

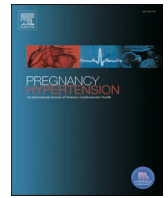


Since January 2020 Elsevier has created a COVID-19 resource centre with free information in English and Mandarin on the novel coronavirus COVID-19. The COVID-19 resource centre is hosted on Elsevier Connect, the company's public news and information website.

Elsevier hereby grants permission to make all its COVID-19-related research that is available on the COVID-19 resource centre - including this research content - immediately available in PubMed Central and other publicly funded repositories, such as the WHO COVID database with rights for unrestricted research re-use and analyses in any form or by any means with acknowledgement of the original source. These permissions are granted for free by Elsevier for as long as the COVID-19 resource centre remains active.

Contents lists available at [ScienceDirect](https://www.sciencedirect.com)

# Pregnancy Hypertension: An International Journal of Women's Cardiovascular Health

journal homepage: [www.elsevier.com/locate/preghy](http://www.elsevier.com/locate/preghy)

## Self-monitoring of blood pressure in pregnancy: A mixed methods evaluation of a national roll-out in the context of a pandemic

Hannah Wilson<sup>a,1</sup>, Katherine L. Tucker<sup>b,1,\*</sup>, Alison Chisholm<sup>b</sup>, James Hodgkinson<sup>c</sup>, Layla Lavallee<sup>b</sup>, Lucy Mackillop<sup>d</sup>, Alexandra E. Cairns<sup>d</sup>, Lisa Hinton<sup>e</sup>, Charlie Podschies<sup>f</sup>, Lucy C. Chappell<sup>a,2</sup>, Richard J. McManus<sup>b,2</sup>

<sup>a</sup> School of Life Course Sciences, King's College London, London, UK

<sup>b</sup> Nuffield Department of Primary Care Health Sciences, University of Oxford, Oxford, UK

<sup>c</sup> Institute of Applied Health Research, University of Birmingham, Birmingham

<sup>d</sup> Nuffield Department of Women's & Reproductive Health, University of Oxford, Oxford

<sup>e</sup> The Healthcare Improvement Studies Institute, University of Cambridge, Cambridge, UK

<sup>f</sup> Maternity and Women's Health Policy Team, NHS England and NHS Improvement, UK

### ARTICLE INFO

#### Keywords:

Pregnancy  
Self-monitoring  
Blood pressure  
Implementation

### ABSTRACT

**Objective:** To evaluate how English maternity units implemented self-monitoring of blood pressure (SMBP) in pregnancy in response to the COVID-19 pandemic.

**Design:** Mixed methods including surveys, anonymised patient data and in-depth interviews with women.

**Setting:** Maternity units across England.

**Participants:** 45 maternity units completed a survey about the implementation of SMBP (supported by the provision of guidance and blood pressure monitors) during the pandemic, 166 women completed a survey about their experiences of SMBP, and 23 women took part in in-depth interviews. Clinical data from 627 women undertaking SMBP were available from 13 maternity units.

**Results:** SMBP was predominantly used to provide additional BP monitoring for hypertensive or high-risk pregnant women. Overall maternity units and women were positive about its use in terms of reducing the need for additional face-to-face contacts and giving women more control and insight into their own BP. However, there were challenges in setting up SMBP services rapidly and embedding them within existing care pathways, particularly around interpreting readings and managing the provision of monitors.

**Conclusions:** A considerable proportion of maternity units in England commenced a SMBP service for hypertensive or high-risk women from March 2020. There is a need for further research into appropriate care pathways, including guidance around white coat or masked hypertension and the use of SMBP postnatally.

### 1. Introduction

The COVID-19 pandemic compelled the clinical community to provide an alternative to some face-to-face consultations for pregnant and postnatal women through rapidly implementing self-monitoring of blood pressure (SMBP). A recent survey conducted prior to the pandemic suggests around 20 % of women informally self-monitor their blood

pressure (BP) during pregnancy, including around half of those with hypertension self-monitor, although many (49 %) do not share their readings with relevant health professionals. [1] Prior to the pandemic, maternity staff were generally in favour of SMBP but had concerns about its impact on women, staff workload and the reliability and accuracy of readings. [2,3].

National guidelines for SMBP in pregnancy were rapidly produced at

**Abbreviations:** BP, blood pressure; SMBP, self-monitoring of blood pressure.

\* Corresponding author at: Nuffield Department of Primary Care Health Sciences, Radcliffe Primary Care Building, Radcliffe Observatory Quarter, University of Oxford, Oxford OX2 6GG, UK.

E-mail address: [Katherine.tucker@phc.ox.ac.uk](mailto:Katherine.tucker@phc.ox.ac.uk) (K.L. Tucker).

<sup>1</sup> Joint first authors.

<sup>2</sup> Joint senior authors.

<https://doi.org/10.1016/j.preghy.2022.07.006>

Received 11 March 2022; Received in revised form 8 July 2022; Accepted 25 July 2022

Available online 28 July 2022

2210-7789/© 2022 The Author(s). Published by Elsevier B.V. on behalf of International Society for the Study of Hypertension in Pregnancy. This is an open access article under the CC BY license (<http://creativecommons.org/licenses/by/4.0/>).

the start of the COVID-19 pandemic, and remote consultations introduced where possible. Pregnant women were advised to take public health measures such as social distancing and self-isolation to lower their risk of COVID-19 exposure. Guidance recommended prioritising SMBP for women with chronic hypertension, gestational hypertension or pre-eclampsia, those with risk factors, or those required to self-isolate. [4,5] There was an offer of free BP monitors, validated for pregnancy use, from NHS England/Improvement in April 2020 and a substantial number of maternity units around the UK (71 %, 125/177) took up the offer. Over 16,000 BP monitors have been provided to maternity units since March 2020.

This evaluation aimed to examine how maternity units implemented SMBP in pregnancy during the COVID-19 pandemic, and the potential advantages and disadvantages of SMBP for women and healthcare professionals.

## 2. Methods

This evaluation includes data from March 2020 to March 2021. It comprised surveys of maternity unit staff and women, interviews with women and analysis of anonymised individual patient data regarding the characteristics of those women provided with monitors.

### 2.1. Maternity unit survey

All 125 maternity units in England that had been provided with free BP monitors by NHS England were contacted by email between December 2020 and February 2021 and asked to complete a survey about their implementation of SMBP since March 2020. Emails came from NHS England and asked sites to contact the research team for details of how to complete the survey. A single reminder was sent to non-responders. (Appendix 1).

### 2.2. Pregnant and postpartum women survey

Women who were currently pregnant or who had had a baby since March 2020 were asked about their experiences with SMBP in an online survey active between December 2020 and January 2021 (Appendix 2). The survey was publicised by maternity units that had implemented SMBP, 21 sites agreed to do this and most advertised through the units Facebook pages, some contacted women known to have completed home monitoring. Additionally, the charity Action on Pre-Eclampsia (APEC) advertised the survey on twitter.

### 2.3. Analysis of maternity unit data on women provided with self-monitoring

All maternity units that were provided with free BP monitors by NHS England/Improvement were asked to provide anonymised clinical details of the women (and their babies) who had undertaken SMBP using a BP monitor provided by their maternity unit. Data were collected between March 2020 and January 2021. Descriptive statistics were completed.

### 2.4. In-depth interviews with women

Telephone interviews with women who SMBP from March 2020 were carried out between January and March 2021 across five NHS hospitals: Birmingham Women's and Children's NHS Foundation Trust, Manchester University NHS Foundation Trust, Guy's and St Thomas' NHS Foundation Trust, Oxford University Hospitals NHS Foundation Trust, and Croydon Health Services NHS Trust.

Sites were selected to achieve geographic and sociodemographic diversity, from among sites with which the research team had established links during the BUMP trials.

Women were invited and given information about the study by a

research midwife. Details of those willing to be interviewed were passed to the researcher who obtained their informed consent. Interviews were conducted by two social scientists (JH (male) and AC (female)) with experience of interviewing pregnant women on the subject of hypertension and self-monitoring of blood pressure. Analysis carried out by one of them (AC).

Interviews were carried out by telephone following a topic guide (Appendix 3) then transcribed verbatim and coded in NVivo.[6] A coding frame was developed and a thematic analysis undertaken.[7].

### 2.5. Approvals

The pooled service evaluation was approved by NHS England. The qualitative interviews with women were approved by a Research Ethics Committee (West Midlands – South Birmingham: ref 17/WM/0241) and the Health Research Authority.

### 2.6. Funding

National Institute for Health Research (NIHR) Applied Research Collaboration Oxford and Thames Valley (ARC-OxTV) and an NIHR Programme Grant for Applied Health Research (RP-PG-0614–20005). The funders did not have input into the study design, interpretation of results or decision to publish. The views expressed in this publication are those of the authors and not necessarily those of the NHS, the National Institute for Health Research or the Department of Health and Social Care.

## 3. Results

### 3.1. Maternity unit survey

Of 125 maternity units who had been provided with free validated BP monitors by NHS England, 45 (36 %) responded to the survey. Prior to the pandemic, most (78 %, 35/45) responding maternity units did not regularly provide BP monitors to pregnant women for SMBP. All increased their provision of BP monitors. Most (89 %, 40/45) used BP monitors provided by NHS England, some (38 %, 17/45) used BP monitors provided by their maternity service and a further 12 units (27 %, 12/45) enabled use of women's own BP monitors. Three maternity units had procured BP monitors but were yet to commence provision. All responding maternity units provided women with OMRON or Microlife branded BP monitors, validated for use in pregnancy, as provided by NHS England.[8].

#### 3.1.1. Use of SMBP

The commonest group of pregnant women given BP monitors were those with hypertension. Around half of maternity units also extended the SMBP service into the postnatal period (56 %, 25/45) and 19 units (42 %) provided monitors to normotensive pregnant women with risk factors (Table 1). In most units (93 %, 42/45), SMBP was predominantly used for additional monitoring (e.g. daily/ several times per week) rather than as a replacement for a routine/ scheduled face-to-face contact. Almost all maternity units (98 %, 44/45) provided written information as suggested by Royal College of Obstetricians and Gynaecologists' guidance.[9] The majority of units (69 %, 31/45) did not use a telemonitoring service or app; of those that did, half used Hampton, whilst the other half used other platforms (Sensyne BPmHealth, Florence).[10].

Around half of units (53 %, 24/45) additionally asked some (24 %, 11/45) or all (29 %, 13/45) women to self-test their urine for protein alongside SMBP. Monitor return rates varied widely but averaged around 40 % (range 0 to 100 %). Most (78 %, 35/45) units were planning to reuse BP monitors in future. (Appendix 1 and Table 1) Key benefits identified by sites included reduced face-to-face contacts and hospital footfall during the pandemic, and improved convenience for

**Table 1**  
Key findings from the survey of 45 Maternity Units.

	n (%) of maternity units (total = 45)
Groups of women provided with monitors	
Gestational hypertension	40 (89 %)
Chronic hypertension	35 (78 %)
Hypertension in the postnatal period	25 (56 %)
Risk factors for hypertension/pre-eclampsia (normotensive)	19 (42 %)
Protocols for SMBP	
SMBP used for additional (rather than replacement) monitoring	42 (93 %)
BP monitors supplied by midwives (vs other healthcare professionals)	40 (89 %)
Written information provided alongside BP monitor	44 (98 %)
Telemonitoring service alongside SMBP	14 (31 %)
Maternity Assessment Unit (or equivalent) first point of contact	34 (76 %)
Urine self-testing alongside SMBP	24 (53 %)

women. Key challenges included service setup within existing pathways, the supply, management and return of monitors, managing follow-up and identifying eligible women. (Appendix 1).

### 3.2. Women's survey

166 women responded to the online questionnaire regarding their experiences with SMBP, of whom around half of women (45 %, 75/166)

**Table 2**  
Characteristics and key responses of 166 women who completed the survey about their blood pressure self-monitoring experience during the pandemic.

Characteristic	n (%) of women (total = 166)
Currently pregnant	53 (32 %)
Gave birth since March 2020	110 (66 %)
Experienced pregnancy loss	3 (2 %)
Hypertension in pregnancy	75 (45 %)
Risk factors for hypertension in pregnancy	51 (31 %)
Normotensive without risk factors for hypertension in pregnancy	40 (24 %)
English as first language	148 (89 %)
Ethnicity	% of women n (total = 166)
White	139 (84 %)
Black, African, Caribbean or Black British	11 (7 %)
Asian or Asian British	5 (3 %)
Mixed or multiple	5 (3 %)
Other	6 (4 %)
Experiences of antenatal care since March 2020	% of women n (total = 166)
SMBP during pregnancy	126 (76 %)
Mixed face to face and remote care	84 (51 %)
Mostly face-to-face care	72 (43 %)
Preference for face-to-face care	99 (60 %)
Felt completely or reasonably safe having remote care	117 (70 %) (*total = 125)
Supported to speak up about concerns	138 (83 %)
Use of SMBP since March 2020	% of women n (total = 126)
Monitored because midwife or obstetrician asked	90 (71 %)
Monitored of own initiative or family/friend suggestion	15 (2 %)
Views on SMBP	% of women n (total = 126)
Felt safe undertaking SMBP	124 (98 %)
SMBP made me feel more confident	98 (78 %)
SMBP made me feel more anxious	3 (2 %)
SMBP gave more control, independence or insight into BP	68 (54 %)
SMBP gave greater convenience (BP was more accurate at home)	47 (37 %)
SMBP gave improved ability to manage white coat hypertension	30 (24 %)

had hypertension during pregnancy (Table 2). The women who took part were representative of the general pregnant population with similar age and ethnicity.[11].

#### 3.2.1. Experiences of provision of maternity care since March 2020

Most responding women (76 %, 126/166) had monitored their BP at home during their current or most recent pregnancy. Around half (51 %, 84/166) had received a mixture of face-to-face and remote antenatal care; most (60 %) had a preference for face-to-face antenatal care. Most women (71 %, 90/126) had undertaken SMBP because their obstetrician or midwife had asked them to monitor 'for additional BP readings' between regular face-to-face antenatal appointments. (Table 2).

#### 3.2.2. Women's views on SMBP

Positive aspects of SMBP identified by women included more control, independence or insight into their own BP (54 %, 68/126), greater convenience (37 %, 47/126), feeling that their BP was more accurate at home and improved ability to manage white coat hypertension (24 %, 30/126). Almost half felt there were no negative aspects of SMBP (44 %, 55/126) but of those that did, 53 % (37/71) had uncertainty about appropriate follow-up and 21 % (15/71) had issues relating to the BP monitor, cuffs and/or the telemonitoring application.

#### 3.2.3. Women's views on safety

The majority of women (70 %, 117/125) felt completely or reasonably safe having some or all of their antenatal care remotely during the coronavirus pandemic. Most (83 %, 138/166) had felt supported to speak up and be heard about safety concerns. Almost all women who self-monitored their BP during the COVID-19 pandemic (98 %, 124/126) felt safe undertaking SMBP.

### 3.3. In-depth interviews with women

Twenty-three telephone interviews took place with women who had SMBP during the pandemic, including women with gestational hypertension (9/23), chronic hypertension (7/23) and those with risk factors but not hypertension at the time of interview (7/23). (Numbered quotes refer to Table 3 and Appendix 4).

The following themes and subthemes were identified:

- Experiences and effects of self-monitoring of blood pressure.
  - confidence and trust.
  - anxiety and reassurance.
  - convenience.
  - managing white coat hypertension.
  - empowerment.
- Remote vs face-to-face appointments.
  - reducing covid 19 risk.
  - usual care and additional clinic visits.
  - blended care.
- App and telemonitoring.
  - benefits of app and telemonitoring.
  - blood pressure thresholds.
  - Saturation of themes was reached.

#### 3.3.1. Experiences of SMBP

Overall, women reported feeling confident undertaking SMBP and their experiences were broadly positive. The monitor was trusted, easy to use with clear instructions. Being able to monitor BP regularly reassured women that raised BP would be detected without delay. This reduced anxiety, particularly for women who had had experiences of pre-eclampsia in the past or currently had hypertension (see Quotes 1–5 in Appendix 4).

SMBP was convenient for women and time saving: "a trip into hospital would take about, you know, two and a half hours or something instead of

**Table 3**

Brief illustrative quotes from telephone interviews (see Appendix 4 for full quotes).

Themes	Quote [may be edited for brevity: full quote available in Appendix 4]	History
<b>1. Experiences and effects of self-monitoring of blood pressure</b>		
- confidence and trust	When they first gave me the kit to do it at home, we spent quite a while going through how to put the cuff on, so I feel very confident that I'm doing it correctly.	No HT
- anxiety and reassurance	I would keep an eye on it and knowing it has been fine so if I did get a high reading, it would have just happened. It wasn't like it had been going on for days ... I found it really reassuring.	No HT
- convenience	It saved me having to find childcare to look after my daughter... a trip into hospital would take about two and a half hours instead of two minutes doing it at home.	GHT
- managing white coat hypertension	It was a good thing because it helped put me at ease... When I went to my face to face appointments my blood pressure was always higher when I was in clinic...so actually having, having that reassurance and knowing that at home it was fine helped ease, ease a lot of the anxiety as well.	No HT, history of PE
- empowerment	Certainly it's given me, a) confidence and b) the awareness of what high blood pressure means... being involved only helps educate you.. probably it's easier to go and sit and put your arm in front of the midwife and she takes your reading and off you go.	No HT
<b>2. Remote vs face-to-face appointments</b>		
- reducing covid 19 risk	[SMBP] was good in some ways because at that time I think the virus was quite high, so I didn't want to be going in every time.	GHT
- additional clinic visits	It was very useful, especially like it's Covid... if I felt not sure about myself, I just check my blood pressure. So I don't have to go to the day assessment unit, I check my blood pressure first.	GHT & diabetes
- blended care	Because I had a mixture of face to face and remote contact I was able to build up a good relationship... when I was face to face but then translated into the phone kind of relationship as well so any questions, I had I felt comfortable enough to ask.	No HT, prev PE
<b>3. App and telemonitoring</b>		
- benefits of app and telemonitoring	I think it was at the start of my third trimester I got a link sent through for me to register the readings straight onto the [name] Trust and I found that really helpful because up until then I'd been keeping a note of it so that when I spoke to the consultant, I had a full list of all the readings that I'd had. But it was much better being able to put it straight onto the App and so the reading would be there, and the App would also tell me straight away whether or not it was too high	No HT
- blood pressure thresholds	Firstly when I was put on, I was never told, "oh, you know, you should be this and it should be under this or, you know, within the top number or the bottom." Now I've kind of got a better clue of what should be normal or close to normal I suppose... I had to actually ask the midwife to, to give me that. Then kind of because the leaflet I was given she didn't agree with the markers on there... She said they were too high for what they should have been, so she changed it to see what was preferably better for me whilst pregnant.	GHT

two minutes doing it at home" (See quotes 6&7). SMBP was considered by women to be valuable for ruling out suspected hypertension and for women who experienced 'white coat hypertension', providing context to interpret high clinic readings, showing that their high BP readings were intermittent rather than constant (Quotes 8 & 9, appendix 4).

SMBP brought insight into the factors that affected an individual's BP, and this sometimes felt empowering, helping women distinguish between signs of pre-eclampsia or symptoms that were non-worrying (Quote 10). One woman described a deferral of hospital admission because she had the option of SMBP (Quote 11).

### 3.3.2. SMBP and remote vs face-to-face consultations

SMBP was welcomed by women who preferred to avoid the risk of contracting COVID-19 when attending hospital appointments. This was common for women whose pregnancies were relatively low risk, but also sometimes for women with hypertension and other complicating factors. Others thought infection risk was managed well and felt safe during hospital visits (Quotes 12–14). Some women felt conflicted about attending face-to-face appointments, wishing both to avoid infection but ensure they were being adequately checked for pregnancy complications, which felt compromised by remote care (Quote 15).

Most reported SMBP was used in addition to usual care, rather than to reduce face-to-face contact. However, for some women, SMBP reduced the need for additional clinic visits to monitor BP between appointments (Quote 16). For women with higher risk pregnancies, SMBP was sometimes used in addition to frequent Maternity Assessment Unit (MAU) visits, with SMBP slightly reducing the frequency (for example, from three to two/ week). For women whose BP needed ongoing management, in-person consultations were felt to be necessary (Quote 17).

For some women, SMBP meant some routine appointments were carried out remotely. Women generally appreciated the convenience of remote appointments, which saved travel and waiting time and reduced time away from work or the care of family members. Remote (online or telephone) consultations had a different quality from face-to-face and were thought not always to be a suitable alternative. (Quote 18). Not all were offered remote consultations, but for those who were, a blend of face-to-face and remote care appeared to facilitate trust, convenience, and confidence in the care because relationships were established before remote care began (Quotes 19 and 20).

SMBP was generally experienced positively for women with and without hypertension. Although it did not greatly reduce attendance at standard antenatal visits for women overall, women with hypertension more often reported that they used SMBP to reduce the number of additional visits to clinic than women without hypertension, while women with white coat hypertension often reported they valued that SMBP allowed them to compare clinic with home readings.

### 3.3.3. Using an app or telemonitoring

Women who used an app or telemonitoring found it reassuring that they would receive a message if their submitted BP reading was high, and they needed to take action. Some women perceived their home readings were actively monitored by HCPs, but this was not undertaken in every site. Women liked graphs that showed their BP patterns over time and said it was helpful to receive a reminder if they had forgotten to submit a reading (Quotes 21–24). Nearly all women said they were clearly told the thresholds for taking action, and these remained unchanged throughout their pregnancies. However, occasionally a HCP would instruct them to take action at a higher or lower threshold than the one indicated on the app or instructions (Quote 25).

### 3.4. Clinical outcome data from maternity units given BP monitors by NHS England for SMBP in pregnancy

Thirteen maternity units across England (10 %) were able to contribute data from a total of 627 women undertaking SMBP between March 2020 and January 2021. The average gestation for commencing

SMBP was 27 weeks, with just 2 % (12/627) starting monitoring after birth. (Table 4) Data about scheduled face-to-face clinic visits and telephone calls were available from 519 (83 %) women concerning a total of 6715 contacts: there were 1373 (20.4 %) scheduled telephone consultations (mean calls/woman = 2.7), compared to 3751 (55.9 %) scheduled face-to-face visits (mean visits/woman = 7) and a further 1591 (23.7 %) unscheduled visits. Data were available from 555 deliveries, with characteristics reported in Table 4.

## 4. Discussion

### 4.1. Main findings

In maternity units who responded to our survey, SMBP increased during the pandemic, aided by the provision of free monitors and national guidelines. SMBP was often used for additional BP readings over and above usual care rather than as a replacement for routine face-to-face contact, though several sites also formalised telephone appointments. SMBP was mostly instituted for those diagnosed with pregnancy hypertension but some women at higher risk were also included. Post-natal provision was limited. Very few women responding to the survey said that they monitored of their own accord, although this is discrepant with the findings from our larger survey.(1) Women from all backgrounds were offered self-monitoring, with a higher proportion of uptake from Black and Asian women compared to national ethnicity data, perhaps reflecting the increased prevalence and risk of hypertension in these women.

**Table 4**  
Maternal Characteristics of women who self-monitored BP at 13 UK sites.

Maternal characteristics	N = 627*
Gestation SMBP started <sup>†</sup>	Median 28.0 (IQR 20.1–35.0)
Age	33 (SD 5.7)*
Body mass index	29 (SD 6.7)*
First baby	248 (40 %)*
Hypertension	% (n) (627 women)
Chronic hypertension	146 (23 %)
Gestational hypertension	192 (31 %)
Pre-eclampsia	46 (7 %)
Ethnicity	%(n) (627 women)
White British or White other	366 (58 %)
Black British or Black	85 (14 %)
Asian	44 (7 %)
Mixed/other	71 (11 %)
Not stated	61 (10 %)
Deliveries	N = 555
Livebirths	555
Spontaneous vaginal delivery	237 (43 %)
Assisted vaginal delivery	65 (12 %)
Elective Caesarean Section	119 (21 %)
Emergency Caesarean Section	131 (24 %)
Stillbirth	6
Neonatal death	1
Gestation in weeks at delivery (live births)	Median 38.6 (IQR 37.3–39.6)
Birthweight (g)	Median 3235 (IQR 2780–3570)
Admission to Neonatal Unit	80/337 (24 %)*
Other pregnancy outcomes	
Miscarriages	4
Terminations	3
Postpartum stay	384 women (69 % of those with delivery data)
Nights postpartum stay	Median 2 (IQR 1–3)
Single night stay	153/384 (40 %)
Four nights or less	317/384 (83 %)

Continuous data are given as mean (SD) unless shown otherwise as median (interquartile range).

<sup>†</sup>To the nearest week, \*Data available n = 616 for age and parity and n = 608 for body mass index. Data were available from 555 deliveries, with neonatal unit admission data on 337 infants.

### 4.2. Women's views

Almost all women who responded to the survey felt safe monitoring their own BP during the COVID-19 pandemic and the majority stated that SMBP made them feel more confident. Key benefits for women included more control and independence over their care and an insight into their own BP. This was confirmed and explored during the interviews in which women expressed their confidence in monitoring and having broadly positive, reassuring, and empowering experiences of SMBP. This is likely to be true both in and outside of a pandemic. Although the survey of women's views suggested some women felt more anxious SMBP, this was not supported by the qualitative work presented here or in previous studies.[12].

### 4.3. Strengths and limitations

These findings provide a timely insight into the perspectives of pregnant women and maternity units on the rapid implementation of SMBP in pregnancy in England since March 2020. The survey, clinical data and interview findings support each other providing breadth and depth. These data add evidence to current understanding about SMBP in pregnancy and provide insights about how implementation should be supported.

This research took place during the second wave of the COVID-19 pandemic when the NHS was under considerable pressure, making data collection challenging. All maternity units were offered monitors and while most took them up only around a third responded to this study. The observational clinical data gathered did not have a comparison group and the survey of women's views represented a self-selected sample. The women's survey has potential for bias due to its small size and because some maternity units publicised the survey more widely than others. The size of the survey meant that comparative analysis was not possible. No data were available on clinical or cost effectiveness of SMBP, or on outcomes on a large enough scale to provide safety data, but this is being systematically evaluated in recently completed trials.[13].

### 4.4. Clinical context and recommendations

Willingness to engage with SMBP was probably reflected in the speed of implementation during the pandemic. The timely development of guidance and access to monitors appears to have been integral to implementation, but challenges remained. The SMBP services established did not typically reduce standard antenatal face-to-face visits, though may have reduced additional visits, with around one in five appointments moving to telephone. Only half of units reported using self-testing of urine, but combining this with SMBP could potentially allow more appointments to be completed virtually and prevent duplication.

Challenges were noted around initial implementation and embedding remote monitoring within the existing clinical pathways, and also around monitor supply, storage, and return. Understanding the significance of SMBP readings and adapting results into care pathways was an issue for both HCPs and women, and a lack of confidence in how to manage home-clinic differences may have affected hesitancy around reducing face-to-face visits.

Most hospitals had concerns about the return of monitors, particularly as ongoing replacement was not covered in the initial scheme or budget. Women with hypertensive pregnancies have an ongoing elevated cardiovascular risk, so a strategy that permitted women to keep their BP monitor in the longer term, to promote identification and management of ongoing hypertension, would be ideal in targeting this risk and removing the issues around monitor return. This could be explored with the support of primary care networks and those who commission clinical services.

Telemonitoring (such as through an app) was seen by HCPs as a safety net that would ensure women get the response to a raised reading,

but very few hospitals used a telemonitoring service. This appeared to represent a further challenge, particularly under pandemic conditions; setting up new telemonitoring systems at the same time as SMBP required further time and additional local approval. In spite of the challenges and the lack of effectiveness data, most maternity units planned to continue an SMBP service in the future. Guidance for maternity units on appropriate data collection during their implementation could have better supported decisions around long-term implementation.

#### 4.5. Relevant research and recommendations

It is not yet clear how care pathways might change post-pandemic, or if remote monitoring will become part of routine care. A recent survey of obstetricians found that almost all (96 %) thought that SMBP had a place in usual care suggesting its ongoing use is highly likely.[14] The challenge going forward will be to use and incorporate SMBP in a way that supports improvements in care and outcomes. To do this, further research is needed to evaluate what works in practice and how SMBP can be embedded within routine care in a way that can improve care, the experience of women and maternal and fetal outcomes. In particular, considering how to integrate clinic and home BPs (including consideration of white coat and masked hypertension) is a priority, together with understanding how SMBP best informs titration of antihypertensive medication in pregnancy. This research should make considerable efforts to include ethnic minority groups who are at an increased risk of hypertensive disorders but are often underrepresented in research.

## 5. Conclusions

A considerable proportion of maternity units in England rapidly commenced a SMBP service shortly after the start of the COVID-19 pandemic in the UK, supported by guidance and provision of free monitors. SMBP was predominantly used to provide additional BP monitoring for hypertensive or high-risk pregnant women. Overall, maternity units and women were positive about its use, though there were challenges in setting up the service and embedding it within existing care pathways. Further work is needed to establish clearer care pathways in order to harness benefits and minimise risks without additional costs.

### Authors' contributions

LC and RM conceived and led the study. HW led the development and collection of the survey data, collection of clinical data and carried out the analysis of survey data with support from LL, LC, AC and LM. LL and LM collected and curated clinical data. AC and JH completed the qualitative interviews and AC completed the qualitative analysis with support from LH. KT completed the statistical analysis of clinical data. KT and HW wrote the first draft of the paper with AC. All authors have reviewed drafts of this paper.

### Funding

This work was funded from a National Institute for Health Research (NIHR) Applied Research Collaboration Oxford and Thames Valley (ARC-OxTV). LM received support from NIHR Oxford Biomedical Research Centre. LH is based in The Healthcare Improvement Studies Institute (THIS Institute), University of Cambridge. THIS Institute is supported by the Health Foundation, an independent charity committed to bringing about better health and healthcare for people in the UK. RM and LC are NIHR Senior Investigators. The views expressed in this publication are those of the authors and not necessarily those of the NHS, the NIHR or the Department of Health and social care.

### Role of the funder

The funders had no role in study design, data collection, data analysis, data interpretation, writing of the report, or in the decision to submit for publication. All authors had full access to all the data in the study.

### Declaration of Competing Interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

### Acknowledgements

We thank Lucy Curtin, for administrative support and AS for PPI input. Marcus Green, Chair of the charity APEC for his support with the survey. None of this would be possible without the participating women, site research midwives and doctors for their contributions.

### Appendix A. Supplementary data

Supplementary data to this article can be found online at <https://doi.org/10.1016/j.preghy.2022.07.006>.

### References

- [1] K.L. Tucker, J. Hodgkinson, H.M. Wilson, C. Crawford, R. Stevens, S. Lay-Flurrie, M. Dale, N. Astbury, L.C. Chappell, R.J. McManus, Current prevalence of self-monitoring of blood pressure during pregnancy: the BUMP Survey, *J Hypertens*. 39 (5) (2021) 994–1001.
- [2] E. Kalafat, C. Benlioglu, B. Thilaganathan, A. Khalil, Home blood pressure monitoring in the antenatal and postpartum period: A systematic review meta-analysis, *Pregnancy Hypertens*. 19 (2020) 44–51.
- [3] L. Hinton, J. Hodgkinson, K.L. Tucker, L. Rozmovits, L. Chappell, S. Greenfield, et al., Exploring the potential for introducing home monitoring of blood pressure during pregnancy into maternity care: current views and experiences of staff—a qualitative study, *BMJ Open*. 10 (12) (2020) e037874.
- [4] TheKing'sFund. Reconfiguring maternity services <https://www.kingsfund.org.uk/publications/reconfiguration-clinical-services/maternity-services-1>.
- [5] NHS. When to self-isolate and what to do <https://www.nhs.uk/conditions/coronavirus-covid-19/self-isolation-and-treatment/when-to-self-isolate-and-what-to-do/2021>.
- [6] QSR International Pty Ltd NVivo (Version 12) 2018 <https://www.qsrinternational.com/nvivo-qualitative-data-analysis-software/home>.
- [7] V. Braun, V. Clarke, Using thematic analysis in psychology, *Qualitat. Res. Psychol*. 3 (2) (2006) 77–101.
- [8] Y. Chung, A. de Greeff, A. Shennan, Validation and compliance of a home monitoring device in pregnancy: microlife WatchBP home, *Hypertens Pregnancy*. 28 (3) (2009) 348–359.
- [9] RCOG. Royal College of Obstetricians and Gynaecologists guidelines - Self-monitoring of blood pressure in pregnancy <https://www.rcog.org.uk/globalassets/documents/guidelines/2020-03-30-self-monitoring-of-blood-pressure-in-pregnancy.pdf2020>.
- [10] BPm-Health: <https://www.sensynehealth.com/bpm-health> Contact: info@sensynehealth.com, Florence: <http://www.simple.uk.net/home/videos/flo-and-pih-kim-hinshaw> Contact: phil.oconnell@simple.uk.net, Hampton: <https://help.k2ms.com/portal/kb/hampton-blood-pressure-monitoring> Contact: <https://www.k2ms.com/k2-hampton-contact-form.aspx>.
- [11] Office of National Statistics. Birth Summary Tables, England and Wales 2018. <https://www.ons.gov.uk/peoplepopulationandcommunity/birthsdeathsandmarriages/livebirths/datasets/birthsummarytables>. 2019.
- [12] L. Hinton, K.L. Tucker, S.M. Greenfield, J.A. Hodgkinson, L. Mackillop, C. McCourt, T. Carver, C. Crawford, M. Glogowska, L. Locock, M. Selwood, K.S. Taylor, R. J. McManus, Blood pressure self-monitoring in pregnancy (BuMP) feasibility study: a qualitative analysis of women's experiences of self-monitoring, *BMC Pregnancy Childbirth*. 17 (1) (2017).
- [13] G. Dougall, M. Franssen, K.L. Tucker, L.M. Yu, L. Hinton, O. Rivero-Arias, et al., Blood pressure monitoring in high-risk pregnancy to improve the detection and monitoring of hypertension (the BUMP 1 and 2 trials): protocol for two linked randomised controlled trials, *BMJ Open*. 10 (1) (2020) e034593.
- [14] B. Fletcher, L.C. Chappell, L. Lavallee, H.M. Wilson, R. Stevens, L. Mackillop, R. J. McManus, K.L. Tucker, Changes to management of hypertension in pregnancy, and attitudes to self-management: An online survey of obstetricians, before and following the first wave of the COVID-19 pandemic, *Pregnancy Hypertens*. 26 (2021) 54–61.