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Is self-monitoring of blood pressure in pregnancy safe and effective?

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Standfirst: Guidelines encourage the use of self-monitoring of blood pressure in pregnancy, and research suggests that women prefer it. But the blood pressure monitoring in pregnancy group (BUMP) explain that our enthusiasm may run ahead of the evidence. They outline what is known and call for better understanding before self-monitoring is implemented.

Self-monitoring of blood pressure (BP) outside pregnancy is increasingly popular with patients and health care professionals. Around 1:3 people self-monitor¹ and it is more accurate than BP readings taken in clinic.² Anecdotal reports in the UK suggest that self-monitoring in pregnancy is commonplace, although few robust data exist to quantify this accurately.

Around two thirds of women diagnosed with gestational hypertension were already self-monitoring according to a Canadian pilot survey.³ Another small, Canadian survey found that 78% of obstetricians used self-monitoring to check for “white coat” hypertension (WCH) in women whom they diagnosed with hypertension in pregnancy, rather than ambulatory blood pressure measurement (ABPM; wearing a small digital blood pressure monitor that measures BP repeatedly over a 24-hour period).⁴ BP Guidelines recommend home monitoring for women with chronic hypertension and poorly controlled BP and for women with gestational hypertension, for example 2013 ACOG (American College of Obstetricians and Gynaecologists) guidelines, so it is likely that the practice will become more common.⁵ The American Heart Association (AHA)/ American Society of Hypertension (ASH)/ Preventive Cardiovascular Nurses Association (PCNA) joint statement⁶ and ESH guidelines have highlighted the importance and potential of self-monitored BP measurement and describe it as “theoretically ideal for monitoring changes in BP during pregnancy”.⁷

If shown to be acceptable to women and accurate for screening and monitoring of normal and high BP in pregnancy, greater use of home monitoring could augment clinic based monitoring significantly. It may allow for the reorganisation of antenatal care. Availability of self-monitored results could allow health care professionals to spend more time on responding appropriately to BP results rather than actually performing monitoring. Alternatively, self-monitoring could integrate effectively with a group prenatal care model, wherein women do their own readings in the clinic and these are reviewed by the midwife.⁸

There are reasons why self-monitoring may or may not be a good idea in pregnancy (see box 1). The aim of this article is to explain what is known about the evidence for self-monitoring and suggest a way forward. We extracted key studies from Medline searches up to March 2014, without limiting by publication date or language. We additionally searched the BHS⁹ and dabl¹⁰ websites (which both summarise BP monitor validation studies published in peer reviewed journals) to identify relevant validation studies.

The scale of the problem

Hypertensive disorders during pregnancy (box 2) are a leading cause of maternal mortality worldwide.¹¹ They are associated with fetal growth restriction, low birth weight, preterm delivery, respiratory distress syndrome, and admission to neonatal intensive care.¹²

In women who have died from pre-eclampsia, substandard care has been identified in 46% of maternal deaths and 65% of fetal deaths.¹³ In these cases, different management could reasonably have been expected to alter the outcome; in particular failures to identify and act on known risk factors at booking appointments and to recognise and respond to signs and symptoms from 20 weeks' gestation have been noted. This suggests that health care professionals could do better and may provide a basis for change from the status quo.

One in ten women have raised BP (>140/90mmHg), with or without proteinuria, during pregnancy worldwide,¹⁴ and the proportion of women with high BP, and risk factors for high BP, is increasing. In the USA, for example, the percentage of women who are obese (BMI > 30) or overweight (BMI > 25) has increased almost 60% in the last 30 years - there is a three-fold increase in the risk of pre-eclampsia associated with obesity.^{15,16} The number of pregnant women over 40 in the UK has more than doubled in the last 24 years,¹⁷ and advanced maternal age is associated with around a 50% increase of pre-eclampsia.¹⁸

Pre-eclampsia manifests long before clinical symptoms,^{19,20} and there is evidence that women in the UK develop the condition between antenatal visits. In 383 confirmed cases of eclampsia, 323 (85%) women had been seen by a doctor or midwife in the week before their first convulsion, but at that point 36 (11%) had neither hypertension nor proteinuria, 32 (10%) had proteinuria but no hypertension, and 71 (22%) had hypertension alone.²¹

Current guidelines recommend BP monitoring at routine antenatal visits with "increased frequency" for those at higher risk,²² but comprehensive systematic reviews have not identified any screening test (including those based on demographic characteristics, biomarkers or ultrasound screening) that have sufficient accuracy or cost-effectiveness to introduce into clinical practice, and consequently intermittent BP monitoring in a clinic setting remains the mainstay of pre-eclampsia detection in antenatal care.²³ Earlier identification of rising BP amongst asymptomatic women could improve targeting of resources for close monitoring and outcomes. Such measurement provides a potential benefit of self-monitoring between clinic appointments.

Blood pressure in pregnancy

Clinic measurements are more vulnerable to error compared to out-of-office monitoring; at home more measurements can be taken and white coat hypertension is avoided. The variability of BP is heightened in pregnancy,²⁴ and debate continues

about what constitutes normal blood pressure in pregnancy and how this may change by trimester. Clinic measurements could lead to unnecessary monitoring or missed opportunities to detect raised BP, though there are no reliable data to describe this currently. Data from ambulatory monitoring suggest that outcomes in those with white coat hypertension in pregnancy are similar to those with normotension.²⁵

Will women self-monitor?

We know pregnant women are willing to undertake repeated self-measurements, comply with monitoring schedules²⁶ and are able to accurately record BP data.²⁷ It does not appear to increase anxiety,²⁸ even when using more complex telemonitoring equipment.^{29,30} Clinicians promoting self-monitoring report being encouraged by women's co-operation, competence and genuine desire to participate in their own healthcare.^{Error! Bookmark not defined.}^{31,32} Over 98% of women with hypertension in pregnancy reported liking being involved in their BP management.³

Self-monitoring of BP in pregnancy is more acceptable to pregnant women than more frequent clinic visits,³³ hospitalisation³⁰ or ambulatory monitoring.^{34,35} In a study of 81 healthy pregnant women, 95% found self-monitoring of BP (using Omron HEM705CP) acceptable compared to 78% 24-hour ABPM.³⁶ Home monitoring caused less discomfort, and rarely interfered with activities or disturbed sleep.

Is self-monitoring accurate?

There is a scarcity of home monitors validated and deemed accurate for use in pregnancy and in pre-eclampsia, in contrast to the number validated for use in the general population. Specific validation of monitors in a pregnant population is important because several monitors have in the past failed validation, mostly due to falsely low readings.^{37,38} Five monitors have been validated as being accurate within pre-defined margins by one of the three most widely used protocols produced by, respectively, the British Hypertension Society,³⁹ the Association for the Advancement of Medical Instrumentation Standard,⁴⁰ or the International Protocol of the European Society of Hypertension,⁴¹ for home use in pregnancy.^{42,43,44,45,46} Even validated monitors may not be accurate for *all* pregnant women; for example, though obesity is an established risk factor for pre-eclampsia,⁴⁷ when the accuracy of three commercially available devices was tested on 55 pregnant women with upper arm circumference >35cm, none was accurate.⁴⁸

How should self-monitoring be done?

In essential hypertension, a minimum of three days and ideally seven days self-monitoring is currently recommended, although the evidence underlying this is not particularly compelling.⁴⁹ Conclusions from ambulatory monitoring in pregnancy suggest that a level of 135/85 mmHg best predicts future pregnancy-induced hypertension, but these threshold values have not been established firmly.^{50,51} Clear reference thresholds for self-monitoring have not been established to diagnose

hypertension in pregnancy.^{49,52} Little data are available comparing clinic thresholds with self-monitored BP in pregnancy and the studies they are drawn from have significant methodological weaknesses.

At a more basic level incomplete understanding of normal blood pressure in pregnancy means that any monitoring in pregnancy is challenging. BP changes through the trimesters, falling and then rising again, thus a woman may have a BP that starts at 100/70 mmHg, falls in mid-trimester to 90/60 mmHg and then rises to 135/85 mmHg (for example), but is still considered within normal limits (<140/90mmHg by clinic measurement), despite the rise from booking BP. It is unclear whether monitoring frequency should change if there is a marked increment in blood pressure without crossing this threshold of 140/90 mmHg.⁵³ Despite this, at present only the 140/90mmHg threshold is accepted for all trimesters.²⁶ Women with pre-existing hypertension may have more unpredictable BP in pregnancy due to medication changes to stop treatment or change to safer medicines in early pregnancy.

In the absence of clear evidence, there is little guidance on how often BP should be measured. The US guidelines recommend that in women with hypertension before pregnancy “the diagnosis should be confirmed by multiple measurements and may incorporate home or other out-of-office BP readings”, but there is no statement concerning what this means practically, for example how frequently BP should be measured.⁵⁴ NICE guidelines on hypertension in pregnancy conclude that research is needed to determine the optimal frequency and timing of measurement and on the role of screening for proteinuria in women who have existing hypertension and those who may develop pre-eclampsia.⁵⁵

Are pregnancy outcomes different if self-monitoring is used?

It is not known whether self-monitoring will alter outcomes. In the UK, a pilot RCT included a weekly self-monitoring regime in eighty low risk women combined with a reduced antenatal visit schedule.⁵⁶ A larger trial did not go ahead, perhaps because the predicted number of low risk women required was 10,000. A future trial may be better to focus on the role of self-monitoring in a higher risk group where fewer numbers would be needed and women would be more likely to gain benefit.⁵⁷

Few data exist on the safety of self-monitoring, but there are conflicting reports regarding how well women follow instructions from health care professionals.^{33Error! Bookmark not defined.,58} In one small study, women who recorded their own BP responded appropriately by contacting healthcare professionals when repeated readings were persistently raised.⁵⁹ However, researchers found 10 out of 21 pregnant women in another study⁴² had poor understanding of the instructions given and the importance of alerting midwives in the Day Assessment Unit (DAU) when their BP was raised above a threshold. Issues included language barriers and personal/ work commitments.

The bottom line

Self-monitoring of BP appears to be feasible and acceptable to pregnant women. It might add to the efficacy of modern antenatal care. However, new evidence is required to establish the precise place of self-monitoring during and after pregnancy (see box 3). If self-monitoring is or becomes widespread, research may be difficult to undertake. We believe that until the evidence base is considerably stronger, further implementation of self-monitoring of BP in pregnancy, at least formally by the NHS, should be delayed.

Regardless, the trend towards self-monitoring is set to increase, and it is important to acknowledge this and respect people's choices. We suggest that GPs and midwives at least need to be sensitive to this, and could enquire whether women in their care are self-monitoring, and if so would they like to share the results or receive any help interpreting them. They should also discuss the uncertainty around how the results are best interpreted.

Contributors and Sources

The first draft of this paper was written by James A. Hodgkinson, Katherine L. Tucker (both research fellows) and Richard J. McManus (GP and NIHR Professor).

Subsequent drafts were edited for critical content by all authors including Carole Crawford and Mary Selwood (research midwife and qualified midwife/researcher respectively), Sheila M. Greenfield, Lisa Hinton and Louise Locock (qualitative researchers), Khalid Khan, Lucy MacKillop, Christine McCourt (obstetrician, obstetric physician and professor of maternal health respectively). We extracted key studies from Medline searches up to March 2014, without limiting by publication date or language. We additionally searched the BHS and dabl websites (which both summarise blood pressure monitor validation studies published in peer reviewed journals) to identify relevant validation studies. Richard J. McManus will act as guarantor.

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Declaration of competing interests

We have read and understood the BMJ Group policy on declaration of interests and declare the following interests:

RM is a member of the NIHR HTA Trials Board, and has received funding in terms of blood pressure monitoring equipment for research studies from Omron and Lloyds Pharmacy.

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Boxes

Box 1:

Advantages and disadvantages of home monitoring of blood pressure in pregnancy

Potential advantages

Increased accuracy

Patient friendly

Potential to free health care professional time or reduce clinic visits

Potential to identify white coat hypertension

Potential disadvantages

Few monitors have been validated for use in pregnancy

Poor understanding of normal blood pressure in pregnancy: no diagnostic thresholds for home monitoring of blood pressure in pregnancy

No currently known blood pressure parameter in the early stage of pregnancy appears to permit reliable discrimination within white coat hypertensives between those who have continued white coat hypertension and those who develop either pre-eclampsia or gestational hypertension later in their pregnancy

No evidence earlier detection of high blood pressure through home monitoring will alter outcomes

No evidence on how to implement home monitoring in practice: optimal frequency and timing of home monitoring is unknown

Box 2:

Types of hypertension during pregnancy

Chronic hypertension: hypertension (>140/90mmHg) present before 20 weeks or being treated at time of referral to maternity services

Gestational hypertension: new hypertension presenting after 20 weeks without significant proteinuria

Pre-eclampsia: new hypertension presenting after 20 weeks of pregnancy combined with significant proteinuria (if urinary protein: creatinine ratio > 30mg/mmol or a validated 24hour urine collection results shows > 300mg protein)¹

White coat hypertension: hypertension (>140/90mmHg) at the clinic or office only, where ambulatory or home blood pressure is normal (typically using a threshold of <135/85 mmHg)

Box 3:
Research questions

Can self-monitoring of BP lead to earlier detection of raised BP in pregnancy, and does this improve outcomes?

What is the place of self-monitoring once raised BP has been detected?

How does self-monitoring impact on women's knowledge and confidence, their feelings about their body, their sense of self-efficacy and how they position themselves within care and in relation to professionals?

Could self-monitoring help professionals to respond to more women-/ community-centred approaches to care, thereby promoting partnership working?

Table 1: Current monitors validated for home use in pregnancy

Author (Year)	Device	Protocol	Pregnancy	Pre-eclampsia	Non-proteinuric hypertension
de Greeff (2006) ⁴³	Microlife BP 3AC1-1	BHS	A/A**	B/A**	N/A
		AAMI	Pass**	Pass**	N/A
Reinders et al (2005) ⁴⁴	Microlife BP 3BTO-A*	BHS	A/B	A/B	B/B
		AAMI	Pass	Pass	Pass
Chung et al (2009) ⁴²	Microlife WatchBP Home	BHS	A/A	B/A	N/A
		AAMI	Pass	Pass	N/A
de Greeff et al (2009) ⁴⁵	Omron M7 (HEM-780-E)	BHS	A/A	B/B	N/A
de Greeff et al (2009) ⁴⁵	Omron MIT*	BHS	A/A	A/A	N/A
Golara et al (2002) ⁴⁶	Omron MIT*	BHS	B/A	B/A	N/A
		AAMI	Pass	Pass	N/A

Notes:

* These models are discontinued but equivalent monitors with slightly different model numbers though essentially similar hardware may be available.

** This study has not been fully published (only as an abstract) and thus it is not possible to know if correct validation procedures were followed.

BHS – British Hypertension Society protocol. Monitors can be rated from A to D, with A and B constituting a pass

AAMI - Association for the Advancement of Medical Instrumentation protocol

References

- ¹ 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, 582068.
- ² Hodgkinson J, Mant J, Martin U, Guo B, Hobbs FDR, Deeks JJ et al. Relative effectiveness of clinic and home blood pressure monitoring compared to ambulatory blood pressure monitoring in the diagnosis of hypertension: a systematic review. *BMJ* 2011; 342:d3621
- ³ Magee LA, von Dadelszen P, Chan S, Gafni A, Gruslin A, Helewa M, et al. Women's views of their experiences in the CHIPS (Control of Hypertension in Pregnancy Study) Pilot Trial. *Hypertens Pregnancy*. 2007;**26**(4):371-87.
- ⁴ Dehaeck U, Thurston J, Gibson P, Stephanson K, Ross S. Blood pressure measurement for hypertension in pregnancy. *J Obstet Gynaecol Can*. 2010 Apr;**32**(4):328-34.
- ⁵ Hypertension, Pregnancy-Induced – Practice Guideline. American College of Obstetricians and Gynaecologists. 2013.
- ⁶ 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.
- ⁷ 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.
- ⁸ Ickovics JR, Reed E, Magriples U, Westdahl C, Schindler RS, Kershaw TS: Effects of group prenatal care on psychosocial risk in pregnancy: results from a randomized controlled trial. *Psychosoc Health* 2011, 26:235-250.
- ⁹ <http://www.bhsoc.org//index.php?CID=246> [Accessed 4/4/2014]
- ¹⁰ http://www.dableducational.org/_sphygmomanometers/devices_2_sbpm.html [Accessed 4/4/2014]
- ¹¹ Khan KS, Wojdyla D, Say L, Gulmezoglu AM, Van Look PF. WHO analysis of causes of maternal death: a systematic review. *Lancet* 2006;**367**(9516):1066-1074.
- ¹² Altman D, Carroli G, Duley L, Farrell B, Moodley J, Neilson J et al. Do women with pre-eclampsia and their babies benefit from magnesium sulphate? The Magpie Trial: a randomised placebo-controlled trial. *Lancet* 2002;**359**(9321):1877-90.
- ¹³ Maternal and Child Health Research Consortium. *Confidential enquiry into stillbirths and deaths in infancy: 8th annual report, 1 January-31 December 1999*. London: Maternal and Child Health Research Consortium, 2001.

-
- ¹⁴ Duley L. The global impact of pre-eclampsia and eclampsia. *Semin Perinatol.* 2009 Jun;**33**(3):130-7
- ¹⁵ Bodnar LM, Ness RB, Markovic N, Roberts JM. The risk of preeclampsia rises with increasing prepregnancy body mass index. *Annals of Epidemiology.* 2005;15:475–82.
- ¹⁶ Wang Y, Beydoun MA, Liang L, Caballero B, Kumanyika SK. Will all Americans become overweight or obese? estimating the progression and cost of the US obesity epidemic. *Obesity.* 2008;16:2323–30.
- ¹⁷ Office for National Statistics Statistical Bulletin: Conceptions in England and Wales 2012. ONS London 2014.
- ¹⁸ Lamminpää R, Vehviläinen-Julkunen K, Gissler M, Heinonen S. Preeclampsia complicated by advanced maternal age: a registry-based study on primiparous women in Finland 1997-2008. *BMC Pregnancy Childbirth.* 2012;12:47
- ¹⁹ Khong TY, De Wolf F, Robertson WB, Brosens I. Inadequate maternal vascular response to placentation in pregnancies complicated by pre-eclampsia and by small-for-gestational age infants. *Br J Obstet Gynaecol.* 1986 Oct;**93**(10):1049-59.
- ²⁰ Redman CW, Sargent IL. Latest advances in understanding preeclampsia. *Science* 2005 Jun 10;**308**(5728):1592-4.
- ²¹ Douglas KA, Redman CW. Eclampsia in the United Kingdom. *BMJ* 1994; **309**(6966):1395-1400.
- ²² National Institute for Clinical Excellence. Antenatal care. NICE clinical guideline CG62, 2008.
- ²³ Meads CA, Cnossen JS, Meher S, Juarez-Garcia A, ter Riet G, Duley L, et al. Methods of prediction and prevention of pre-eclampsia: systematic reviews of accuracy and effectiveness literature with economic modelling. *Health Technol Assess.* 2008 Mar;12(6):iii-iv, 1-270.
- ²⁴ Ayala DE, Hermida RC, Mojón A, Fernández JR, Silva I, Ucieda R, Iglesias M. Blood pressure variability during gestation in healthy and complicated pregnancies. *Hypertension* 1997 Sep;30(3 Pt 2):611-8.
- ²⁵ Bellomo G, Narducci PL, Swifts F, Pastorelli G, Stangoni G, Angeli G et al. Prognostic value of 24-hour blood pressure in pregnancy. *JAMA* 1999; 282(15):1447-52.
- ²⁶ National Institute for Clinical Excellence. Hypertension in Pregnancy. NICE clinical guideline CG107, 2010.
- ²⁷ Kitagawa M, Akiyama Y, Omi H, Sago H, Natori M. Development and clinical application of a telemedicine support system in the field of perinatal patient management. *Journal of Obstetrics & Gynaecology Research* 2000;**26**(6):427-34.
- ²⁸ Rayburn WF, Zuspan FP, Piehl EJ. Self-monitoring of blood pressure during pregnancy. *Am J Obstet Gynecol.* 1984;**148**(2):159-62.
- ²⁹ Swindells HE, Mooney P, Cartwright W, Dalton KJ. Blood pressure telemetry from home. *Midwife Health Visitor & Community Nurse,* 1990;**26**(3):88-90.

-
- ³⁰ Cartwright W, Dalton KJ, Swindells H, Rushant S, Mooney P. Home measurement of pregnancy hypertension. *Professional Care of Mother and Child* 1993;**3**(1):8-9.
- ³¹ Rayburn WF, Zuspan FP, Piehl EJ. Self-monitoring of blood pressure during pregnancy. *Am J Obstet Gynecol.* 1984;**148**(2):159-62.
- ³² Rayburn WF, Piehl EJ, Compton AA. Clinical significance of home blood pressure monitoring during pregnancy. *Clinical and Experimental Hypertension - Part B Hypertension in Pregnancy* 1985;**4**(1):63-73.
- ³³ Naef RW 3rd, Perry KG Jr, Magann EF, McLaughlin BN, Chauhan SP, Morrison JC. Home blood pressure monitoring for pregnant patients with hypertension. *J Perinatol.* 1998 May-Jun;**18**(3):226-9.
- ³⁴ Cartwright W, Dalton KJ, Swindells H, Rushant S, Mooney P. Objective measurement of anxiety in hypertensive pregnant women managed in hospital and in the community. *British Journal of Obstetrics & Gynaecology* 1992;**99**(3):182-5.
- ³⁵ Denolle T, Weber JL, Calvez C, Getin Y, Daniel JC, Lurton O et al. Diagnosis of white coat hypertension in pregnant women with teletransmitted home blood pressure. *Hypertens Pregnancy* 2008;**27**(3):305-13.
- ³⁶ Taylor RS, Freeman L, North RA. Evaluation of ambulatory and self-initiated blood pressure monitors by pregnant and postpartum women, *Hypertens Pregnancy* 2001;**20**(1):25-33.
- ³⁷ Reinders A, Cuckson AC, Jones CR, Poet R, O'Sullivan G, Shennan AH. Validation of the Welch Allyn 'Vital Signs' blood pressure measurement device in pregnancy and pre-eclampsia. *BJOG* 2003 Feb;**110**(2):134-8.
- ³⁸ Natarajan P, Shennan AH, Penny J, Halligan AW, de Swiet M, Anthony J. Comparison of auscultatory and oscillometric automated blood pressure monitors in the setting of preeclampsia. *Am J Obstet Gynecol.* 1999 Nov;**181**(5 Pt 1):1203-10.
- ³⁹ O'Brien E, Petrie J, Littler W, Deswiet M, Padfield PL, Altman DG, et al. British-Hypertension-Society Protocol for the Evaluation of Blood-Pressure Measuring Devices. *Journal of Hypertension* 1993;**11**(Suppl 2):S43-S62.
- ⁴⁰ Association for the Advancement of Medical Instrumentation. American national standard. Electronic or automated sphygmomanometer. Arlington, VA: AAMI; 1993.
- ⁴¹ O'Brien E, Atkins N, Stergiou G, Karpettas N, Parati G, Asmar R, Imai Y, Wang J, Mengden T, Shennan A; Working Group on Blood Pressure Monitoring of the European Society of Hypertension. European Society of Hypertension International Protocol revision 2010 for the validation of blood pressure measuring devices in adults. *Blood Press Monit.* 2010 Feb;**15**(1):23-38.
doi:10.1097/MBP.0b013e3283360e98.
- ⁴² Chung Y, de Greeff A, Shennan A. Validation and Compliance of a Home Monitoring Device in Pregnancy: Microlife WatchBP Home. *Hypertension in Pregnancy* 2009;**28**(3):348-359.

-
- ⁴³ de Greeff A, Reggiori F, Anthony J, Shennan A. The Microlife 3AC1: An accurate blood pressure measurement device in pregnancy and pre-eclampsia *J Hypertens* 2006;**24** (suppl 4):S279 Abstract P14.475
- ⁴⁴ 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: an International Journal of Obstetrics and Gynaecology* 2005, **112**: 1-6.
- ⁴⁵ de Greeff A, Beg Z, Gangji Z, Dorney E, Shennan AH, Accuracy of inflationary versus deflationary oscillometry in pregnancy and preeclampsia; Omron MIT versus Omron M7. *Blood Pressure Monit.* 2009, **14**:37-40
- ⁴⁶ Golará M, Benedict A, Jones C, Randhawa M, Poston L, Shennan AH. Inflationary oscillometry provides accurate measurement of blood pressure in pre-eclampsia *Br J Obstet Gynaecol* 2002;**109**:1143-1147
- ⁴⁷ Duckitt K, Harrington D. Risk factors for pre-eclampsia at antenatal booking: systematic review of controlled studies. *BMJ*. 2005 Mar 12;**330**(7491):565.
- ⁴⁸ Schwartz WJ 3rd, Rayburn WF, Turnbull GL, Christensen HD. Blood pressure monitoring during pregnancy. Accuracy of portable devices designed for obese patients. *J Reprod Med.* 1996 Aug;**41**(8):581-5.
- ⁴⁹ Hypertension: clinical management of primary hypertension in adults - NICE guideline CG127. National Institute for Clinical Excellence. 2011. <http://guidance.nice.org.uk/CG127> [accessed 4/4/2014]
- ⁵⁰ Hermida RC, Ayala DE. Diagnosing gestational hypertension and pre-eclampsia with the 24-hour mean of blood pressure. *Hypertension* 1997; **30**:1531–1537.
- ⁵¹ Hermida RC, Ayala DE. Reference thresholds for 24-h, diurnal, and nocturnal ambulatory blood pressure mean values in pregnancy. *Blood Pressure Monit.* 2005, **10**:33–41.
- ⁵² The Seventh Report of the Joint National Committee on Prevention, Detection, Evaluation, and Treatment of High Blood Pressure - Complete Report. 2004. <http://www.nhlbi.nih.gov/guidelines/hypertension/inc7full.htm> [Accessed 4/4/2014]
- ⁵³ Lindheimer MD, Akbari A. Hypertension in pregnant women. In S. Oparil & M. A. Weber (Eds.), *Hypertension: A companion to Brenner and Rector's The Kidney* (pp. 688-701). 2000. Philadelphia: W. B. Saunders.
- ⁵⁴ Working Group report on High Blood pressure in pregnancy. National High Blood Pressure Education Program. 2000. *National Institutes of Health*.
- ⁵⁵ Antenatal care: routine care for the healthy pregnant woman. National Collaborating Centre for Women's and Children's Health. RCOG Press, March 2008.
- ⁵⁶ Ross-McGill H, Hewison J, Hirst J, Dowswell T, Holt A, Brunskill P, Thornton JG. Antenatal home blood pressure monitoring: a pilot randomised controlled trial. *British Journal of Obstetrics & Gynaecology* 2000 Feb;**107**(2):217-21.
- ⁵⁷ Thornton JG, Authors' reply *BJOG*. 2000;**107**:1181.

⁵⁸ Aberg A. Diagnostic methods for pregnancy hypertension. *International Journal of Technology Assessment in Health Care* 1992;**8**(Suppl 1):72-4.

⁵⁹ Waugh J, Habiba MA, Bosio P, Boyce T, Shennan A, Halligan AW. Patient initiated home blood pressure recordings are accurate in hypertensive pregnant women. *Hypertens Pregnancy* 2003;**22**(1):93-7.