









RESEARCH ARTICLE

Enabling scale and spread of technology-enabled remote monitoring of blood pressure at home: findings from a rapid qualitative evaluation

[version 1; peer review: awaiting peer review]

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Abstract

Background

High blood pressure (BP) is a leading cause of morbidity and mortality. Blood pressure home monitoring improves blood pressure control, but there is limited evidence about the implementation of specifically 'technology-enabled' remote monitoring of blood pressure (TERM) at home. This evaluation aims to improve the evidence base on what constitutes TERM BP services, how they work, and what influences their implementation, impacts, spread, and scale.

Methods

A multi-method, rapid qualitative evaluation involved four sites that implemented TERM BP. Across sites, we conducted interviews with staff (n=35) and patients (n=15) and analyzed key service documents. Three workshops with site staff, patients, and regional and national stakeholders helped refine the learning process. Thematic analysis and synthesis, and triangulation against existing literature, helped inform recommendations and was guided by the Non-adoption, Abandonment, and challenges to Scale-up, Spread and Sustainability of the technology framework. The patients and public voices informed the evaluation design and conduct.

Results

TERM BP implementation varies in governance, patient eligibility, technology, workforce, and workflow. Perceived impacts include improved blood pressure control, case-finding, and a more efficient workload distribution. The parallel running of technology-enabled and paper-based pathways mitigates access inequalities, but involves a high administrative workload. Sociotechnical influences on implementation relate to technology user-friendliness and adaptability, health system relationships and resources, practice capabilities and learning cultures, and patient acceptability and enablement. Flexibility within a planned, gradual approach that embeds skills in teams and systems and impacts evidence generation support scale and spread.

Conclusions

Technology and social forces co-evolve to shape TERM BP pathways and manage co-existing tensions, including planning, emergence, demand, and capacity. Decision makers should establish implementation guidance and commissioning criteria, address regulatory issues, and enable evidence generation and shared learning. Further research is needed on the impact of TERM BP, especially in integrated care and related to inequalities.

Plain English summary

High blood pressure affects more than a quarter of the population in the UK. Managing it well can help prevent further health problems. One way to help people control high blood pressure is to use devices such as home blood pressure monitors and mobile phones. This is called technology-enabled remote monitoring of blood pressure at home. We still need to understand more about what works well when using technology-enabled remote monitoring.

In this study, we looked at how, where, why, and for whom technology-enabled remote monitoring of blood pressure is used. We interviewed 35 healthcare professionals and 15 patients across four sites (for example, general practices). We held three workshops with healthcare professionals, other decision makers, and patients to discuss and refine the findings.

We found that technology-enabled remote monitoring of blood pressure was used in various ways. Sometimes, the service is delivered by general practice and sometimes by staff working in a local area to support patients across many general practices. At most sites, technology-enabled remote monitoring is managed by a nurse or pharmacist instead of a general practitioner (GP). Support from a variety of clinical and non-clinical staff is important. Most patients were engaged and motivated to use technology-enabled remote monitoring, although some were concerned about whether they were using the monitors correctly. The patients also highlighted that technology-enabled remote monitoring may not be a good fit for

everyone.

Technology-enabled remote monitoring can support both patients and healthcare professionals in managing high blood pressure, but more research is needed to understand the wider impact (e.g., on demand for GP appointments). Decisionmakers should consider how technology-enabled remote monitoring can be gradually expanded to reach more people. Planning is needed to ensure that it is widely accessible and does not place too much extra burden on the staff.

Keywords


Primary care; hypertension; blood pressure; technology; self-monitoring; remote monitoring; qualitative; UK

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Introduction

Context: a growing focus on innovative approaches to managing hypertension in policy and practice

Hypertension is an important public health issue given its prevalence and links to the risks of cardiovascular disease (CVD). According to Public Health England (PHE), 11.8 million adults aged 16 years or older in England have hypertension, approximately 26.2% of the adult population¹. PHE estimates that for every ten people diagnosed with hypertension, another seven are undiagnosed and untreated¹. Hypertension is a primary risk factor for several CVDs such as coronary artery disease, congestive heart failure, and atrial fibrillation², and is considered by the World Health Organisation (WHO) as one of the most preventable causes of premature death³. There is compelling evidence for the benefits of controlled blood pressure (BP) on CVD outcomes⁴⁻⁶, though several studies suggest that adequately controlling BP is challenging⁷⁻⁹. A 2021 UK-based study found that only two in five adults between ages 40 and 69 on hypertension treatment have their BP adequately controlled⁸.

National initiatives in the United Kingdom (UK) have long sought innovative approaches to support patients with hypertension¹⁰⁻¹³, including to improve BP control and cardiovascular outcomes. Examples include the national BP Optimization Programme (now completed, but which focuses on tools for managing hypertension in primary care) and the ongoing Cardiovascular Disease Prevention (CVDPREVENT) audit to support quality improvement in general practice, which started in 2019/2020^{14,15}. As part of the growing interest in innovative approaches for managing hypertension, policymakers, commissioners, and healthcare providers have also focused on the potential to use technology. This reflects a wider interest in technology-enabled care across different clinical conditions (and not only hypertension), to improve access to care and the effectiveness and efficiency of healthcare delivery, as well as to help address growing demands for care and workforce capacity constraints¹⁶. Some hypertension-focused programmes specifically look to use technology to enable remote monitoring of BP in home settings. These included the 2020 BP@home program, which provided BP monitors to NHS organizations in England¹⁷; the 2015/2016 Scale-Up BP program, which focused on implementing TERM BP in Scotland¹⁸; and the current Connect Me program in Scotland¹⁹, which involves multiple remote monitoring pathways, including TERM BP. In England, local and regional health system decision-makers at the practice, primary care network (PCN), integrated care board (ICB), and integrated care system (ICS) levels have implemented remote monitoring programs for BP^{10,12,20}.

In this context, the Digitally Enabled Care in Diverse Environments (DECIDE) center for rapid evaluation of technology-enabled remote monitoring evaluated the implementation of technology-enabled remote monitoring (TERM) of blood pressure (BP). The overarching aim of the evaluation was to improve the evidence based on what works, how, why, and in which contexts as it relates to TERM BP. The evaluation is nested in wider efforts to provide timely, practical learning that can help health system decision makers at the national, regional, and local levels make informed decisions about how to

implement, sustain, spread, and scale remote care pathways. The intended government shifts in healthcare – from hospitals to communities, sickness to prevention, and analog to digital care – underline the need for such evidence and learning to support changes in the health service, including in relation to major public health challenges such as hypertension.

Key insights and gaps in the literature on blood pressure home monitoring, including TERM BP

We conducted a rapid scoping review of the literature on BP remote monitoring, focusing on the UK context, to help scope the context and focus our evaluation. Full details of the methods and findings from the literature review are available in the Open Science Framework data repository²¹.

Based on 18 papers from peer-reviewed literature and 12 papers from grey literature, we found that all BP remote monitoring, also known as ‘home BP monitoring’ or ‘self-monitoring,’ relies on some form of technology, such as upper arm blood pressure machines. Paper-based BP remote monitoring includes patients using a BP monitor to take readings and communicate readings to a healthcare professional (HCP) in person through email, phone call, or post. Technology-enabled remote monitoring of BP involves higher levels of technology-enablement where patients use a BP monitor to take the readings and then communicate readings back to a healthcare professional via a weblink, that patients access through an SMS message, or through a mobile application^{22,23}. ‘Technology-enabled’ remote monitoring of BP relies on using a data platform communications technology to request patients to take BP measurements and for patients to share blood pressure measurements with healthcare staff. Monitors and related equipment (such as BP cuffs) are also considered part of this technology.

BP remote monitoring (paper-based and technology-enabled) has been found in randomized controlled trials to be effective in improving BP control in patients with hypertension^{11,13,24,25}, including high-risk individuals with existing CVD, diabetes, or chronic kidney disease²⁶. Compared to usual care, both paper-based and TERM BP approaches were found to effectively control BP²⁴. While there is limited evidence on the extent of BP remote monitoring. A study of 11 million patients in the UK found that, in 2016/2017, only 25.6% of those diagnosed with hypertension had a record of home or ambulatory blood pressure monitoring prior to their diagnosis²⁷. In summary, while the evidence in support of BP remote monitoring is strong, there is less understanding of the specific impact of TERM BP and there is scope to improve overall adoption into practice.

Despite compelling evidence on clinical outcomes (namely, BP and BP control) from BP remote monitoring, evidence on the impacts of BP remote monitoring on health service utilization is inconclusive^{28,29} and on cost-effectiveness is mixed³⁰⁻³². There is considerable variation in the implementation and delivery of care pathways involving TERM BP, but details are limited to the nature of care pathways and implementation processes and on the impacts of TERM BP in the existing evidence base^{12,23,33}. There are significant evidence gaps

related to understanding which types of remote monitoring BP (paper-based, technology-enabled) approaches can support improved patient outcomes and service impacts in specific contexts, how, and why.

In the following sections, we set out the aims and research questions that guided our evaluation of TERM BP implementation. We then describe the evaluation design and methods used before presenting our findings related to TERM BP service pathways, perceived impacts, and influences on implementation, spread, and scale. In the discussion, we situate the findings within the existing evidence (returning to key insights from the literature review described above) related to BP remote monitoring and the wider sociotechnical literature, concluding with a set of recommendations for decision makers.

Research aim and questions

Against this background, our evaluation sought to study and learn from the implementation of TERM BP. Our core research question was: How can interventions focused on the remote monitoring of blood pressure be designed, implemented, spread, scaled, and sustained to optimize patient outcomes and impacts on health services in the United Kingdom (UK)? The following sub-questions guided the evaluation.

- a) How is technology-enabled remote monitoring of blood pressure implemented (i.e., examining variations in approaches taken)?
- b) How can implementation challenges be navigated and effectively addressed?
- c) How do different implementation approaches contribute to and affect patient uptake and experience, outcomes, and health service impact?
- d) Do (and how do) considerations of inequalities impact decisions to implement, spread, and scale specific approaches, and what impact do the chosen approaches have on efforts to address inequalities?
- e) What are the key considerations for those looking to scale, spread, and sustain technology-enabled remote monitoring of blood pressure at home?

We conceptualize *spread* as entailing efforts to transfer successful interventions beyond the original adoption context (e.g., from one general practice to another, from one PCN to another), *scale-up* as establishing an infrastructure that can support widespread adoption (e.g., to new patients in the same PCN), and *sustainability* as maintaining an intervention (in its original or adapted form) over time, where that is merited and supports desired outcomes³⁴.

Design and methods

Evaluation design and approach

We conducted a multi-method rapid evaluation involving qualitative data collection initially via a series of scoping interviews and then subsequently across four primary care sites that had implemented TERM for BP. Qualitative data collection included a document review, interviews with service delivery

staff and patients, and site visits to each of the four sites. Subsequent multi-stakeholder workshops with site staff, a wider range of patients with TERM BP, and regional and national stakeholders helped refine learning. The rapid evaluation approach included regular communications with NHS England (specifically the BP@Home team, part of NHS@Home) as the policy customer for the evaluation to understand current policy influences and share timely feedback. The evaluation forms part of a 3-year programme of work by DECIDE, funded by the National Institute for Health and Care Research (NIHR) Health and Social Care Delivery Research (HSDR) program. DECIDE is a collaboration between the University of Oxford and the RAND Europe.

Conceptual Framework. This theory-driven evaluation was sensitized by a sociotechnical systems perspective on health services research³⁵ and the NASSS (Non-adoption, Abandonment, and Challenges to Scale-up, Spread, and Sustainability) framework^{34,36}. The NASSS framework (shown in Figure 1) acted as a primary sensitizing device to understand the various factors that affect implementation, spread, and scale, and as an analytical tool to help us understand and explain the complexity involved in TERM BP service delivery and evolution and adaptation over time. The NASSS is informed by complexity and social science perspectives to understand the adoption, spread, and scale of technology in healthcare settings. It includes seven domains: (i) the nature of the health condition (including both physical and sociocultural factors); (ii) technology type (including both material/physical properties and associated knowledge needed for it to work, supply models, and commercial/IP considerations); (iii) the value proposition (for developers, patients, health service); (iv) the role of adopters (e.g., healthcare staff, system decisionmakers, patients, and carers); (v) organizational and wider support (capacity for innovation, support structures, and processes framing innovation decisions and implementation and monitoring over time); (vi) the wider system (e.g., sociocultural, political, regulatory); and (vii) potential for adaptation over time.

The NASSS informed the development of the interview guide and sensitized our analytical approach. The condition and value proposition domains helped us think about who the TERM BP was used for and why. Insights from our scoping interviews and wider work of DECIDE led us to adapt NASSS domain categories related to influences on implementation (i.e., technology, adopters, organizations, wider system) into four domains to inform accessible communications with evaluation participants, the domains being technology and supplier, health and care system, provider organizations and workforce, and patients. The NASSS domain of embedding and adaptation is applied across these domains. Finally, we considered what aspects of each domain were used or are needed for the spread and scale of TERM BP as prerequisites or perhaps as adapted and evolved over time.

Evaluation methods

The evaluation was conducted in three phases. Phase 1 involved scoping interviews. Phase 2 involved a document review, staff and patient interviews, and site visits. Phase 3 involved a series

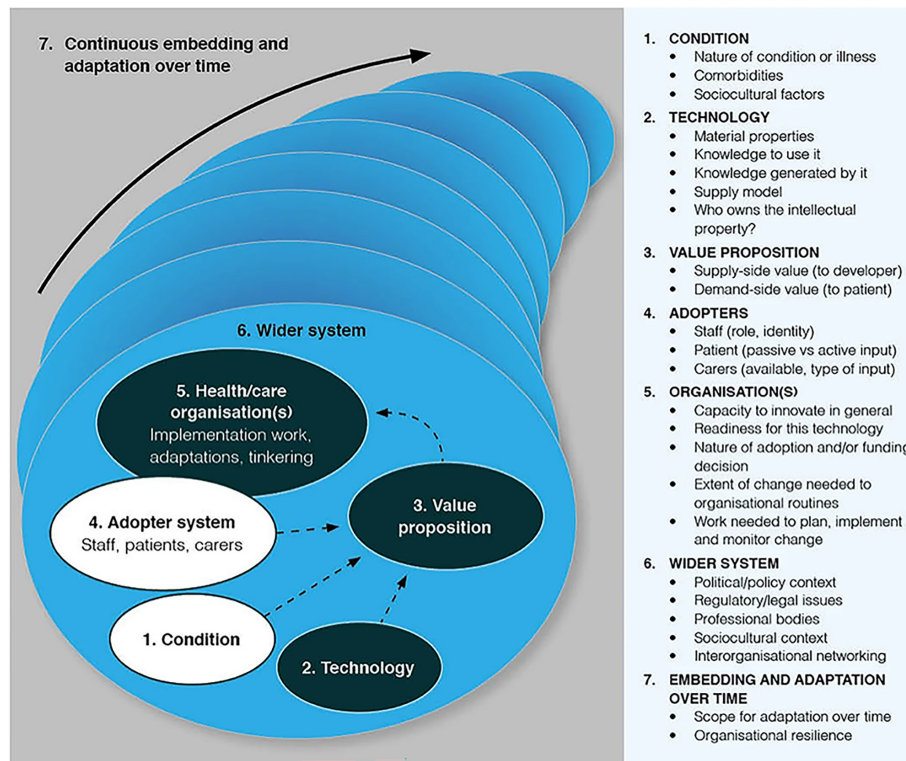


Figure 1. The NASSS framework (Non-adoption, Abandonment, and challenges to Scale-up, Spread, and Sustainability) to understand the various factors that affect implementation, spread and scale³⁷.

of online workshops, bringing together four primary care sites that had implemented TERM BP, a wider set of patients, and regional and national decision makers. We set out the methods for each phase as follows.

Phase 1: Scoping interviews (January 2024 to February 2024)

We conducted 30 scoping interviews to understand the landscape of TERM BP in the UK, refine the evaluation questions, and inform primary care site sampling (see below).

We initially sought a purposive, maximum-variation sample of interviewees via DECIDE’s governance structure and wider networks. We then broadened this using a snowballing approach to identify additional interviewees. This enabled diversity in research, clinical, and PPIE expertise, as well as those involved in policy and decision-making at the national, regional, and local levels (e.g., leads from integrated care boards, Health Innovation Networks, and general practices).

Phase 2: Qualitative evaluation of four primary care sites (March 2024 to March 2025)

We conducted a qualitative evaluation of four primary care sites implementing TERM BP to understand the implementation processes, appreciate the complexity of TERM BP as a service intervention, and explore diverse influences on implementation, spread, and scale. We sought a purposive sample of sites that had implemented TERM BP for some time, rather

than those in early implementation, to enable us to learn about implementation processes over time and to inform considerations for spread and scale. We sought diversity in terms of site geography, technology used, and workforce models to support the implementation of the TERM BP (see Table 1). We used pseudonyms for the sites and technologies they used.

See the Data Availability section for access to information for the full analysis of the findings at each site.

Document review

We undertook a focused document review of TERM BP service planning or operational documents (2–3 per site) that primary care sites could share to help us understand the origins of the service, service set-up, implementation, staff involvement, and workflows for TERM BP, such as the protocol sites developed to inform service workflows for TERM BP.

Staff and patient interviews

Staff and patient interviews allowed us to explore the implementation context and influence on shaping implementation and the evolution and adaptation of services over time. At each site, we identified a lead that provided contact information to staff participants. We aimed to sample staff across a range of roles involved in planning, design, and/or delivery service pathways for TERM BP, including clinical staff, such as GPs, nurses, pharmacists, and administrative staff, for example

Table 1. Characteristics of primary care sites.

Site name	Number of practices	Practice size (no. of registered patients)	Service start year	Programme lead	Clinical lead	Staff support	Technology	Governance
Mid-Town Practice	1	9,900	2021	Practice manager	Clinical pharmacist	HcAs, nurse associate and receptionists	Technology A, used by staff to send SMS messages to patients (containing link to input BP readings) and follow up tasks to specific clinicians	Practice
South Coast PCN	1 practice, 9 in the PCN	3,700 (practice) 50,000 (PCN)	2020	ICB level staff	PCN clinical pharmacist	Digital care coordinator, HcAs and nurse assistant at the PCN level. GP staff also provide support with recruitment and follow up as needed	Technology B, which includes 1) a patient facing mobile application interface (for inputting BP readings and messaging HcPs) and 2) a data platform used by the PCN to contact and manage patients	PCN/ ICB
Green Hills Practice	1 practice, 4 in the cluster	9,000	2018	GP partner	Nurse manager	Nurse associates and trainee nurses. Relies on support from HcAs and the reception team and input from GPs	Technology C, used by staff to send SMS messages to patients (containing link to input BP readings) and follow up tasks to specific clinicians Technology D (not widely used), staff sends SMS messages to patients (containing link to input BP readings) and follow up tasks to specific clinicians	Practice
North Market Practice	5 practices, 6 in the PCN	26,000	2020	GP partner	Advanced care practitioner	GPs, nurses, HcAs, physician associates	Technology A, used by staff to send SMS messages to patients (containing link to input BP readings) and follow up tasks to specific clinicians.	Practice

GP, general practitioner; HCA, healthcare assistant; ICB, integrated care board; PCN, primary care network; SMS, short message service.

receptionists, and where possible included staff from the PCN and/or system-level, that is, ICB, Health and Social Care Partnership (HSCP). Staff at each site supported the identification of patients for interviews, aiming to recruit patients with varying characteristics, such as age, ethnicity, and clinical condition(s). Across the four sites, we interviewed 35 staff members (healthcare professionals and system leaders) and 15 patients (Table 2).

Semi-structured interviews with staff included questions about the motivation and rationale for TERM BP, the nature of the service pathway, and implementation processes, including influences on the pathways and adaptation over time, perceived impacts and unintended consequences, and information of relevance to spread and scale efforts. Semi-structured interviews

with patients explored their experience of TERM BP, including overall perceptions of how it is working for them, the level of guidance and support received from the practice, and any improvements they would like to make to the service pathway.

The interviews were conducted with MS Teams or telephone calls. All interviews were digitally recorded and transcribed with contemporaneous notes taken by interviewers (FW, JW, SMO, HT, Sma, and DM). Each interview was then summarized using dedicated Rapid Assessment Procedure (RAP) sheets^{38,39}.

Site visits

We conducted site visits at three sites, allowing us to gain a sense of the organizational context and setting, explore the physical areas surrounding the delivery of TERM BP, meet

Table 2. Summary of participants across primary care sites.

Site	Healthcare professionals	Patients
Mid-Town Practice	10	5
South Coast Primary Care Network	7	4
Green Hills Practice	10	3
North Market Practice	8	3
Cross site workshop*	7	22
Total	49	37

* Workshop participants included some from the interviews. The patient workshop included a mix of patients from primary care sites and nonsites.

with and engage staff involved in designing and delivering the service, and share emerging findings. At the fourth site, we were unable to schedule a visit due to availability and instead spent additional time with the site lead over MS Teams to discuss the context and setting of the service, clarify questions, and share emerging findings.

Phase 3: Online workshops (February 2025 to March 2025)

Three online workshops were conducted towards the end of data collection to support cross-case analysis and triangulate and refine the findings. The first workshop involved healthcare professionals across primary care sites (N=7). The second workshop involved patients from sites that participated in interviews, and additional patients and caregivers with lived experience of BP remote monitoring recruited through a University of Oxford PPIE mailing list (n=22). The third workshop involved a wider range of stakeholders in the implementation, design, and spread of TERM BP, including policymakers, ICB staff, clinical staff, and non-clinical staff (practice managers and digital care coordinators). Stakeholders (n=17) were identified via wider networks and with input from the BP@Home team, with the content of the workshop focused on refining policy recommendations for national and regional decision-makers related to the implementation, scale, and spread of TERM BP.

Analysis and synthesis. We began by drawing together document analysis and RAP sheets from each primary care site into a single summary document using NASSS as a synthesizing device. We then conducted a thematic analysis under each adapted NASSS domain, again being technology and supplier, health and care system, provider organizations and workforce, and patients - both within and across primary care sites. To aid in this process, we held four online analysis workshops involving the research team to share emergent findings, summarize emerging themes within and across sites, and identify themes related to spread and scale. Case studies, which involved document review, semi-structured interviews, and a site visit, were written as part of the analytic process (see Data Availability for access to full case studies).

Alongside NASSS as the overarching analytical framework, our analysis and inference making also drew on two theoretical perspectives to further explore the influences on the implementation, spread, and scale of TERM BP. This included dialectical perspectives⁴⁰⁻⁴² and sociotechnical traditions in science, technology, and innovation studies, specifically the literature on sociotechnical regimes⁴³⁻⁴⁶. Dialectical perspectives helped us consider the co-existing tensions and trade-offs at play in implementing TERM BP and their implications for implementation. The literature on sociotechnical regimes and transitions helped us consider how technology and health services systems impact each other and adapt and co-evolve to deliver TERM BP.

Ethics and governance

The Research Governance, Ethics, and Assurance team at the University of Oxford (sponsor) classified the project as a service evaluation, and thus did not require research ethics approval.

All participants had the capacity to provide informed consent and were provided with a project information sheet and consent form detailing the study aims, design, contacts, and data privacy. The participants were informed that they had the right to withdraw from the study at any point without needing to provide a reason. All the interviews were digitally recorded and written using summary notes. We used pseudonyms for the sites and technologies they used.

The project advisory group comprised three individuals with clinical, research, and public involvement experiences with BP remote monitoring. The group met regularly over the course of the evaluation to inform them of data collection materials, reflect on emerging findings, and inform them of the dissemination strategy. Wider input from the DECIDE Steering Committee⁴⁷ informed the evaluation design, conduct, and avenues for dissemination.

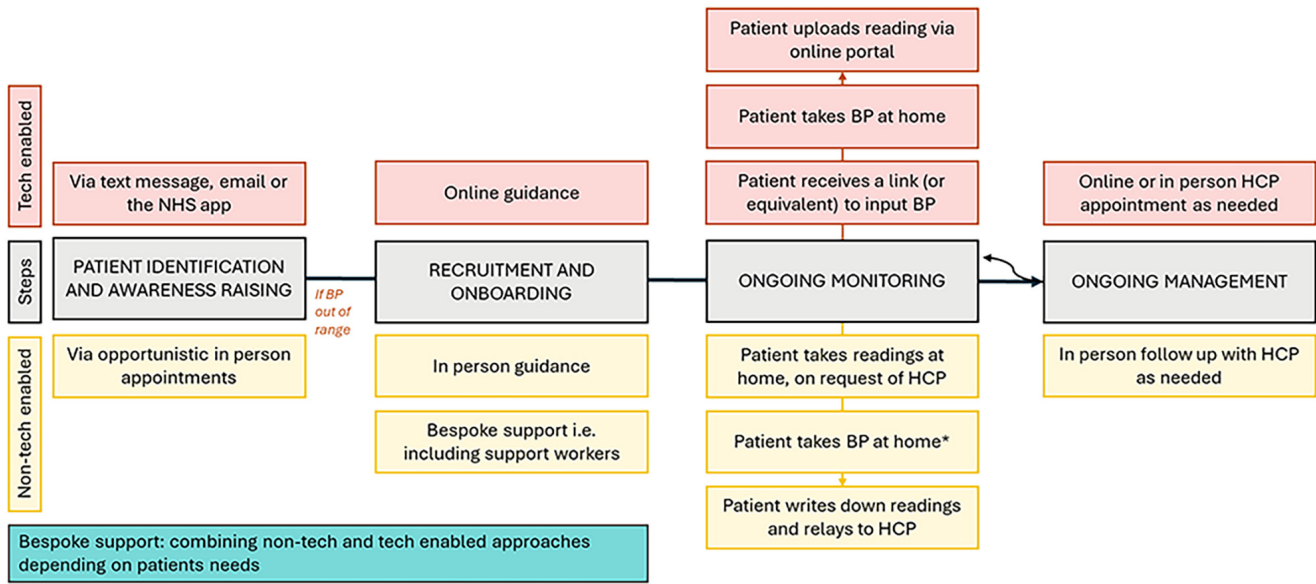
Patient and public involvement and engagement

The evaluation was shaped by the involvement of the patients and the public from the outset. Early discussions with two Patient and Public Involvement and Engagement (PPIE) experts drawn from the wider DECIDE programme⁴⁷ informed the evaluation design, sampling, and conduct. A dedicated PPIE group, involving three people with lived experience of remote blood pressure monitoring, contributed to interview guide development, input for analysis, and helped design and participate in a workshop with patient voice representatives.

Results

How is tech enabled remote monitoring of blood pressure implemented?

Across the study sites, care pathways for technology-enabled BP remote monitoring tended to include three key stages: patient identification and awareness-raising, recruitment and onboarding, and ongoing monitoring and management (Figure 2). Patient identification and awareness raising refer to activities that are used to identify patients who might benefit from



*Patients also have the option to have their blood pressure taken at the GP practice or pharmacy. This figure focuses on remote monitoring at home.

Figure 2. The remote monitoring of blood pressure pathway.

BP remote monitoring and help make patients aware that these services exist. Recruitment and onboarding activities support patients to take up the service, such as offering TERM BP to patients and support for registration, education on how to take BP measurements and how to share measurements with the healthcare team, information sharing on how the service works, how patients and HCPs will engage with the process, and any other support and communication prior to a patient taking and sending their first reading. Ongoing monitoring includes patients receiving requests to complete BP remote monitoring on a user interface (e.g., SMS message or mobile application) and the use of a data platform and interface by healthcare staff to process and appropriately follow up on the results of BP measurements.

Interplay of emerging circumstances and financial, clinical quality, and efficiency drivers as motivations for TERM BP

The emergence of the COVID-19 pandemic was a catalyst for greater digitization of health services and provided an impetus for greater focus on TERM BP. While consideration of digitally enabled care existed before the pandemic, staff at two sites flagged that reduced social contact during the pandemic accelerated the recourse to more remote care approaches, so that practices could in some way monitor the health of their patients and utilize staff working from home.

As one GP shared:

“We became increasingly concerned about long term condition monitoring not happening during COVID, and the remobilization of this [...]there was still significant risk happening at this time, this was in-between

[COVID lockdown] waves, so we then looked at, is there any remote data gathering that at least we can get some indication [of] how well patients are controlled and then we can we can help prioritise. So Technology C, as a remote assessment tool, came in really at that time.” GHP-4

Although the pandemic catalyzed implementation, several staff across all sites noted motivations to improve care quality in BP control and hypertension management, which were bolstered by Quality Outcomes Framework (QOF) targets for hypertension¹ management in England tied to payments to general practices. In Scotland, where QOF is not in use, decision-makers implemented the program in alignment with Realistic Medicine⁴⁸ to improve patient empowerment and shared decision making. Other motivations flagged by some staff across the sites included a desire to help staff work more efficiently and help patients engage more actively with their own health conditions.

A value proposition with both shared and distinct potential benefits for staff and patients

The value proposition associated with TERM BP pathways (that is, the value that these pathways are seen as potentially

¹ Related to record keeping, HYP001: Establishes and maintains a register of hypertensive patients.; HYP008, the percentage of patients aged 79 years or under with hypertension who have measured their BP in the preceding 12 month is 140/90mmHg or less; HYP009, the percentage of patients aged 80 or over with hypertension in whom the last blood pressure reading was 150/90mmHg or less.

offering) has both shared and distinct elements across healthcare staff and patients. Staff see potential value related to facilitating more accurate diagnosis, improving access to care for patients with hypertension, and supporting hypertension and medicine management. Releasing time for face-to-face GP consultations for patients who cannot engage remotely, thereby targeting inequalities in access to care, was also seen as a potential value. Related to this was a value proposition of educating patients about blood pressure and supporting them in managing their own health, which holds potential in managing patients' utilization of the health system, an area relevant to healthcare providers and policymakers alike.

As one healthcare assistant (HCA) commented:

"We've got to get the message out there... You know, you can take self-responsibility. You can have this check at home. You can be in charge of when you [take your BP], when you need to do it [...] It kind of gets the message out as well how important blood pressures are." SCP-4

Many of these issues are also important to patients, particularly improved access to care, knowledge of blood pressure and hypertension (thereby providing reassurance to some patients), and engagement with overall health to support better hypertension management.

As illustrated by one patient:

"I worry about it [less] because I'm confident that I've got a handle on it." SCP-7

The patient commented that engagement with TERM BP aided health-seeking behaviors.

"I got back on the bike, I got back in the pool and the blood pressure came back down." SCP-7.

A few staff members at South Coast PCN noted that not all were motivated by such potential benefits, particularly in younger adults who do not think they need to monitor their BP.

Gradual expansion of use cases and eligible populations for TERM BP is mediated by resources and capacity, with limited consideration of inequalities

The eligible population for TERM BP evolved over time, with all primary care sites adapting who and what they used TERM BP for, in line with the resources and capacity to deliver the service. All sites began using TERM BP for the monitoring and management of patients diagnosed with hypertension, including medication adjustments, and all sites have since expanded to use TERM BP to include the diagnosis of patients without previously diagnosed hypertension. Several staff across all sites noted that this included patients who had an out-of-range in-person reading when presenting to the health service for other reasons, where the clinical staff wanted to verify the reading, which may lead to other activities (e.g., blood test and electrocardiogram) to establish a diagnosis of hypertension, as well as patients who may benefit from remote monitoring due

to long-term conditions or in light of prescribed medication. In Mid-Town Practice and South Coast PCN, patients who wished to engage with their BP irrespective of a relevant health condition were also included in the BP remote monitoring service.

North Market Practice initially focused on patients who could not engage in in-person BP checks, either as a result of their work situations or specific health conditions, which made it difficult to travel to the practice. In addition, we did not explicitly consider the inequalities in the design for which TERM BP is used.

Varying levels of (de) centralization in TERM BP pathway governance with implications for resourcing, leadership, coordination, and relationship management

Across primary care sites, TERM BP is governed either at the practice or ICB level. In North Market Practice, Green Hills Practice, and Mid-Town Practice, all decision-making is made at the practice level, while at South Coast PCN, strategic decision making occurs at the ICB level and TERM BP is delivered by the PCN, with some support, that is, referrals or follow up, from practices as needed. For the South Coast PCN, one staff member noted that a PCN model was seen as an efficient way to deliver TERM BP at scale, with technology selection and funding occurring at the ICB level and coordination and delivery through PCNs.

Across interviews, there was no evidence that one governance model was more effective than the other. The appropriateness of a practice-led governance model seemed to depend substantially on effective GP leadership on existing practice-level resources (staff capacity and technological skills) to enable new ways of working and team relations. Where TERM BP was governed at the ICB level and delivered by the PCN, some staff flagged that substantial effort from the ICB programme lead and other ICB staff were required to engage with and ensure program buy-in from GP partners. This reflected variation in the ability and/or willingness of general practices to implement new programs due to capacity constraints, uncertain long-term funding, unclear benefits, and reluctance to change established models of care and invest time in new pathways. General practice and ICB-led/PCN-delivered models have inherent trade-offs in autonomy versus control over independent general practices. In addition, what works for implementation in one setting may be less efficient for a scale and spread strategy, a matter we return to in the Discussion.

Workforce organization characterized by reconfiguration of staff roles and new roles in multi-professional teams of clinical and nonclinical staff

Delivering TERM BP relies on teams of clinical and non-clinical staff working together, regardless of how the pathways are governed. Across primary care sites, there were both *programme leads*, who initiated the effort, garnered support, and helped to set the strategic direction, as well as *clinical leads*, who were clinically responsible for patient care through the TERM BP service pathway (see Table 1). Although program leadership varied from GP partners to practice managers

to ICB staff, the workforce to deliver TERM BP looked fundamentally similar and utilized multi-professional teams. Some staff noted that ICB-led and PCN-delivered models required effective coordination between the PCN and practice staff from multiple practices, which was supported at the South Coast PCN through a dedicated digital care coordinator, a newly formed role.

At all sites, most interviewed staff spoke of clinical responsibility for TERM BP shifting to non-GP clinicians, such as clinical pharmacists, nurses, and advanced care practitioners (see Table 1). Across sites, clinical leads were supported by different mixes of HCAs and various nursing roles including nurse associates, trainee nurses, and physician associates (see Table 1). In most sites (except for North Market Practice), the clinical lead was seen by all interviewed staff as the first line of clinical guidance for any questions related to patient care and follow-up, meaning that initial questions from HCAs or nurse staff would go to the clinical lead before escalation with the patient's GP or the duty doctor. In North Market Practice, HCAs were seen more to facilitate communication between patients and their GPs, so the shift to non-GP roles was more limited.

Most sites engaged existing staff in pathway delivery rather than establishing new roles, although over time, all practice-led sites brought on additional staff to deliver the service. An exception was the PCN-led model, which required the creation of a new role in the form of a digital care coordinator.

A few staff members across sites explained how the role of HCAs and nurse associates expanded to involve a greater degree of patient care related to disease management for hypertension, for example, follow-up required for out-of-range readings; and specifically with managing and addressing incoming BP measurements including how to account for an incomplete set of readings. Regarding the clinical background necessary to make clinical judgements, one nurse commented,

"It's not black and white because [...] there's some blood pressures, you think, OK, it doesn't fit in the guidelines but you have to take the patient into consideration here. [...] It's not on target, but is it reasonable for the age or condition, you know, and cognitive awareness and things, is that reasonable? [...] But that's a clinician's decision making that needs to go in with that as well." GHP1

Clinical training (both formal and on-job learning) was provided to support the clinical staff at all sites to deliver new responsibilities. Additionally, staff at Mid-Town Practice, Green Hills Practice, and South Coast PCN received technical training and education on how to use the remote monitoring data communication platforms, some of which were developed in-house and some provided by technology suppliers through training videos, a WhatsApp chat support community, and a regular newsletter to support ongoing education. The training at the South Coast PCN was particularly extensive, as illustrated by this quote from an HCA:

"We had training sessions [over] three or four months, where we had an appointment blocked off each shift and [the clinical lead] was coming in, and the more they did with us, the more we got on top of it. So we first of all kind of got familiar with the computer software and then we were gradually introduced to the whole set up about what we look for, how we can compare the information with Technology B patient facing app with the GP [electronic health record system]. So [the clinical lead] was slowly increasing the workload and the understanding over those months." SCP-4

A TERM BP service pathway with common overarching stages but a variety of implementation approaches reflective of local contexts and needs

The implementation of TERM BP service pathways across primary care sites involved common stages of patient identification and awareness, recruitment and onboarding, and ongoing monitoring and management, with seemingly warranted variations in the implementation of these stages.

For patient identification and awareness, all sites used some form of technology to identify patients based on established criteria. While Mid-Town Practice, Green Hills Practice and North Market Practice drew on data from the GP EHR system to do so, the South Coast PCN utilized population health data provided by the ICB. All sites additionally identified patients through in-person approaches, namely, during appointments where patients' BP was found to be out-of-range or other community events that included BP checks. For recruitment and onboarding, clinical staff at all sites were involved in recruitment, while onboarding responsibilities were shifted from GPs and typically sat with HCAs or administrative staff (i.e., receptionists) for all sites except for South Coast PCN, which utilized the PCN digital care coordinator role. Finally, for monitoring and management, HCAs or nursing roles across the sites handled most of the responsibility in coordination with TERM BP clinical leads in Mid-Town Practice, Green Hills Practice, and South Coast PCN. HCAs at North Market Practice acted more as a liaison between patients and patients' GPs.

Table 3–Table 5 provide a high-level overview expanded in the narrative that follows.

Patient identification and awareness raising: Where opportunistic case finding meets planned efforts based on a known diagnosis

Patients were identified through multiple channels, both planned and opportunistic, across all the sites. Planned recruitment utilizes a range of software and requires differing levels of manual input. Some processes, such as Green Hills Practice, are fully automated by the data platform to identify patients from the EHR and automatically request measurements using SMS messages. Other processes were more manual, for example at South Coast PCN, where searches utilized a population health tool, but enabled staff to select patient criteria, such as cardiovascular risk or deprivation index, to prioritize patients for outreach. Opportunistic identification at all sites happened during in-person appointments where a clinic reading was

Table 3. Summary of TERM BP activities across primary care sites – Patient identification and awareness.

Patient Identification and Awareness		
Site name	Data platform used	Patient Identification Approaches*
Mid-Town Practice	Previously used Technology B, now using Technology A. Another software is used to include paper-based readings into the EHR system	Conduct searches of general practice records using software add-on to EHR system
South Coast PCN	Has always used Technology B platform, which relies on the patient-facing Technology B patient facing app	Identification/risk stratification through population health tool, scheduled via Technology B patient facing app
Green Hills Practice	The practice now uses Technology C, though Technology D is also available. They were involved in a pilot with yet another technology	Patients are identified in-person at annual health checks, as well as via an API which automatically identifies patients who would benefit from remote monitoring (e.g. coded hypertensives)
North Market Practice	The practice uses Technology A and has always used it. It is integrated with the EHR system	For long term condition reviews, recalls are automatic within the EHR system Patients are also identified in person at clinics.

* Approaches using data and technology in addition to in-person identification approaches. API = application programming interface; EHR = electronic health record; PCN = primary care network.

Table 4. Summary of TERM BP activities across primary care sites – Patient recruitment and onboarding.

Site name	Recruitment and Onboarding			
	Recruitment	In person onboarding	Onboarding via text message (Y/N)	Monitor loan (Y/N)
Mid-Town Practice	Patients are typically recruited via text. However they can also be recruited by any member of clinical staff.	Typically HCAs	Yes	No
South Coast PCN	Patients are recruited using details from population health tool or in-person at PCN or community led health check events	HCAs, although the PCN clinical pharmacist and digital care coordinator can support remotely	Yes	No
Green Hills Practice	In-person as well as remotely via text message	HCAs and the nursing team support the clinical aspects of onboarding, and reception staff support with queries and monitor loans.	Yes	Yes
North Market Practice	In person and through the EHR	Patients are provided with guidance in-clinic (if applicable) and via text from Technology A	Yes	Sometimes, for patients who cannot afford monitors, subject to availability

EHR, electronic health record; GP, general practitioner; HCA, healthcare assistant; PCN, primary care network

outside the normal range, as well as through health and well-being clinics run by PCN staff at South Coast PCN, and by community pharmacies associated with Mid-Town Practice and North market practice.

Raising awareness appeared to be limited and varied across the sites. Staff at the South Coast PCN and Green Hills Practice flagged that opportunistic in-person circumstances were an opportunity to talk to patients about TERM BP, which relied on in-the-moment decisions about when to raise the subject and

with which patients. The South Coast PCN raised awareness of TERM BP through community events at GP surgeries and markets, and at North Market Practice, there was a local initiative to support BP checks at gyms.

Patient recruitment and onboarding: A mix of human-mediated activities and codified information resources on TERM BP technology platforms

Patient *recruitment* was performed at all sites by clinical staff, including GPs, nurses, and HCAs, which could naturally follow

Table 5. Summary of TERM BP activities across primary care sites – Ongoing monitoring and management.

Site name	Ongoing Monitoring and Management				
	How patients share back measurements	Number of measurements requested for ongoing monitoring of hypertensive population	How are measurements input into patient record	Who primarily does follow up	How follow up occurs
Mid-Town Practice	Text message includes link to website for data entry	2 readings per day for 4-7 days	The HCA or nurse associate reviews readings on a centrally managed inbox and then clicks to populate	The HCA or nurse associates triage readings. In cases of elevated readings, the pharmacist usually manages follow up.	SMS, email, phone call
South Coast PCN	Input via mobile app	2 readings per day for 7 days	Measurements are automatically populated into patients' electronic health record	The PCN HCA or nurse assistant does primary follow up, although this can also be actioned by the clinical pharmacist	Mobile app
Green Hills Practice	SMS includes link to website for entry	2 readings per day for 7 days	Readings automatically populate into patients' electronic health record	HCAs and the nursing team follow up with patients, using an existing template for responding on the Technology C platform.	SMS, phone call
North Market Practice	SMS includes link to website for entry	2 readings per day for 4-7 days	HCA reviews and then clicks to populate into EHR	HCAs follow up with patients and liaise with GPs and other clinical staff on treatment decisions	SMS, phone call

EHR, electronic health record; GP, general practitioner; HCA, healthcare assistant; PCN, primary care network; SMS, short message service

in-person identification channels. Across sites, responsibilities for patient *onboarding* were shifted away from GPs, and staff noted that these responsibilities typically sat with HCAs or administrative staff. Onboarding was relatively informal in terms of not having written guidance for staff (only Green Hills Practice had a set of structured onboarding instructions for staff that covered specific content), but interviewees at all sites conveyed that it generally involved providing instructions on the process of TERM BP, including how to input readings on a platform (whether through mobile app registration or engaging with the data platform via an SMS link), the technique of taking a BP reading using BP monitors, the duration and frequency of measurement, what to do if patients needed help, and, at Green Hills Practice, monitor provision to patients.

In-person support was complemented by online instructions linked to the TERM BP technology platform and user interface, for example, via an SMS message from the practice linked to other information and resources at Green Hills Practice, Mid-Town Practice, and North Market Practice. At the South Coast PCN, where patients used a mobile app, an email post-patient registration on the app provided information on the importance of BP monitoring, how to use the platform, and how to take BP readings. Staff at all sites noted that patients who struggle with technology are able to contact support staff, but only in Mid-Town Practice was there a bespoke pathway for patients

who may require additional support, such as patients with learning disabilities or severe mental illness.

Loaning of monitors, which was initially offered by both Green Hills Practice and North Market Practice during the patient onboarding process, required substantial additional work to maintain and track the return of monitors.

As a receptionist highlighted:

"I give them like a few weeks after it should be due back and then I'll phone them, if they don't answer me by phone, I'll send them a text message and then I'll just keep a note in my book when I do all these. There was one person I had to chase for a year and eventually got it back. So it does take a wee while to chase them up as well." GHP-3B

All sites highlighted a lack of sustained funding and equitable access to monitors as challenges. Even within loaning systems, site reports often lack a sufficient number of monitors, especially those with large cuff sizes. In North Market Practice, the administratively heavy work of tracking and maintaining monitors ultimately led the practice to halt their loaning process. The ICB at the South Coast PCN has funded a supply of monitors to give to patients who partake in TERM BP, but the supply of these monitors is becoming limited.

Ongoing monitoring and management: shifts to non-GP roles with triaging of cases needing clinical attention and parallel traditional services to mitigate inequalities

Responsibility for BP measurement requests and follow-up with patients tended to sit with clinical non-GP staff across sites, typically the HCAs and/or nurse staff, with cases requiring clinical attention triaged to clinical leads, and with severe out-of-range cases referred back to the GP or duty doctor (see Table 5). Unlike the other three sites, North Market Practice HCAs acted more as intermediaries between the patient and the patients' GPs, liaising with GPs for any medication changes and communicating changes to patients. Two sites were also able to leverage offsite support teams to deliver TERM BP: North Market Practice had a digital team, including HCAs that were part of the practice, but at a location separate from other practices. PCN staff at the South Coast PCN were located in different offices across the PCN footprint.

In addition to planned workflows and workloads, additional and unplanned work (often hidden from formalized job roles and activities) occurred when staff needed to help patients troubleshoot. For example, an HCP at Mid-Town Practice related this to inaccurate readings due to the use of an incorrect cuff size or an inappropriate measurement technique. A few staff members across sites noted the additional work needed to follow up with patients not responding to requests for BP measurements. Multiple approaches were taken at all sites to follow up with non-responding patients as part of ongoing monitoring and management, ranging from SMS messages through data platforms, emails, or telephone calls. One staff member at the South Coast PCN, where TERM BP was delivered through a PCN-led approach, commented:

"We try to contact the patient directly by telephone and we also get their GPs involved so we can compare what recent activity has been occurring on the GP's record from the patient. So we can obviously get the GP involved by basically saying, look, you know this person is on blood pressure medication, we can see their blood pressure still going up [...] Then we look on their GP records to see if they have an appointment booked or if they have blood test taken." SCP-4

Another nurse also highlighted the amount of work it takes to appropriately address incoming BP measurements.

"It is a lot of work. [...] It is not just a matter of the patients doing the blood pressure, you have to then make sure the result is then followed up appropriately. So although it's very efficient and gives a much more accurate picture of somebody's bp control, there is a lot of background work that goes into it – so making sure it's followed up, making sure it goes to the right clinician, making sure a patient's well informed about what's happened to that blood pressure. So it doesn't reduce your work, definitely not. I would say you spend more time doing admin around it and you have to be very strict on how you follow the protocol through." GHP-1

In addition to technology-enabled remote blood pressure monitoring pathways, paper-based pathways were a precursor to TERM BP at three sites: green hills, south coast PCN, and Mid-Town practice. Many staff members flagged that paper-based pathways continue to be a route for remote monitoring, especially for those who cannot or do not engage digitally. TERM BP represented a new technology as well as a new process for North Market Practice. All sites viewed a paper-based approach as necessary to account for patient preferences and mitigate inequalities in access. As one GP commented:

"So the beauty is with doing a lot of this work remotely, is it does free up time to actually capture people who might struggle to do that and we can bring them into surgery and make sure there are appointments for them." MTP-7.

However, the paper-based pathway for BP remote monitoring was associated with a high administrative workload by some staff at practice-led sites, a few of whom also raised concerns about potential safety issues if out-of-range readings were not addressed in a timely manner. Given the overall volume of work associated with TERM BP, Mid-Town Practice and North Market Practice work with community pharmacies to undertake TERM BP; Mid-Town Practice in particular is actively directing patients to community pharmacies for ambulatory blood pressure monitoring.

One pharmacist, working with Mid-Town, noted *"because the surgery seems to be inundated as well with patients, I think [the surgery are] using [...] the whole pharmacy network to help with review [of] blood pressure."* MTP-1.

How do different implementation approaches contribute to and affect patient uptake and experience, outcomes, and health service impact?

Perceived impacts on patients: Improved blood pressure control and case-finding supported by patient engagement and convenience for some but not all patients

Multiple staff across all sites reported improved clinical outcomes because of TERM BP, primarily improving BP control for patients diagnosed with hypertension, as shown by improved QOF outcomes. Several staff members, particularly in Green Hills Practice and North Market Practice, attributed improvements to a more accurate measure of BP than one-off clinic readings, reduced risk of human error through automatic averaging, and better ongoing understanding of a patient's condition through frequent monitoring as needed. Two HCPs in the South Coast PCN also felt that TERM BP helped patients avoid hospitalizations due to the ability to monitor patients more closely on an ongoing basis, although there were no quantitative data to support this perception. A few staff members at Mid-Town Practice and South Coast PCN highlighted the improved hypertension case finding as a result of TERM BP, as indicated by business intelligence tools showing relatively higher proportions of diagnosed patients in practices using TERM BP compared to those in the PCN that did not.

Interviews and workshops with patients revealed that BP remote monitoring helped support a more activated patient population through greater patient awareness and engagement with their health. One patient explained this as follows.

“having seen the figures for myself, I know whether they are good or bad” MTP-12.

As a result of BP remote monitoring, some patients reported feeling more responsible for managing their own health, which was corroborated by many staff members. Staff across the four sites conveyed that some patients initiated readings on their own, that is, without being prompted by practice.

While there was widespread support for the benefits of BP remote monitoring, some patients highlighted concerns about technology-enabled pathways, excluding those with low digital literacy. We expand this in the section on inequalities.

Perceived impacts on staff and services: more efficient workload distribution, capacity release for those who need in-person appointments, but high administrative workload

Many staff across all sites reported perceived more efficient working as a result of TERM BP by saving time through a decreased in-person appointment time or reduction in appointments altogether, although quantitative data to back this perception were not provided. One GP in Green Hills Practice illustrated the following.

“If I see somebody who [has] just developed diabetes and I’m concerned about [their] renal function and they’ve got hypertension and I don’t really need to see them in six months, but I want to make sure their blood pressure’s all right in six months [...], whereas for the other conditions I might want to just review them in a year and do some blood testing and monitoring, in which case they need to attend. I would send them a reminder to get me some remote blood pressure monitoring done in six months.” GHP-4

A few clinicians at Mid-Town Practice, Green Hills Practice and North Market Practice also reported that time savings allowed for better resource allocation, that is, more time for patients who need in-person care or more efficient use of in-person appointments. Even so, some staff, namely HCAs and nursing staff, acknowledged that the workload associated with BP remote monitoring was high to recruit, onboard, follow up, and chase patients, especially given the increasing volume of patients using TERM BP and to deliver TERM services in parallel with the administrative work associated with the paper-based process.

What influences the implementation and delivery of remote monitoring, and how can challenges be navigated and addressed?

1) Ease of technology use for staff: intuitiveness, familiarity, routinization, and integration with NHS IT systems, but with some interoperability challenges

Across sites, many staff members found that the diverse data platforms used to request and receive BP readings were relatively “easy” to use, referring to the intuitiveness of the

technology and no need for extensive training. One GP commented:

“everyone gets a little bit nervous about change and new things, but you know it’s so intuitive [the] software its easy” MTP-7.

In some cases, the path dependency created from earlier technology commissioning decisions interacted with technology useability and functionality to impact the adoption and implementation of TERM BP. In North Market Practice, familiarity with the platform owing to its use for other purposes, such as appointment booking, also enabled ease of use.

The interoperability between the TERM BP data platform and the GP EHR systems was seen as a key technological functionality essential for adoption at all sites. In general, full interoperability was in place and was seen as the key to enabling efficient workflows, such as the automatic transfer of BP measurements from data platforms to EHR systems, which obviated the need for double data entry. An administrative staff member at the Green Hills Practice articulated the process:

“For a while it was just the manual form for everybody to record 7 days of readings twice daily, so twice in the month, twice in the evening, and then they would hand that in to us. Then there was Technology C, that’s online you send them a text message, they complete the form after a week online. It’s then submitted to the practice electronically, all the averaging and everything’s done automatically with that. So that was taking away obviously time for the GP and for the admin staff and actually having to average it.” GHP-3a

However, some issues related to interoperability have been encountered. For example, in Green Hills Practice and Mid-Town Practice (with respective previous suppliers), a lack of full interoperability meant that the staff needed to enter patient information (e.g., medications) manually. At the South Coast PCN, staff explained the need to physically reset connectivity between the two systems, which hampered progress with initial TERM BP implementation and is currently an occasional issue yet to be fully resolved. While interoperability is critical for implementation and sustainability, staff adjustments to such issues suggest that there appears to be a minimum level required, beyond which staff appear to adapt their current systems and ways of working.

Other functionalities of data platforms that are essential to patients include batch messaging (of invites or requests) to patients, automatic averaging of BP measurements, and automatic coding of measurements using Systematized Nomenclature of Medicine Clinical Terms (SNOMED) for recording clinical patient data, primarily because they enable efficient working and save clinical staff time⁴⁹.

2) Technology adaptability mediated by supplier willingness to adapt functionalities, supplier-NHS site relationships, and wider regulatory landscape

Supplier interactions with sites helped enable technological adaptation to support local health system needs. For example,

the staff at North Market Practice worked closely with the data platform supplier during the early stages of implementation, providing an experimental site to help drive technology development (NMP-1).

“I think they [Technology A supplier] have done well out of us as much as we’ve done well [...]. I think we drove a lot of the pilot... and as an organisation, we were highly utilized and drove a lot of the development from it and I think that’s a good thing. We were the petri dish. A lot of these experiments happened, and yet there’s very little regard to the value that it adds to the overall development of digital technology and health innovation in terms of that...” (NMP-1)

Suppliers at some sites provided support in the form of ongoing adaptations to both the staff- and patient-facing software interface, as well as virtual or in-person support for staff and patients throughout recruitment, onboarding, and ongoing monitoring. For example, in Green Hills Practice, the supplier took on feedback from patients who wanted to add the date and time of their reading, but made this optional so as not to create a barrier to patients submitting readings. At South Coast PCN, the supplier highlighted ongoing support for staff via WhatsApp and regular catch-ups, support for patient recruitment via in-person events, and regular app updates to respond to patient feedback.

However, staff across sites reported mixed experiences with the level of support and their relationship with technology suppliers in terms of suppliers’ willingness to collaborate, troubleshooting, and adapting technology functionalities. Some staff at Green Hills Practice, Mid-Town Practice, and South Coast PCN commented on desired adaptations in areas such as the ability to customize messages to patients, make changes to monitoring duration and frequency, and address connectivity issues between the TERM BP data platform and GP EHR systems to improve staff and patient platform usability. Many staff at these sites found that their respective suppliers were quite active in seeking feedback and input for ongoing improvements. However, according to one staff member, the relationship between their practice and the TERM BP technology supplier has waned substantially over time.

While supplier willingness to adapt to technology offers and the nature of supplier and NHS-site relationships were key influences on technology adaptation and improvement over time, some suppliers also flagged barriers to innovation and improvement related to the regulatory environment. Cumbersome and bureaucratic regulatory processes, for example, for medical device applications, such as clinical decision support and impacted technology offerings. A participant from a technology supplier company commented on how regulation impacted decision-making in the design of their offering:

“We don’t want to become a medical device, so we don’t make a clinical assessment of the patients’ blood pressure reading and we expect clinicians to be reviewing it [...] and they are very familiar with that. Some

practices who are burdened have often asked us for red flagging and triaging etc. ...but we have had to be taking decision not to do that...It’s a lot. You’ve then have to clinically validate what you’ve done...” (MTP-8)

3) Relationships between regional health systems, local practices, and local health organizations to support the implementation of TERM BP

The regional health system support for the implementation of TERM BP varies widely. The common aspects of support provided at the ICB/ICS level (or through HSCPs in Scotland) for PCNs and/or practices across the ICB footprint centered around technology provision through commissioning the data platform used for TERM BP or for patient identification and population health analytics tools. At the South Coast PCN, resourcing and support were more extensive, according to an ICB staff member. It included financial incentives for PCNs to meet specific thresholds for control of targets for hypertensive patients, funding new PCN roles such as the digital care coordinator role, covering time for one-on-one peer support (by a PCN with established TERM BP implementation to PCNs newly undergoing implementation), as well as facilitating peer networking and knowledge sharing through formal structures such as routine meetings or group chats.

Despite strong support from the ICB at the South Coast PCN, ICB staff commented that initial reluctance from GP leadership in some practices was a barrier to implementation. This required substantial ICB effort to allay GP’s unease about patients being managed by PCN staff and in the absence of guaranteed long-term funding. Sustained funding has helped increase engagement and reassure GPs that activities contingent on funding of new technology would not be a wasted effort. Coordination roles – specifically the digital care coordinator at the PCN level – also helped bridge and broker connections between the ICB, PCNs, and general practices. One ICB staff member commented,

“what we did to try and support [integration across PCNs] is first of all, we brought in the digital care coordinator role [as] a way for us to almost have somebody sitting in a practice or in a PCN that could help us with – What are the barriers? Who do we need to talk to? What’s the digital maturity like in that practice? What’s their attitudes towards [the PCN]?.. and I think that has been the way we’ve started to deliver a truly working as a system rather than in silo.” SCP-6

Alongside material support, relationships between regional (i.e., ICB, HSCP) and local (i.e., PCNs, general practices) organizations influenced implementation. At the South Coast PCN, close working between the ICB and individual PCNs and between PCNs led to large productive relationships. A few staff members noted that this helped progress TERM BP implementation through clear and jointly discussed implementation processes. An ICB staff member illustrated the following:

“Previously the ICB would get some money for hypertension intervention and then they would give it to each

of the PCNs and go 'Right off you go - go do what you want. You just need to come back with some results'. But actually, what we did was: 'This is our technology, so this is how we want you to implement it.' We very much owned it and then we supported them to deliver it, and I think that that has actually had such a positive impact because they've all worked together." SCP-2

Other sites pursuing practice-led models in England had mixed views of the role of PCNs in enabling or inhibiting TERM BP implementation, with some staff members flagging the need for leadership and cultural alignment across PCN practices for such models to work. Locally, Mid-Town and North Market practices strengthened their relationships with other local health organizations, such as community pharmacies, to carry out ambulatory BP remote monitoring. The staff at North Market Practice also coordinated with gyms through the local council to conduct BP checks.

4) Capacity, capabilities, communications, and culture as key forces supporting distributed work in multi-professional teams and the delivery of parallel services

Leadership culture and capability, most notably commitment and effective engagement with TERM BP services, were seen as key forces in promoting staff buy-in and sustaining delivery. Across sites, several staff flagged dedicated programs and clinical leadership as key to spearheading and championing TERM BP services, mobilizing wider staff buy-in and engagement, and ensuring its sustainability over time. At the South Coast PCN, a few HCPs emphasized the key role played by the PCN clinical lead in raising awareness about TERM BP services across PCNs and practices and as a focal point for timely support.

Effective communication and clear roles are key to delivering TERM BP through distributed work in multi-professional teams. For certain tasks like reading and triaging BP readings, sites utilized a 'pooled' approach which allowed staff with the same role (e.g. multiple HCAs) to address a common inbox, promoting collaboration, timely action and system resilience. At North Market Practice and South Coast PCN, such workforce organizations also supported effective working across multiple sites. Team responsibilities, though outlined from the initial planning stages (via flowcharts/protocols) at all sites, evolved and adapted to address issues that had come up, mostly around managing workloads. Some staff at Mid-Town Practice, South Coast PCN, and Green Hills Practice spoke to the importance of frequent communication among team members to support problem-solving and relational work. A non-clinical staff member from the Mid-Town Practice highlighted the following:

"They have good communication/feedback between the health care professionals [...] They can trouble shoot together. There are clear roles and responsibilities, but they are in constant communication, so it runs really smoothly. 'It's teamwork and talking to each other, because without that it's just a process' (MTP-1).

Dedicated time helped ensure that tasks associated with TERM BP did not negatively impact other staff responsibilities, although capacity remains a challenge across sites. According to a few staff at South Coast PCN, Green Hills Practice, and Mid-Town Practice, the scaling of TERM BP activities as well as remote monitoring of other conditions has led to an increase in dedicated time needed for existing staff or the hiring of additional staff. Given the overall volume of work associated with TERM BP, Mid-Town practice is actively engaging with community pharmacies in a move to shift more responsibility for BP remote monitoring to community pharmacies through ambulatory blood pressure monitoring.

While there was a clear pathway for TERM BP, all sites also had an adapted process for BP remote monitoring that used more traditional forms of communicating BP measurements back to the staff, including paper, email, and telephone. As discussed earlier, such parallel pathways have additional administrative workload implications, and staff experience points to the importance of dedicated time for delivery and the challenges in workforce capacity needed to support scaling in the context of parallel services.

As one nurse commented:

"We're short staffed through holiday and a member of staff leaving, I know that there are about 30-40 paper workflows of home BP monitoring sitting to be reviewed by the nursing team. That worries me because what if there is a blood pressure sitting in the pile that really needs reviewed? These are challenges." (GHP-1).

All sites were committed to a culture of continuous learning and adaptation alongside their initial plans for implementation. At sites such as Green Hills Practice and North Market Practice, this culture was rooted in strong foundations in formal quality improvement while in others such as Mid-Town Practice, the practice culture according to a few staff there reflected a more general openness to continuous improvement through 'trial and error'. As emphasized by a GP in Green Hills Practice,

"We're very happy to try new things and we don't rest on our laurels, that's very much our practice ethos ... Just because we've done something one way for years, does not preclude us from changing it at all." (GHP-7)

Organizational learning was also supported by upskilling efforts at all sites (e.g., for nurse associates and HCAs). Training, which typically occurred informally through 'on the job' learning, supported staff to understand how to handle/triage incoming BP measurements and gave them the knowledge/confidence to adapt and work flexibly with BP measurement data (including how to manage missing data, i.e. whether a partially completed series of BP readings is sufficient in particular circumstances).

However, many of the new activities delivered by staff in TERM BP pathways occur with limited regulation of novel roles and

functions, which some clinicians during the workshop identified as a barrier to fully utilizing HCAs or other non-GP clinical staff in the TERM BP pathway. For example, although HCAs at North Market Practice are used to liaise between patients and their GPs, their expanded scope in carrying out follow-ups related to TERM BP is seen as a potential risk in the absence of clarification from regulators on expanded roles and the ability or desire for GP partners to take on such risk. One clinician acknowledged the following.

“We are probably towards the increased risk of trying something new.” (NMP-4).

5) Patient acceptability contingent on perceived convenience, trust and support from staff, technology user-friendliness and needs for reassurance

While there is growing acceptance of remote care with predominantly positive patient views related to TERM BP providing reassurance, reduced anxiety, and understanding of a health condition, views about the convenience of TERM BP pathways are mixed.

Most patients across primary care sites found TERM BP services to be acceptable, a sentiment echoed by the staff and workshop participants. Patient acceptance of digital care has evolved alongside a shift in expectations regarding remote care accelerated by the COVID-19 pandemic. This includes increased acceptance of receiving care from non-GP staff and growing opportunities for care in community settings, such as community pharmacies. Many, but not all, interviewed patients noted convenience as a key motivator for engaging with TERM BP, particularly in light of the reduced logistical challenges associated with attending in-person appointments. As illustrated by a few patients,

“It’s a bit of nuisance to get to the GP, you can’t always park and you don’t really want to go there and catch a load of bugs [...] anything you can do at home which is straightforward is good” (MTP-11).

“[Technology enabled blood pressure measurement and submission] literally takes seconds” (MTP-13)

However, this view is not shared. Another patient who was a shift worker was highlighted.

“I have found it a little difficult to slot [blood pressure monitoring] in. I mean – it takes 10–15 minutes, because you are supposed to do three measurements.” (NMP-10).

Two healthcare staff at South Coast PCN and Green Hills Practice also flagged that TERM BP may not be as convenient for patients who have to go to the practice anyway, specifically for hypertension or other reasons.

Most patients generally found TERM BP technology to be user-friendly, but some also flagged problematic features that

impeded user-friendliness, such as the limited time window for submitting readings (quickly expiring links), difficulties accessing the platform used to upload BP results, and the inability to enter data incrementally across the week. Some patients participating in a workshop said that they lacked confidence in using the technology and raised concerns about whether they were using the devices (placing monitor cuffs) correctly and about the overall accuracy of their readings. Many patients expressed a desire for greater reassurance and confirmation that their devices worked correctly with finding ways to assess them, for example, by informally testing their monitor readings against those used in a hospital. Other patients, however, chose to go to the pharmacy to get their BP readings taken *“properly”* (MTP-2).

Access to the needed guidance and support has emerged as a key influence on the implementation of TERM BP. While staff at most sites discussed providing onboarding and training processes for patients, many patients reported receiving minimal guidance from healthcare staff on what monitor to use or how to use monitors. Some patients did not see this as problematic, feeling that they could access needed information and knew that help by the practice was available if needed; yet other patient workshop participants highlighted that more guidance on measurement techniques and monitor selection would have been helpful. One participant noted that while she felt confident in taking readings, others may not.

“somebody who is not used to [taking] blood pressures, then they would need a bit of training to learn the skill.” (GHP-Patient-11)

In addition to onboarding activities, follow-up communication with healthcare professionals affected patient confidence and trust in engaging with TERM BP, with patients having varying preferences regarding the nature of communication needed. Mutual trust in the patient-healthcare professional relationship and an understanding of how healthcare professionals engage with readings impact patient expectations regarding follow-up communications. One patient expressed confidence that their reading was being read by an HCP.

“[if] there was a problem [the practice] would contact me” (MTP-13).

Even so, another expressed a desire for verbal follow-up, and some patients were ‘put off’ by automated text responses, which some staff attributed to not realizing a person was behind their care and prompted more tailored messages:

“it would be very helpful, it would be very reassuring to physically be told don’t worry” (GHP-11).

Incidents shared by workshop patients where practices lost readings or an HCP questioned the validity of patient submitted readings can impact trust in TERM BP services. One patient commented,

“I think there is a suspicion that they think I fudge it. And so they want to have a proper reading that is taken in the surgery.” (SCP – 7).

While most patients interviewed demonstrated digital literacy and successfully engaged with TERM BP, many highlighted concerns about others who might not be able to do so, as related to socioeconomic, cognitive, and infrastructure-related determinants of inequalities.

Do (and how do) considerations of inequalities impact decisions to implement, spread, and scale specific approaches, and what impact do the chosen approaches have on efforts to address inequalities?

TERM BP improves access for some patients but is not a solution for all

TERM BP can reduce inequalities in access to care for some patient populations but exacerbate inequalities for others in the absence of adequate mitigation and management approaches.

For example, one staff member at Green Hills Practice noted that for individuals living in rural areas, the ability to monitor BP at home helps reduce the need for travel, which can act as a barrier to access care. Some staff at North Market Practice and Green Hills Practice also flagged that not having to take time off work to go in-person to the surgery enabled patient uptake in light of TERM BP convenience.

However, staff and patients across primary care sites generally agreed that the digital requirements of TERM BP increased, excluding individuals without Internet access, a suitable device, or digital literacy. Efforts to support digital inclusion involved the provision of devices and, to a limited degree, only at South Coast PCN access to the Internet and data, but these solutions are limited by waitlists and availability. Three of the four sites initially loaned out or provided free monitors or discounts for monitor purchase, although as previously mentioned, over time have scaled these offers down due to loss of monitors and lack of supply.

Physical and cognitive issues can also influence access inequalities. Proactive approaches were taken by sites to target patients who may need additional support, such as visiting house-bound patients in North Market Practice and bespoke approaches for patients with learning disabilities or serious mental illnesses in Mid-Town Practice. A few patients in the workshop reported sensory issues (i.e., autism) related to causing discomfort with BP cuffs, or how visual or physical impairments such as arthritis can also hinder the use of BP monitors. Some patients in North Market Practice use specialized monitors with voice prompts or traffic light systems to overcome these barriers. A GP in Green Hills Practice felt that patients with multiple long-term conditions found Technology C repetitive and lengthy to complete.

There are mixed views on the influence of age on patients' ability to engage with TERM. While many staff members expressed the view that older adults might face greater challenges with

digital literacy and technological engagement, or due to not having a mobile phone or challenges related to frailty, this perspective was not universally shared. A few staff from Green Hills Practice reported that older adults, in their 70s and 80s, have little problem with the technology, and that engagement among working-age adults between 40–60 was lower.

Sites also maintained the option for in-person monitoring and a paper-based option that does not require online uploading results for patients who could not engage digitally. Most staff viewed these alternative pathways as essential, and some felt that time savings from remote monitoring opened up in-person time to people who were unable to engage in remote approaches as a way of tackling inequalities (although quantitative data to support this assumption were not accessible).

While the sites put in place the adaptations discussed above to address potential inequalities in access, patients and staff alike acknowledged that more could be done to ensure that TERM BP is accessible to diverse populations.

What are the key considerations for those looking to scale, spread, and sustain Technology-Enabled Remote Monitoring of Blood Pressure at home?

The insights gained into the origins, implementation, evolution, and adaptation of TERM BP services at primary care sites also shed light on key considerations for local, regional, and national decision makers looking to scale (reach new patients), spread (implement in new contexts), and sustain technology-enabled remote monitoring of BP at home over time. These insights are based on direct experiences of sustainability and scale at all sites, spread efforts at the South Coast PCN (ICB-governed and PCN-delivered), and staff views about key influences on spread at Mid-Town Practice, Green Hills Practice and North Market Practice based on their general practice-level implementation experiences.

These insights point to sustainability, scale, and spread as socio-technical co-evolutionary processes, where wider system conditions, human agency, and technological capabilities meet.

The interplay of system conditions, human agency, and technology in a learning health system: the roles of secured funding, managed risk-taking, and organizational culture

Across sites, both sustaining TERM BP services and scaling them to reach more diverse types of patients and use cases (such as monitoring and management of hypertension, diagnosis, and monitoring of patients with long-term conditions and on certain medications) occurred gradually, with wider system conditions (e.g., funding availability in the health system) and human agencies playing key roles. This happened through securing funding and gradually adapting patient eligibility criteria to scale services, managing risk-taking, and embedding cultures open to improvement and new ways of working.

Throughout sustainability, scale, and spread efforts, sites learned from experience of implementation and established capacity and capabilities to reconfigure the staff workload to address

the increased volume of work or to bring on additional staff over time, which all sites did.

Technology functionalities also co-evolved with changing needs identified by sites, with adaptations such as automatic input and coding into the GP system, and automated patient identification also supporting scaling to a broader patient population. Some sites such as South Coast PCN had to continually seek funding to support the technology, while Mid-Town Practice and North Market Practice were resourceful in leveraging technology solutions for which they were already using for other purposes (e.g., for appointment booking) and applying them by adapting use cases to TERM BP.

Funding in the context of sustainability scale and spread

Efforts to secure long-term funding in resource-constrained health systems have been a key mediating force in sustainability, spread, and scale. This has been challenging and accentuated by weak and inconclusive evidence based on the impact of BP remote monitoring on service utilization and cost-effectiveness, as highlighted in our review of the literature on TERM BP (to access in full, see section on Data Availability). Staff at the South Coast PCN emphasized how data on impact on services, as it relates to technology-enabled remote monitoring, is key for informing business cases for scale and spread to commissioners. At this site, two staff members referred to local evidence from a neighboring PCN within the same ICB, indicating reductions in GP consultation time, helping persuade GPs across practices to implement TERM BP alongside efforts to secure funding from multiple sources. GPs at South Coast PCN also referred to the well-known but ongoing problem where short-term funding approaches in the wider health system, tied to specific technologies and projects, lead to initiatives ending and saw this as a disincentive for sustaining staff engagement.

Managed risk taking in the context of sustainability, scale and spread

Committed organizational leadership has also been critical in transforming clinical practices and scaling the TERM BP pathways. Commitment of leadership translated into willingness to take on some level of risk – financial, clinical, and regulatory – to implement TERM BP. According to the experiences of staff across all sites, such ‘risk taking’ has been supported through a gradual and staged approach, training and on the job upskilling, alongside clear protocols for escalation of cases needing clinical attention. Drawing on regional support through the ICB or HSCP also helped mitigate practice-level risks for most sites. While all sites depended on ICBs/HSCPs for data platform licences, the support for risk management varied from very little else in North Market Practice to funding a new role, providing financial incentives, and creating structures for peer support and knowledge sharing at South Coast PCN.

Moreover, GP leadership took on risks in the context of limited formal regulation of how HCPs are involved in TERM BP pathways, which has been mentioned earlier.

Cultures supporting continual improvement and resilience need for sustainability, spread and scale

The evidence on the implementation of diverse models of TERM BP at the primary care sites points to there being no ‘one right way’ for implementation and that an overly prescriptive approach would impede implementation in local contexts. What is common across the gradual approach to implementation and scale that we discussed earlier were organizational cultures of openness to and embracing continuous improvement. Key adaptations related to staffing (e.g., recruitment, redistributing work), pathway implementation decisions (e.g., batching invites to patients, adjusting how referrals are made from the practice to PCN staff (i.e., direct appointment booking or sending a request, based on practice workflows), technological adjustments to support platform usability and interoperability (e.g., improving staff interface), and improvements to patient education and communication to support onboarding and ongoing monitoring and management (e.g., personalizing SMS messages and staff customizing follow up messages).

Similarly, cultures supportive of adaptation and flexibility helped practices develop the resilience needed to sustain and scale TERM BP pathways. All sites started implementing the current version of TERM BP services (in terms of the technology in use) during the years of the COVID-19 pandemic, i.e. around 2020–2021 and three of the four primary care sites had a pre-existing paper-based BP remote monitoring process, two of which had earlier engaged in pilots of TERM BP, which were not continued in their original form but provided meaningful learning that informed the design and operationalization of new TERM BP pathways in terms of staffing (e.g., greater reliance on non-GP staff, pooled working with multiple staff of the same profession type supporting delivery) to support a resilient service. The South Coast PCN and North Market Practice created new structures and roles to enable delivery, such as the PCN digital care coordinator role and a back office to centrally handle patient BP data and staff communication tasks by a dedicated digital care team, respectively. Looking ahead, Mid-Town practice plans to engage more with a local community pharmacy to take readings as a means to reduce the administrative burden on the practice and support long-term resilience and scaling of the service.

Discussion

Enriching the evidence base on implementation, sustainability, spread and scale of TERM BP

This evaluation set out to improve our understanding of the implementation of TERM BP in terms of what works, why, and how, and to draw out learning that can inform the scale, broader spread, and sustainability of TERM BP. This study adds to the currently limited evidence on the nuances of TERM BP implementation.

Diverse implementation contexts were examined, and an overarching structured framework of the TERM BP pathway stages was identified. Within this framework, we found both

more common elements and areas of variation in implementation approaches across contexts in terms of how patients are identified, recruited, onboarded, and monitored and managed over time. For example, key shared elements across contexts include a shift towards non-GP roles in delivering TERM BP pathways and key data platform functionalities such as automatic averaging and coding. Some key areas of diversity include multiple approaches for how patients can be proactively identified and recruited using various software tools and data sources, specific workforce arrangements in pathway delivery, varying levels of automation in processes for incorporating BP measurements into GP EHR systems, and diverse approaches to how patients are followed up with by staff for non-response, such as email, phone, SMS message, and mobile app message.

Our evaluation provides practical insight into how different pathway stages are operationalized, which could help decision-makers seek to implement pathways in a new context or to spread and scale them. We surface emergence and the often unplanned or additional work that goes into service delivery (e.g., troubleshooting with patients, finding workarounds for technology issues, managing and maintaining monitors for loans). We explore how various TERM BP governance model options (e.g., practice-level, regional) work in practice. We also shed light on the diverse types of NHS staff who are important for pathway delivery, extending beyond the clinical roles discussed in the literature, such as GPs, nurses, healthcare assistants and pharmacists^{23,33}, to include receptionists and digital care coordinators. Relatedly, we highlight limitations in the current regulation of new service delivery roles and activities, specifically for healthcare assistants. We provide insight into both staff workload distribution and workload in multiprofessional teams to deliver ongoing management and monitoring, as well as parallel services, that is, paper-based options coexisting with TERM BP. Such considerations have significant implications for service planning and design, including in relation to required staff capacity, roles, and time, and in workflow planning and risk management.

The insights we gained into the influences on the implementation of TERM BP service pathways contribute to an improved understanding of how and to what extent implementation challenges can be addressed and how TERM BP pathways can gradually evolve and adapt to deliver a feasible service. Many of the influences on TERM BP pathways identified in our evaluation sites are consistent with those identified in the literature, including technological interoperability and integration⁴⁹; ease of use of technology for staff and patients⁵⁰; the importance of clear workforce roles; flexibility in patient recruitment approaches; patient characteristics and attitudes such as digital literacy^{51,52}; the nature of information and support for onboarding patients²²; patient and staff relationships and access to funding for the service⁴⁹. Our evaluation explores the nuances of how these influences play out. For example, while the literature mainly focuses on the theme of trust in the context of patient trust in technology⁵¹, our evaluation insights also reveal the importance of staff trusting the accuracy of patient readings in

addition to patients' trust that their data are being monitored. Few studies analyzed in our literature review include detailed information about how patients and healthcare professionals interact around monitoring data^{23,33}; we explored this and the additional roles healthcare staff take in contacting patients and following up on out-of-range readings. In the context of TERM BP in general practice, our evaluation identified the importance of committed leadership and cultures that promote experimentation and change as critical to mobilizing buy-in from staff and for sustaining and scaling services.

The evaluation also contributes to the scarcity of evidence looking beyond the implementation of TERM BP in a single organizational context, to considerations of relevance for spread and scale. While many of the influences on implementation in single contexts are similar when considering scale and spread, influences related to longer-term proactive financial and staff capacity planning and resilience, the embedding of skills in teams and systems to avoid single points of failure, staging of volume of activity and adaptation in pathway approaches over time, and consideration of the potentially diverse baselines at which different organizations seek to implement TERM BP services become all the more prominent. Finally, we consider how relationships between general practices, PCNs, and ICBs, and the nature and scale of support (financial, coordination, facilitating learning, and exchange) can bolster sustainability, scaling, and spread of service implementation.

Finally, the existing literature examining how the uptake and experience of TERM BP is affected by diverse patient characteristics is highly limited. Although some studies do consider approaches to addressing digital exclusion through onboard processes and guidance⁵¹. Our evaluation findings point to the importance of running parallel technology and paper-based and face-to-face services to not exacerbate inequalities, and of considering additional outreach for specific patient groups, for example, for patients who cannot engage digitally or cannot easily travel for face-to-face appointments.

Co-evolutionary forces in health and innovation systems underpinning TERM implementation, sustainability, spread, and scale

TERM BP pathway implementation was often influenced by interdependent *sociotechnical* factors, in line with the literature on technology adoption and the NASSS framework⁵³. The value proposition for adopter organizations, stakeholders, and the wider system varied, with patient and staff motivations entailing a mix of common (e.g., quality of care) and unique factors (e.g., financial and workload management incentives for provider organization and health system decision-makers, convenience, and reassurance for patients). Influencing forces related to the technology and the technology supplier, TERM BP governance and wider health system, workforce, and patient-related influences played out in the gradual routinization of TERM BP services over time, and changes in one aspect (e.g., technology functionalities such as capability to batch invites, staff capacity, and role reconfiguration) influenced changes in others (e.g.,

ability to deliver a manageable workload and staged service scaling). The confluence of technology enablement and human mediation is integral to TERM pathway delivery. For example, this was evident in patient onboarding (which entailed online resources and direct staff support) and in the dependence on patient outcomes and reading accuracy for appropriate human use of technology.

As introduced earlier (see the section on sustainability, scale, and spread), technological and social influences co-evolved. Wider innovation systems literature^{44,46,54–58} points to an innovating health system as the “*process, experience, and result of the interactions between diverse institutions, individuals, organisations, networks, ideas, capabilities, values, and behaviours. These interactions are nested within evolving policy priorities (healthcare policy, innovation policy), changing social, political and economic environments, and dynamic healthcare systems*”⁵⁹. In sociotechnical theory and sociotechnical regimes thinking^{44,45,58}, novel sociotechnical regimes (structures that promote stability and persistence) become stabilized by strong alignment between social and technical aspects of a system, and emerge when experimentation gradually transforms incumbent regimes and replaces them⁴³. This is enabled by shared learning and exchange between experimental niches, policy/political impetus, quality or cost-related benefits, or wider landscape developments that can put pressure on established regimes⁴⁶.

This co-evolutionary dynamics was evident in the implementation of TERM BP pathways, embedding them over time through continual learning and adaptation, and in the perceived determinants of effective scale and spread. For example, adaptability in technology functionalities and the willingness of technology suppliers to work with health system actors – alongside securing funding for TERM BP services, workforce upskilling and reconfiguration, and growing patient acceptance of remote healthcare – enabled sustainable and scalable pathway implementation. Technology functionalities evolved to meet health system needs (e.g., interoperability with GP EHR systems, batch messaging, automated alerts for out-of-range readings, and changes to the staff interface to improve accessibility.) Health services practices have evolved to enable technology embedding and use (e.g., changes in workforce and workload distribution, workarounds to deal with technology limitations). Approaches to risk management (e.g., escalation protocols, cultures of openness to suggesting improvements and seeking support, engaged clinical leadership) co-evolved with the wider technology development and regulatory landscape, helping to address challenges related to a lack of regulation for new roles for functions involved in TERM BP delivery or regulatory barriers to using technological solutions more prominently in clinical decision making. Funding constraints and uncertainties co-evolved with health service efforts to seek and ensure sustainable resources for services (e.g., leading to phased scaling to new population segments) and influenced how some sites used available resources (e.g., decisions on sending reminder messages through email, so as not to exceed the monthly message allowance on the data platform).

Co-existing tensions in TERM BP design and implementation

The process of implementation was reflective of the dialectics of organizational and systems change^{40–42}, most notably reflected in co-existing tensions between opportunism and active choice). In a broad sense, dialectics refers to aspects of social processes that have to do with contradictions and competing co-existing forces shaping interactions^{40,41} emphasizing heterogeneity and a lack of constancy, with destabilizing and competing forces (that are neither inherently good nor bad) as drivers of change in the present order. These forces can challenge the status quo and, in turn, generate adaptation and change^{40,42}. Most notably, in relation to TERM BP, these dialectics were reflected in co-existing tensions between demand and capacity, technological possibilities versus regulatory safeguards and constraints, opportunistic versus evidence-driven commissioning, rigidity versus flexibility, planning versus emergence, autonomy versus control, increased versus decreased workload, and patient empowerment versus patient exclusion. Some of these tensions stemmed from features internal to the TERM BP pathway governance and organizational delivery structures and processes, and others from the coexistence of external environmental forces (e.g., financial conditions and the nature of populations serviced by local or regional health services). All tensions were managed through gradual adaptation and evolving social and technical determinants.

To illustrate, in terms of the impetus for TERM BP pathways and their commissioning, tensions between health service *demand versus capacity* drove a focus on finding innovative ways to deliver needed patient care and manage hypertension as a major public health concern. The interplay of *opportunistic versus evidence-based commissioning* was also evident, including relational elements, path dependencies (technology suppliers with whom sites worked in the past for other purposes), and a degree of criteria-based approaches. Serendipitous and opportunistic aspects often impact final decisions, and this dynamic is exacerbated by the lack of clear national standards and criteria for commissioned services and clear commissioning processes and routes.

In terms of pathway delivery, tensions between *technological possibilities versus regulatory safeguards and constraints* have impacted the nature of technology applications in patient monitoring and management and on the design of associated risk management in TERM BP pathways. Related to this, coexisting tensions of *rigidity versus flexibility* also played out in pathway implementation, for example, in determining the extent to which technological functionalities could or could not be adapted to deliver specific functions, such as more advanced medical device functions, in light of regulatory bureaucracy.

Coexisting tensions of *planning versus emergence* were evident in the diverse areas of adaptation in pathway delivery over time, including staging for whom and for what the service is offered and managing high workloads by adjusting staff responsibilities and roles enabled by pooled working. Forces of

autonomy and control also coexisted in TERM BP pathways with general practices' views on the needed levels of autonomy, presenting a potential challenge to moving to more ICB-governed models in a spread agenda, depending on funding, cultural alignment, and leadership relations in the system. Across sites, we saw varying levels of decentralization in governance (practice governance at three sites, ICB-led governance in a fourth site), but all sites depended on (to varying degrees) regional health system institutions for funding and, in some cases, wider peer-to-peer learning. While the site with an ICB-governed TERM BP service included more extensive funding and support from the ICB and PCN, some GPs were initially reluctant to 'give up' their clinical autonomy and shift their patient care to the PCN. We also found examples where activities specific to TERM BP could be scaled even at the practice level, that is, through a back-office function within practice. For both practice and PCN-led models, structures that enable peer learning are particularly important to support planning and early implementation efforts.

Dialectical tensions may also be at play in the pursuit of efficiency in healthcare delivery through TERM BP services, with workload redistribution *increasing workload* for some staff and *decreasing or changing the nature of workload* for others. The shift in monitoring activities from GPs to other roles potentially led to overall service efficiencies, but not without coexisting tensions of adding to the workload of some other types of staff (e.g., receptionists, HCAs).

Finally, coexisting tensions between *patient empowerment vs patient exclusion* played a role in how services sought to manage and mitigate inequalities in access. TERM BP services were seen by staff and some patients to provide value in educating patients about high blood pressure and empowering them towards greater self-management of their long-term conditions. On the other hand, there were concerns that digital approaches would inevitably mean that some patients would not or could not take part, for example, due to digital exclusion or specific conditions that made taking in-home measurements difficult.

Limitations

This study has several limitations. First, the rapid evaluation focused on four sites, centered primarily at the general practice level. Given that we were interested in the experiences of practices with relatively mature implementations of TERM BP, our selection of sites may have introduced bias towards practices that are more advanced and potentially resourced, financially stable, or operationally effective, more generally. In our site recruitment, we aimed to select sites that varied across a number of practice characteristics; however, the primary care sites may not be representative of the experiences and perspectives of all general practices across the UK. That said, we are reassured by the data they share in relation to diverse experiences and the spread of practices across different geographies. Second, the

interviews with the staff provided insight into some, but not all, experiences within the practices. Due to resource and time constraints associated with rapid evaluation, each primary care site included perspectives from a limited number of patients; these were recruited through the practices themselves. While the evaluation team engaged with practices to convey the importance of diverse patient views, convenience sampling was part of this process, with a focus on patients approached by general practices who agreed to be contacted by the research team and who agreed to participate in the interview. We attempted but were not able to recruit any carer participants, although a member of the PPIE advisory group was also a carer and brought that perspective. We did not gather data from people who did not participate in TERM BP. Through our patient workshop, we gathered additional perspectives from patients with diverse backgrounds and experiences, to mitigate the limited number of patient interviews.

Conclusion

Reflecting on our findings, we identified several avenues for further research. Future research should focus on understanding the relative impact of TERM BP (as compared to paper-based approaches to BP remote monitoring more generally). Understanding the added value of the technology-enablement of TERM BP, especially for service utilization and cost-related analyses, is important for informing evidence-based funding, scale, and spread of TERM BP. This could include evidence of the extent to which TERM BP decreases or increases the volume of workload versus changes in the nature of the workload for diverse types of staff. Cost-related analyses might explore differences in costs between single practices and scaled TERM BP service pathways. Identifying standardized measures to support such impact studies, such as specific measures of service utilization, is an area for further research. Our evaluation focused on TERM BP in the context of general practice; future research could move beyond primary care and consider TERM BP within the wider context of the integration of healthcare across care settings.

While interviews and workshops included the patient perspective, future research would also benefit from insights stemming from more diverse patient populations, such as exploring the uptake or abandonment of TERM BP for patients with multiple markers of disadvantage. Our findings also suggest that further studies may elicit how best to adapt current TERM BP pathways to incorporate more proactive outreach to patients who need it; for example, follow-up for patients who may need or desire more reassurance and in different formats, such as verbal communications where needed/feasible.

Finally, in reflecting on the insights and analysis discussed in this paper and the formative value of this evaluation, we conclude with some recommendations for those looking to design, implement, spread, and scale technology-enabled remote monitoring of blood pressure in the future.

Stakeholder	Recommendation
National policy	<ul style="list-style-type: none"> Establish guidance on the implementation of TERM BP, laying out a common overarching framework as a guiding structure within which decisions about governance, workforce and workflow configuration, technology platforms and patient populations can be adapted to local contexts and needs. Establish standards laying out minimal criteria technology platforms and suppliers need to meet, related to platform technical functionalities and interoperability requirements, regulation, and data governance. Relatedly, ensure commissioning criteria that are clear but not overly rigid, given the importance of technology adaptability to local needs and contexts. If hypertension management and tech-enabled remote monitoring of BP is a national priority for spread and scale, consider how monitor supply can be funded, to support accessibility for those who cannot afford to purchase monitors on their own. Consider also logistics of loaned monitor management.
Regional and local decision makers	<ul style="list-style-type: none"> Consider national implementation guidance and nationally set minimal technology requirements (within potential future national commissioning frameworks) alongside discussions with local stakeholders, to inform local/regional commissioning approaches that are fit for purpose to local contexts. Ensure transparent and robust commissioning and procurement. Nurture communities of practice to share learning between different adopting organisations and to inform scale and spread strategies. In doing so, consider that different organisations in a locality or region may be at different baselines in terms of experience, financial circumstances and capacity to implement TERM BP, and that adapting pathways will be needed to reflect the differing baselines. If TERM BP delivery models are to be governed and led by local and regional bodies (e.g. PCN/ICP), consider how a requisite degree of general practice autonomy and flexibility in implementation can be considered alongside some centralised aspects of service delivery.
Providers of TERM BP healthcare services	<ul style="list-style-type: none"> Design TERM BP in the context of a wider service for blood pressure monitoring, which will include traditional and tech-enabled services co-existing to meet the needs of diverse patients inclusively. This will have implications on both workforce and workflow planning, and on the nature of relationships with external organisations such as community pharmacies who may offer blood pressure measurement and ambulatory monitoring. When designing TERM BP services, consider how workforce and workload needs to be reconfigured (including the delivery of parallel tech enabled and traditional services) and impact on staff interactions as well as potential changes in the nature of patient interactions with staff. This is important for assessing optimal division of labour, capacity planning and capability building, devising clear escalation and triage protocols to ensure safe practice and risk management, for informing effective communication with patients about how to engage with TERM BP services. Plan for adaptability and emergence in service design and implementation, to allow adjustments based on learning. Establish processes for collecting data (in line with any minimal data sets laid out by policymakers) on service uptake, patient and health service impacts and cost-effectiveness, that can be used to evaluate the service and make decisions about sustainability, scale and spread. Make sure the patient has all the information needed in order to properly measure blood pressure at home including information on what monitors are approved, recommendations on monitor maintenance and measurement technique. Consider possible adaptations for patients who can engage with TERM BP but need or prefer more reassurance or additional support.
Technology suppliers	<ul style="list-style-type: none"> Adaptability of technology is important for commissioners and service providers. In designing a technology offer, consider what has to be fixed and where there is scope for adaptation and personalisation, and ensure interoperability with NHS systems. Technology advances on the horizon may have an impact on the existing supplier landscape. Consider how your offer may interact, adapt and plug and play with the competitive innovation landscape and emerging developments. Focus on value for money and understand your market. For TERM BP, 'the' fanciest' service isn't always the optimal, sustainable and scalable solution. Consider how to maximise the scope of the technology to mitigate inequalities in access related to socio-economic, digital literacy, connectivity and other areas of disadvantage (e.g. via informational resources, nature of user interface, onboarding and troubleshooting support services). Provide transparent and accessible information on data governance to commissioners, service providers and patients.
Patients and carers	<ul style="list-style-type: none"> Talk to your healthcare provider to ensure clarity on the purpose of TERM BP, how you can engage, how the NHS service will deliver.

Consent

All the patients and staff members provided written informed consent. References to the participant quotes were de-identified to protect anonymity.

Data availability

A literature review and primary care site summaries (pseudonymized) are available using the OSF data repository: DOI 10.17605/OSF.IO/G8A6M (URL: <https://osf.io/g8a6m/>)

Literature review: <https://osf.io/g8a6m/files/osfstorage/68550a1ce0d018106bd16536>

Primary care site 1 (MTP): <https://osf.io/g8a6m/files/osfstorage/6854f89589ba519b17d1af23>

Primary care site 2 (GHP): <https://osf.io/g8a6m/files/osfstorage/6854f895b50949cedcd1ad87>

Primary care site 3 (SCP): <https://osf.io/g8a6m/files/osfstorage/6854f898380bf6c8675cfd0f>

Primary care site 4: (NMP): <https://osf.io/g8a6m/files/osfstorage/6854f89a690921fbeb16528>

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