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STATE-OF-THE-ART REVIEW

Modern Management and Diagnosis of Hypertension in the United Kingdom: Home Care and Self-care

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Abstract

BACKGROUND The effective diagnosis and management of hypertension is one of the most important parts of cardiovascular prevention internationally and this is no different in the United Kingdom. Approximately 14% of the UK population currently receive treatment for hypertension. Recent UK guidelines from the National Institute of Health and Care Excellence have placed greater emphasis on the utilization of out-of-office measurement of blood pressure to more accurately diagnose hypertension.

OBJECTIVE The aim of the present study was to provide a state-of-the-art review of the evidence for screening, diagnosing, and managing hypertension, as implemented in the United Kingdom, with an emphasis on the role of self-monitored and ambulatory blood pressure monitoring in routine clinical care.

METHOD Consideration was given to the use of ambulatory and home monitoring to confirm a diagnosis of hypertension and the use of self-monitoring and self-management to monitor and guide treatment. The evidence for the use of self-monitoring in patients with hypertension was examined, both in isolation, and in combination with lifestyle and treatment interventions.

FINDINGS There is a place for self-monitored blood pressure in specific underresearched populations such as the elderly, specialist conditions, ethnic groups, and during pregnancy and this is discussed here.

CONCLUSIONS The evidence supporting the use of out-of-office monitoring in all aspects of routine clinical care has increased substantially in recent years and is reflected in increased utilization by patients and clinicians alike. Several areas require further research but it is clear that out-of-office monitoring is here to stay and is fast becoming an important part of hypertension management in the United Kingdom.

KEY WORDS blood pressure, hypertension, self-monitoring, home monitoring, self-management

INTRODUCTION: HYPERTENSION IN A UK CONTEXT

The detection and treatment of hypertension (HTN)—perhaps the most important modifiable risk factor for cardiovascular disease (CVD) worldwide—is an important part of preventative care as provided in the United Kingdom.[1,2] Approximately 14% of the UK population receive treatment for HTN, mostly delivered through

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primary care and led by general practitioners (family physicians), working in tandem with nursing, pharmacy, and administrative colleagues.[3] Utilizing the integrated nature of the National Health Service (NHS), specialist input into HTN management concentrates on the identification and treatment of secondary HTN and the ongoing management of difficult cases such as those with resistant HTN or complex comorbid disease.[4] National UK policy is guided by evidence-based national guidelines for HTN developed by the National Institute for Health and Care Excellence (NICE). Since 2011, these guidelines have placed much greater emphasis on the utilization of out-of-office measurement of blood pressure (BP) using ambulatory (ABPM) and home or self-monitored blood pressure (SMBP).[5]

This study seeks to provide a state-of-the-art review of the evidence for screening, diagnosing, and managing HTN as implemented in the United Kingdom, with an emphasis on the role of SMBP or ABPM (definitions in Table 1) in routine clinical care. Consideration is given to the current evidence underpinning methods of screening and diagnosis with home and ABPM, optimum treatment targets and protocols for managing HTN with self-monitored readings, and the evidence for using SMBP in specialist subpopulations such as the elderly, multimorbid, certain ethnic groups, and in pregnant women.

DIAGNOSING HYPERTENSION IN A UK CONTEXT

Screening for Hypertension. Hypertension is typically detected in the United Kingdom through either opportunistic or systematic screening in a primary care setting.[6] Opportunistic screening is part of the UK pay-for-performance program and results in about 90% of all adults >40 years of age having a BP check within a 5-year time period. Systematic screening has increased in recent years through the introduction of the NHS health check in 2009, where patients aged 40 to 74 years with no history of CVD are invited for assessment of risk factors including BP.[7] Uptake of this program has not been universal,[8,9] with nonattenders citing reasons for nonattendance such as a lack of understanding about what it involves and that such screening is not a priority.[10] However, in those who do attend, recent studies have suggested that high BP, requiring further diagnostic testing, is detected in 34% men and 25% of women,[11] and there is some evidence that a systematic approach to screening can increase detection of HTN compared with opportunistic screening.[12]

An alternative and novel approach to screening in primary care is through self-screening in the community. This involves nonphysicians or individuals measuring their own BP in settings such as pharmacies, libraries, or supermarkets.[13] Most self-screening is opportunistic and a recent review of nonphysician screening for HTN identified wide variation in the uptake of screening by eligible patients (6%-99%), with variation consistent across settings.[6] Few studies followed up participants adequately, but in those that did, approximately 0.5% to 6.6% of participants screened went on to have a new diagnosis of hypertension.[14,15] At the moment, such screening in the United Kingdom is on an ad hoc basis but it is growing with several large pharmacy groups in particular offering it as a service.[16]

Table 1. Definitions of Blood Pressure Measurements Described in Present Study

Term	Definition
Clinic blood pressure	Clinic blood pressure reading from a single clinic visit using a mercury or electronic sphygmomanometer
24-hour ambulatory blood pressure	Ambulatory blood pressure measured at 15- to 60-min intervals over 24 h (intervals vary between day- and night-time periods)
Daytime ambulatory blood pressure	Ambulatory blood pressure measured at 15- to 30- min intervals during the daytime (definition of daytime varies, but is typically from 7 AM to 11 PM)
Night-time ambulatory blood pressure	Ambulatory blood pressure measured at 30- to 60-min intervals during the night (definition of night-time varies, but is typically from 11 PM to 7 AM)
Home blood pressure (or self-monitored blood pressure)	Mean of 6 d of self-monitored blood pressure readings (readings typically taken in the morning and/or evening) after discarding the first days' readings
Out-of-office blood pressure	Daytime ambulatory blood pressure or home blood pressure
Out-of-office hypertension	Daytime ambulatory blood pressure or home blood pressure ≥135/85 mm Hg
Home-clinic blood pressure difference	The difference between out-of-office blood pressure and automated blood pressure measured in the clinic

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Diagnosis of Hypertension. In those patients who screen positive for possible HTN, accurate measurement of BP is essential to confirm a diagnosis of HTN.[17] Traditionally, this has been achieved using clinic measurements based on individual readings taken on several different occasions.[18-20] However, it has long been recognized that home or ambulatory (out-of-office) BP provide more accurate estimates of the patients' true mean BP.[21] This is in part because multiple readings are taken (giving a statistical advantage) and measurements taken outside of a clinic environment (during ordinary activity) are better correlated with long-term cardiovascular outcomes including stroke.[22-24]

Clinic BP readings often are different from the corresponding out-of-office BP. Those with high clinic BP readings (≥140/90 mm Hg), but normal mean out-of-office pressure (<135/85 mm Hg) are considered to have white-coat HTN.[25] These patients have a cardiovascular risk similar to patients with normotension, are at risk for overtreatment but do need following up for future development of HTN.[25] Conversely, patients with high out-of-office BP (≥135/85 mm Hg) but normal clinic BP (<140/90 mm Hg) have an increased risk for target organ damage[26] and cardiovascular morbidity and mortality,[27,28] but often remain unrecognized and therefore potentially undertreated. Thus, relying on clinic BP alone can lead to incorrect classification of BP status and hence inappropriate management.[29,30]

Use of Ambulatory BP in the Diagnosis of HTN. In the United Kingdom, NICE guidelines recommend that patients undergo daytime ambulatory or home monitoring if BP is raised in the clinic, to confirm a diagnosis of HTN (Fig. 1),[5] a recommendation now supported—at least in draft form—in the United States by the Preventive Services Task Force.[31] This new approach to diagnosis has been found to be cost-effective because the additional costs of out-of-office measurement are more than counter-balanced by the reduction in drug and follow costs from misdiagnosis.[17] Using ABPM to confirm a diagnosis of HTN was found to reduce costs (between US $70 and $457 per patient) and increase quality of life postdiagnosis (through better targeting of care—incremental quality-adjusted life-years (QALY) between −0.004 and 0.022 per patient) in men and women of all ages.[17]

While reducing white-coat HTN, and the white-coat effect, this strategy may arguably lead to unnecessary monitoring for some patients with very high BP and will not capture patients with masked HTN. However, even in individuals with very high clinic pressures, a white-coat effect is still common and potentially white-coat HTN can still exist. In Europe[32] and North America,[33,34] clinical guidelines recommend that out-of-office monitoring be considered when white-coat and masked HTN is suspected—for example in the case of high clinic pressures with no end-organ damage and frequent side effects. These guidelines suggest various patient characteristics that might predispose someone with white-coat or masked HTN,[32] although the large number of predictors makes their use in guiding targeted out-of-office monitoring impractical.[35] Future research should focus on strategies that allow better targeting of out-of-office BP monitoring for detection and management of masked HTN in routine practice.

Use of Self-monitored BP in the Diagnosis of HTN. The additional prognostic value of ABPM over office readings has been well established[21,23,24,36,37] and evidence suggests that SMBP readings, taken at home, are superior prognostically for cardiovascular outcomes.[38] A recent systematic review looked at the relationship between home and clinic BP compared with all-cause mortality, cardiovascular events, and mortality. The authors found that SMBP had a significantly greater predictive value for all-cause (hazard ratio [HR] per 10 mm Hg increase in systolic BP [SBP]: 1.14; 95% confidence interval [CI], 1.01-1.29) as well as cardiovascular mortality (HR, 1.29; 95%, CI 1.02-1.64), and cardiovascular events (HR, 1.14; 95% CI, 1.09-1.20).[38]

A comprehensive 2011 systematic review assessed studies that made an HTN diagnosis with clinic or home BP measurements compared with an ABPM measurement. The authors concluded that neither home nor clinic measurements were sufficiently accurate compared with a reference standard of ABPM.[29] However, there were very few studies at the time that looked at the use of SMBP for the diagnosis of HTN. Since then, 2 studies have been conducted: One analyzed patients from a HTN clinic and recorded high diagnostic test performance for SMBP compared with ABPM,[39] and the other reported high sensitivity and modest specificity but utilized a community-based cohort with a lower prevalence of sustained hypertension (54% vs 65% in untreated patients).[40] Overall, ABPM retains its preeminence over SMBP in diagnosis at least.

Both European Society for Hypertension (ESH)[32] and NICE guidelines[5] suggest that

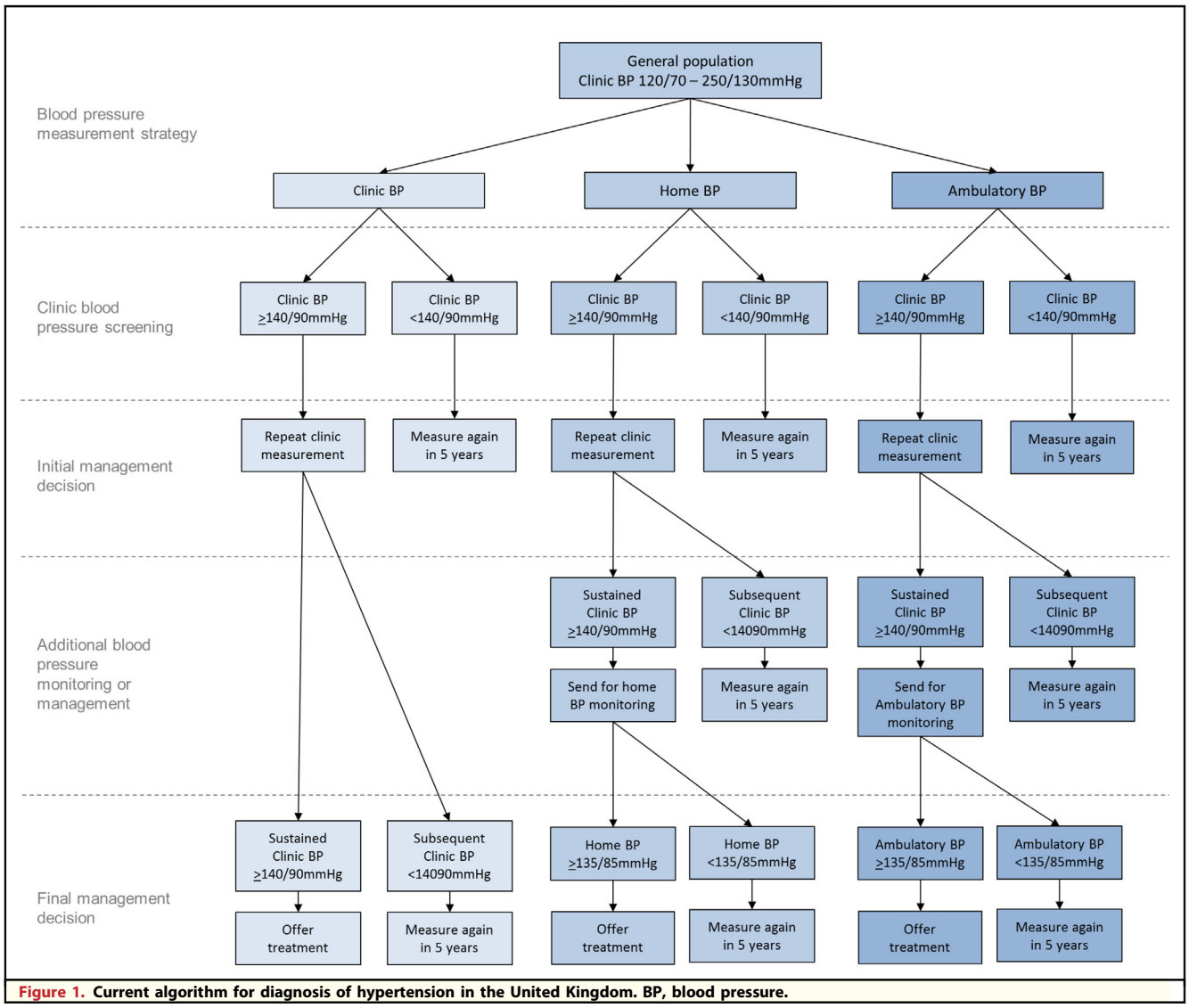

Figure 1. Current algorithm for diagnosis of hypertension in the United Kingdom. BP, blood pressure.

SMBP can be used as an alternative if ABPM is not available or tolerated. Current diagnostic (and treatment) thresholds for out-of-office measurement are based on previous work that compared 8575 ABPM to contemporaneous clinic readings taken by trained staff.[41] The research found that the equivalent daytime mean ABPM for an office measurement of 140/90 mm Hg was 4/3 mm Hg less, which has led to an ABPM and SMBP diagnostic threshold of 135/85 mm Hg (Table 2).[41] This same threshold is recommended in almost all current international hypertension guidelines.[5,32-34,42] However, one study[43] suggests that the systolic threshold in particular may be too high. Studying a hypertensive population, the study found that thresholds of 130/85 mm Hg, and 145/90 mm Hg for grades 1 and 2 HTN (Table 2) better predicted outcomes for cardiovascular events over an 8-year follow-up.[43] A recent study comparing home and daytime ABPM in 270 participants found that ABPM readings were higher than the corresponding self-measured BP readings, suggesting that lower thresholds may be more appropriate for home readings.[44] Despite this, for the time being the international unanimity of 135/85 mm Hg at home being equivalent to 140/90 mm Hg in the clinic is likely to prevail.

Treatment of HTN in the United Kingdom. Hypertension can be classified into 3 groups, according to clinic BP level, which are used to guide treatment: stage 1 (mild, 140-159/90-99 mm Hg),

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Table 2. Current UK Classifications of Hypertension According to Clinic and Out-of-Office Blood Pressure Level

Category	Clinic SBP Thresholds (mm Hg)	Out-of-office SBP Thresholds (mm Hg)	Clinic DBP Thresholds (mm Hg)	Out-of-office DBP Thresholds (mm Hg)
Optimal	<120		<80	
Normal	120-129		80-84	
High normal	130-139	<135	85-89	<85
Grade 1 HTN	140-159	135-149	90-99	85-94
Grade 2 HTN	160-179	≥150	100-109	≥95
Grade 3 HTN	≥180		≥110	

DBP, diastolic blood pressure; HTN, hypertension; SBP, systolic blood pressure.

stage 2 (moderate, 160-179/100-109 mm Hg), and stage 3 (severe, >180/110 mm Hg) (Table 2). In the United Kingdom, treatment is recommended for all patients with stage 2 or 3 HTN, with treatment for stage 1 dictated by risk (see later).

Angiotensin-converting enzyme (ACE) inhibitors or low-cost angiotensin II receptor blockers are recommended for patients <55 years, and calcium channel blockers for those aged ≥55 or of African or Caribbean origin.[5] These recommendations are based on the original ABCD concept from Morris Brown's work comparing systematic monotherapy treatment cycles rotating through angiotensin-converting-enzyme (ACE) inhibitor (A), b-blocker (B), calcium-channel blocker (C) and diuretic (D) therapies in order to optimise treatment[45]. This has been modified in the light of subsequent trial evidence and cost-effectiveness modelling to ACD with beta blockers no longer recommended first line.[5,46,47] Others have argued that reducing BP per se is more important than choice of drug.[32,48]

A key difference between UK practice and that from elsewhere has been the change from the use of thiazide diuretics—bendroflumethiazide was for many years the UK thiazide diuretic of choice—to the use of thiazide-like diuretics.[5] This was in light of limited data suggesting benefit from low-dose thiazide diuretics and resulted in recommendations for the use of indapamide and chlorthalidone.[49] These recommendations have been supported by subsequent meta-analyses.[50,51] For fourth-line drug choices, data had been sparse with only a weak recommendation for the use of spironolactone. This recommendation has been justified by the results of the PATHWAY II study, showing that spironolactone in these circumstances lowered BP by around double that of a β-blocker or ACE inhibitor.[52]

The treatment of patients with stage 1 HTN in the United Kingdom is less intensive than elsewhere, particularly in the United States. UK guidelines suggest that only those with stage 1 HTN and additional risk factors (eg, diabetes, renal disease, or high estimated CVD risk) should receive antihypertensive treatment.[5] This is because of the paucity of evidence to support pharmacologic treatment in grade 1 HTN without additional risks: A Cochrane review[53] examined 8912 patients from 4 clinical trials investigating the benefits of treating uncomplicated mild HTN compared with placebo. No significant reduction in mortality was found with treatment (risk ratio, 0.85; 95% CI, 0.63-1.15), nor was any reduction in coronary artery disease, stroke, or total cardiovascular events observed in a subgroup of 7080 patients. The authors and subsequent commentators[53,54] pointed to a lack of power in previous trials and meta-analyses to show significant results because of low event rates and relatively short follow-up in the population of interest. The Blood Pressure Treatment Trialists' subsequent work suggests that low-risk patients can gain benefit from treatment, albeit with high numbers needed to treat.[55] The result of expert opinion in rationalizing these data is that UK guidance promotes lifestyle modification in low-risk patients with stage 1 HTN[5] whereas guidelines from Europe[32] and America[34,56,57] encourage drug therapy. The results of SPRINT (Systolic Blood Pressure Intervention Trial) may affect these guidelines. SPRINT included 9361 patients at increased cardiovascular risk with a baseline SBP of 130 mm Hg or more. Patients were randomly assigned to a standard BP target of 140 mm Hg versus an intensive target of 120 mm Hg and primary composite outcome was myocardial infarction, acute coronary events, stroke, heart failure, or death from cardiovascular causes. The trial was stopped after 3 years due to the significantly lower rate of primary outcomes in the intensive treatment group (1.65% versus 2.19% per year; HR, 0.73; 95% CI, 0.64-0.89; $P < .001$). All-cause mortality was lower in the intensive treatment group

(HR, −0.73; 95% CI, 0.60-0.90; $P = .003$). Patients in the intensive treatment group had higher rates of serious adverse events but not injurious falls. However, given the significance of the differences in cardiovascular events and all-cause mortality between the standard and intensive treatment groups, UK and international guidelines seem likely to recommend lower BP targets for high-risk patients in the future.[58]

Treatment targets in the United Kingdom largely mirror those from elsewhere, particularly since European and US guidelines have dropped previous more aggressive targets.[5,32,56] The net effect is that there is almost uniform acceptance of a 140/90 mm Hg target for those with essential HTN requiring treatment with lower targets in diabetes and perhaps stroke. This is relaxed to 150/90 mm Hg for older patients with divergence from the United States only in terms of the age threshold at which this occurs (Joint National Committee on Prevention, Detection, Evaluation and Treatment of Blood Pressure [JNC] 8: >65 years; NICE: >80 years). These may change radically over the coming years given the significance of the results of the SPRINT trial.[58]

In patients prescribed drug therapy, monitoring is essential to ensure BP is controlled to target and patients remain adherent to medication. Traditionally in the United Kingdom, monitoring has involved repeated visits to the general practitioner in a primary care setting at 6- to 12-month intervals. However, the advent of cheap, automated BP monitors has encouraged more SMBP in routine clinical practice.

Self-monitoring. Self-monitoring provides an opportunity to gain important data regarding BP control and to avoid overtreatment of those with a significant white-coat effect. In the United Kingdom, it is estimated that around 30% of a hypertensive primary care-based population monitor their BP at home, which is similar if slightly lower than seen in equivalent populations in the United States and Canada.[59,60] Guidelines, as previously discussed, recommend self-monitoring largely as an adjunct to ABPM for the diagnosis of HTN, but in practice self-monitoring has found a significant place in the ongoing management of HTN: a survey of 557 family physicians in the United Kingdom with patients who self-monitor, showed that >80% used self-monitoring for ongoing management compared with 37% who used it for diagnosis.[61]

Data to support such use are available: A comprehensive systematic review and meta-analysis found that self-monitoring alone versus usual care in 26 studies of moderate-strength evidence led to significant BP reductions at 6 months (3.9 mm Hg for SBP and 2.4 mm Hg for diastolic [DBP]), but not at 12 months.[62] When self-monitoring was combined with additional support, the effect size was greater and appeared to last longer. Twenty-five high-strength evidence studies comparing SMBP plus additional support with usual care showed reductions in SBP of between 3.4 and 8.9 mm Hg at 12 months.[62]

Additional support in the included studies ranged from regular face-to-face counseling or telecounseling provided by nurses or pharmacists (giving the opportunity for disease management, education, or checking BP) to behavioral intervention classes covering nondrug therapies or medication management, telemonitoring, or web-based tools with or without counseling and miscellaneous support including medication tracking tools, hypertension information leaflets, and home visits. Interestingly however, few studies have explicitly compared the titration of antihypertensive medication on the basis of home or clinic readings.[62]

There has been some concern about the accuracy of BP readings reported by patients.[63] Two studies looked at the accuracy of reporting in patients who were measuring the readings as part of routine clinical practice and unaware that the home monitor recorded readings. A sample of 39 patients found a difference of 10 mm Hg or more between recorded and automatic SBP readings in 23% of patients and a difference of 5 mm Hg or more between recorded and automatic DBP readings in 36% of patients.[64] Another study found that 36% of reported BP readings were lower than the stored readings and 9% of reported BP readings were higher than the stored measurements.[65] Telemonitoring, where BP readings are transmitted electronically from the monitor to the general practitioner or health professional, is the obvious solution to these issues and has been shown to improve BP control compared with clinic monitoring.[66] However, the costs of this, to date, have precluded its use on a wide scale in the United Kingdom. There has, however, been some use of simple text-based telemonitoring in the NHS, for instance the "Florence" system.[67]

The protocols recommended for self-monitoring in the United Kingdom are similar to those recommended by Pickering and colleagues in their 2008 "Call to Action" and similarly by the ESH.[68,69] The data underlying these are not particularly robust but evidence is accumulating that around 4 to 5 days of monitoring is probably optimal.[40]

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Few studies have looked at the long-term benefit of self-monitoring, and none in a UK context: Two US studies followed up patients for between 24 and 60 months.[70,71] Both showed a significant reduction in SBP and DBP, which is reassuring. Data on "hard" clinical endpoints are similarly sparse: One study included hypertensive patients with overt diabetic nephropathy who self-monitored and self-titrated their BP compared with patients receiving routine care over 5 years. The intervention was associated with less frequent primary endpoints and longer survival, although patients were not randomly allocated to the treatment groups.[72] One Japanese trial that aimed to assess the benefit of a lower, self-monitoring-led BP target, failed to detect a difference between groups, largely because participating physicians ignored the study protocol leading to very similar achieved BPs.[73] Taken together, these data suggest that more evidence is required before UK guidance recommends self-monitoring for ongoing routine management in hypertension. Trials currently recruiting should provide better data.[74]

Self-management of HTN. One area where the United Kingdom has led internationally, is in the concept and trialing of self-monitoring with self-titration of antihypertensive medication. One small study in Canada previously suggested that this technique might help with the control of BP.[75] The TASMINH2 (Telemonitoring and Self-Management in Hypertension 2) and TASMIN-SR (Targets and Self-Management for the Control of Blood Pressure in Stroke and at Risk Groups) trials tested the concept in landmark studies showing that, with adequate training, patients could safely self-monitor and self-titrate, following predetermined plans agreed with the family physician at baseline. In the former trial, patients with essential HTN who self-managed in this way had significantly lower SBP after 1 year: mean systolic difference 5.4 mm Hg (95% CI, 2.4-8.5). The effect was probably mediated by the additional medication implemented by those who self-managed and there was little evidence of increased side effects in this group.[76] Subsequent economic analysis showed the intervention to be cost-effective with incremental cost-effectiveness ratios of US $2299 per QALY for men and $6968 per QALY for women.[77] Patients liked self-management and were largely confident about self-titration.[78] Fidelity to the trial procedures showed that although not all titration opportunities were taken, patients still followed the protocol better (on about 55% of occasions) than doctors in similar situations (25%-41%).[73,79,80]

The TASMIN-SR trial tested a development of the self-titration intervention in a hypertensive population with multiple morbidities (stroke, coronary heart disease [CHD], diabetes, and/or chronic kidney disease [CKD]).[81] Patients again monitored and titrated their own BP at home over 12 months according to a plan devised in collaboration with their general practitioners. At 12 months, office SBP was 9.2 mm Hg (95% CI, 5.7-12.7) lower than the usual care group, again probably explained by an increase in medication usage but with no increase in side effects. Taken together, these studies suggest that for the right patients, self-management can be a very effective intervention. To our knowledge, no data currently exist describing the implementation of self-management in the United Kingdom.

MANAGEMENT OF HTN IN SPECIAL GROUPS

Hypertension affects such a large proportion of the population—in the United Kingdom >7 million people—that it is inevitable that modern management must encompass several special groups. This section discusses these groups in further detail, both with respect to their overall care and with specific consideration of the role of self-care.

Older Patients. The population is aging[82,83] and consequently, the number of people living with age-related chronic conditions is increasing.[84] Hypertension is the number 1 comorbid condition in older people with multiple chronic conditions[85] and 52% of those aged ≥80 years are prescribed ≥2 antihypertensive medications (equivalent ~1.25 million people in the United Kingdom).[86] The HYVET (Hypertension in the Very Elderly) trial[87] showed that moderate reduction of BP in a fit elderly population (with baseline SBP of >160 mm Hg and a target of <150 mm Hg) is beneficial in terms of preventing stroke and CVD.[87] This approach has been widely accepted in clinical guidelines and routine clinical practice, although it is unclear whether these findings are generalizable to less healthy, frail, older patients, those with multiple morbidities or those with lower baseline BP, all of whom may be at higher risk for adverse events such as falls.[88,89] Indeed, some evidence suggests that larger BP reductions and multiple antihypertensive prescriptions in older people may be harmful[90-92]: A recent meta-analysis, which included the HYVET

trial, suggested that despite benefit from modest reductions in SBP, larger reductions in SBP and higher intensity treatment may be associated with increased all-cause mortality.[90]

Because of the increased risk for adverse events in older people,[90] careful monitoring of the BP response to treatment and potential side effects is required and SMBP offers such an option. The majority of SMBP trials have been conducted in younger cohorts (50-65 year olds),[93] with a few small trials targeting patients aged ≥60 years.[94,95]

Meta-analysis suggests that SMBP is as effective at reducing BP in older patients compared with younger patients (mean SBP reduction of 1.93 mm Hg for those aged ≥60 years versus 1.69 mm Hg for those aged <60 years).[93] Future trials should explore the effectiveness of SMBP in the management of HTN in older patients.

Multiple Morbidities. Many people in the United Kingdom have >1 chronic condition (multiple morbidity, 23%), leading to difficulties in management, as much of the evidence base is confined to single diseases.[84] One of the most common comorbid conditions is HTN: Only 22% have HTN without comorbidity and the literature suggests that the highest prevalence of 2-disease clusters includes HTN as one of the diseases.[84,96] Few HTN trials exclusively target patients with multiple morbidities and those that do tend to be in particular groups such as stroke, CHD, or diabetes, considered separately here. Interestingly, in a post hoc analysis, the HYVET investigators found that the frailty index did not interact with the observed treatment effect.[97] Although clearly frailty and multiple morbidity are related, they are different concepts. There is some evidence that self-management of BP can result in small, nonsignificant improvements in outcomes of patients with multiple morbidities.[98] Indeed, the recent TASMINH-SR trial of self-monitoring with self-titration in patients with multiple morbidities found that self-management significantly lowered BP.[81]

Diabetes. The UK thresholds for the treatment of HTN in individuals with type 2 diabetes are a clinic BP of <140/80 mm Hg, or <130/80 mm Hg if there is kidney, eye, or cerebrovascular damage.[99] These are informed by the results of the ACCORD (Action to Control Cardiovascular Risk in Diabetes) trial, which showed that patients targeted to tighter SBP control (<120 mm Hg) did not show any significant reduction in the incidence of cardiovascular events compared with patients with an SBP target of >130 mm Hg.[100]

However, the recommended treatment targets vary between guidelines; ESH suggests a target <140/85 mm Hg,[32] the JNC 8 suggests a target of <140/90 mm Hg,[56] and the Canadian Hypertension Education Program (CHEP) recommends <130/80 mm Hg.[101] First-line antihypertensive therapy in the United Kingdom is usually an ACE inhibitor based on cost assessment.[99,102]

There are no specific recommendations for self-monitoring in patients with diabetes but home thresholds should probably be adjusted for lower DBP (ie, 135/75 mm Hg).[99] Few UK trials have examined self-monitoring of BP in a population with diabetes, but examples of US studies include a trial in Washington in which participants had HTN and either diabetes or renal disease. The study showed self-monitoring alone had no effect, whereas self-monitoring with nurse management showed significant reduction in SBP.[103] A large New York trial, including hypertensive patients with diabetes, showed that those without diabetes had a greater increase in BP control.[104]

Finally, a study of veterans in Iowa exclusively recruited patients with diabetes and HTN.[105] The authors reported that self-monitoring alone over a 6-month period did not improve SBP control; however, when self-monitoring was combined with nurse management, a significant decrease in SBP was observed and this difference was maintained for 6 months after the intervention.[105] These studies suggest cointerventions such as nurse support may be important for this group as a complement to self-monitoring.

Chronic Kidney Disease. There is limited evidence for the diagnostic and treatment thresholds in a hypertensive population with CKD and this is reflected in the guidelines. UK guidelines do not suggest a specific threshold for patients with CKD (<140/90), unless they are also diabetic (<130/80),[99] the JNC also suggests a threshold of <140/90 mm Hg. Home and ambulatory thresholds are not specifically recommended in patients with CKD so they should remain at 135/85 for stage 1 HTN. Although several randomized controlled trials of self-monitoring of BP have included patients with CKD,[76,81,103,106-108] there are none we are aware of that have specifically looked at thresholds and methods of self-monitoring in this population.

Ethnic Minority Groups. The incidence of HTN varies by ethnic group and south Asians, Afro-Caribbeans, and people of African descent have a greater risk for HTN, around 3 to 4 times greater in

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those of African descent and 2- to 3-fold higher in South Asians.[109,110] The increased susceptibility to HTN results in greater mortality from stroke and end-stage renal disease in patients of an Afro-Caribbean or West African background (although not from CHD), and greater mortality from CHD, stroke, and end-stage renal disease in those of South Asian descent. The pathology behind this is not fully understood but it is likely to be a mixture of genetic and environmental factors.[111] These findings are consistent in US populations where the prevalence of HTN in the black population is significantly higher than white and Hispanic populations.[112] In the current UK guidelines, calcium channel blockers are recommended as a first-line therapy in black individuals of African or Caribbean descent.[5]

One study assessed how differences in ethnicity affected the comparison between clinic BP and ABPM.[113] Results from the study found that when BP was measured carefully, the differences between the ethnic groups were small and unlikely to be clinically relevant but casual BP measurements were more likely to lead to inaccuracies particularly for Afro-Caribbean and South Asian individuals.[113] A US study investigated whether home monitoring varied by race, education, or income.[114] The authors reported that there was no significant association between black, white, or Hispanic groups, but use of a home BP monitor was significantly associated with higher income and higher education.

Pregnancy. Worldwide, 10% of women experience an increase in BP during pregnancy.[115] Hypertensive disorders in pregnancy, including preeclampsia, are a leading cause of maternal deaths in the United Kingdom and worldwide.[116,117] Furthermore, hypertensive pregnancy has been linked to an increase in lifetime cardiovascular risk and also carrys a risk for the baby, with 8% to 10% of all preterm births resulting from hypertensive disorders.[118,119]

Early hypertensive treatment and timely delivery can prevent morbidity. As most cases of gestational HTN and preeclampsia are asymptomatic in the early stages, regular monitoring is important. Current UK guidelines recommend BP monitoring at each routine antenatal visit with "increased frequency" for those at higher risk, and define gestational HTN as BP $\geq$140/90 mm Hg at 20 weeks gestation and onward.[120] Local guidelines for additional monitoring and the use of ABPM to confirm hypertensive pregnancy vary across the United Kingdom. A key issue is the fact that few automated BP measurement devices validated for use in pregnancy and preeclampsia are currently available.[121-124]

Once HTN has been diagnosed during pregnancy, women with uncomplicated chronic HTN are managed with the aim of keeping BP <150/100 mm Hg and those with target organ damage (eg, renal disease) with a lower target of 140/90.[125] The most commonly recommended antihypertensive medications are labetalol and nifedipine, with methyldopa also an option for some patients. Antagonists of the renin-angiotensin system are contraindicated in pregnancy.[125]

Current NICE guidelines recommend that pregnant women with uncomplicated chronic HTN are not offered treatment to reduce DBP to <80 mm Hg.[125] CHIPS (Control of Hypertension in Pregnancy Study)[126] found that there was no significant difference between less-tight control (target DBP 100 mm Hg) and tight control (target DBP 85 mm Hg) in terms of pregnancy loss, high-level neonatal care, overall maternal complications, or the number of women who received magnesium sulphate for preeclampsia; however, less-tight control was associated with a significantly higher frequency of severe maternal hypertension. This is likely to improve clinical confidence in reducing BP to a diastolic threshold of 85 mm Hg during hypertensive pregnancy.

Self-monitoring has the potential to provide additional measurements in pregnancy with little or no disturbance of lifestyle and without increasing demand on the health care system, indeed if shown to be safe, self-monitoring could be used to reduce antenatal vists.[127] The importance and potential of SMBP measurement has been noted in both an American Heart Association/American Society of Hypertension/Preventive Cardiovascular Nurses Association joint statement and the ESH guidelines[68]; however, there are surprisingly few data on self-monitoring of BP in the pregnant population. Several small studies have found self-monitoring during pregnancy to be feasible, popular, and potentially useful in the detection of gestational HTN, although to our knowledge no large randomized trial has been completed.[128-130] Self-monitoring during pregnancy is not currently recommended in the UK NICE guidelines.[125]

CONCLUSIONS

This review has considered the treatment of HTN in the United Kingdom, with particular emphasis on out-of-office measurement. UK guidance has led the world in the incorporation of out-of-office

measurements in diagnosis and for ongoing management, patients are leading the way with their use of self-monitoring. There are several aspects where the evidence needs to catch up, but it seems likely that the use of ambulatory and self-monitoring is here to stay.

REFERENCES

1. Lewington S, Clarke R, Qizilbash N, Peto R, Collins R. Age-specific relevance of usual blood pressure to vascular mortality: a meta-analysis of individual data for one million adults in 61 prospective studies. Lancet 2002;360(9349):1903–13.
2. Lozano R, Naghavi M, Foreman K, et al. Global and regional mortality from 235 causes of death for 20 age groups in 1990 and 2010: a systematic analysis for the Global Burden of Disease Study 2010. Lancet 2012;380(9859):2095–128.
3. NHS England. General medical services (GMS) contract quality and outcomes framework (QOF), Guidance for GMS contract 2013/14 2013/14. Available at: http://www.hscic.gov.uk/media/14018/QOF-Guidance-GMS-Contract-2013-14/pdf/QOF_guidance_GMS_contract_2013_14.pdf. Accessed September 24, 2015.
4. McManus RM. Hypertension. In: Stevens AR, Mant J, Simpson S, eds. Health care needs and assessment. The epidemiologically based needs assessment reviews (3rd series). Oxford: Radcliffe Medical Press; 2007.
5. National Clinical Guideline Centre. Hypertension: clinical management of primary hypertension in adults; clinical guideline 127. London, UK: Royal College of Physicians; 2011.
6. Fleming S, Atherton H, McCartney D, et al. Self-screening and non-physician screening for hypertension in communities: a systematic review. Am J Hypertens 2015;28:1316–24.
7. Public Health England. NHS Health Check: our approach to the evidence. Available at: https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/224537/NHS_Health_Check_our_approach_to_the_evidence_v2.pdf. Accessed February 22, 2016.
8. Baker C, Loughren EA, Crone D, Kallfa N. A process evaluation of the NHS Health Check care pathway in a primary care setting. J Public Health (Oxf) 2015;37(2):202–9.
9. Chang KC, Soljak M, Lee JT, et al. Coverage of a national cardiovascular risk assessment and management programme (NHS Health Check): retrospective database study. Prev Med 2015;78:1–8.
10. Jenkinson CE, Asprey A, Clark CE, Richards SH. Patients' willingness to attend the NHS cardiovascular health checks in primary care: a qualitative interview study. BMC Fam Pract 2015;16:33.
11. Forster AS, Dodhia H, Booth H, et al. Estimating the yield of NHS health checks in England: a population-based cohort study. J Public Health (Oxf) 2015;37(2):234–40.
12. Garrison GM, Oberhelman S. Screening for hypertension annually compared with current practice. Ann Fam Med 2013;11(2):116–21.
13. Houle SK, Chuck AW, Tsuyuki RT. Blood pressure kiosks for medication therapy management programs: business opportunity for pharmacists. J Am Pharm Assoc 2012;52(2):188–94.
14. Bray ML, Edwards LH. Prevalence of hypertension risk factors among Hispanic Americans. Public Health Nurs 1991;8(4):276–80.
15. Engstrom S, Berne C, Gahnberg L, Svardsudd K. Efficacy of screening for high blood pressure in dental health care. BMC Public Health 2011;11:194.
16. Blood Pressure Testing. LloydsPharmacy. 2015. Available at: http://www.lloydspharmacy.com/en/info/blood-pressure-testing. Accessed September 24, 2015.
17. Lovibond K, Jowett S, Barton P, et al. Cost-effectiveness of options for the diagnosis of high blood pressure in primary care: a modelling study. Lancet 2011;378(9798):1219–30.
18. National Institute for Health and Care Excellence. Clinical management of primary hypertension in adults. London: NICE; 2006.
19. Mancia G, de Backer G, Dominiczak A, et al. 2007 ESH-ESC Guidelines for the management of arterial hypertension: the task force for the management of arterial hypertension of the European Society of Hypertension (ESH) and of the European Society of Cardiology (ESC). Blood Press 2007;16(3):135–232.
20. Chobanian AV, Bakris GL, Black HR, et al. The Seventh Report of the Joint National Committee on Prevention, Detection, Evaluation, and Treatment of High Blood Pressure: the JNC 7 report. JAMA 2003;289(19):2560–72.
21. Dolan E, Stanton A, Thijs L, et al. Superiority of ambulatory over clinic blood pressure measurement in predicting mortality: the Dublin outcome study. Hypertension 2005;46(1):156–61.
22. Mancia G, Zanchetti A, Agabiti-Rosei E, et al. Ambulatory blood pressure is superior to clinic blood pressure in predicting treatment-induced regression of left ventricular hypertrophy. SAMPLE Study Group. Study on ambulatory monitoring of blood pressure and lisinopril evaluation. Circulation 1997;95(6):1464–70.
23. Ohkubo T, Hozawa A, Nagai K, et al. Prediction of stroke by ambulatory blood pressure monitoring versus screening blood pressure measurements in a general population: the Ohasama study. J Hypertens 2000;18(7):847–54.
24. Staessen JA, Thijs L, Fagard R, et al. Predicting cardiovascular risk using conventional vs ambulatory blood pressure in older patients with systolic hypertension. Systolic Hypertension in Europe Trial Investigators. JAMA 1999;282(6):539–46.
25. Pickering TG, Coats A, Mallion JM, Mancia G, Verdecchia P. Blood pressure monitoring. Task force V: white-coat hypertension. Blood Press Monit 1999;4(6):333–41.
26. Sega R, Trocino G, Lanzarotti A, et al. Alterations of cardiac structure in patients with isolated office, ambulatory, or home hypertension: data from the general population (Pressione Arteriose Monitorate E Loro Associazioni [PAMELA] Study). Circulation 2001;104(12):1385–92.
27. Ohkubo T, Kikuya M, Metoki H, et al. Prognosis of "masked" hypertension and "white-coat" hypertension detected by 24-h ambulatory blood pressure monitoring 10-year follow-up from the Ohasama study. J Am Coll Cardiol 2005;46(3):508–15.

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March–April 2016: 274–287

28. Mancia G, Facchetti R, Bombelli M, Grassi G, Sega R. Long-term risk of mortality associated with selective and combined elevation in office, home, and ambulatory blood pressure. Hypertension 2006;47(5):846–53.
29. Hodgkinson J, Mant J, Martin U, et al. Relative effectiveness of clinic and home blood pressure monitoring compared with ambulatory blood pressure monitoring in diagnosis of hypertension: systematic review. BMJ 2011;342:d3621.
30. Jin Y, Bies R, Gastonguay MR, Stockbridge N, Gobburu J, Madabushi R. Misclassification and discordance of measured blood pressure from patient's true blood pressure in current clinical practice: a clinical trial simulation case study. J Pharmacokinet Pharmacodyn 2012;39(3):283–94.
31. Piper MA, Evans CV, Burda BU, Margolis KL, O'Connor E, Whitlock EP. Diagnostic and predictive accuracy of blood pressure screening methods with consideration of rescreening intervals: a systematic review for the U.S. Preventive Services Task Force. Ann Intern Med 2015;162(3):192–204.
32. Mancia G, Fagard R, Narkiewicz K, et al. 2013 ESH/ESC guidelines for the management of arterial hypertension: the Task Force for the Management of Arterial Hypertension of the European Society of Hypertension (ESH) and of the European Society of Cardiology (ESC). Eur Heart J 2013;34(28):2159–219.
33. Pickering TG, Hall JE, Appel LJ, et al. Recommendations for blood pressure measurement in humans and experimental animals: part 1: blood pressure measurement in humans: a statement for professionals from the Subcommittee of Professional and Public Education of the American Heart Association Council on High Blood Pressure Research. Circulation 2005;111(5):697–716.
34. Dasgupta K, Quinn RR, Zarnke KB, et al. The 2014 Canadian Hypertension Education Program recommendations for blood pressure measurement, diagnosis, assessment of risk, prevention, and treatment of hypertension. Can J Cardiol 2014;30(5):485–501.
35. Sheppard JP, Fletcher B, Gill P, Martin U, Roberts N, McManus RJ. Predictors of the home-clinic blood pressure difference: a systematic review and meta-analysis. Am J Hypertens 2016;29:614–25.
36. Hansen TW, Kikuya M, Thijs L, et al. Prognostic superiority of daytime ambulatory over conventional blood pressure in four populations: a meta-analysis of 7,030 individuals. J Hypertens 2007;25(8):1554–64.
37. Imai Y, Ohkubo T, Sakuma M, et al. Predictive power of screening blood pressure, ambulatory blood pressure and blood pressure measured at home for overall and cardiovascular mortality: a prospective observation in a cohort from Ohasama, Northern Japan. Blood Press Monit 1996;1(3):251–4.
38. Ward AM, Takahashi O, Stevens R, Heneghan C. Home measurement of blood pressure and cardiovascular disease: systematic review and meta-analysis of prospective studies. J Hypertens 2012;30(3):449–56.
39. Nasothimiou EG, Tzamouranis D, Roussias LG, Stergiou GS. Home versus ambulatory blood pressure monitoring in the diagnosis of clinic resistant and true resistant hypertension. J Hum Hypertens 2012;26(12):696–700.
40. Nunan D, Thompson M, Heneghan CJ, Perera R, McManus RJ, Ward A. Accuracy of self-monitored blood pressure for diagnosing hypertension in primary care. J Hypertens 2015;33(4):755–62.
41. Head GA, Mihailidou AS, Duggan KA, et al. Definition of ambulatory blood pressure targets for diagnosis and treatment of hypertension in relation to clinic blood pressure: prospective cohort study. BMJ 2010;340:c1104.
42. Ogihara T, Kikuchi K, Matsuoka H, et al. The Japanese Society of Hypertension Guidelines for the Management of Hypertension (JSH 2009). Hypertens Res 2009;32(1):3–107.
43. Niiranen TJ, Asayama K, Thijs L, et al. Outcome-driven thresholds for home blood pressure measurement: international database of home blood pressure in relation to cardiovascular outcome. Hypertension 2013;61(1):27–34.
44. Chrubasik-Hausmann S, Chrubasik C, Walz B, Monting JS, Erne P. Comparisons of home and daytime ambulatory blood pressure measurements. BMC Cardiovasc Disord 2014;14:94.
45. Dickerson JE, Hingorani AD, Ashby MJ, Palmer CR, Brown MJ. Optimisation of antihypertensive treatment by crossover rotation of four major classes. Lancet 1999;353(9169):2008–13.
46. Major cardiovascular events in hypertensive patients randomized to doxazosin vs chlorthalidone: the antihypertensive and lipid-lowering treatment to prevent heart attack trial (ALLHAT). ALLHAT Collaborative Research Group. JAMA 2000;283(15):1967–75.
47. Dahlof B, Sever PS, Poulter NR, et al. Prevention of cardiovascular events with an antihypertensive regimen of amlodipine adding perindopril as required versus atenolol adding bendroflumethiazide as required, in the Anglo-Scandinavian Cardiac Outcomes Trial-Blood Pressure Lowering Arm (ASCOT-BPLA): a multicentre randomised controlled trial. Lancet 2005;366(9489):895–906.
48. Wald NJ, Law MR. A strategy to reduce cardiovascular disease by more than 80%. BMJ 2003;326(7404):1419.
49. McManus RJ, Caulfield M, Williams B. NICE hypertension guideline 2011: evidence based evolution. BMJ 2012;344:e181.
50. Olde Engberink RH, Frenkel WJ, van den Bogaard B, Brewster LM, Vogt L, van den Born BJ. Effects of thiazide-type and thiazide-like diuretics on cardiovascular events and mortality: systematic review and meta-analysis. Hypertension 2015;65(5):1033–40.
51. Roush GC, Ernst ME, Kostis JB, Tandon S, Sica DA. Head-to-head comparisons of hydrochlorothiazide with indapamide and chlorthalidone: antihypertensive and metabolic effects. Hypertension 2015;65(5):1041–6.
52. Williams B, MacDonald TM, Morant S, et al; for The British Hypertension Society's PATHWAY Studies Group. Spironolactone versus placebo, bisoprolol, and doxazosin to determine the optimal treatment for drug-resistant hypertension (PATHWAY-2): a randomised, double-blind, crossover trial. Lancet 2015;15:00257–63.
53. Diao D, Wright JM, Cundiff DK, Gueyffier F. Pharmacotherapy for mild hypertension. Cochrane Database Syst Rev 2012;8:CD006742.
54. Tavares A. Pharmacotherapy for mild hypertension. Sao Paulo Med J 2012;130(6):417–8.
55. The Blood Pressure Lowering Treatment Trialists' Collaboration. Blood pressure-lowering treatment based on cardiovascular risk: a meta-analysis of individual patient data. Lancet 2014;384(9943):591–8.
56. James PA, Oparil S, Carter BL, et al. 2014 evidence-based guideline for the management of high blood pressure in adults: report from the panel members appointed to the Eighth Joint National Committee (JNC 8). JAMA 2014;311(5):507–20.
57. Sanchez RA, Ayala M, Baglivo H, et al. Latin American guidelines on

hypertension. Latin American Expert Group. J Hypertens 2009;27(5): 905–22.
58. SPRINT Research GroupWright JT Jr, Williamson JD, Whelton PK, et al. A randomized trial of intensive versus standard blood-pressure control. N Engl J Med 2015;373(22): 2103–16.
59. Baral-Grant S, Haque MS, Nouwen A, Greenfield SM, McManus RJ. Self-monitoring of blood pressure in hypertension: a UK primary care survey. Int J Hypertens 2012;2012:582068.
60. Bancej CM, Campbell N, McKay DW, Nichol M, Walker RL, Kaczorowski J. Home blood pressure monitoring among Canadian adults with hypertension: results from the 2009 Survey on Living with Chronic Diseases in Canada. Can J Cardiol 2010;26(5): e152–7.
61. McManus RJ, Wood S, Bray EP, et al. Self-monitoring in hypertension: a web-based survey of primary care physicians. J Hum Hypertens 2014;28(2):123–7.
62. 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(3):185–94.
63. Myers MG, Stergiou GS. Reporting bias: Achilles' heel of home blood pressure monitoring. J Am Soc Hypertens 2014;8(5):350–7.
64. Myers MG. Reporting bias in self-measurement of blood pressure. Blood Press Monit 2001;6(4):181–3.
65. Mengden T, Hernandez Medina RM, Beltran B, Alvarez E, Kraft K, Vetter H. Reliability of reporting self-measured blood pressure values by hypertensive patients. Am J Hypertens 1998;11(12): 1413–7.
66. Purcell R, McInnes S, Halcomb EJ. Telemonitoring can assist in managing cardiovascular disease in primary care: a systematic review of systematic reviews. BMC Fam Pract 2014;15:43.
67. Cottrell E, Chambers R, O'Connell P. Using simple telehealth in primary care to reduce blood pressure: a service evaluation. BMJ Open 2012;2(6).
68. Pickering TG, Miller NH, Ogedegbe G, Krakoff LR, Artinian NT, Goff D. Call to action on use and reimbursement for home blood pressure monitoring: a joint scientific statement from the American Heart Association, American Society of Hypertension, and Preventive Cardiovascular Nurses Association. Hypertension 2008;52(1):10–29.
69. Mancia G, Grassi G. The new European Society of Hypertension/European Society of Cardiology (ESH/ESC) guidelines. Ther Adv Cardiovasc Dis 2008;2(1):5–12.
70. Bosworth HB, Powers BJ, Olsen MK, et al. Home blood pressure management and improved blood pressure control: results from a randomized controlled trial. Arch Intern Med 2011;171(13):1173–80.
71. Shea S, Weinstock RS, Teresi JA, et al. A randomized trial comparing telemedicine case management with usual care in older, ethnically diverse, medically underserved patients with diabetes mellitus: 5 year results of the IDEATel study. J Am Med Inform Assoc 2009;16(4):446–56.
72. Sawicki PT, Muhlhauser I, Didjurgeit U, Baumgartner A, Bender R, Berger M. Intensified antihypertensive therapy is associated with improved survival in type 1 diabetic patients with nephropathy. J Hypertens 1995;13(8):933–8.
73. Asayama K, Ohkubo T, Metoki H, et al. Cardiovascular outcomes in the first trial of antihypertensive therapy guided by self-measured home blood pressure. Hypertens Res 2012;35(11):1102–10.
74. McManus RJ. ISRCTN83571366 Telemonitoring and/or self-monitoring in hypertension (TASMINH4): a randomised controlled trial 2014. Available at: http://www.isrctn.com/search?q=tasminh4. Accessed February 24, 2016.
75. Zarnke KB, Feagan BG, Mahon JL, Feldman RD. A randomized study comparing a patient-directed hypertension management strategy with usual office-based care. Am J Hypertens 1997;10(1):58–67.
76. McManus RJ, Mant J, Bray EP, et al. Telemonitoring and self-management in the control of hypertension (TASMINH2): a randomised controlled trial. Lancet 2010;376(9736):163–72.
77. Kaambwa B, Bryan S, Jowett S, et al. Telemonitoring and self-management in the control of hypertension (TASMINH2): a cost-effectiveness analysis. Eur J Prev Cardiol 2014;21: 1517–30.
78. Jones MI, Greenfield SM, Bray EP, et al. Patients' experiences of self-monitoring blood pressure and self-titration of medication: the TASMINH2 trial qualitative study. Br J Gen Pract 2012;62(595):e135–42.
79. Bray EP, Jones MI, Banting M, et al. Performance and persistence of a blood pressure self-management intervention: telemonitoring and self-management in hypertension (TASMINH2) trial. J Hum Hypertens 2015;29(7):436–41.
80. Crowley MJ, Grubber JM, Olsen MK, Bosworth HB. Factors associated with non-adherence to three hypertension self-management behaviors: preliminary data for a new instrument. J Gen Intern Med 2013;28(1):99–106.
81. 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(8):799–808.
82. Division of the Department of Economic and Social Affairs of the US. World Population Prospects Fact Sheet. New York: Division of the Department of Economic and Social Affairs of the US; 2006.
83. Office for National Statistics. Mid-year population estimates: Aging increase in the 'oldest old'. Available at: http://www.ons.gov.uk/peoplepopulationandcommunity/birthsdeathsandmarriages/ageing.
84. Barnett K, Mercer SW, Norbury M, Watt G, Wyke S, Guthrie B. Epidemiology of multimorbidity and implications for health care, research, and medical education: a cross-sectional study. Lancet 2012;380(9836):37–43.
85. Violan C, Foguet-Boreu Q, Roso-Llorach A, et al. Burden of multimorbidity, socioeconomic status and use of health services across stages of life in urban areas: a cross-sectional study. BMC Public Health 2014;14:530.
86. Sheppard JP, Singh S, Fletcher K, McManus RJ, Mant J. Impact of age and sex on primary preventive treatment for cardiovascular disease in the West Midlands, UK: cross sectional study. BMJ 2012;345: e4535.
87. Beckett NS, Peters R, Fletcher AE, et al. Treatment of hypertension in patients 80 years of age or older. N Engl J Med 2008;358(18): 1887–98.
88. Callisaya ML, Sharman JE, Close J, Lord SR, Srikanth VK. Greater daily defined dose of antihypertensive medication increases the risk of falls in older people—a population-based study. J Am Geriatr Soc 2014;62(8):1527–33.
89. Tinetti ME, Han L, Lee DS, et al. Antihypertensive medications and serious fall injuries in a nationally representative sample of older adults. JAMA Intern Med 2014;174(4): 588–95.
90. Bejan-Angoulvant T, Saadatian-Elahi M, Wright JM, et al. Treatment of hypertension in patients 80 years and older: the lower the better? A

meta-analysis of randomized controlled trials. J Hypertens 2010;28(7):1366–72.
91. Molander L, Lovheim H, Norman T, Nordstrom P, Gustafson Y. Lower systolic blood pressure is associated with greater mortality in people aged 85 and older. J Am Geriatr Soc 2008;56(10):1853–9.
92. Benetos A, Labat C, Rossignol P, et al. Treatment with multiple blood pressure medications, achieved blood pressure, and mortality in older nursing home residents: the PARTAGE Study. JAMA Intern Med 2015;175:989–95.
93. Agarwal R, Bills JE, Hecht TJ, Light RP. Role of home blood pressure monitoring in overcoming therapeutic inertia and improving hypertension control: a systematic review and meta-analysis. Hypertension 2011;57(1):29–38.
94. Friedman RH, Kazis LE, Jette A, et al. A telecommunications system for monitoring and counseling patients with hypertension. Impact on medication adherence and blood pressure control. Am J Hypertens 1996;9(4 Pt 1):285–92.
95. Broege PA, James GD, Pickering TG. Management of hypertension in the elderly using home blood pressures. Blood Press Monit 2001;6(3):139–44.
96. Sinnige J, Braspenning J, Schellevis F, Stirbu-Wagner I, Westert G, Korevaar J. The prevalence of disease clusters in older adults with multiple chronic diseases—a systematic literature review. PLoS One 2013;8(11):e79641.
97. Warwick J, Falaschetti E, Rockwood K, et al. No evidence that frailty modifies the positive impact of antihypertensive treatment in very elderly people: an investigation of the impact of frailty upon treatment effect in the HYpertension in the Very Elderly Trial (HYVET) study, a double-blind, placebo-controlled study of antihypertensives in people with hypertension aged 80 and over. BMC Med 2015;13:78.
98. Bray EP, Holder R, Mant J, McManus RJ. Does self-monitoring reduce blood pressure? Meta-analysis with meta-regression of randomized controlled trials. Ann Med 2010;42(5):371–86.
99. NICE. NICE clinical guideline 87: type 2 diabetes: the management of type 2 diabetes. Issued in May 2009 and updated in 2014. Available at: https://www.nice.org.uk/guidance/cg87. Accessed September 8, 2015.
100. Accord Study GroupCushman WC, Evans GW, Byington RP, et al. Effects of intensive blood-pressure control in type 2 diabetes mellitus. N Engl J Med 2010;362(17):1575–85.
101. Stella S, Daskalopoulou DMR, Zarnke KB, et al. The 2015 Canadian hypertension education program recommendations for blood pressure measurement, diagnosis, assessment of risk, prevention, and treatment of hypertension. Can J Cardiol 2015;31:549–68.
102. Schädlich PK, Brecht JG, Rangoonwala B, Huppertz E. Cost effectiveness of ramipril in patients at high risk for cardiovascular events: economic evaluation of the HOPE (Heart Outcomes Prevention Evaluation) study for Germany from the Statutory Health Insurance perspective. Pharmacoeconomics 2004;22(15):955–73.
103. Hebert PL, Sisk JE, Tuzzio L, et al. Nurse-led disease management for hypertension control in a diverse urban community: a randomized trial. J Gen Intern Med 2012;27(6):630–9.
104. Ogedegbe G, Tobin JN, Fernandez S, et al. Counseling African Americans to control hypertension: cluster-randomized clinical trial main effects. Circulation 2014;129(20):2044–51.
105. Wakefield BJ, Holman JE, Ray A, et al. Effectiveness of home telehealth in comorbid diabetes and hypertension: a randomized, controlled trial. Telemed J E Health 2011;17(4):254–61.
106. Magid DJ, Ho PM, Olson KL, et al. A multimodal blood pressure control intervention in 3 healthcare systems. Am J Manag Care 2011;17(4):e96–103.
107. Margolis KL, Asche SE, Bergdall AR, et al. Effect of home blood pressure telemonitoring and pharmacist management on blood pressure control: a cluster randomized clinical trial. JAMA 2013;310(1):46–56.
108. Ogedegbe G, Tobin JN, Fernandez S, et al. Counseling African Americans to Control Hypertension (CAATCH) trial: a multi-level intervention to improve blood pressure control in hypertensive blacks. Circ Cardiovasc Qual Outcomes 2009;2(3):249–56.
109. Cappuccio FP, Cook DG, Atkinson RW, Strazzullo P. Prevalence, detection, and management of cardiovascular risk factors in different ethnic groups in South London. Heart 1997;78(6):555–63.
110. Chaturvedi N, McKeigue PM, Marmot MG. Resting and ambulatory blood pressure differences in Afro-Caribbeans and Europeans. Hypertension 1993;22(1):90–6.
111. Cappuccio FP. Ethnicity and cardiovascular risk: variations in people of African ancestry and South Asian origin. J Hum Hypertens 1997;11(9):571–6.
112. Burt VL, Whelton P, Roccella EJ, et al. Prevalence of hypertension in the US adult population. Results from the Third National Health and Nutrition Examination Survey, 1988-1991. Hypertension 1995;25(3):305–13.
113. Martin U, Haque MS, Wood S, et al. Ethnicity and differences between clinic and ambulatory blood pressure measurements. Am J Hypertens 2015;28(6):729–38.
114. Poon IO, Etti N, Lal LS. Does the use of home blood pressure monitoring vary by race, education, and income? Ethn Dis 2010;20(1):2–6.
115. Duley L. The global impact of pre-eclampsia and eclampsia. Semin Perinatol 2009;33(3):130–7.
116. Knight M, Kenyon S, Brocklehurst P, Neilson J, Shakespeare J, Kurinczuk JJ, on behalf of MBRRACE-UK, eds. Saving Lives, Improving Mothers' Care. Lessons learned to inform future maternity care from the UK and Ireland Confidential Enquiries into Maternal Deaths and Morbidity 2009-2012. Oxford: National Perinatal Epidemiology Unit, University of Oxford; 2014:2014.
117. Cantwell R, Clutton-Brock T, Cooper G, et al. Saving mothers' lives: reviewing maternal deaths to make motherhood safer: 2006-2008. The eighth report of the Confidential Enquiries into Maternal Deaths in the United Kingdom. BJOG 2011;118(Suppl 1):1–203.
118. National Collaborating Centre for Women's and Children's Health. Hypertension in pregnancy: the management of hypertensive disorders during pregnancy. London, UK: Royal College of Obstetricians and Gynaecologists; 2010.
119. Slattery MM, Geary M, Morrison JJ. Obstetric antecedents for preterm delivery. J Perinat Med 2008;36(4):306–9.
120. NICE. CG 62: Antenatal care 2008 (updated 2014). Available at: https://www.nice.org.uk/guidance/cg62. Accessed August 21, 2015.
121. Chung Y, de Greeff A, Shennan A. Validation and compliance of a home monitoring device in pregnancy: microlife WatchBP home. Hypertens Pregnancy 2009;28(3):348–59.
122. De Greeff A, Reggiori F, Anthony J, Shennan AH. A validated algorithm for blood pressure measurement in pregnancy and pre-eclampsia: microlife 3BTO-A vs microlife 3AC1 (2006) Poster Day 1 - Oxidative

Stress, Hypertension in Pregnancy, 25:sup1, 75-233, DOI: 10.1080/10641950600783898.

123. Reinders A, Cuckson AC, Lee JTM, Shennan AH. An accurate automated blood pressure device for use in pregnancy and pre-eclampsia: the microlife 3BTO-A. BJOG 2005;112(7):915–20.
124. Golara M, Benedict A, Jones C, Randhawa M, Poston L, Shennan AH. Inflationary oscillometry provides accurate measurement of blood pressure in pre-eclampsia. BJOG 2002;109(10):1143–7.
125. NICE. CG 107 hypertension in pregnancy: the management of hypertensive disorders during pregnancy 2010 (updated in 2011). Available at: https://www.nice.org.uk/guidance/cg107. Accessed August 21, 2015.
126. Magee LA, von Dadelszen P, Rey E, et al. Less-tight versus tight control of hypertension in pregnancy. N Engl J Med 2015;372(5):407–17.
127. Hodgkinson JA, Tucker KL, Crawford C, et al. Is self monitoring of blood pressure in pregnancy safe and effective? BMJ 2014;349:g6616.
128. Denolle T, Daniel JC, Calvez C, Ottavioli JN, Esnault V, Herpin D. Home blood pressure during normal pregnancy. Am J Hypertens 2005;18(9 Pt 1):1178–80.
129. Rey E, Pilon F, Boudreault J. Home blood pressure levels in pregnant women with chronic hypertension. Hypertens Pregnancy 2007;26(4):403–14.
130. Lo C, Taylor RS, Gamble G, McCowan L, North RA. Use of automated home blood pressure monitoring in pregnancy: is it safe? Am J Obstet Gynecol 2002;187(5):1321–8.