

# Home blood pressure monitoring: Australian Expert Consensus Statement

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Measurement of blood pressure (BP) by a doctor in the clinic has limitations that may result in an unrepresentative measure of underlying BP which can impact on the appropriate assessment and management of high BP. Home BP monitoring is the self-measurement of BP in the home setting (usually in the morning and evening) over a defined period (e.g. 7 days) under the direction of a healthcare provider. When it may not be feasible to measure 24-h ambulatory BP, home BP may be offered as a method to diagnose and manage patients with high BP. Home BP has good reproducibility, is well tolerated, is relatively inexpensive and is superior to clinic BP for prognosis of cardiovascular morbidity and mortality. Home BP can be used in combination with clinic BP to identify 'white coat' and 'masked' hypertension. An average home BP of at least 135/85 mmHg is an appropriate threshold for the diagnosis of hypertension. Home BP may also offer the advantage of empowering patients with their BP management, with benefits including increased adherence to therapy and lower achieved BP levels. It is recommended that, when feasible, home BP should be considered for routine use in the clinical management of hypertension.

**Keywords:** blood pressure, blood pressure measurement, guidelines, home blood pressure, hypertension, management, treatment

**Abbreviations:** 24-ABPM, 24-h ambulatory BP monitoring; BP, blood pressure; CVD, cardiovascular disease

## INTRODUCTION

There is a strong association between high blood pressure (BP) and cardiovascular mortality [1]. About 30% of the Australian adult population have hypertension, although the prevalence is very high (e.g. >80%) in those aged at least 65 years [2,3]. High BP is the most important modifiable population factor contributing to absolute cardiovascular disease (CVD) risk [4]. There is good evidence that BP reduction with antihypertensive therapy reduces cardiovascular events, particularly in those with moderate to severe hypertension [5,6]. More than half of the Australians with elevated BP are not taking antihypertensive medication, but have a high absolute risk of CVD and would benefit from treatment [2].

Uncertainty with respect to the 'true underlying BP' is a recognized barrier to correctly diagnose and treat high BP in Australian general practice [7]. Problems with accuracy of clinic BP as a diagnostic tool arise due to the high prevalence of readings that are discordant with out-of-clinic BP. The major advantage of out-of-clinic BP monitoring is that it provides a relatively large number of BP measurements away from the medical environment where the BP relates more closely to risk than does clinic BP. Although home BP monitoring is already in widespread use in Australia and other countries, there is a wide variation in the protocol used and the interpretation of home BP values, indicating a need for guidance [7–11].

The purpose of this document is to provide information on the utility of home BP in the assessment and management of high BP. The review process involved compilation of a draft document by the writing committee, with the intention of updating previous international consensus statements and contextualizing with Australian practice taking into account the overall cardiovascular risk. The manuscript was re-drafted on open discussion among the writing committee during several teleconferences, and then posted to the website of the High Blood Pressure Research Council of Australia with an open call for members to comment. Additional review by a secondary reference panel of Australian professors with expertise in BP was undertaken to produce this final document.

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### WHAT IS HOME BLOOD PRESSURE AND HOW DOES IT RELATE TO TWENTY-FOUR-HOUR AMBULATORY BLOOD PRESSURE MONITORING?

Home BP refers to the self-measurement of BP at home and is optimal when readings are taken seated at rest at around the same time in the morning and evening, usually over a period of 1 week. The BP values are recorded by the patient using a validated, automatic BP device, and then conveyed to their doctor for interpretation. The average BP over the monitoring period (discarding the first day of recordings) is used to gauge the risk related to BP. The method is reasonably convenient for patients, is well tolerated [12] and relatively inexpensive. Home BP has reasonable precision, and when approached in a standardized fashion, appears to have better reproducibility than clinic BP and 24-h ambulatory BP monitoring (24-ABPM) [13–15]. Compared with 24-ABPM, home BP is more widely available and provides values of longer-term (day-to-day) BP variability.

The 24-ABPM offers some advantages beyond home BP, such as more detailed identification of morning BP surge, short-term BP variability and nocturnal hypertension or ‘non-dipping’ BP patterns in which prognosis is worse [16,17]. It is possible to also measure night-time BP using

**TABLE 2. Summary points**

High BP is the most important modifiable population factor contributing to cardiovascular disease risk.
Uncertainty with respect to ‘true underlying BP’ is a barrier to correctly diagnose and treat high BP in general practice.
Home BP provides a more reliable estimate of BP predicting risk than clinic BP.

BP, blood pressure.

some home BP devices, which provide night-time BP values comparable to 24-ABPM [18–21]. BP measured with home BP has also been shown to have good correlation with daytime 24-ABPM [22]. Table 1 provides a summary comparison of the two methods, as well as clinic BP.

Several international guidelines recommend using home BP as an alternative to 24-ABPM for high BP assessment and management [23–25]. Japanese researchers [26] are the strongest advocates for preferential use of home BP on the basis of a significant body of literature generated in that population. There are many potential scenarios in which complementary use of the methods could aid patient management. For example, among patients with evidence of target organ disease, but normal home BP, night-time BP from 24-ABPM may help explain the clinical findings and thus, therapy may be tailored towards controlling night-time BP [27] (Table 2).

### HOME BLOOD PRESSURE AND PROGNOSIS

Multiple BP measures away from the clinic have a better predictive value than clinic readings regarding BP-related clinical outcomes, and studies with 24-ABPM have shown prognostic superiority beyond clinic and home BP for predicting cardiovascular events [28,29]. Compared with clinic BP, home BP has stronger associations with hypertensive target organ disease [30–34], as well as being a better predictor of cardiovascular events and mortality [35–41]. Despite this, there is a lack of randomized,

**TABLE 1. Comparison of considerations when measuring clinic blood pressure, home blood pressure and 24-h ambulatory blood pressure monitoring**

Considerations	Clinic BP	Home BP	24-ABPM
<b>Doctor-related</b>			
Confidence in assessment	No	Yes	Yes
Ability to monitor the effect of therapies	Yes	Yes	Yes
Medicare rebate	Yes	No	No
Ability to identify ‘white-coat’ and ‘masked’ hypertension	No	Yes	Yes
Ability to identify nocturnal BP	No	Yes	Yes
Availability for repeat measures	High	High	Low
Reproducibility	Low	High	Moderate
‘Hypertension’ threshold determined	Yes	Yes	Yes
Reference thresholds determined	Yes	Limited	Limited
Prognostic value	Low	High	High
<b>Patient-related</b>			
Cost of device	Relatively cheap	Relatively cheap	Relatively expensive
Health insurance rebate	Not applicable	Yes	No
Tolerability	Yes	Yes	Generally ok
Encourages engagement and empowerment with medical management	Moderate	High	Moderate
Encourages adherence to prescribed medication	Moderate	High	Moderate
<b>Healthcare system-related</b>			
Health economic benefit	Moderate	High	High
Availability of devices	Yes	Yes	May be limited

Adapted from [83,119]. 24-ABPM, 24-h ambulatory blood pressure monitoring; BP, blood pressure.

controlled data showing that antihypertensive intervention based on home BP improves prognosis [42] or is superior to clinic BP [43]. It should also be noted that clinic BP still has an important role in general practice for screening BP as part of the usual physical examination for CVD risk and also for monitoring BP in those people where there is little (or no) discrepancy between clinic and out-of-clinic BP.

## HOME BLOOD PRESSURE FOR DETECTION OF WHITE-COAT AND MASKED HYPERTENSION

While the gold standard for determining white-coat or masked hypertension is 24-ABPM [44], home BP can also be used to detect these phenomena among treated or untreated patients [45–50]. White-coat hypertension is relatively common, with a prevalence of approximately 13% in the general population and approximately 32% among adults with hypertension based on clinic readings [51; all remaining references, 51–119, are contained in the supplementary material]. It is yet to be fully confirmed if white coat hypertension confers increased cardiovascular risk, however, the condition is associated with increased probability for developing sustained hypertension and type 2 diabetes [53,54], but does not appear to increase mortality risk [55,56]. Interpretation of mortality risk data can be problematic due to differing definitions of white-coat hypertension, and the possibility that patients with white-coat hypertension were commenced on antihypertensive treatment based on repeated high BP readings in the doctor's clinic [57].

Home BP measurement can be used to detect masked hypertension [48–50], which carries a similar risk for incident cardiovascular events to that of sustained high BP [55,56,58]. Prevalence rates range from 10 to 17% [24] and may be up to 29% in untreated patients with diabetes [59] or even as high as 50% in some studies of patients with treated hypertension [58] or exercise hypertension [60]. It remains unclear whether treatment of masked hypertension or white-coat hypertension is beneficial, but since each condition is associated with increased cardiovascular risk due to developing sustained hypertension, appropriate ongoing monitoring of these patients is advised. Masked hypertension should be suspected in general practice when the clinic BP appears normal, but there is target organ damage consistent with having hypertension (Table 3).

## HOME BLOOD PRESSURE FOR ASSESSMENT OF ANTIHYPERTENSIVE TREATMENT

Home BP provides a reliable estimate of the effectiveness of antihypertensive treatment [61–65]. A pharmacist-led

**TABLE 3. Summary points**

Home BP is optimal when readings are taken around the same time in the morning and evening (usually over 7 days).
Home BP is superior to clinic BP in terms of associations with end-organ disease, cardiovascular events and mortality.
Home BP can be used to detect 'white-coat' and 'masked hypertension'.

BP, blood pressure.

randomized controlled study found that therapy guided by home BP compared with usual care based on clinic BP led to significantly more patients achieving BP control, larger BP reductions, more medication intensification and higher patient satisfaction [62]. The addition of home BP telemonitoring managed by pharmacists produces similar improvements in BP control [66]. Home BP can also be used to identify true drug resistance [61,64]. A meta-analysis on the effectiveness of home BP measured with additional patient support showed a significant reduction in BP over 12 months of intervention [67].

## COST-EFFECTIVENESS OF HOME BLOOD PRESSURE

Health economic assessment using home BP compared with usual care based on clinic BP or in combination with 24-ABPM is complex and varies between countries, as well as study designs. There has been a strong call to action to use and reimburse the costs of home BP measurement in the United States [68], but little movement in Australia. Most home BP devices are relatively cheap (~AUD 100), and may be reimbursable through Australian private health insurance. Lending schemes (hire or borrow) through healthcare providers can also be used to improve access to home BP devices.

Home BP has been shown to be cost neutral after taking into account the number of consultations, drugs, referrals, equipment and training expenses [69], and cost-effective in terms of reduced medication [70] and potential health insurance savings [71]. Health system savings may also accrue by avoiding treating white-coat hypertension [72]. In keeping with these data [69–72], a meta-analysis of randomized controlled studies found that home BP monitoring was associated with lower medical costs, but these savings were offset by equipment and technology costs relating to telemonitoring, such that overall home BP was more costly than usual care [73]. Telemonitoring is distinct from routine home BP, and despite being an effective means to reduce BP [74], cheaper home BP telemonitoring methods need to be developed to improve cost-effectiveness of this approach [73]. At present, telemonitoring is not common in Australia.

## OTHER ADVANTAGES OF HOME BLOOD PRESSURE MEASUREMENT

Home BP has advantages of engaging and empowering the patient in their own BP management, strengthening the doctor–patient relationship and increasing adherence to therapy [66,75–77]. Additionally, regular home BP monitoring can lead to lower BP than standard care [78–80] and more active treatment by doctors [79]. On the basis of limited evidence, a systematic review [81] concluded that improved medication adherence by using home BP was not as successful in the primary care setting compared with hospital-based or non-clinical (community centre/work place) settings, suggesting that patient adherence-enhancing strategies may need to be considered for optimizing care in general practice (e.g. patient education and follow-up contact with health professionals leading to clinical action/change) [82] (Table 4).

**TABLE 4. Summary points**

Home BP can be used to estimate the effectiveness of antihypertensive treatment.
Health system savings are possible using home BP.
Home BP may help engage and empower the patient in their hypertension management and increases adherence to therapy, thus improving hypertension control.

BP, blood pressure.

## STANDARDIZED MEASUREMENT OF HOME BLOOD PRESSURE

It is well known that a multitude of intrinsic (e.g. level of relaxation) and extrinsic (e.g. BP device validation) factors can affect the reliability of BP readings in all settings, and care should be taken to minimize these potential sources of error by adopting a standardized approach. The recommendations in Table 5 are based on international guidelines [23,83], and review articles [84], with Australian context built in.

### What blood pressure device to use?

A validated, automated BP monitor (preferably with storage memory) using a correct-sized upper arm cuff should be used.

The device should be tested for validity in the specific patient population intended for use (e.g. pregnant, arrhythmia) [23]. A list of validated devices can be found at the British Hypertension Society website (<http://www.bhsoc.org/bp-monitors/bp-monitors/>). Validation is judged according to British Hypertension Society standards [85] or the International Protocol [86,87] based on comparison with mercury sphygmomanometry. Devices with storage memory (or unbiased methods such as that achieved with

**TABLE 5. Recommendations for patients on how to measure home blood pressure**

<p>What BP device to use?</p> <p>Use a validated automated machine, preferably with storage memory (a list of validated BP devices can be found at <a href="http://www.bhsoc.org/bp-monitors/bp-monitors/">http://www.bhsoc.org/bp-monitors/bp-monitors/</a>)</p> <p>Buy<sup>a</sup>, hire or borrow a machine</p> <p>Use an appropriate-sized cuff (fits the arm within the accepted range indicated on the cuff)</p> <p>Use an upper arm cuff (not a wrist or finger cuff)</p>
<p>When to take home BP?</p> <p>Take measures at around the same time in the morning and evening</p> <p>Take before medication, food or vigorous exercise</p> <p>Take for 7 days (5 day minimum)</p> <p>Take as advised by your doctor, for example, before visiting the doctor or after medication change</p>
<p>How to take home BP?</p> <p>Sit quietly for 5 min (no talking/distractions such as TV/extreme temperatures)</p> <p>Sit with feet flat on floor, legs uncrossed, upper arm bare, back and arm supported (relaxed position with the cuff at heart level)</p> <p>Take two BP readings 1 min apart</p> <p>Record each BP reading in a paper diary or an electronic spreadsheet</p> <p>Take a copy of the BP readings to the doctor appointment<sup>b</sup></p> <p>Do not smoke or drink caffeine 30 min before measuring BP</p> <p>Do not measure your BP if uncomfortable, stressed or in pain</p>

BP, blood pressure.

<sup>a</sup>Automated BP machines can be purchased from a chemist, online or from a medical equipment supplier. Rebates (up to 100% depending on individual policy) are available from most Australian private health insurance providers.

<sup>b</sup>Average the BP values over all the days, but discard the readings on the first day of monitoring.

telemonitoring) are preferred because patient diaries may lack reliability due to selective reporting [88–91].

An appropriate-sized cuff must be used (i.e. fits the arm within the accepted range indicated on the cuff). A cuff that is too small will overestimate BP ('under-cuffing'), and a cuff that is too large will underestimate BP ('over-cuffing') [92]; thus, inappropriate cuff size ('mis-cuffing') can lead to incorrect home BP values [93]. Wrist and finger cuff monitors should be avoided as these are less likely to have passed validation testing and have greater propensity for inaccuracy due to arm positioning [23]. However, in patients with a very large arm circumference that is beyond the cuff range, it may be a reasonable option to use a validated wrist device.

### When to take home blood pressure?

As advised by a healthcare provider, home BP should be measured at around the same time in the morning and the evening over a 7-day period.

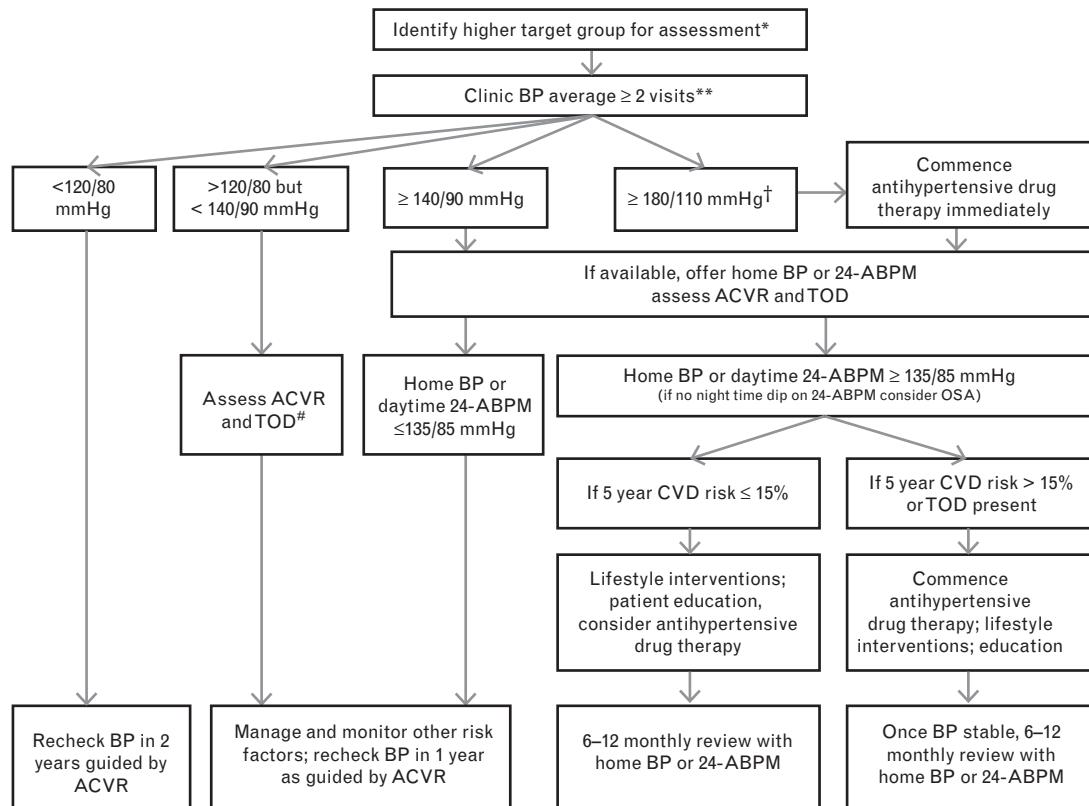
Monitoring should only be performed over periods as directed by a healthcare provider. This may include initial assessment of BP, but also to assess the effects of treatment. Typically, this would be the 7-day period before a clinic visit; approximately 4 weeks after initiating a change in medication regimen [94] or at regular long-term intervals (e.g. 6 months) in keeping with appropriate clinical follow-up according to baseline cardiovascular risk [84,95], as per the treatment algorithm (Fig. 1). A period of 7 days appears to be the measurement period with the best prognostic and diagnostic value [96,97], and is the accepted standard [23,25,26,83,98], although a minimum of 5 days has been shown to provide a reliable estimate of BP control [99,100].

The circadian pattern of BP changes from the morning to evening, with evidence linking morning and evening high BP to increased cardiovascular risk [101–104]. Home BP should be recorded in the morning (before medication if treated) and in the evening. Measures should be taken after voiding and before food or vigorous exercise. Caffeine and cigarettes each have an acute pressor effect, and when combined, are additive [105]. Home BP, therefore, should preferably be measured before, or at least 30 min after, these stimulants. It may be useful to ask patients to record home BP at other times in addition to the morning and evening (or in positions other than sitting as described in the next section).

### How to take home blood pressure?

At home, BP should be measured in a quiet room after 5 min seated rest; two readings should be taken, 1 min apart, with the BP recorded immediately in a diary (if device has no memory function).

The seated position should be feet flat on floor, legs uncrossed, upper arm bare, back supported and arm supported in a relaxed position, with the cuff at heart level. If the cuff is above or below the level of the heart, BPs may be decreased or increased, respectively (approximately 0.7 mmHg/cm) due to the contribution of hydrostatic pressure changes and local vasoactive responses [106]. If the cuff is applied so that its midpoint is at about the midpoint of the upper arm, this will approximate the level of the heart. Patients should not be distracted (e.g. talking,



**FIGURE 1** Proposed algorithm for blood pressure (BP) assessment in general practice. Home BP values determined from the average of two morning and two evening readings (taken over 7 days), but discarding the first day of monitoring. This algorithm is derived from: the Australian Heart Foundation Guidelines to Management of Hypertension (2010); the Australian National Vascular Disease Prevention Alliance, Guidelines for the assessment of absolute cardiovascular disease risk; the Australian Ambulatory Blood Pressure Monitoring Consensus Position Statement (2012); The United Kingdom National Institute of Clinical Excellence Clinical Management of Primary Hypertension in Adults Guidelines (2011); the Canadian Hypertension Education Program Recommendations for the Management of Hypertension (2012); the European Society of Hypertension and of the European Society of Cardiology Guidelines for the management of arterial hypertension (2013) and Palatini Ambulatory and home blood pressure measurement (2012). \*Higher-risk individuals include all adults aged 45–74 years without known history of CVD, Aboriginal and Torres Strait Islander adults aged 35 years or older, adults with diabetes aged 45–60 years, adults who are overweight or obese, adults with atrial fibrillation. \*\*Australian Heart Foundation Guidelines suggest ‘multiple measurements taken on several separate occasions, for example, at least twice, one or more weeks apart unless severe.’ †If hypertensive emergency/accelerated hypertension refer same day for specialist care. #If raised ACVR or evidence of TOD, consider home BP or 24-ABPM. 24-ABPM, 24-h ambulatory BP monitoring; ACVR, absolute cardiovascular risk; CVD, cardiovascular disease; OSA, obstructive sleep apnoea; TOD, target organ disease.

television). Similarly, BP should not be taken if the patient is affected by extremes of temperature, or is uncomfortable, stressed or in pain.

After 5 min rest, the patient should take two consecutive measures 1 min apart, and after each measure record the SBP and DBP. Patients may not be compliant with a rest period before recording BP and this could lead to higher home BP values [107]. They should be asked to note any unusual things that may affect readings. Standing BP may be requested when orthostatic hypotension is suspected. BP measures at 1 and 3 min after standing are recommended in these circumstances. The home BP measure is derived by averaging of the BP values after discarding the first day of readings (Table 6).

### USE OF HOME BLOOD PRESSURE FOR HIGH BLOOD PRESSURE ASSESSMENT/ BLOOD PRESSURE THRESHOLDS

Whilst 24-ABPM is recommended in Australia for diagnosis and provision of optimal care related to BP management, concerns remain about availability, the logistics of training and cost. Assessment of high BP has lower cut points for BP

measured away from the clinic due to reduction in white-coat effects. Definitions of BP categories based on clinic, home and 24-ABPM are denoted in Table 7. The recommended home BP hypertension threshold of at least 135/85 mmHg is based on a systematic review of evidence by a writing committee of the European Society of Hypertension [83]. Gaps in evidence exist with respect to home BP thresholds across BP categories.

Analyses from the International Database of Home Blood Pressure in Relation to Cardiovascular Outcome (IDHOCO) Investigators [108–110] provide rounded home BP thresholds across clinic BP categories according to European hypertension management guidelines [24]. These home BP thresholds were derived from 10-year

**TABLE 6. Summary points**

Many factors can affect the reliability of home BP readings and care should be taken to minimize this possibility by using a standardized approach to measurement.
Home BP devices should be validated.
Standing BP measures may be taken when orthostatic hypotension is suspected.

BP, blood pressure.

**TABLE 7. Definition of blood pressure categories in Australia based on average SBP and DBP measured in the clinic, home or with 24-h ambulatory blood pressure monitoring**

BP category	Clinic BP (mmHg)	Home BP (mmHg)	24-ABPM (mmHg)		
			24-h	Day	Night
'Normal'	<120/80	Not yet determined	<115/75 <sup>a</sup>	<120/80 <sup>a</sup>	>105/65 <sup>a</sup>
High-normal threshold	≥120/80	Not yet determined	≥115/75 <sup>a</sup>	≥120/80 <sup>a</sup>	≥105/65 <sup>a</sup>
Stage 1 (mild) hypertension threshold	≥140/90	≥135/85 <sup>b</sup>	≥130/80	≥135/85	≥120/70
Stage 2 (moderate) hypertension threshold	≥160/100	≥145/90 <sup>c</sup>	≥148/93 <sup>a</sup>	≥152/96 <sup>a</sup>	≥139/84 <sup>a</sup>
Stage 3 (severe) hypertension threshold	≥180/110	Not yet determined	≥163/101 <sup>a</sup>	≥168/105 <sup>a</sup>	≥157/93 <sup>a</sup>

Home BP values determined from the average of two morning and two evening readings (taken over 7 days), but discarding the first day of monitoring. 24-ABPM, 24-h ambulatory blood pressure monitoring; BP, blood pressure. As per usual recommendations, if the patient's SBP or DBP falls into different categories, the higher diagnostic category is applied.

<sup>a</sup>Thresholds based on systematic review and consensus by a writing committee of the Australian Consensus Statement [44].

<sup>b</sup>Thresholds based on systematic review and consensus by a writing committee of the European Society of Hypertension [83].

<sup>c</sup>Thresholds based on systematic review and consensus by a writing committee of the International Database of Home Blood Pressure in Relation to Cardiovascular Outcome Investigators [108,109].

cardiovascular risk estimates and tended to be slightly lower than previous recommendations [83]. However, there was evidence that home BP thresholds may be slightly higher among people aged at least 60 years [109], which could have clinical relevance, but further investigation will be needed to confirm this.

Guidelines produced by the National Vascular Diseases Prevention Alliance [for adults without known history of CVD aged 45 years and over (35 years and over for Aboriginal Australians and Torres Strait Islanders)] recommend that the decision to medicate previously untreated patients should be based on an absolute CVD risk assessment [111]. Algorithms used in the Australian cardiovascular risk calculator are based on clinic BP measures. Whilst there is little evidence to guide this, we suggest correcting the home BP measure before entry into the risk calculator (i.e. add 5 mmHg to the SBP and DBPs) [112].

## SCREENING FOR HYPERTENSION

Clinic BP remains the most practical way to screen for high BP [28]. However, clinic BP readings by a doctor will overestimate cardiovascular risk in white-coat hypertension and underestimate risk in masked hypertension. A potentially important advance in screening has been the use of unobserved automated BP recording [113]. This gives an approximation of average daytime ABPM and minimizes the white-coat effect. While there are sound reasons to promote the widespread use of unobserved automated BP measurement in the clinic, in pharmacies and at other sites where BP screening is undertaken, more data are needed to confirm the value of this method.

The algorithm for BP assessment in general practice (Fig. 1) takes into consideration current national and international BP and absolute CVD risk management guidelines [24,25,28,44,111,114,115]. As stated above, at present, cardiovascular risk calculations are based on clinic BP

readings. When relevant, individual disease management guidelines can be referred to [111,116–118] (Table 8).

In conclusion, home BP offers several advantages beyond clinic BP: detection of white-coat and masked hypertension, better prognostic indication, better evaluation of BP control, improved long-term compliance with drug treatment (and, thereby, hypertension control) and greater engagement with and empowerment of patients. It is cost-effective and may also be used as a complementary tool to 24-ABPM. Home BP should be recorded using validated devices in a systematic and standardized fashion at the direction of health practitioners. It is optimal for decisions regarding BP therapy to be made with consideration of absolute cardiovascular risk and, when feasible, home BP should be considered for routine use in clinical practice.

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## Conflicts of interest

There are no conflicts of interest.

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**TABLE 8. Summary points**

Home BP hypertension threshold is at least 135/85 mmHg.  
The decision to medicate should be based on absolute risk estimation.

BP, blood pressure.

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