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Hypertension

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SYNOPSIS

Defining hypertension in pregnancy is challenging because blood pressure levels in pregnancy are dynamic, having a circadian rhythm and also changing with advancing gestational age. The accepted definition is a sustained systolic (sBP) of ≥140 mmHg or a sustained diastolic blood pressure (dBP) ≥90 mmHg, by office (or in-hospital) measurement.

Measurement of blood pressure in pregnancy should follow standardised methods, as outside pregnancy. Blood pressure measurement may occur in three types of settings, which will dictate in part, which measurement device(s) will be used. The settings are (1) health care facility; and two types of settings outside the facility: (2) 'ambulatory' blood pressure measurement (ABPM); and (3) home blood pressure measurement (HBPM). Furthermore, blood pressure can be measured using auscultatory (mercury or aneroid devices) or automated methods.

Factors to consider when selecting a blood pressure measurement device include validation, disease specificity, observer error and the need for regular recalibration. The accuracy of a device is repeatedly compared to two calibrated mercury sphygmomanometers (the gold standard), by trained observers, over a range of blood pressures and for women with different hypertensive disorders of pregnancy; only a few devices have been validated among women with pre-eclampsia.

This chapter discusses the advantages and/or disadvantages of the various settings and devices.

Low- and middle-income countries (LMICs) bear a disproportionate burden of maternal morbidity and mortality from the hypertensive disorders of pregnancy. While regular blood pressure monitoring can cost-effectively reduce this disparity, LMIC-health systems face unique challenges that reduce this capacity. Assessment of service gaps and programmatic responses to ensure access to blood pressure measurement are a priority, supported where appropriate by implementation research.

DEFINING HYPERTENSION

Defining what represents hypertension in pregnancy is complicated by the fact that blood pressure levels in pregnancy are even more dynamic than they are in non-pregnant women. Blood pressure levels in pregnancy vary according to gestational age, and the circadian rhythm in women with a hypertensive disorder of pregnancy may differ by more than in normotensive pregnant women and non-pregnant women.

Outside pregnancy, both sBP and dBP peak in the afternoon and drop in the evening and during the night. However, this pattern tends to be blunted in women with gestational hypertension and pre-eclampsia among whom it tends to peak in the evening and overnight[1,2]. Proposed theories to explain this include a compensatory mechanism to maintain organ blood flow during sleep in response to ischaemia, or a disturbance in hypothalamic pituitary adrenal periodicity and in sympathetic nervous system activity[3].

Blood pressure tends to reach its nadir during pregnancy just before or at 20 weeks' gestation, with some variation by parity. In nulliparous women, sBP reaches its nadir at 17 weeks, and dBP at 19 weeks. These troughs in blood pressure are slightly later in multiparous women – 18 weeks for sBP and 20 weeks for dBP[4].

KEY POINT

Hypertension in pregnancy is a sustained sBP ≥140 mmHg or dBP ≥90 mmHg by office (or in hospital) measurement

Hypertension is defined according to systolic and diastolic criteria, with either needing to be sustained (i.e., present on repeat measurement): sBP ≥140 mmHg or a dBP ≥90 mmHg. A dBP of 90 mmHg represents a level that is both: (1) two standard deviations above values at any point in normal pregnancy, and (2) associated with increased perinatal morbidity in non-proteinuric hypertension. Systolic blood pressure is included in the definition, recognising that it is more susceptible to environmental influences and an inferior predictor of adverse pregnancy outcomes than is dBP[5–7]. Furthermore, a focus on sBP is appropriate given that inadequate treatment of severe systolic hypertension has been recognised as a major failing in the care of women who died with pre-eclampsia[8]. A conservative diagnostic approach is particularly important where ANC follow-up may be less reliable, as illustrated by the following quote:

> "If they feel there is any fluctuations or rise in blood pressure, immediately they should refer to the primary health center or directly refer to the gynecologist . . . then the initial proper treatment can be started to the hypertension with the help of the gynecologist then they can continue treatment until delivery."
>
> Health Administrator, Bagalkot, India

On average, obese women have higher blood pressure in each trimester compared with those who are not obese, even when an appropriately sized cuff is used. The difference is about 10 mmHg for sBP and 8 mmHg for dBP[4].

The importance of repeat measurement

It is important to remember that blood pressure, whether systolic or diastolic, must be confirmed to be elevated on repeat measurement before the woman can be considered to be hypertensive to reduce the potential for misdiagnosis based on a spurious reading or the patient's anxiety during the consultation. The first auscultatory measurement should be discarded (as the first is *in lieu* of taking blood pressure by palpation), and two additional measurements should be taken and averaged to get the blood pressure for that visit. Ideally, repeat measurement should be at least 15 minutes apart at that visit.

Up to 30–70% of women with an office blood pressure of ≥140/90 mmHg are found to have normal blood pressure on subsequent measurements on the same visit, or after serial measurement by ABPM (i.e., serial measurements by a portable recording device over 24 hours) or HBPM (i.e., measuring the blood pressure at home)[5,9–12]. Whether the woman is reassessed in hours, days, or weeks will depend on the level of the blood pressure and the underlying hypertensive disorder of pregnancy diagnosed or suspected, as the elevated office blood pressure may be owing to a situational rise, the 'white coat' effect, or early manifestations of pre-eclampsia[13,14].

Severe hypertension

Severe pregnancy hypertension is defined as sBP ≥160 mmHg or a dBP ≥110 mmHg. The systolic value was reduced from 170 mmHg by most international societies after recognition that a sBP ≥160 mmHg is associated with an increased risk of stroke in pregnancy[15,16].

KEY POINT

Severe hypertension in pregnancy is a sustained sBP ≥160 mmHg or dBP ≥110 mmHg

What is not included in the definition of pregnancy hypertension

A relative rise in blood pressure of 30 mmHg in sBP or 15 mmHg in dBP is *not* part of the definition of a hypertensive disorder of pregnancy, given that it is within the variation seen in all trimesters of pregnancy, and there is a high false positive rate if it is taken as a diagnostic criterion for pre-eclampsia[17].

Mean arterial pressure (MAP) is not part of the definition of hypertension in pregnancy as there are no clinical studies that relate MAP levels to risk and outcomes.

Blood pressure measurements taken in the community

Outside pregnancy, a widely accepted threshold for normal (daytime) ABPM or HBPM is <135/85 mmHg[18]. As such, a diagnosis of hypertension in pregnancy is *consistent with* a daytime ABPM or average HBPM of sBP ≥135 mmHg and/or dBP ≥85 mmHg[19,20].

KEY POINT

A diagnosis of hypertension in pregnancy in a community setting is consistent with a daytime ABPM or average HBPM of sBP ≥135 or dBP ≥85 mmHg

It is recommended that given issues with automated blood pressure machines in pregnancy and/or self-monitoring techniques, that elevated values outside the office be confirmed in the office/clinic setting. (These issues are discussed in detail under blood pressure measurement devices and HBPM sections, below.)

There can be discordance between blood pressure values taken in the office/clinic compared with those taken in the community. When the discordance cannot be attributed to the blood pressure machine and/or the measurement technique, two patterns of discordance are widely recognised. 'White coat' effect is defined as an elevated blood pressure in the health facility (i.e., ≥140/90 mmHg), but a normal measurement in the community (i.e., average daytime ABPM or average HBPM values <135/85 mmHg). 'Masked' hypertension is defined as a normal blood pressure in the health facility (i.e., <140/90 mmHg), but an elevated measurement in the community (i.e., average daytime ABPM or average HBPM values ≥135/85 mmHg). Outside pregnancy, it is widely recognised that patients with 'white coat' effect are at lower, but not baseline, risk of adverse cardiovascular outcomes related to hypertension (such as cardiac or renal disease)[21–28]. Also, patients with 'masked' hypertension (i.e., normal office blood pressure but elevated ABPM) are at similar cardiovascular risk to patients who are hypertensive in both the facility and community settings[29,30]. Both 'white coat' effect and 'masked' hypertension are discussed in detail, along with the implications for pregnancy outcome, in Chapter 3.

BLOOD PRESSURE MEASUREMENT TECHNIQUE

Blood pressure measurement in pregnancy should follow the same standardised technique as outside pregnancy[18,31,32] and the 'Best Practice Points' below for recommendations specific to pregnant women. In brief, the following steps should be taken:

1. The woman must be **positioned** appropriately: seated, still, and with her legs uncrossed, feet flat on the floor, and her back resting on the back of the chair. Women should be in the sitting position that gives a blood pressure reading that reflects the true value; supine positioning has the potential to cause hypotension, and left lateral positioning has the potential to give a spuriously low reading, because the right arm is frequently elevated above the level of the heart during blood pressure measurement[33].
2. The woman **should not talk, read, look at her phone/computer, or watch television**.
3. The woman's **arm should be resting at the level of her heart**. This may require use of a pillow.
4. The woman should **rest for 5 minutes** before her blood pressure is taken.
5. The **blood pressure cuff should be placed on the woman's bare upper arm**, and not over clothing.
6. The **blood pressure cuff must be the right size**. It must be long enough and wide enough. The length should cover two-thirds of the distance between her shoulder and elbow; the bottom should end up about 1–2 cm above the elbow. The width must be such that the

inflatable part of the blood pressure cuff should go around about 80% of the woman's upper arm where the blood pressure is being measured. If the cuff is too small (e.g., a 22–32 cm cuff used on a 35 cm circumference arm), it will overestimate sBP by 7–13 mmHg and dBP by 5–10 mmHg.

7. The blood pressure should be measured using **appropriate technique for the machine in use**.
   a. Use of **auscultatory techniques** requires a stethoscope and special training. Blood pressure is taken at least three times, with the first measurement discarded as it is the range-finding measurement; the second and third measurements are taken one minute apart and the average is the measurement for that visit. Korotkoff phase V (marked by the disappearance of Korotkoff sounds) should be used for designation of dBP; compared to phase IV (marked by muffling of Korotkoff sounds); identification of phase V is more reliable[34] than that of phase IV and pregnancy outcomes are similar when either is used[35]. Korotkoff phase IV should be used for dBP only if Korotkoff sounds are audible as the dBP level approach 0 mmHg.
   b. Use of **automated devices** requires the operator to follow the manufacturer's instructions carefully. Two measurements are taken 1 minute apart and the average is the measurement for that visit.

Blood pressure measurement devices

Blood pressure can be measured using auscultatory devices (mercury, aneroid, or liquid-crystal sphygmomanometer) or automated methods. Mercury devices have largely been removed from clinical areas owing to safety concerns. Table 1.1 outlines the advantages and disadvantages of auscultatory and automated methods[36].

Auscultatory methods

Auscultatory methods are used primarily in the health facility (i.e., office/clinic or hospital) setting (with health care personnel trained to use stethoscopes), as discussed below.

Aneroid devices appear to give more variable blood pressure readings; one study found that 50% of aneroid devices had at least one reading that was more than 10 mmHg different from others, compared with only 10% of mercury devices[37].

The liquid-crystal device is a hybrid sphygmomanometer developed as an alternative to mercury; in an initial study in pregnancy, this hybrid device appears to be accurate and may be a reasonable alternative to mercury sphygmomanometry (or an automated device)[38].

Table 1.1 Blood pressure measurement methods[36]

	Auscultatory methods	*Automated**
Method	Observer uses a stethoscope and a mercury, aneroid, or crystal device to directly identify Korotkoff sounds reflecting sBP and dBP	Oscillometric: proprietary algorithms use maximal oscillations during cuff inflation or deflation to *estimate* sBP and dBP Ultrasonographic: ultrasound transducer uses Doppler principles to estimate sBP and dBP
Advantages	Uniformly available in all clinical settings	Widely available for purchase at reasonable prices Avoids observer bias
Disadvantages	Observer bias and observer error related to external noise or auditory acuity	Sensitive to physical movement
Comments	Mercury devices have been removed from most clinical settings Aneroid devices require recalibration every 2 years	Require validation in pregnancy and pre-eclampsia specifically Most devices used in ABPM or HBPM are oscillometric

ABPM, ambulatory blood pressure monitoring; dBP, diastolic blood pressure; HBPM, home blood pressure monitoring; sBP, systolic blood pressure

* List of validated automated blood pressure devices is available at http://www.bhsoc.org/default.stm

Automated devices

Automated machines may be used in the office/clinic, community, or home settings, as discussed below. A comprehensive list of automated devices approved for HBPM can be found at http://www.dableducational.org and http://www.bhsoc.org/default.stm.

When choosing an automated blood pressure measurement device, considerations include validation, disease specificity, observer error (largely eliminated with automated devices), and the need for regular recalibration. A key issue is that ideally, women who are pregnant or postpartum should use devices that are accurate for use in both pregnancy and pre-eclampsia. First, detection of pre-eclampsia is a major objective of all antenatal care as maternal and perinatal complications are focused in this group of women. Second, women with chronic or gestational hypertension are at increased risk of pre-eclampsia[39–49]; women with pre-existing hypertension have an approximately 20% risk of pre-eclampsia[39–43], and women with gestational hypertension have a risk as high as 35% if they present with gestational hypertension prior to 34 weeks[44–49]. Unfortunately in practice, there may be no pregnancy and pre-eclampsia approved device available locally in well- or under-resourced settings, making calibration a particularly important concept to understand (see below).

The accuracy of a device is repeatedly compared with two calibrated mercury sphygmomanometers (the gold standard), by trained observers, over a range of blood pressures and for women with different hypertensive disorders of pregnancy. This must be done for pregnant women compared with non-pregnant subjects, as well as specifically for women with pre-eclampsia. Pre-eclampsia is associated with decreased vessel wall compliance and increased interstitial oedema that can lead to under-reading of blood pressure by the algorithm used by any given automated device; on average, the under-reading is by 5 mmHg in systolic and diastolic, although there is wide variation[50]. A device that is accurate for measurement of blood pressure in a healthy pregnant woman may be inaccurate in a woman with pre-eclampsia.

Although automated blood pressure measurement devices will eliminate some observer error, only some devices have been validated in pregnancy[51–53] and in pre-eclampsia, specifically[54,55]. It should be noted that in a randomised controlled trial of 220 hypertensive pregnant women, approximately 20% of whom had pre-eclampsia, management using a mercury sphygmomanometer or a validated automated electronic blood pressure device (Omron HEM-705CP) was associated with similar maternal and fetal outcomes[1]. If anything, severe hypertension was more common in the group that had blood pressure measured by the automated device, possibly related to a reduction in observer error associated with use of an automated device.

Recalibration involves comparing readings from an aneroid or automated blood pressure machine with those taken with a mercury manometer. As most mercury manometers have been removed from clinical settings around the world, most clinics will have available to them only aneroid devices. Aneroid devices require the most frequent calibration in comparison with automated devices[56]. As the devices that women use will be compared with the clinic aneroid device in many settings, it is critical to understand that aneroid devices must be recalibrated every 2 years against mercury devices, usually by the hospital biomedical department; this must be arranged separately by practitioners with private offices. In under-resourced settings, procurement processes will need to be strengthened to specify devices that are amenable to calibration and adjustment, together with a means of tracking device maintenance within health facilities over months and years of use.

Blood pressure measurement settings

The settings will drive (in part) the choice of blood pressure measurement devices, as discussed above[19]. Table 1.2 outlines which devices are used in which settings.

Health facility blood pressure measurement

Health facility blood pressure measurement is usually undertaken by a physician, nurse, or other trained health care provider in an office, clinic, or hospital setting. It involves use of any of the aforementioned blood pressure measurement devices, although most clinics and hospitals use aneroid or automated devices. The potential for 'white coat' effect is reduced when multiple readings are taken, using proper technique (see

Table 1.2 Blood pressure measurement devices used in various settings

	Mercury or liquid-crystal sphygmomanometer	*Aneroid device*	*Automated device*
Office/clinic/hospital	✓	✓	✓
Out-of-office			
Community			
Obstetric day unit	✓	✓	✓
24 hour ABPM	–	–	✓
Home	–	–	✓

ABPM, ambulatory blood pressure monitoring

'Blood pressure measurements taken in the community', above), and by either trained non-physician health care providers or using a fully automated machine that takes multiple readings[57–59].

The fact that health facility blood pressure measurements may also be falsely normal in the approximately 10% of patients with 'masked' hypertension[60] underscores the need for community-measurement, by either ABPM or HBPM.

Ambulatory blood pressure measurement

ABPM is a process by which blood pressure readings are obtained either in a community setting (serially over a 24 hour period using an automated measuring device) or by serial blood pressure measurements in an obstetric or maternal health ambulatory care setting. This could be in a specialised day unit where women can be monitored over several hours without facility admission, or a formal programme in which health care workers visit women in their homes.

ABPM has the advantage of reducing errors associated with clinic measurements[61]. Also, ABPM in the community provides a more comprehensive, actual blood pressure profile of a patient's blood pressure during daily activities and at night during sleep during which women with pre-eclampsia may have a diminished decrease in their blood pressure or an actual rise[36]. The addition of ABPM to health facility measurements may be of particular value when women have non-severe hypertension in the office or other facility setting and pre-eclampsia is not suspected, particularly if office blood pressure values are fluctuating.

Pregnant women with elevated office blood pressure measurements but normal ABPM (i.e., 'white coat' effect) are at lower risk of adverse maternal and perinatal complications such as severe hypertension, preterm delivery and admission to neonatal intensive care[9,49,54,62,63]. However, studies have demonstrated that ABPM has only modest predictive value for adverse outcomes such as severe hypertension, preterm delivery and admission to the NICU[9,19,49,63]. Therefore, the service priority is to assure comprehensive conventional measurement of blood pressure in pregnancy during clinical encounters.

Home blood pressure measurement

HBPM is undertaken by the woman in a home environment using an automated blood pressure device. Several proposed monitoring schedules have been recommended. All involve duplicate measurements taken at least twice daily over several monitoring days[18,64]. When HBPM values are normal but health facility blood pressure is elevated, repeated HBPM (or ABPM) are recommended outside pregnancy[18].

Regardless of the brand of automated device used by the woman, or the chosen system of measurement (ABPM or HBPM), the woman should be educated about the appropriate blood pressure monitoring procedures and interpretation

of the values recorded, including when and whom to call about blood pressure values of concern.

Which is best – ambulatory blood pressure measurement or home blood pressure measurement?

In the past two decades, both ABPM and HBPM have gained popularity in confirming diagnosis and improving blood pressure monitoring, compliance with antihypertensive medication, and achievement of blood pressure targets[27]. Evidence from cross-sectional studies shows that HBPM and ABPM have modest diagnostic agreement[65] and they are similar in identifying patients with 'white coat' effect and 'masked' hypertension. However, HBPM offers some advantages. HBPM is economical, comfortable, engages the patient and is easy to repeat when disease evolution is suspected, a particularly important issue in pregnancy[66]. Also, pregnant women and practitioners prefer HBPM to ABPM[67]; a Canadian survey on the practices surrounding the use of ABPM by maternity care providers to diagnose hypertension and to rule out the 'white coat' effect indicated that the majority preferred to use HBPM, while only a minority used ABPM[68]. ABPM is less comfortable; up to 15% of patients enrolled in ABPM may discontinue the process because of discomfort[69]. There is an important cautionary note about HBPM, however; HBPM values have not been validated against adverse pregnancy outcomes, and, to date, no randomised trial has assessed the impact of either HBPM or ABPM on maternal or perinatal outcomes[17].

Literature from outside pregnancy suggests that addition of ABPM or HBPM to office/clinic measurements is cost-effective[19,70]. However, further implementation research will be needed in pregnant women before we can be confident that the favourable outcomes seen outside pregnancy can be generalised to pregnancy.

UNDER-RESOURCED SETTINGS

Regular blood pressure monitoring is an essential, cost-effective intervention for early identification and management of the hypertensive disorders of pregnancy[71]. Regular blood pressure monitoring may reduce the burden of maternal morbidity and mortality from the hypertensive disorders of pregnancy that disproportionately affect women in LMICs[72–75]. The obvious priority is the availability of functioning equipment to measure blood pressure. Additional challenges to address include a lack of good quality antenatal care, inadequate staffing of health facilities, and gaps in health care worker competency.

Availability of equipment in good repair

A service challenge in many LMIC health facilities, including maternity wards, is poorly functioning or absent equipment that prevents health care workers from taking blood pressure measurements (or those that are accurate) and acting on the results[71,76,77]. For example, the Malawi Demographic Health Survey (DHS) reports that only 64% of health centres offering ANC services were equipped with blood pressure measurement apparatus[78]. The following quotes serve to further highlight this from the perspectives of both health care workers and women:

> "You must make equipment available, like the sphygmomanometer, just ordinary sphyg . . . is not available until a patient just throws a fit that you know that the problem is high. So, making sure simple, simple, things that can save life are available, like I said sometimes, the sphygmomanometer to monitor blood pressure . . ."
>
> Focus Group Discussion participant from SOGON (Society of Gynaecology & Obstetrics of Nigeria (SOGON)

> "Even sometimes you find out that in a health center that there is no appropriate instrument to take blood pressure. You get to a primary health centre and find out that there is nothing."
>
> Focus Group Discussion participant from SOGON (Society of Gynaecology & Obstetrics of Nigeria (SOGON)

There are several novel technologies that may improve access to accurate blood pressure measurement at community and health facility levels[80,81,83–87]:

1. *A semi-automated blood pressure device and vital signs early warning tool*[83–85] This device is unique for many reasons, most importantly because it is one of a few to be accurate in

pregnancy and pre-eclampsia, and it is the only device known to be accurate at the low blood pressure values seen commonly in pregnancy. The 'traffic light' early warning system alerts untrained health care workers to the need for urgent intervention and referral of women with hypertension or shock (secondary to obstetric haemorrhage or sepsis), even if the vital sign thresholds are not well understood by that health care worker. In addition, the device achieves the criteria stipulated by WHO for use of automated devices in low-resource settings. These features include the following: (a) reliance on manual inflation (deflating automatically), limiting the power requirements; (b) use of sealed lithium batteries that are charged through a micro-USB port, a method that is ubiquitous even in low-resource settings; and (c) the low cost of only $19 USD. The device is being evaluated at both community- and institutional-levels in a number of LMIC sites; qualitative evaluation to date of both trained and untrained health care users has been overwhelmingly positive. A randomised controlled trial is underway to assess the ability of the device to reduce maternal mortality and morbidity in under-resourced settings.

2. *An interface connecting blood pressure devices to mobile smartphone and tablet technology*[86] This technology is currently under development. An audio-based interface allows for blood pressure readings (amongst other vital signs) to be automatically recorded for tracking and trending. Furthermore, there is potential for further transmission of advice from a central facility to minimally trained health care workers based on the blood pressure values.
3. *A solar panel-powdered blood pressure device*[87] A semi-automated blood pressure device designed for under-resourced settings charges using a solar panel and fulfills other WHO criteria for use of devices in LMICs. Furthermore, qualitative evaluation has demonstrated acceptability by non-physician health care workers. Although the device has been validated as accurate for use in a non-pregnant population, it has not been validated for use in pregnancy, and so cannot be used in a pregnant population at the current time.

In summary, the current priority is the procurement, distribution and maintenance of standard blood pressure apparatus of robust manufacture that can withstand heavy use. Innovative blood pressure measurement devices for low-resource settings have great potential to reduce maternal mortality from pre-eclampsia and eclampsia in LMICs. With an emphasis on task-sharing, blood pressure measurement devices must not rely on knowledge of proper auscultation with a stethoscope in order that more workers can use the devices correctly (Figure 1.1). Investments will be needed to realise the potential of these technologies[88], particularly if a focus is placed on implementation in the community[89].

Quality antenatal care

The provision of good quality ANC is an evidence-based intervention that reduces maternal and neonatal mortality and morbidity, particularly in LMICs[90,91]. The quality of ANC is measured by three dimensions: number of visits, timing of initiation of care, and inclusion of all recommended components of care[90].

Number of antenatal care visits

Compared to a country's defined standard care, attending a reduced number of antenatal visits is associated with an increase in perinatal mortality[92]. Globally, only 64% of pregnant women receive the

Figure 1.1 Taking blood pressure in the primary health centre with an automated device

recommended minimum of four ANC visits in pregnancy[93]. A disproportionate number of these women reside in LMICs, such as rural Nigeria where only 39% of pregnant women were found to attend four or more ANC visits[94]. However, this pattern of fewer than recommended ANC visits has also been reported in inner city women in high-income countries[95].

KEY POINT

WHO recommends that the first ANC visit be within the first 4 months of pregnancy

Timing of initiation of care

Despite WHO recommendations to start ANC within the first 4 months of pregnancy, on a global scale, many women start ANC in the second or third trimester[96]. This is a particular issue in sub-Saharan Africa[96], such as in Tanzania where the median month of first visit for ANC was 5.5 months[97]. However, unsatisfactory patterns of care are also reported by other developing countries, such as Cambodia where the Cambodian Demographic Health Survey found that 30% of women who received ANC started that care in the second trimester[98].

Inclusion of all recommended components of care

The critical importance of inclusion of blood pressure in ANC is illustrated by the following quote:

> "Eclampsia doesn't happen frequently without pre-eclampsia and the way to know that, first, is the blood pressure"
>
> Focus Group Discussion participant from Society of Gynaecology & Obstetrics of Nigeria (SOGON)

Blood pressure measurement (and urine testing for proteinuria) is a key component of ANC that has as a primary aim, the detection of pre-eclampsia[90]. Although blood pressure measurement is one of the more commonly received components of ANC in LMICs[90,99,100], many women still do not have their blood pressure measured[91,100,101] and there is variability in rates of measurement from country to country. According to Demographic Health Survey publications, the proportion of women receiving ANC who have their blood pressure measured is >90% in Cambodia and Ghana, just over 85% in Nepal, Pakistan and Rwanda[90,98,102–104], but only 53% in Laos[105] and variable in many African countries (i.e., 75% in Malawi[78], 52.5% in Uganda[96] and 40% in Kenya[106]).

KEY POINT

Blood pressure measurement is one of the more commonly received components of ANC in LMICs, but estimates vary from country to country

Continued efforts are required to improve access to quality ANC. Predictors of women's attendance at four or more ANC visits and receipt of good quality ANC have been identified and are listed in Table 1.3[90,107]. Included among these characteristics are higher maternal education and higher household economic status. It follows from this information that interventions that aim to reduce maternal and perinatal morbidity and mortality from pre-eclampsia may focus in the short-term on targeting women at higher risk, such as those with lower levels of education and lower socioeconomic status. A sustainable longer-term intervention will require a multi-sectoral approach involving entire communities, including governments and policy-makers with the aim of improving access to education by girls and women and reducing economic inequalities[90]. However, to generate confidence in the health system and appropriate demand for services, women must be assured that each and every antenatal attendance will lead to provision of the essential components of care, such as blood pressure measurement using a correct technique and with functional equipment.

Health care worker staffing

The challenges of measuring blood pressure may be compounded by an inadequate number of health care workers and/or a lack of their training to measure blood pressure using appropriate technique. Inadequate staffing numbers can strain the ability of a facility to diagnose pre-eclampsia,

Table 1.3 Factors associated with better access to antenatal care (ANC)

	Attendance at ≥4 ANC visits	*Receipt of quality ANC*
Maternal characteristics		
Older age	✓	✓
Higher parity	✓	✓
Higher maternal education	✓	✓
Higher household economic status	✓	✓
Non-smokers	✓	
Women have a say in decision-making	✓	
Higher paternal education	✓	
Maternal occupation other than agriculture	✓	
Urban residence		✓
Exposure to general media		✓
Characteristics of ANC		
Receiving ANC from a skilled provider		✓
Receiving ANC in a hospital		✓

whether during ANC visits in an overcrowded health centre, or monitoring women in labour on a maternity ward. Although task-shifting to the community level and use of automated devices may address some service access gaps, the emphasis needs to be on functionality across the levels of the health system whether under government authority or other initiatives[77]. Interventions to improve health worker training and maintenance of competency for good maternity care are needed[99,101]. Appendix 1.1[108,109] contains an example of material used to train community health care workers to take blood pressure using the Microlife 3AS1-2 semi-automated blood pressure device (Figure 1.2).

Figure 1.2 Taking blood pressure in the community with the Microlife 3AS1-2 hand-held device

BEST PRACTICE POINTS

(Please see Appendix 1.2 for the evaluation of the strength of the recommendation and the quality of the evidence on which they are based.)

Diagnosis of hypertension

1. The diagnosis of hypertension should be confirmed by health facility blood pressure measurements.
2. Hypertension in pregnancy should be defined as a sBP ≥140 mmHg and/or dBP ≥90 mmHg, based on the average of at least two measurements, taken at least 15 minutes apart, using the same arm.
3. For the purposes of defining superimposed pre-eclampsia in women with pre-existing hypertension, 'resistant hypertension' should be defined as the need for three antihypertensive medications for blood pressure control at ≥20 weeks' gestation.
4. A 'transient' hypertensive effect should be defined a sBP ≥140 mmHg or a dBP ≥90 mmHg which is not confirmed on the same visit after the woman rests, or on subsequent visits.
5. A 'white coat' hypertensive effect refers to blood pressure that is elevated in a health facility (i.e., sBP ≥140 mmHg or dBP ≥90 mmHg) but by ABPM or HBPM, sBP is <135 mmHg and dBP is <85 mmHg.
6. 'Masked' hypertension refers to blood pressure that is normal in a health facility (i.e., sBP <140 mmHg and dBP <90 mmHg) but elevated by ABPM or HBPM (i.e., sBP of ≥135 mmHg or dBP ≥85 mmHg).
7. Severe hypertension should be defined as a sBP of ≥160 mmHg or a dBP of ≥110 mmHg based on the average of at least two measurements, taken at least 15 minutes apart, using the same arm. This finding should prompt urgent intervention to control the blood pressure.

Blood pressure measurement

1. Blood pressure should be measured using standardised technique, particularly with the woman seated and her arm at the level of the heart.
2. An appropriately sized cuff (i.e., length of 1.5 times the circumference of the arm) should be used.
3. Korotkoff phase V (marked as disappearance of Korotkoff sounds) should be used to designate dBP.
4. If blood pressure is consistently higher in one arm, the arm with the higher values should be used for all blood pressure measurements.
5. Blood pressure can be measured using a mercury sphygmomanometer, calibrated aneroid device, or an automated device that has been validated for use in pre-eclampsia.
6. Automated blood pressure machines that have not been validated for use in pre-eclampsia may under- or over-estimate blood pressure in those women, so those readings should be compared with those using mercury sphygmomanometry or a calibrated aneroid device.
7. In the health facility setting, when blood pressure elevation is non-severe and pre-eclampsia is not suspected, ABPM or HBPM is useful to confirm persistently elevated blood pressure.
8. When HBPM is used, maternity care providers should ensure that women have adequate training in measuring their blood pressure and interpreting the readings taken.
9. The accuracy of all blood pressure measurement devices used in health facilities should be checked regularly (e.g., annually) against a calibrated device.
10. The accuracy of all automated devices used for HBPM should be checked regularly against a calibrated device (e.g., at multiple ANC for an individual woman).

PRIORITIES FOR UNDER-RESOURCED SETTINGS

Table 1.4 outlines priorities for under-resourced settings. Unlike most diagnostic or therapeutic interventions in the area of hypertensive disorders of pregnancy, measurement of blood pressure and diagnosis of hypertension have more priorities at the community rather than the facility level. A sample policy brief that focuses on blood pressure measurement is contained in Appendix 1.3.

WHAT INTERNATIONAL GUIDELINES SAY (APPENDIX 1.4)

Abbreviations for Clinical Practice Guidelines are ACOG (American College of Obstetricians and Gynecologists)[110], AOM (Association of Ontario Midwives), NICE (National Institutes of Clinical Excellence)[111], NVOG (National Obstetrics and Gynaecology Society, Netherlands)[112], PRECOG (Pre-eclampsia Community Guideline)[119], PRECOG II (Pre-eclampsia Community Guideline II)[120], QLD (Queensland, Australia)[113,114], SOGC (Society of Obstetricians and Gynaecologists of Canada)[115], SOMANZ (Society of Obstetric Medicine of Australia and New Zealand)[116], WHO (World Health Organization)[117].

In a review of international clinical practice guidelines on the hypertensive disorders of pregnancy[118], nine guidelines stated that pregnancy hypertension was defined by both sBP and dBP together (≥140/90 mmHg) (QLD, NICE, NVOG, ACOG, SOGC, SOMANZ 2014), or dBP alone (≥90 mmHg) (PRECOG, PRECOG II, AOM); no definition is offered by the WHO guidelines. Eight of 10 guidelines define severe hypertension, seven as blood pressure ≥160/110 mmHg (NICE, QLD, NVOG, AOM, ACOG, SOGC, SOMANZ) and one as ≥170/110 mmHg (PRECOG II); one document specifies that severe hypertension requiring urgent treatment is ≥170/110 mmHg (SOMANZ 2014).

Table 1.4 Priorities for under-resourced settings

	Antepartum & postpartum	
	Initial priority	*Ultimate goal*
Community		
Primary health care centre (detect, stabilise and refer)	Availability of BP measurement devices Measurement of BP at each ANC and PNC visit	Availability of BP measurement devices Measurement of BP at each ANC and PNC visit Training and re-training of health workers with regards to appropriate BP measurement technique Training of community health care workers to take BP at home visits
Facility		
Secondary-level facility (detect, manage and refer if necessary)	Availability of BP measurement devices Measurement of BP at each ANC and PNC visit	Availability of BP measurement devices Measurement of BP at each ANC and PNC visit Training and re-training of health workers with regards to appropriate BP measurement technique
Tertiary-level (referral) facility (detect and manage definitively)	Availability of BP measurement devices Measurement of BP at each ANC and PNC visit	Availability of BP measurement devices Measurement of BP at each ANC and PNC visit Training and re-training of health workers with regards to appropriate BP measurement technique

ANC, antenatal care; BP, blood pressure; PNC, postnatal care

PRIORITIES FOR FUTURE RESEARCH

These cover care in well- and under-resourced settings, particularly as mercury sphygmomanometers have been removed from the vast majority of health facilities internationally, and their most common replacement, aneroid devices, are not as accurate and require regular calibration. An alternative to mercury manometry is needed. Low-cost, energy-efficient and robust automated blood pressure machines are needed for use in LMICs, in order that women have blood pressure measured (and accurately) as part of high-quality ANC. Also, further research is needed into the usefulness of HBPM in the ANC of all women, to detect and manage the hypertensive disorders of pregnancy. Implementation research on which cadres of health care workers, including community health workers, can accurately use the automated devices will enhance task sharing at facilities and in the community.

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