office SBP <130 mm Hg. Using a spline regression analysis, the morning home SBP level associated with the lowest CVD risk was 124 mm Hg.[21] Morning home SBP was more closely associated with the risk of both stroke and coronary artery disease events compared with office SBP.[22] The J-HOP study (Japan Morning Surge-Home Blood Pressure), a nationwide practice-based study, demonstrated that morning home SBP ≥135 mm Hg was associated with a statistically significant higher stroke risk than morning home SBP <135 mm Hg, and morning SBP improved the discrimination of incident stroke (C statistic, 0.802) beyond traditional risk factors including office SBP (C statistic, 0.756). Better discrimination of incident stroke was present for morning versus evening SBP (C statistic, 0.802 versus 0.764).[23] In J-HOP, masked uncontrolled hypertension, defined as office BP <140/90 mm Hg and home BP ≥135/85 mm Hg was associated with increased stroke risk.[24]

Moreover, in a recent post hoc analysis, a home SBP <125 mm Hg was associated with the lowest risk of CVD events in high-risk individuals with hypertension and diabetes mellitus or a history of stroke.[25] These data suggest that patients may receive additional CVD risk reduction benefits by achieving a home BP of <125 mm Hg, especially among high-risk individuals with hypertension. However, on-treatment home BP targets should be evaluated in large randomized controlled outcome trials.

Trial Evidence for Improved Hypertension Control With Self-Monitoring of Home BP

There is now a large body of empirical evidence indicating better BP control with HBPM.[28] Uhlig et al[29] conducted a systematic review and meta-analysis of 52 studies that compared HBPM to usual care. The results showed that HBPM alone without co-interventions (ie, one-to-one counseling, remote telemonitoring, and educational classes) to be associated with lower BP at 6 months but not 12 months compared with usual care. However, compared with usual care, HBPM when given with co-interventions was associated with a reduction in BP at 12 months. In a more recent systematic review and meta-analysis, Tucker et al[28] identified 25 trials that compared HBPM to usual care. HBPM was more effective than usual care at lowering BP at 12 months, but this effect was strongly influenced by whether co-interventions were given. There was no difference in BP comparing HBPM alone without co-interventions (web/phone feedback, education, in-person counseling or telecounseling) versus usual care. In contrast, there was a reduction in BP when HBPM was combined with co-interventions, with the reduction increasing with the intensity of co-intervention. The results of both systematic reviews and meta-analyses suggest that the benefits of HBPM on BP control are greatest when given with interventions.

More recent studies using 135/85 mm Hg as the home BP target have shown better BP control with HBPM with or without telemonitoring versus usual care.[30,31] Similar or better BP lowering has been observed in individuals titrating their own antihypertensive medication using HBPM under medical supervision.[32,33] Two studies showed that treatment titration aiming at achieving home BP levels <135/85 mm Hg improved indices of subclinical organ damage.[34,35] Stergiou et al[36] showed that compared to a strategy combining ABPM and office BP monitoring, HBPM resulted in similar outcomes in terms of end-organ damage regression. Longer-term follow-up of self-BP monitoring trials suggests that these benefits are sustained.[37] The benefits of HBPM may be mediated through the optimization of antihypertensive therapy (eg, reduction of clinical inertia) combined with increased medication adherence.[38]

Taken together, these results provide strong evidence suggesting that the use of HBPM to guide antihypertensive management may lead to better BP control, particularly when

accompanied by co-interventions. Finally, data indicate that HBPM with or without telemonitoring is cost-effective when compared to office BP measurement or usual care in individuals with hypertension.[39–43]

Home BP Threshold of 130/80 mm Hg

The 2017 ACC/AHA BP Guideline for the Prevention, Detection, Evaluation, and Management of High Blood Pressure in Adults[2] suggested lower BP thresholds (ie, office BP goal of 130/80 mm Hg) with the aim of preventing organ damage and CVD events.[44] At lower BP levels, the differences between office and home or daytime ambulatory BP values are smaller.[45] Data from observational studies using the regression and outcome-derived approaches suggest that the BP threshold for having high BP corresponding to an office BP of 130/80 mm Hg is 130/80 mm Hg for home and daytime BP on ABPM.[12]

The 2017 ACC/AHA BP guideline definition for hypertension status (office BP ≥130/80 mm Hg and home BP ≥130/80 mm Hg) has markedly changed the prevalence of hypertension subtypes compared to prior thresholds (ie, office BP ≥140/90 mm Hg and home BP ≥135/85 mm Hg). In the J-HOP study,[44] a general practice-based national registry of home BP, the prevalence of normotension, white coat uncontrolled hypertension, masked uncontrolled hypertension, and sustained hypertension was 31%, 15%, 19%, and 36%, respectively according to the thresholds (ie, 140/90 mm Hg for office BP and 135/85 mm Hg for home BP) proposed by the previous Joint National Committee 7 and the 2018 European Society of Cardiology/European Society of Hypertension guidelines. The prevalence of normotension, white coat uncontrolled hypertension, masked uncontrolled hypertension, and sustained hypertension was 14%, 17%, 10%, and 58%, respectively, according to the 2017 ACC/AHA BP guideline threshold definitions (ie, 130/80 mm Hg for both office BP and home BP).[44] Thus, the greatest impact of the reclassification of hypertension is an increased prevalence of sustained hypertension and lower prevalence of normotension. The population-based Ohasama study also demonstrated similar changes in the distribution of these 4 hypertension subtypes.[46,47]

A recent analysis of the Ohasama study demonstrated that partial masked hypertension, defined as having masked hypertension on HBPM but not ABPM or alternatively on ABPM but not HBPM, and complete masked hypertension, defined as having masked hypertension on both ABPM and HBPM, were associated with a similar risk for stroke events, when masked hypertension was defined using the BP thresholds of either the 2017 ACC/AHA BP guideline or the 2018 European Society of Cardiology/European Society of Hypertension guideline.[46]

A recent analysis of the Dallas Heart Study (n=5768) and the North Carolina Masked Hypertension study (n=420) used the regression-based approach to determine home BP thresholds corresponding to office BP of 130/80 mm Hg. Home BP was measured by research staff visiting the participants' home in the Dallas Heart Study, whereas home BP was self-measured in the North Carolina Masked Hypertension study. In these studies, home BP thresholds were 129/80 mm Hg in black participants, 130/80 mm Hg in white participants, and 126/78 mm Hg in Hispanic participants.[48] According to an outcome-derived approach based on the composite of CVD events or all-cause mortality over 11 years of follow-up of Dallas Heart Study participants, the home SBP thresholds corresponding to office SBP of 130 mm Hg were 130 mm Hg in black participants, 129 mm Hg in white participants, and 131 mm Hg in Hispanic participants. Home BP thresholds were identified using the outcomes-based approach for SBP only as home diastolic BP was not associated with outcomes. Both the regression-derived and outcome-derived approaches in these studies support a home BP threshold of 130/80 mm Hg for hypertension status in several racial/ethnic groups.[48] As these data are supported primarily by observational studies, randomized controlled trials should examine whether lowering of home BP leads to a reduction in cardiovascular events and also determine the optimal BP thresholds to define hypertension.[49]

There are several ongoing studies based on use of out-of-office BP in hypertension management. The INFINITY (Intensive Versus Standard Blood Pressure Lowering to Prevent Functional Decline in Older People Trial) recently demonstrated that intensive BP reduction to target 24-hour ambulatory SBP to <130 mm Hg resulted in slower progression of subcortical white matter disease in hypertensive adults of 75 years or older. However, no benefit in the cognitive or functional outcome was observed. The HIPAC trial ([Hypertension, Intracranial Pulsatility, and Brain A-Beta Accumulation in Older Adults], URL: http://www.clinicaltrials.gov. Unique identifier: NCT03354143) and MASTER ([Masked-Uncontrolled Hypertension Management Based on Office BP or on Ambulatory Blood Pressure Measurement] study, URL: http://www.clinicaltrials.gov. Unique identifier: NCT02804074)[50] will further clarify its role in the management of hypertension and prevention of target organ complications.

The Asia BP@Home study, the first study designed to investigate home BP control status in different Asian countries/regions using standardized home BP measurements taken with the same validated HBPM device, which has data memory capabilities, demonstrated that home BP is relatively well controlled at hypertension specialist centers.[51] However, almost half of all patients had uncontrolled morning BP according to the 2017 ACC/AHA BP guideline, with significant country/regional differences. In a study that enrolled 1443 patients taking antihypertensive medication from 15 Asian specialist centers in 11 countries/regions between April 2017 and March 2018, BP was controlled in 68.2% of patients using a morning home SBP normality cutoff of <135 mm Hg, and in 55.1% of patients using an office SBP cutoff of <140 mm Hg. However, when the cutoff values were changed to the 2017 ACC/AHA BP guideline threshold (SBP <130 mm Hg), only 53.6% of patients had controlled morning home SBP.[51]

Morning and Nocturnal Home BP

There are 3 subtypes of masked hypertension: morning hypertension, daytime hypertension, and nocturnal hypertension.[44] Although the current reference standard for identifying all 3 types of masked hypertension is ABPM,[52] HBPM can also be used.

Four studies conducted in Asia (Ohasama, J-HOP, HOMED BP, and HONEST) demonstrated that morning

home BP was a predictor of future CVD events.[13,20–23] The measurement of home BP during the morning period has been recommended before taking medications in several guidelines.[1–3] The 2018 European Society of Cardiology/European Society of Hypertension guidelines recommend HBPM being performed during the morning and evening, with the latter being measured before dinner. However, in Asian countries, individuals usually eat dinner before returning home from work, and in Japan, adults usually take an evening bath. For this reason, evening home BP measurement just before bedtime is recommended,[3–6] and in the absence of evening home BP measurement, morning home BP measurement alone may be sufficient for identifying hypertension as a first step toward home BP-guided management and has been successful in self-titration studies.[4,5,32,33] An additional advantage of conducting morning BP measurements before taking medications is the ability to detect through BP levels among individuals taking antihypertensive medications in the morning.[53]

In addition to controlling morning and evening home BP, the control of nocturnal BP should be considered since evidence suggests it is the most important aspect of the 24-hour BP profile for predicting the risk for CVD outcomes.[54,55] In the past, nighttime BP could only be measured with ABPM, but more recently, new HBPM devices have been developed that measure nighttime BP.[56,57] These devices automatically measure and store BP readings at preprogrammed times (eg, 2 AM, 3 AM, and 4 AM) or at a fixed time period after going to bed (eg, 2, 3, and 4 hours after going to bed). The device is removed by the person the next morning, after awakening. The minimum number of readings and the interval for obtaining a reliable estimate of nocturnal home BP have not been determined.[58] Nocturnal hypertension is common among high-risk patients, including those with diabetes mellitus, chronic kidney disease, or sleep apnea. The J-HOP study showed that nocturnal home BP was more closely associated with hypertensive organ damage than office, morning home, and evening home BP. Among individuals with controlled morning home BP (<135/85 mm Hg), uncontrolled nocturnal BP (≥120/70 mm Hg) has been associated with increased urinary albumin/creatinine ratio and plasma NT-proBNP (N-terminal pro-B-type natriuretic peptide).[59] In the J-HOP study, nocturnal home SBP was a stronger predictor of CVD events than office and morning home SBP measurements.[60] It has been shown that there is good agreement between HBPM and ABPM for detecting nondippers.[61] A recent meta-analysis showed that ABPM and nocturnal HBPM provide similar BP values and associations with target organ damage.[62] Thus, either ABPM or nocturnal HBPM may be useful for detecting nocturnal hypertension and nondippers and for the management of uncontrolled nocturnal BP.

In prior studies, an office BP of 140/90 mm Hg has corresponded with a nighttime BP of 120/70 mm Hg and a home BP and daytime BP on ABPM of 135/85 mm Hg (Table 2). Also, for an office BP of 130/80 mm Hg, which corresponds to a 130/80 mm Hg threshold for home BP and daytime BP on ABPM, the 2017 ACC/AHA BP guideline recommends a nighttime BP threshold of 110/65 mm Hg for having nocturnal hypertension (Table 2). A large proportion of patients with controlled morning home SBP have uncontrolled nighttime SBP: 30% using a 120 mm Hg threshold for nighttime SBP; and 56% using a 110 mm Hg threshold for nighttime SBP.[63] Thus, nocturnal HBPM may identify individuals with controlled morning BP who have high nighttime SBP and residual CVD risk, especially among those who at increased risk for having nocturnal hypertension (eg, those with CKD, sleep apnea, or diabetes mellitus).

Table 2. Corresponding Values of Clinic, Home, Daytime, Nighttime, and 24-Hour BP Measurements (2017 American College of Cardiology/American Heart Association Guidelines)

Clinic	HBPM	Daytime ABPM	Nighttime ABPM	24-Hour ABPM
120/80	120/80	120/80	100/65	115/75
130/80	130/80	130/80	110/65	125/75
140/90	135/85	135/85	120/70	130/80
160/100	145/90	145/90	140/85	145/90

ABPM indicates ambulatory blood pressure monitoring; BP, blood pressure; and HBPM, home blood pressure monitoring.

Additional Measures on HBPM

Additional information provided by HBPM should also be investigated for possible clinical relevance. In particular, increased day-by-day BP variability on HBPM has been reported to be associated with increased CVD risk, independent of average home BP level in both general and clinical populations.[17,64–66] Further, large seasonal home BP variation and inverse seasonal home BP changes (ie, an increase in home BP during the summer compared to the winter) have been associated with an increased risk of CVD events in individuals taking antihypertensive medication.[67]

Barriers to HBPM

HBPM requires a long-term commitment from patients in taking their BP over days or weeks. Clinicians are often concerned that some patients may obtain self-home measurements too frequently leading to additional consultations and may self-modify their treatment inappropriately.[68] Furthermore, variation in BP may lead to concerns. Also, HBPM devices without memory function capabilities require reliance on the individual to document their BP readings. Some previous studies have suggested that such documentation may be erroneous although more recent data suggest that 90% or more of readings are accurate.[69] Providers are concerned about the use of nonvalidated HBPM devices, lack of knowledge of where to purchase validated devices, and lack of knowledge of standardized HBPM protocols.[70] An additional barrier is that providers may not have time to properly train patients.[68] Finally, practices may not have the infrastructure to implement co-interventions.

Follow-Up Strategy for Treated Hypertensive Individuals Using HBPM and ABPM

The Figure shows a strategy for those already on treatment of hypertension based on office BP, HBPM, and ABPM that we recommend. Among individuals with office BP ≥130/80 mm Hg, HBPM should be conducted to exclude white coat uncontrolled hypertension. Individuals are diagnosed with

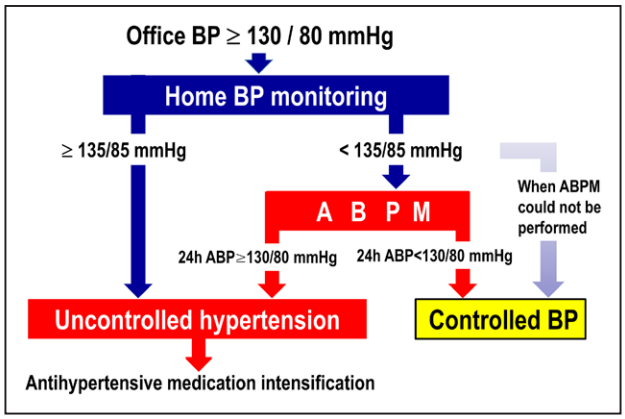

Figure. Follow-up strategy of treated individuals with uncontrolled office hypertension. This approach is not representative of the 2017 American College of Cardiology/American Heart Association BP guideline. ABPM indicates ambulatory blood pressure monitoring; and BP, blood pressure.

uncontrolled hypertension if home BP ≥135/85 mm Hg. If white coat uncontrolled hypertension is concerned or there is evidence of target organ damage among individuals with home BP <135/85 mm Hg, ABPM should be performed. Individuals are diagnosed with controlled BP if ABPM <130/80 mm Hg in 24 hours. For the detection of masked uncontrolled hypertension, HBPM may also performed in individuals with treated hypertension who have office BP <130/80 mm Hg if baseline cardiovascular risk is high.

Conclusions

There is strong evidence that high home BP is associated with increased CVD risk. HBPM can be used to identify specific hypertension phenotypes such as white coat hypertension, masked hypertension, white coat uncontrolled hypertension, and masked uncontrolled hypertension. Morning hypertension, based on the average of morning home BP readings, and nocturnal hypertension, based on the average of nighttime BP readings on nocturnal HBPM can be detected by newer HBPM devices. The proposal of using lower office BP and home BP thresholds by the 2017 ACC/AHA BP guideline (ie, 130/80 mm Hg for both office BP and home BP) has raised new perspectives about hypertension diagnosis and management, but has also added some uncertainties in this field. Randomized controlled trials are needed to define the optimal home BP threshold and target goal for the appropriate use of HBPM in routine management of hypertension, including investigations focused on the nocturnal home BP levels.

Perspectives

In the era of exponential progress in the field of information and communication technology, having home BP values self-measured by patients daily, and remotely sent to electronic health records and providers may increase the accuracy of hypertension diagnosis, and the efficacy of its management, in particular when HBPM is accompanied by co-interventions. In addition, HBPM accompanied by information on patients' living conditions could provide integrated data that might more precisely guide hypertension management, thus helping to reduce CVD risk.[71] Available evidence suggests that HBPM is an important adjunct to office BP measurement for the diagnosis of hypertension and for monitoring BP control among patients taking antihypertensive medication. In addition, HBPM may itself have a favorable impact on hypertension control, by improving medication adherence. Although office BP remains the standard method for evaluating BP in real-world clinical practice, data from systematic reviews and meta-analyses suggest that HBPM particularly when accompanied by co-interventions reduces BP and is associated with a higher rate of BP control. Therefore, HBPM is an important tool for the management of hypertension.

Sources of Funding

None.

Disclosures

K. Kario has received research grants from Omron Healthcare and A&D Co; R.J. McManus has received blood pressure monitors for research purposes from Omron; G. Parati has received honoraria for lectures by Pfizer, Sanofi, Bayer Healthcare, and Omron Healthcare; M.A. Weber has received travel support from Omron. The other authors report no conflicts.

References

1. Williams B, Mancia G, Spiering W, et al; ESC Scientific Document Group. 2018 ESC/ESH Guidelines for the management of arterial hypertension. *Eur Heart J*. 2018;39:3021–3104. doi: 10.1093/eurheartj/ehy339
2. Whelton PK, Carey RM, Aronow WS, et al. 2017 ACC/AHA/AAPA/ABC/ACPM/AGS/APhA/ASH/ASPC/NMA/PCNA Guideline for the prevention, detection, evaluation, and management of high blood pressure in adults: executive summary: a report of the American College of Cardiology/American Heart Association task force on clinical practice guidelines. *Hypertension*. 2018;71:1269–1324.
3. Shimamoto K, Ando K, Fujita T, et al; Japanese Society of Hypertension Committee for Guidelines for the Management of Hypertension. The Japanese Society of Hypertension Guidelines for the Management of Hypertension (JSH 2014). *Hypertens Res*. 2014;37:253–390. doi: 10.1038/hr.2014.20
4. Park S, Buranakitjaroen P, Chen CH, et al; HOPE Asia Network. Expert panel consensus recommendations for home blood pressure monitoring in Asia: the Hope Asia Network. *J Hum Hypertens*. 2018;32:249–258. doi: 10.1038/s41371-017-0025-y
5. Kario K, Park S, Buranakitjaroen P, et al. Guidance on home blood pressure monitoring: a statement of the HOPE Asia Network. *J Clin Hypertens (Greenwich)*. 2018;20:456–461.
6. Kario K, Chen CH, Park S, Park CG, Hoshide S, Cheng HM, Huang QF, Wang JG. Consensus document on improving hypertension management in Asian Patients, taking into account Asian characteristics. *Hypertension*. 2018;71:375–382. doi: 10.1161/HYPERTENSIONAHA.117.10238
7. Pierdomenico SD, Pierdomenico AM, Coccina F, Clement DL, De Buyzere ML, De Bacquer DA, Ben-Dov IZ, Vongpatanasin W, Banegas JR, Ruilope LM, Thijs L, Staessen JA. Prognostic value of masked uncontrolled hypertension. *Hypertension*. 2018;72:862–869. doi: 10.1161/HYPERTENSIONAHA.118.11499
8. Kario K, Thijs L, Staessen JA. Blood pressure measurement and treatment decisions: masked and white coat hypertension. *Circ Res*. 2019;124:990–1008.
9. Imai Y, Otsuka K, Kawano Y, Shimada K, Hayashi H, Tochikubo O, Miyakawa M, Fukiyama K; Japanese Society of Hypertension. Japanese society of hypertension (JSH) guidelines for self-monitoring of blood pressure at home. *Hypertens Res*. 2003;26:771–782. doi: 10.1291/hypres.26.771
10. Imai Y, Kario K, Shimada K, Kawano Y, Hasebe N, Matsuura H, Tsuchihashi T, Ohkubo T, Kuwajima I, Miyakawa M. Japanese Society of Hypertension Committee for Guidelines for Self-monitoring of Blood Pressure at Home. The Japanese Society of Hypertension guidelines for self-monitoring of blood pressure at home (Second Edition). *Hypertens Res*. 2012;35:777–795.
11. Muntner P, Shimbo D, Carey RM, Charleston JB, Gaillard T, Misra S, Myers MG, Ogedegbe G, Schwartz JE, Townsend RR, Urbina EM, Viera AJ, White WB, Wright JT Jr; on Behalf of the American Heart

Association Council on Hypertension; Council on Cardiovascular Disease in the Young; Council on Cardiovascular and Stroke Nursing; Council on Cardiovascular Radiology and Intervention; Council on Clinical Cardiology; and Council on Quality of Care and Outcomes Research. Measurement of blood pressure in humans: a scientific statement from the American Heart Association. *Hypertension*. 2019;73:e35–e66. doi: 10.1161/HYP.0000000000000087

12. Muntner P, Carey RM, Jamerson K, Wright JT Jr, Whelton PK. Rationale for ambulatory and home blood pressure monitoring thresholds in the 2017 American College of Cardiology/American Heart Association Guideline. *Hypertension*. 2019;73:33–38. doi: 10.1161/HYPERTENSIONAHA.118.11946
13. Ohkubo T, Imai Y, Tsuji I, Nagai K, Kato J, Kikuchi N, Nishiyama A, Aihara A, Sekino M, Kikuya M, Ito S, Satoh H, Hisamichi S. Home blood pressure measurement has a stronger predictive power for mortality than does screening blood pressure measurement: a population-based observation in Ohasama, Japan. *J Hypertens*. 1998;16:971–975.
14. Sega R, Facchetti R, Bombelli M, Cesana G, Corrao G, Grassi G, Mancia G. Prognostic value of ambulatory and home blood pressures compared with office blood pressure in the general population: follow-up results from the Pressioni Arteriose Monitorate e Loro Associazioni (PAMELA) study. *Circulation*. 2005;111:1777–1783. doi: 10.1161/01.CIR.0000160923.04524.5B
15. Hänninen MR, Niiranen TJ, Puukka PJ, Johansson J, Jula AM. Prognostic significance of masked and white-coat hypertension in the general population: the Finn-Home Study. *J Hypertens*. 2012;30:705–712. doi: 10.1097/HJH.0b013e328350a69b
16. Tientcheu D, Ayers C, Das SR, McGuire DK, de Lemos JA, Khera A, Kaplan N, Victor R, Vongpatanasin W. Target organ complications and cardiovascular events associated with masked hypertension and white-coat hypertension: analysis From the Dallas Heart Study. *J Am Coll Cardiol*. 2015;66:2159–2169. doi: 10.1016/j.jacc.2015.09.007
17. Ntineri A, Kalogeropoulos PG, Kyriakoulis KG, Aissopou EK, Thomopoulou G, Kollias A, Stergiou GS. Prognostic value of average home blood pressure and variability: 19-year follow-up of the Didima study. *J Hypertens*. 2018;36:69–76. doi: 10.1097/HJH.0000000000001497
18. Bobrie G, Chatellier G, Genes N, Clerson P, Vaur L, Vaisse B, Menard J, Mallion JM. Cardiovascular prognosis of "masked hypertension" detected by blood pressure self-measurement in elderly treated hypertensive patients. *JAMA*. 2004;291:1342–1349. doi: 10.1001/jama.291.11.1342
19. Fagard RH, Van Den Broeke C, De Cort P. Prognostic significance of blood pressure measured in the office, at home and during ambulatory monitoring in older patients in general practice. *J Hum Hypertens*. 2005;19:801–807. doi: 10.1038/sj.jhh.1001903
20. Asayama K, Ohkubo T, Metoki H, Obara T, Inoue R, Kikuya M, Thijs L, Staessen JA, Imai Y; Hypertension Objective Treatment Based on Measurement by Electrical Devices of Blood Pressure (HOMED-BP). Cardiovascular outcomes in the first trial of antihypertensive therapy guided by self-measured home blood pressure. *Hypertens Res*. 2012;35:1102–1110. doi: 10.1038/hr.2012.125
21. Kario K, Saito I, Kushiro T, Teramukai S, Ishikawa Y, Mori Y, Kobayashi F, Shimada K. Home blood pressure and cardiovascular outcomes in patients during antihypertensive therapy: primary results of HONEST, a large-scale prospective, real-world observational study. *Hypertension*. 2014;64:989–996. doi: 10.1161/HYPERTENSIONAHA.114.04262
22. Kario K, Saito I, Kushiro T, Teramukai S, Tomono Y, Okuda Y, Shimada K. Morning home blood pressure is a strong predictor of coronary artery disease: the HONEST Study. *J Am Coll Cardiol*. 2016;67:1519–1527. doi: 10.1016/j.jacc.2016.01.037
23. Hoshide S, Yano Y, Haimoto H, Yamagiwa K, Uchiba K, Nagasaka S, Matsui Y, Nakamura A, Fukutomi M, Eguchi K, Ishikawa J, Kario K; J-HOP Study Group. Morning and evening home blood pressure and risks of incident stroke and coronary artery disease in the Japanese general practice population: the Japan Morning Surge-Home Blood Pressure Study. *Hypertension*. 2016;68:54–61. doi: 10.1161/HYPERTENSIONAHA.116.07201
24. Fujiwara T, Yano Y, Hoshide S, Kanegae H, Kario K. Association of cardiovascular outcomes with masked hypertension defined by home blood pressure monitoring in a Japanese general practice population. *JAMA Cardiol*. 2018;3:583–590. doi: 10.1001/jamacardio.2018.1233
25. Kario K, Iwashita M, Okuda Y, Sugiyama M, Saito I, Kushiro T, Teramukai S, Shimada K. Morning home blood pressure and cardiovascular events in Japanese hypertensive patients. *Hypertension*. 2018;72:854–861. doi: 10.1161/HYPERTENSIONAHA.118.11388
26. Okumiya K, Matsubayashi K, Wada T, Fujisawa M, Osaki Y, Doi Y, Yasuda N, Ozawa T. A U-shaped association between home systolic blood pressure and four-year mortality in community-dwelling older men. *J Am Geriatr Soc*. 1999;47:1415–1421.
27. Tsuji I, Imai Y, Nagai K, Ohkubo T, Watanabe N, Minami N, Itoh O, Bando T, Sakuma M, Fukao A, Satoh H, Hisamichi S, Abe K. Proposal of reference values for home blood pressure measurement: prognostic criteria based on a prospective observation of the general population in Ohasama, Japan. *Am J Hypertens*. 1997;10(4 pt 1):409–418.
28. Tucker KL, Sheppard JP, Stevens R, et al. Self-monitoring of blood pressure in hypertension: a systematic review and individual patient data meta-analysis. *PLoS Med*. 2017;14:e1002389.
29. Uhlig K, Patel K, Ip S, Kitsios GD, Balk EM. Self-measured blood pressure monitoring in the management of hypertension: a systematic review and meta-analysis. *Ann Intern Med*. 2013;159:185–194. doi: 10.7326/0003-4819-159-3-201308060-00008
30. Stoddart A, Hanley J, Wild S, Pagliari C, Paterson M, Lewis S, Sheikh A, Krishan A, Padfield P, McKinstry B. Telemonitoring-based service redesign for the management of uncontrolled hypertension (HITS): cost and cost-effectiveness analysis of a randomised controlled trial. *BMJ Open*. 2013;3:e002681. doi: 10.1136/bmjopen-2013-002681
31. McManus RJ, Mant J, Franssen M, et al; TASMINH4 Investigators. Efficacy of self-monitored blood pressure, with or without telemonitoring, for titration of antihypertensive medication (TASMINH4): an unmasked randomised controlled trial. *Lancet*. 2018;391:949–959. doi: 10.1016/S0140-6736(18)30309-X
32. McManus RJ, Mant J, Bray EP, Holder R, Jones MI, Greenfield S, Kaambwa B, Banting M, Bryan S, Little P, Williams B, Hobbs FD. Telemonitoring and self-management in the control of hypertension (TASMINH2): a randomised controlled trial. *Lancet*. 2010;376:163–172. doi: 10.1016/S0140-6736(10)60964-6
33. McManus RJ, Mant J, Haque MS, et al. Effect of self-monitoring and medication self-titration on systolic blood pressure in hypertensive patients at high risk of cardiovascular disease: the TASMIN-SR randomized clinical trial. *JAMA*. 2014;312:799–808.
34. Kario K, Matsui Y, Shibasaki S, Eguchi K, Ishikawa J, Hoshide S, Ishikawa S, Kabutoya T, Schwartz JE, Pickering TG, Shimada K; Japan Morning Surge-1 (JMS-1) Study Group. An alpha-adrenergic blocker titrated by self-measured blood pressure recordings lowered blood pressure and microalbuminuria in patients with morning hypertension: the Japan Morning Surge-1 Study. *J Hypertens*. 2008;26:1257–1265. doi: 10.1097/HJH.0b013e3282fd173c
35. Kario K, Hoshide S, Shimizu M, Yano Y, Eguchi K, Ishikawa J, Ishikawa S, Shimada K. Effect of dosing time of angiotensin II receptor blockade titrated by self-measured blood pressure recordings on cardiorenal protection in hypertensives: the Japan Morning Surge-Target Organ Protection (J-TOP) study. *J Hypertens*. 2010;28:1574–1583. doi: 10.1097/HJH.0b013e3283395267
36. Stergiou GS, Karpettas N, Destounis A, Tzamouranis D, Nasothimiou E, Kollias A, Roussias L, Moyssakis I. Home blood pressure monitoring alone vs. combined clinic and ambulatory measurements in following treatment-induced changes in blood pressure and organ damage. *Am J Hypertens*. 2014;27:184–192. doi: 10.1093/ajh/hpt206
37. Maciejewski ML, Bosworth HB, Olsen MK, Smith VA, Edelman D, Powers BJ, Kaufman MA, Oddone EZ, Jackson GL. Do the benefits of participation in a hypertension self-management trial persist after patients resume usual care? *Circ Cardiovasc Qual Outcomes*. 2014;7:269–275. doi: 10.1161/CIRCOUTCOMES.113.000309
38. Fletcher BR, Hartmann-Boyce J, Hinton L, McManus RJ. The effect of self-monitoring of blood pressure on medication adherence and lifestyle factors: a systematic review and meta-analysis. *Am J Hypertens*. 2015;28:1209–1221. doi: 10.1093/ajh/hpv008
39. Omboni S, Gazzola T, Carabelli G, Parati G. Clinical usefulness and cost effectiveness of home blood pressure telemonitoring: meta-analysis of randomized controlled studies. *J Hypertens*. 2013;31:455–467; discussion 467. doi: 10.1097/HJH.0b013e32835ca8dd
40. Jacob V, Chattopadhyay SK, Proia KK, Hopkins DP, Reynolds J, Thota AB, Jones CD, Lackland DT, Rask KJ, Pronk NP, Clymer JM, Goetzel RZ; Community Preventive Services Task Force. Economics of self-measured blood pressure monitoring: a community guide systematic review. *Am J Prev Med*. 2017;53:e105–e113. doi: 10.1016/j.amepre.2017.03.002
41. Fukunaga H, Ohkubo T, Kobayashi M, Tamaki Y, Kikuya M, Obara T, Nakagawa M, Hara A, Asayama K, Metoki H, Inoue R, Hashimoto J, Totsune K, Imai Y. Cost-effectiveness of the introduction of home blood pressure measurement in patients with office hypertension. *J Hypertens*. 2008;26:685–690. doi: 10.1097/HJH.0b013e3282f42285

42. Arrieta A, Woods JR, Qiao N, Jay SJ. Cost-benefit analysis of home blood pressure monitoring in hypertension diagnosis and treatment: an insurer perspective. *Hypertension*. 2014;64:891–896. doi: 10.1161/HYPERTENSIONAHA.114.03780
43. Penaloza-Ramos MC, Jowett S, Mant J, Schwartz C, Bray EP, Sayeed Haque M, Richard Hobbs FD, Little P, Bryan S, Williams B, McManus RJ. Cost-effectiveness of self-management of blood pressure in hypertensive patients over 70 years with suboptimal control and established cardiovascular disease or additional cardiovascular risk diseases (TASMIN-SR). *Eur J Prev Cardiol*. 2016;23:902–912. doi: 10.1177/2047487315618784
44. Kario K. Global impact of 2017 American Heart Association/American College of Cardiology Hypertension Guidelines: a perspective from Japan. *Circulation*. 2018;137:543–545. doi: 10.1161/CIRCULATIONAHA.117.032851
45. Niiranen TJ, Asayama K, Thijs L, Johansson JK, Ohkubo T, Kikuya M, Boggia J, Hozawa A, Sandoya E, Stergiou GS, Tsuji I, Jula AM, Imai Y, Staessen JA; International Database of Home Blood Pressure in Relation to Cardiovascular Outcome Investigators. Outcome-driven thresholds for home blood pressure measurement: international database of home blood pressure in relation to cardiovascular outcome. *Hypertension*. 2013;61:27–34. doi: 10.1161/HYPERTENSIONAHA.111.00100
46. Satoh M, Asayama K, Murakami T, Kikuya M, Metoki H, Imai Y, Ohkubo T. Stroke risk due to partial white-coat or masked hypertension based on the ACC/AHA guideline's blood pressure threshold: the Ohasama study. *Hypertens Res*. 2019;42:120–122. doi: 10.1038/s41440-018-0133-2
47. Poudel B, Booth JN III, Sakhuja S, Moran AE, Schwartz JE, Lloyd-Jones DM, Lewis CE, Shikany JM, Shimbo D, Muntner P. Prevalence of ambulatory blood pressure phenotypes using the 2017 American College of Cardiology/American Heart Association blood pressure guideline thresholds. *J Hypertens*. 2019. In press. doi: 10.1097/HJH.0000000000002055
48. Vongpatanasin W, Ayers C, Lodhi H, Das SR, Berry JD, Khera A, Victor RG, Lin FC, Viera AJ, Yano Y, de Lemos JA. Diagnostic thresholds for blood pressure measured at home in the context of the 2017 hypertension guideline. *Hypertension.* 2018;72:1312–1319. doi: 10.1161/HYPERTENSIONAHA.118.11657
49. Muntner P, Shimbo D. Out-of-clinic blood pressure thresholds for diagnosing and managing hypertension, filling an important evidence gap. *Hypertension.* 2018;72:1266–1268. doi: 10.1161/HYPERTENSIONAHA.118.11980
50. Parati G, Agabiti-Rosei E, Bakris GL, et al. MASked-unconTrolled hypERtension management based on office BP or on ambulatory blood pressure measurement (MASTER) Study: a randomised controlled trial protocol. *BMJ Open*. 2018;8:e021038.
51. Kario K, Tomitani N, Buranakitjaroen P, et al; Hope Asia Network. Home blood pressure control status in 2017–2018 for hypertension specialist centers in Asia: results of the Asia BP@Home study. *J Clin Hypertens (Greenwich)*. 2018;20:1686–1695. doi: 10.1111/jch.13415
52. Anstey DE, Muntner P, Bello NA, Pugliese DN, Yano Y, Kronish IM, Reynolds K, Schwartz JE, Shimbo D. Diagnosing masked hypertension using ambulatory blood pressure monitoring, home blood pressure monitoring, or both? *Hypertension*. 2018;72:1200–1207. doi: 10.1161/HYPERTENSIONAHA.118.11319
53. Stergiou GS, Efstathiou SP, Skeva II, Baibas NM, Roussias LG, Mountokalakis TD. Comparison of the smoothness index, the trough: peak ratio and the morning: evening ratio in assessing the features of the antihypertensive drug effect. *J Hypertens*. 2003;21:913–920. doi: 10.1097/01.hjh.0000059017.82022.83
54. Kario K. *Essential Manual on Perfect 24-Hour Blood Pressure Management From Morning to Nocturnal Hypertension: Up-to-Date for Anticipation Medicine*. Tokyo, Japan: Wiley-Blackwell; 2018:1–309.
55. Hansen TW, Li Y, Boggia J, Thijs L, Richart T, Staessen JA. Predictive role of the nighttime blood pressure. *Hypertension*. 2011;57:3–10. doi: 10.1161/HYPERTENSIONAHA.109.133900
56. Kario K. Nocturnal hypertension: hew technology and evidence. *Hypertension*. 2018;71:997–1009. doi: 10.1161/HYPERTENSIONAHA.118.10971
57. Asayama K, Fujiwara T, Hoshide S, Ohkubo T, Kario K, Stergiou GS, Parati G, White WB, Weber MA, Imai Y; International Expert Group of Nocturnal Home Blood Pressure. Nocturnal blood pressure measured by home devices: evidence and perspective for clinical application. *J Hypertens*. 2019;37:905–916. doi: 10.1097/HJH.0000000000001987
58. Kollias A, Andreadis E, Agaliotis G, Kolyvas GN, Achimastos A, Stergiou GS. The optimal night-time home blood pressure monitoring schedule: agreement with ambulatory blood pressure and association with organ damage. *J Hypertens*. 2018;36:243–249. doi: 10.1097/HJH.0000000000001562
59. Kario K, Hoshide S, Haimoto H, Yamagiwa K, Uchiba K, Nagasaka S, Yano Y, Eguchi K, Matsui Y, Shimizu M, Ishikawa J, Ishikawa S; J-HOP Study Group. Sleep blood pressure self-measured at home as a novel determinant of organ damage: Japan morning surge home blood pressure (J-HOP) study. *J Clin Hypertens (Greenwich)*. 2015;17:340–348. doi: 10.1111/jch.12500
60. Kario K, Kanegae H, Tomitani N, Okawara Y, Fujiwara T, Yano Y, Hoshide S; on Behalf of the J-HOP Study Group. Nighttime blood pressure measured by home blood pressure monitoring as an independent predictor of cardiovascular events in general practice: the J-HOP Nocturnal BP Study. *Hypertension*. 2019;73:1240–1248. doi: 10.1161/HYPERTENSIONAHA.118.12740
61. Stergiou GS, Nasothimiou EG, Destounis A, Poulidakis E, Evagelou I, Tzamouranis D. Assessment of the diurnal blood pressure profile and detection of non-dippers based on home or ambulatory monitoring. *Am J Hypertens*. 2012;25:974–978. doi: 10.1038/ajh.2012.82
62. Kollias A, Ntineri A, Stergiou GS. Association of night-time home blood pressure with night-time ambulatory blood pressure and target-organ damage: a systematic review and meta-analysis. *J Hypertens*. 2017;35:442–452. doi: 10.1097/HJH.0000000000001189
63. Kario K, Wang JG. Could 130/80 mm Hg be adopted as the diagnostic threshold and management goal of hypertension in consideration of the characteristics of Asian populations? *Hypertension*. 2018;71:979–984. doi: 10.1161/HYPERTENSIONAHA.118.11203
64. Kikuya M, Ohkubo T, Metoki H, Asayama K, Hara A, Obara T, Inoue R, Hoshi H, Hashimoto J, Totsune K, Satoh H, Imai Y. Day-by-day variability of blood pressure and heart rate at home as a novel predictor of prognosis: the Ohasama study. *Hypertension*. 2008;52:1045–1050. doi: 10.1161/HYPERTENSIONAHA.107.104620
65. Johansson JK, Niiranen TJ, Puukka PJ, Jula AM. Prognostic value of the variability in home-measured blood pressure and heart rate: the Finn-Home Study. *Hypertension*. 2012;59:212–218. doi: 10.1161/HYPERTENSIONAHA.111.178657
66. Hoshide S, Yano Y, Mizuno H, Kanegae H, Kario K. Day-by-day variability of home blood pressure and incident cardiovascular disease in clinical practice: the J-HOP Study (Japan Morning Surge-Home Blood Pressure). *Hypertension*. 2018;71:177–184. doi: 10.1161/HYPERTENSIONAHA.117.10385
67. Hanazawa T, Asayama K, Watabe D, Tanabe A, Satoh M, Inoue R, Hara A, Obara T, Kikuya M, Nomura K, Metoki H, Imai Y, Ohkubo T; HOMED-BP (Hypertension Objective Treatment Based on Measurement by Electrical Devices of Blood Pressure) Investigators. Association between amplitude of seasonal variation in self-measured home blood pressure and cardiovascular outcomes: HOMED-BP (Hypertension Objective Treatment Based on Measurement By Electrical Devices of Blood Pressure) study. *J Am Heart Assoc*. 2018;7:e008509. doi: 10.1161/JAHA.117.008509.
68. Jones MI, Greenfield SM, Bray EP, Hobbs FR, Holder R, Little P, Mant J, Williams B, McManus RJ. Patient self-monitoring of blood pressure and self-titration of medication in primary care: the TASMINH2 trial qualitative study of health professionals' experiences. *Br J Gen Pract*. 2013;63:e378–e385. doi: 10.3399/bjgp13X668168
69. Schwartz CL, Seyed-Safi A, Haque S, Bray EP, Greenfield S, Hobbs FDR, Little P, Mant J, Williams B, Mcmanus RJ. Do patients actually do what we ask: patient fidelity and persistence to the Targets and Self-Management for the Control of Blood Pressure in Stroke and at Risk Groups blood pressure self-management intervention. *J Hypertens*. 2018;36:1753–1761. doi: 10.1097/HJH.0000000000001738
70. Grant S, Hodgkinson JA, Milner SL, Martin U, Tompson A, Hobbs FR, Mant J, McManus RJ, Greenfield SM. Patients' and clinicians' views on the optimum schedules for self-monitoring of blood pressure: a qualitative focus group and interview study. *Br J Gen Pract*. 2016;66:e819–e830. doi: 10.3399/bjgp16X686149
71. Kario K, Tomitani N, Kanegae H, Yasui N, Nagai R, Harada H. The further development of out-of-office BP monitoring: Japan's ImPACT Program Project's achievements, impact, and direction. *J Clin Hypertens (Greenwich)*. 2019;21:344–349. doi: 10.1111/jch.13495