

## Blood pressure self monitoring: questions and answers from a national conference

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Cite this as: *BMJ* 2008;337:a2732 doi:10.1136/bmj.a2732

Self measurement of blood pressure was introduced in the 1930s and is now practised by almost 10% of the general population of the United Kingdom.<sup>1,2</sup> Because blood pressure monitors are now readily available and cheap (as little as £10; €11.8; \$15), self monitoring is likely to increase—in the United States and Europe up to two thirds of people with hypertension self monitor.<sup>3</sup> At present we have insufficient evidence to make use of multiple blood pressure readings generated from home monitoring in clinical care. This review—which is based on available evidence from randomised trials, systematic reviews, and expert consensus—discusses the clinical importance of self measurement of blood pressure in establishing the diagnosis of hypertension, in subsequent titration of drugs, and in longer term monitoring.

### What is self monitoring of blood pressure?

Self monitoring of blood pressure is when a person (or carer) measures their own blood pressure outside the clinic—at home, in the workplace, or elsewhere.<sup>4</sup> Self monitoring allows multiple measurements and therefore provides a more precise measure of “true” blood pressure and information about variability in blood pressure.

### What are the advantages and disadvantages?

Box 1 gives details of the potential advantages and disadvantages of self monitoring.

### What is the value of self monitoring in diagnosis and prognosis?

Blood pressure can vary widely (fig 1). The main value of self monitoring is that it can provide more precise estimates of the true underlying mean blood pressure than traditional clinic measurements. The table shows the increased precision in mean systolic blood pressure gained from additional measurements for up to two weeks.

### Faster diagnosis

Trials have shown that morbidity and mortality are significantly lower in people whose blood pressure is

reduced earlier rather than later.<sup>5,6</sup> The British Hypertension Society recommends that hypertension is diagnosed by using a series of office blood pressure readings taken over one to 12 weeks, depending on the blood pressure level.<sup>7</sup> Self monitoring can provide more precise data in a much shorter time.

### Improved accuracy

Self monitoring can improve diagnostic and predictive accuracy. A large cohort study in Japan showed that self monitoring predicted the risk of stroke better than office readings. In this study, risk of stroke increased 29% (95% confidence interval 16% to 44%) for each 10 mm Hg increase in home systolic readings versus 9% (0% to 18%) for office readings.<sup>8</sup> The predictive value of home measurement improved with the number of measurements, with the best predictive value being seen with 25 measurements.<sup>9</sup> Another large cohort study used an upper limit for normality of 135/85 mm Hg for self monitoring and found that each 10 mm Hg increase above this was associated with a 17% increase in risk of cardiovascular disease, even when office blood pressure was normal.<sup>10</sup>

### Reduced risk

Self monitoring avoids two situations where office readings can mislead—white coat hypertension, where out of home readings are normal but office readings are

### Sources and selection criteria

We extracted key studies from a Medline search for randomised controlled trials and systematic reviews to the end of 2007. These were supplemented by data from the personal references of study group members. After an open conference in early July 2008, at which the main data from the literature were presented, the group held a writing day to distil what was known and unknown for a series of questions for self monitoring of hypertension.

**Tips for non-specialists**

Self monitored blood pressure is lower than office measured blood pressure by about 10/5 mm Hg  
 International guidelines suggest a threshold of >135/85 mm Hg for diagnosis of uncomplicated hypertension from self monitored blood pressure and target for treatment of ≤135/85 mm Hg  
 European and US guidelines recommend using the mean of two home measurements taken morning and evening for a week after discarding those readings from the first day

raised, and masked hypertension, where the opposite is the case. Risk of death from cardiovascular disease increases progressively from normal readings at home and in the office, to white coat hypertension, then masked hypertension, and finally increased readings at home and in the office.<sup>11</sup> Furthermore, one large cohort study found that the prognosis for masked hypertension was similar to that for uncontrolled office hypertension.<sup>10</sup> People with masked hypertension are rarely identified, and self monitoring may be particularly helpful for this group, especially if it is used as a screening tool for people with high-normal office readings.<sup>3</sup>

**Does self monitoring improve long term control?**

Several randomised trials have examined the effects of self monitoring on blood pressure but not clinical outcomes.<sup>12</sup> A meta-analysis in 2004 reviewed 18 randomised controlled trials including 1359 people with essential hypertension allocated to home blood pressure monitoring and 1355 allocated to the “control” group. Follow-up was between two and 36 months.<sup>12</sup> The meta-analysis showed small reductions of blood pressure in the self monitoring group (4.3/2.4 mm Hg), but the true effect may be smaller as a result of publication bias. Self monitoring did not affect the chances of achieving target blood pressure.

Home monitoring alone seems to have only a modest effect, and many studies of self monitoring have included important cointerventions. These include patient education by lay people, nurses, or pharmacists; telemonitoring or internet communication systems, with or without prompts; intensive nurse led follow-up; and patient led titration of drugs.<sup>12,13</sup> Studies with additional cointerventions show a greater effect size in the intervention arm.

**Box 1 Advantages and disadvantages of self monitoring of blood pressure**

**Potential advantages**

- The ability to take multiple measurements results in better estimation of “true” mean blood pressure for diagnosis and monitoring (reduces effect of inherent variability)
- Better classification of blood pressure status—it removes the problems of white coat hypertension and masked hypertension
- It empowers patients
- It is convenient for patients
- It may lead to better blood pressure control

**Potential disadvantages**

- Measurements are hard to interpret because current evidence on risk of morbidity and mortality is based on office measurements
- Current treatment recommendations are based on office measurement
- It risks overmedicalising the population
- Measurements may be inaccurate (poor technique, or poorly calibrated or validated equipment)
- Normal variation in blood pressure may cause anxiety in the patient
- Requires motivation by patients and professionals

Date	Time	Systolic pressure (mm Hg)	Diastolic pressure (mm Hg)	Heart rate (beats/min)
Day 1	8.31	135	72	56
	8.25	144	76	58
Day 2	8.14	133	73	57
	8.08	162	69	59
Day 3	8.27	155	78	51
	8.21	165	74	54
Day 4	8.15	144	73	55
	8.09	156	78	58
Day 5	8.19	134	79	59
	8.13	157	92	57
Day 6	8.25	163	78	57
	8.19	167	75	57
Day 7	8.20	128	69	59
	8.14	151	72	60

**Fig 1 | Variation in one person’s blood pressure during one week (two readings each day)**

**How does self monitoring reduce blood pressure?**

**Better adjustment of antihypertensive drugs**

Doctors do not always treat patients with documented raised blood pressure even though antihypertensives are known to reduce blood pressure and the risk of cardiac disease.<sup>14-16</sup> Self monitoring of blood pressure may lead patients to discuss their blood pressure with their doctor and this may encourage appropriate prescription of antihypertensives.

**Improved compliance with scheduled treatment**

Self monitoring makes patients more aware of their blood pressure level; this might increase their illness perceptions and subsequent health behaviours and therefore improve adherence to drugs. Of 11 randomised controlled trials of self monitoring that reported measures of treatment adherence, six showed a statistically significant improvement in adherence, but in five of these six trials self monitoring was part of a complex intervention.<sup>17</sup> These trials must be treated cautiously because pill counting was often used to measure compliance as opposed to more reliable methods.<sup>18</sup>

**Improved non-pharmacological interventions**

Self monitoring may lead to improvements in health behaviours, such as diet and exercise, that help reduce blood pressure.<sup>15</sup> A randomised controlled trial found significant changes in body mass index at six and

**Effect of additional monitoring days on standard error of mean systolic blood pressure**

No of days monitored	Standard error of mean systolic blood pressure	
	2 readings/day	2 readings twice daily
1	9.0	7.6
3	6.6	6.0
7	5.1	4.8
14	3.8	3.6

**Box 2 Minimum requirements for an education programme for patients**

Patients should be made aware of the importance of the following:

- Using a validated and calibrated monitor
- Appropriate positioning and size of blood pressure cuff
- Ensuring that they are in the correct seated position—legs uncrossed, back and arm supported
- Taking multiple measurements with rest beforehand
- The effects of factors such as exercise, posture (crossing legs, standing up), and smoking
- Timing of readings—they should be consistent in terms of taking drugs, exercise, smoking, eating, and drinking
- The difference in level between self measurements and professional measurements

Patients' self monitoring technique should be assessed at follow-up visits

12 months in a self monitoring group compared with controls.<sup>19</sup> A reduction in alcohol intake was also seen at six but not 12 months. No effect was seen on self reported physical activity or salt intake.

**Habituation to measurement**

Repeated measurement of blood pressure lowers blood pressure readings.<sup>20</sup> Presumably this is because people habituate to the measurement process and show less of an alarm response when the cuff is inflated. However, results of a randomised trial of self monitoring that included ambulatory monitoring as an outcome measure supported the conclusions of a previous review implying that habituation to measurement was not the reason for the lowering of blood pressure in self monitoring.<sup>12,21</sup>

**How should we handle the difference between home and clinic readings?**

**Implications for treatment**

Most home measurements of blood pressure are lower than those taken by a health professional in the office—

a meta-analysis found that they differed by 6.9/4.9 mm Hg and the difference varied with age and treatment.<sup>22</sup> The British Hypertension Society suggests a “correction” factor in the order of 10/5 mm Hg.<sup>7</sup>

In one trial where antihypertensive drugs were titrated by someone who was blinded to whether the blood pressure results were from home or office readings,<sup>23</sup> the home monitored group had *worse* blood pressure control because of lower prescription of all classes of drugs. This may have resulted from failure to account for the difference between home and office blood pressures.<sup>23</sup>

A systemic review aimed at ascertaining a diagnostic cut-off for hypertension for home measurements—defined as an office equivalent of 140/90 mm Hg<sup>24</sup>—identified different thresholds of self monitored pressures of between 129/84 mm Hg and 137/89 mm Hg, depending on the method of comparison used. Recommendations from the US and Europe have settled on a threshold of 135/85 mm Hg. No studies have assessed morbidity and mortality outcomes from treating to a lower “home target,” but because home blood pressure is systematically lower than office readings it seems appropriate to adopt such a strategy.

**Calculating cardiovascular risk**

We found no studies that looked at the potential differences in calculated risk of cardiovascular disease when using office versus home blood pressure measurements. In the absence of such data, office measures should be used in calculating risk using recognised risk calculators for cardiovascular disease.<sup>25</sup>

**How do I use self monitoring?**

**Diagnosis**

Current guidelines suggest using a mean of seven days of monitoring, with two measurements of blood pressure taken twice daily and the first day's readings discarded.<sup>26</sup> A systematic review found little evidence to determine how many readings are appropriate, with considerable variation in recommendations in the literature.<sup>22</sup>

**Titration of antihypertensives after diagnosis**

We have no clear evidence on how long to monitor after titration of drugs using either office or home measurement. It depends on how long it takes for the pharmacological effects (typically five half lives) and biological effects (varies between drugs) to become apparent.

**Long term monitoring for people on stable treatment**

Data from the PROGRESS trial (Perindopril Protection against Recurrent Stroke study) indicate that true changes in blood pressure occur slowly, and that for patients on stable medication a reasonable time frame for remeasurement would be every six to 12 months (Keenan K, Hayen A, Neal BC, Irwig L, unpublished data, 2008). Although the PROGRESS trial looked at

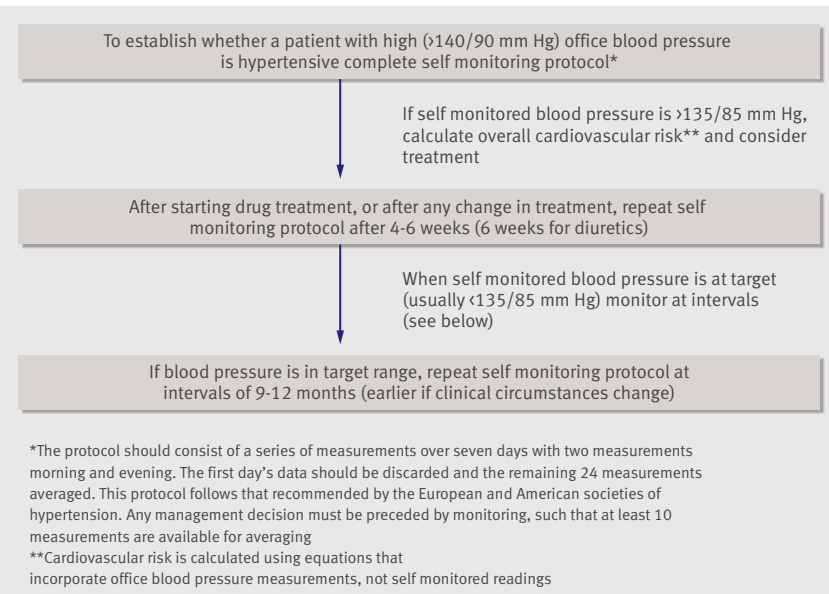


Fig 2 | Suggested model for self monitoring of blood pressure

### Questions for future research

How should self monitored blood pressure be used (as opposed to office measurements) to assess risk of cardiovascular disease?

Should self monitoring be intermittent (<6 monthly) or continuous (weekly or monthly)?

What are the effectiveness and cost effectiveness of treatment based on self monitored blood pressure versus standard care?

What is the effect of self monitoring on long term (>1 year) blood pressure control?

office measurements of blood pressure, this estimate is probably valid for patients who self monitor.

### Schedule

Blood pressure varies throughout the day and drugs are typically taken in the morning. This usually results in peaks and troughs during the day, so it has been recommended that blood pressure is measured in the morning and the evening.<sup>326</sup> Japanese data suggest that blood pressure measured in the morning correlates best with end organ damage, but these findings may be confounded by Japanese customs such as taking hot baths in the evening.<sup>327</sup>

### Which patients may not benefit from self monitoring?

To date, trials of self monitoring have studied people who are willing to monitor themselves, so the question remains whether self monitoring should be recommended for all.<sup>1-28</sup> People with an absolute contraindication for self monitoring are rare and include those in whom it is impossible to measure indirect blood pressure accurately (such as amputees). The evidence for self monitoring in pregnant women, children, and those with vascular problems such as Raynaud's disease is sparse, and self monitoring should be undertaken with caution in these groups. Atrial fibrillation, which may affect the accuracy of oscillometric algorithms in automated monitors, may be problematic, although evidence indicates that accurate readings are possible with standard models.<sup>29</sup> People

with conditions that might preclude self monitoring, such as dementia or stroke, may need the help of a carer. Increased anxiety is often quoted as a problem in self measurement, and anecdotally some people seem not to cope with self monitoring.<sup>3</sup> Studies that have looked for increased anxiety resulting from self monitoring have been negative, but this may reflect the population studied.<sup>19</sup>

### What are the optimum models of care for self monitoring?

Integrating self monitoring into daily practice requires appropriate equipment, systems, and education—of patients and their doctors. Figure 2 shows a suggested model for self monitoring of blood pressure.

### Monitors

Accurate and easy to use monitors are needed for optimal self monitoring. Most automated sphygmomanometers use the oscillometric method. Upper arm (brachial pressure) monitors are preferred to wrist (radial pressure) monitors because few wrist monitors have been clinically validated and they are more dependent on arm position.<sup>326</sup> Most randomised trials have used upper arm monitors.<sup>12</sup> The Medicines and Healthcare Products Regulatory Agency has published guidance on calibration, which suggests following manufacturers' instructions with respect to automated machines.<sup>30</sup>

### Monitoring process

Models vary from people buying machines and monitoring themselves completely, independent of doctors, to schemes where doctors provide a pool of validated machines that patients can borrow intermittently. The efficacy of self monitoring in the practice waiting room is broadly similar to self monitoring at home.<sup>19</sup>

Telemonitoring of blood pressure—transmitting self measured readings to a professional usually via modem, internet, or mobile phone—might reduce the need for healthcare visits and improve blood pressure control.<sup>31</sup> Published trials have generally been small, with limited follow-up, but have shown similar reductions in blood pressure to those seen in the overall meta-analyses.<sup>12</sup> However, a recent large trial has evaluated the use of a web based system for patients and their family doctor to share self monitoring information and gain educational advice. The intervention was beneficial when combined with support from a pharmacist.<sup>13</sup>

Whichever model of monitoring is used, a straightforward method for incorporating self measurements into the clinical record is needed.

### Patient education

Box 2 summarises the minimum requirements for patient education. People should be aware of the main causes of inaccuracy in measurement, which can be divided into three broad categories—patient factors,

### Additional educational resources

#### Resources for patients

Blood Pressure Association ([www.bpassoc.org.uk/BloodPressureandyou/Homemonitoring](http://www.bpassoc.org.uk/BloodPressureandyou/Homemonitoring))—Information about high blood pressure and self monitoring

#### Resources for healthcare professionals

Parati G, Stergiou GS, Asmar R, Bilo G, de Leeuw P, Imai Y, et al. European Society of Hypertension guidelines for blood pressure monitoring at home: a summary report of the Second International Consensus Conference on Home Blood Pressure Monitoring. *J Hypertens* 2008;26:1505-26

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;52:10-29

Cappuccio FP, Kerry SM, Forbes L, Donald A. Blood pressure control by home monitoring: meta-analysis of randomised trials. *BMJ* 2004;329:145-51

British Hypertension Society ([http://www.bhsoc.org/blood\\_pressure\\_list.stm](http://www.bhsoc.org/blood_pressure_list.stm))—List of validated monitors

**SUMMARY POINTS**

Self monitoring of blood pressure is useful in the diagnosis and management of hypertension  
 Multiple measurements of blood pressure allow a better estimation of "true" blood pressure  
 Systematic reviews show that blood pressure is lower when self monitored  
 Self monitored blood pressure correlates better with risk of stroke than office readings  
 Patient education and clinically validated sphygmomanometers are prerequisites for effective self monitoring

technique and measurer factors, and device inaccuracy.<sup>32</sup> Talking (increase of 17/13 mm Hg) or crossing of legs (increase of 7/2 mm Hg) during measurement and arm position (increase or decrease of 8 mm Hg for every 10 cm above or below heart level) can significantly alter measurements. Education regarding disclosure of results is important because studies have shown that up to 20% of readings are not divulged to healthcare professionals.<sup>33</sup>

**Conclusions**

Self monitoring is already used and recommended. Although self monitoring can undoubtedly provide a more precise measure of mean blood pressure than intermittent clinic measurement, and despite more than 20 randomised trials of self monitoring of blood pressure, urgent questions must still be answered by further research.

Thanks to Roger Holder, head of statistics, Primary Care Clinical Sciences, University of Birmingham, who produced the table using data from the Telemonitoring and Self Management in Hypertension study.

**Contributors:** This paper originated from a national self monitoring conference on 3 July 2008 in Oxford. PG initiated the conference, secured funding, and is guarantor. Each author prepared and presented evidence for self monitoring at the conference. These talks were reviewed by the authors and formed the basis of this paper. RJM produced a first draft from these discussions, which was further developed and finally approved by all the authors.

**Funding:** The National Institute for Health Research Health Technology Assessment funded the July conference.

**Competing interests:** None declared.

**Provenance and peer review:** Commissioned; externally peer reviewed.

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