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Research Article

Implementation and use of technology-enabled remote monitoring for chronic obstructive pulmonary disease: a rapid qualitative evaluation

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Abstract

Background: Chronic obstructive pulmonary disease affects around 2% United Kingdom population. Timely identification of patients at risk of deterioration is crucial. Technology-enabled remote monitoring may help prevent deterioration, support chronic obstructive pulmonary disease patients at home and appropriate use of National Health Service services. Evidence on the adoption, use and experience of technology-enabled remote monitoring in the chronic obstructive pulmonary disease pathway is currently limited, impeding efforts to inform effective technology-enabled remote monitoring design and implementation.

Objective: To understand what supports good practice in the implementation and use of technology-enabled remote monitoring in the chronic obstructive pulmonary disease care pathway and draw transferable lessons that can inform spread and scale up.

Design and methods: Rapid evaluation, combining qualitative interviews, focused case studies and stakeholder workshops. Patient and public voices informed evaluation design, conduct and co-design of resources.

Setting and participants: Scoping interviews with a purposive sample of 29 national and regional stakeholders informed selection of four case study sites involved in delivering technology-enabled remote monitoring for chronic obstructive pulmonary disease. Case studies combined interviews with 19 staff and review of 18 documents. Analysis was informed by the non-adoption, abandonment and challenges to scale-up, spread and sustainability of technology framework. A stakeholder workshop (n = 23 participants) refined emerging findings. Interviews with respiratory patients and a co-design workshop informed development of patient-facing resources.

Results: Technology-enabled remote monitoring for chronic obstructive pulmonary disease occurs along a continuum of scope and scale. Technology-enabled care pathways have some common overarching features, but variation is seen across contexts and patient cohorts. Technology-enabled remote monitoring services influence care provision on a system level. Effective implementation is underpinned by service characteristics affecting its use, technology functionalities and organisational capabilities and capacities. Technology-enabled remote monitoring success also depends on defining the data-driven purpose and value proposition, ensuring buy-in, organising the workforce and workload in sustainable ways, data and IT platform interoperability, support for patients in using the service safely and appropriately, utilising existing resources, team buy-in, financial resourcing and clear policy incentives, and openness to ongoing learning. Patients value technology-enabled remote monitoring services that help them feel more connected to healthcare providers and provide timely information and support. Healthcare staff value high-quality patient care, services value affordability and sustainable workload impact.

Limitations: Small-scale qualitative evaluation conducted at pace.

Conclusions: Technology can support remote monitoring but is only one aspect of an effective technology-enabled remote monitoring service. It needs to be embedded in the chronic obstructive pulmonary disease pathway and align with service needs and existing capacity in cost-effective ways and with proportionate oversight of quality and

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safety. Decision-makers need to consider which aspects of the technology are essential, how they can be effectively embedded and supported by an appropriately equipped workforce, and needs of different patient cohorts.
Future work: There is a need for evidence on longer-term effectiveness and cost-effectiveness of technology-enabled remote monitoring for chronic obstructive pulmonary disease, impact on patient and staff experience, and issues of equity of access. Qualitative and quantitative approaches are needed to appreciate varied technology and evolving use in different settings/groups.
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Background

Chronic obstructive pulmonary disease (COPD) presents a major burden for patients and health systems. In the UK an estimated 1.2 million people had a COPD diagnosis in 2012,[1] with COPD exacerbations the second most frequent cause of emergency hospitalisations.[2] Exacerbations often lead to impaired quality of life, repeated hospitalisation[3] and high costs for patients.[4] Early intervention is associated with faster recovery and better health-related quality of life.[5]

Interest is growing to find innovative ways to optimise COPD care, including by using digital technologies to support care remotely.[6,7] Technology-enabled remote monitoring (TERM) involves the use of technology, devices or apps to help patients to monitor and manage their COPD. TERM technologies typically consist of a platform where data is stored and analysed, with separate interfaces for patients (e.g. a computer or smartphone application) and a dashboard for healthcare professionals. Further devices or apps are used by patients to monitor their symptoms (e.g. oxygen saturation, vital signs, spirometry, mood), often offering multiple functionalities (e.g. education, symptom tracking, pulmonary rehabilitation). Remote exchange of information between patients and health professionals assists in diagnosis, monitoring and management.

There is some evidence that using TERM to support COPD patients can bring benefits (e.g. improved self-management, fewer hospital admissions).[8,9] However, questions remain as to whether, when and how to introduce remote monitoring technologies into the COPD care pathway, for whom and why. There remain significant implementation challenges including a high degree of organisational variation in the introduction, delivery and maintenance of technology-enabled remote monitoring. Given the push to develop proactive approaches to identifying and supporting patients at risk of high service utilisation,[6,10] and the potential benefits of TERM to achieve this objective, the need for evaluation is urgent. This paper reports findings from a rapid evaluation in which we sought to identify what care pathways involving TERM for COPD entail and what influences their implementation. We first summarise existing evidence on the use of technology-enabled remote monitoring for COPD and related gaps before setting out methods and key findings. We conclude by setting out recommendations for decision-makers about how to design and implement TERM COPD pathways in ways that account for complexity and consider implementation complexity.

The evidence base for technology-enabled remote monitoring for chronic obstructive pulmonary disease

We conducted a rapid and focused scoping review of the literature on TERM for COPD patients. Specifically, we searched for literature that addressed:

- the definition and description of the remote monitoring technology and its functions
- clinical effectiveness in improving COPD patient outcomes, such as hospitalisations
- evidence on user (patient and healthcare provider) experience
- evidence on implementation and scale
- studies on cost-effectiveness of such technology.

The search and title screening were conducted on 15 March 2024 and repeated on 9 July 2024 and 2 October 2024. See *Report Supplementary Material 1* for detailed review and search strategy.

How and why technology-enabled remote monitoring is used for chronic obstructive pulmonary disease

A range of TERM technologies for COPD is available in the UK, offering a combination of functions, such as education, pulmonary rehabilitation programmes and self-report of symptoms and vital signs. Physiological information captured by wearables or other devices includes heart rate, blood pressure, respiratory rate, oxygen saturation, activity, body temperature and metabolic function, and

sleep metrics.[9,11] Many TERM interventions include elements of self-report (e.g. subjective physical and mental state), which can make it difficult to disentangle the mechanisms of change.[12]

Technology-enabled remote monitoring for COPD typically supports patient self-management in order to prevent exacerbation and non-elective hospitalisation and includes access to (virtual) pulmonary rehabilitation. There is growing interest in TERM for COPD in the health system in light of this potential. For example, two recent National Institute for Health and Care Excellence (NICE) Early Value Assessments (EVA) focused on technologies supporting pulmonary rehabilitation and self-management for COPD.[13,14] EVAs identified[14] that digital technology had the potential to improve outcomes for people with COPD through reducing the risk of an initial exacerbation; reducing the likelihood of repeated exacerbation and rehospitalisation; improving symptoms; improving knowledge of COPD medication, exercise use and awareness of changes and deterioration; and reducing health inequalities in access and outcomes. This is supported by studies[15,16] which indicate the potential of technologies to improve COPD patient outcomes in varied clinical severity scenarios and across different time points, for example, as self-management for chronic care or domiciliary care during an exacerbation (e.g. virtual wards). Systematic reviews of early supported discharge and hospital at home models of care for COPD patients indicate association with lower mortality, fewer readmissions and lower costs.[17]

Evidence on clinical effectiveness, patient outcomes and health service impacts

Prior to the COVID-19 pandemic, NICE guidance on COPD management in adults recommended against offering routine telehealth monitoring as part of management for stable COPD.[18] The majority of pre-pandemic studies on the clinical effectiveness of TERM for COPD patients did not show significant benefits over standard care. More recent evidence remains inconclusive, primarily due to the low quality of studies and mixed results.[8,9,19–21]

The shift in the use of telehealth was largely driven by the need for social distancing during the COVID-19 pandemic, alongside a broader system-wide impetus to rapidly adopt and scale digital technologies, although existing evidence is inconclusive as to whether TERM improves health-related quality of life, frequency of exacerbations, lung function, self-efficacy or mental health symptoms. However, TERM services are typically deemed safe and patients tend to report high overall satisfaction. There are some studies reporting improved exercise capacity and reduced hospitalisations,[21] and promising changes in patient health outcomes and healthcare use.[22–24]

It is unclear how TERM might be best integrated into COPD care pathways to support desired impacts. Evidence on which patient groups would benefit the most is lacking, although some remote monitoring technologies seem to be more effective among severe, post-exacerbation COPD patients.[20] The NICE EVA on digital supported self-management technologies indicated that the biggest value of remote monitoring technologies might be for moderate to severe COPD patients and patients discharged after an exacerbation.[13]

Evidence on implementation and cost-effectiveness

The research examining implementation is sparse; even less evidence exists on scale up of services. Implementation and scaling up of TERM presents significant challenges.[7] Evidence suggests that successful adoption of such technologies depends on diverse factors such as demography, service-user and healthcare professional skills and preferences, workload-related requirements, funding and technological considerations.[7,25,26] For example, COPD patients tend to be from lower socioeconomic backgrounds, and may have limited access to devices and data. Challenges to adopting and using the technology include limited digital literacy, views that digital care delivery is impersonal, and fear of being 'controlled' by telemonitoring data.[25] Conversely, in areas of high unmet need, studies indicate that technologies might increase timely access to services such as pulmonary rehabilitation.[27] Implementation of a new technology might initially increase, rather than reduce staff workload, especially if technologies are used as adjunct to usual care, or if the introduction of technology surfaces a lack of interoperability between existing health systems, or if there is a lack of dedicated and trained personnel.

Evidence on the cost-effectiveness of TERM for COPD is inconclusive, partly as the clinical effectiveness and the use-case for most of the technologies is not yet clearly demonstrated.

In sum, TERM may have the potential to improve COPD care, support self-management and prevent exacerbations but evidence on the extent to which this is achieved in practice is nascent, inconclusive, and of low quality.[8,9,19–21] The intended goals for TERM in COPD often lack clarity and, while evidence on implementation is currently limited,

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it is clear that significant challenges remain. We therefore conducted a rapid evaluation with the aim of supporting good practice in the implementation and use of TERM in the COPD care pathway and drawing transferable lessons to inform potential spread and scale up. We addressed the following questions:

1. How, where, why and by whom is TERM being used in the COPD care pathway, who is it for and how does it help to provide care to patients?
2. What can we learn from implementation of TERM in different patient populations?
3. What are understood to be the key mechanisms of action in TERM for COPD: for example, measurement of physiological data, patient education?
4. What can we learn from implementation and use of existing TERM (by patients and clinicians) that can inform potential rapid take up and use in the context of winter planning, and beyond?

Methods

Origins, design and governance of the study

The study forms part of a 3-year programme of work funded by the National Institute for Health Research Health and Social Care Delivery Programme. Digitally Enabled Care In Diverse Settings (DECIDE) is a collaboration between the University of Oxford and RAND Europe, conducting rapid evaluations of technology-enabled remote monitoring. The DECIDE programme has governance oversight including an Internal Advisory Group made up of primarily senior academics with cross-disciplinary expertise in evaluation, a User Advisory Group with representation of patients and carers and a lay chair, and an overarching Steering Committee with broad membership that contributes to a dedicated advisory committee for each evaluation.

This study uses rapid evaluation to inform the design and delivery of COPD remote monitoring services, including in the context of informing winter pressures planning by the LungHealth@Home team at NHS England. Rapid evaluation uses robust methods and theoretically-informed approaches to enable timely evidence that can inform policy and practice[28] while acknowledging that the need for timely insights may necessitate certain methodological trade-offs in terms of data collection and analysis. This study is informed by the tradition of developmental evaluation involving an emergent approach that captures data that can inform ongoing developments.[29] This project was reviewed by the Oxford Joint Research Office classification committee, which determined that it is service evaluation.

Given rapid turnaround and the limited scale of the evaluation we used qualitative methods (*Figure 1*). These methods align with established principles of rapid evaluation in health care, which emphasise the use of flexible, qualitative approaches to generate timely, actionable insights.[28] By combining interviews, workshops, and focused case studies, we were able to capture data at both individual and organisational levels, and iteratively refine emerging findings. This multi-method approach allowed us to address the layered nature of our research questions – spanning patient and staff experiences, implementation processes, and contextual factors influencing service delivery – within the time-sensitive context of healthcare planning and decision-making. Evaluation design was informed by the NASSS (non-adoption, abandonment and challenges to scale-up, spread and sustainability) framework,[30] which helps to surface and explain the challenges and complexities in technology-supported service change across varied social and technical dimensions (*Figure 2*).[31] Further detail is available in the study protocol.

Sampling and data collection

We conducted data collection between March and September 2024. Data sources are summarised in *Table 1* and described in more detail below.

To understand the context for TERM for COPD, we first conducted 29 scoping interviews with a purposive sample of stakeholders including national and regional decision-makers, providers, technology suppliers, those supporting innovation and evaluation and patient representatives. Interviews were semi-structured, conducted online, and lasted 30–60 minutes. They covered the aim and purpose of TERM, modes of delivery, implementation and definitions of success and helped to identify current technology-enabled services within respiratory care. Combined with a review of websites (e.g. NHS Respiratory Digital Playbook), this process led to identification of nine potential case study sites for further study (see *Figure 1*), from which we invited four.

Case study sites included health settings where technology-enabled remote monitoring for COPD had previously been implemented and/or was being actively used (see *Figure 1*), We sought maximum variation across

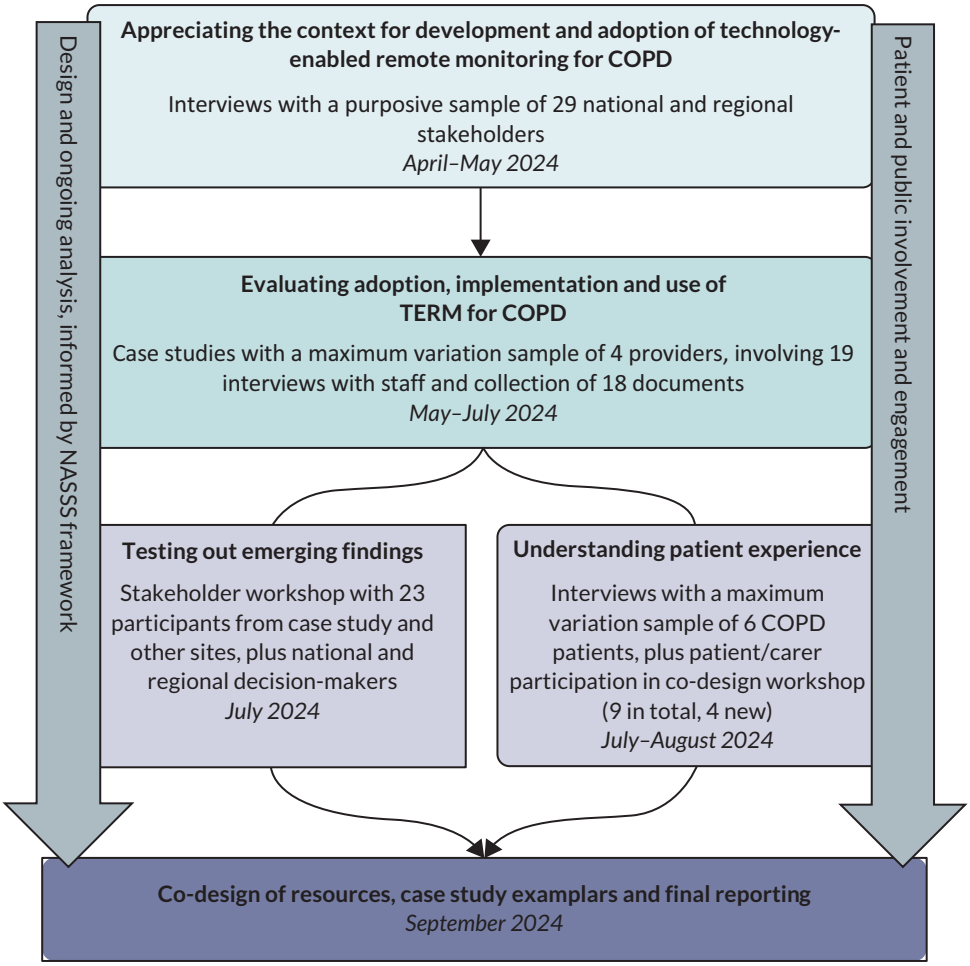

FIGURE 1 Overview of study design and phases of work.

the type, scale, delivery and maturity of TERM being used, extent of adoption and experience with the technology (e.g. early use vs. routinised); health care setting; and target user populations (e.g. COPD patients at highest risk of hospitalisation). While a detailed breakdown of the technologies into functional components could support comparative analysis, this was beyond the scope and aims of the project; as such, detailed descriptions of the core functionalities of the remote monitoring technologies used by the case sites is included in the case study appendices (e.g. *Appendix 1*, *Box 1*).

Between August and September 2024, we interviewed 19 staff across the 4 sites (3–7 per site, 17 females and 2 males). We combined purposive and snowball sampling, asking the main contact at each site, and successive interviewees, to connect us with other potential participants. This provided a diverse sample of staff with clinical, managerial, administrative and evaluative roles. Interviews were semi-structured, conducted online (except for one by telephone) at a place of the participant's choosing, and lasted up to 1 hour covering background to the TERM service; implementation and delivery; the patient journey (e.g. processes for onboarding). We asked interviewees to share relevant service documents (e.g. business case, protocol) resulting in a sample of 18 documents.

We conducted interviews with six patients who were living with chronic respiratory illness (see *Figure 1*). We used snowball sampling to identify potential interviewees, guided by the NHSE patient and public involvement and engagement (PPIE) team, and participants' respiratory networks. All patients were female. Two patients were connected to case sites. Interviews were semi-structured and online, lasted around 40 minutes and explored the lived experience of TERM for COPD patients (this fed into later co-design of patient resources).

Finally, we held a 90-minute stakeholder workshop to test out emerging findings with 23 participants (22 females, 1 male) actively using TERM for COPD in a professional capacity and those supporting innovation.

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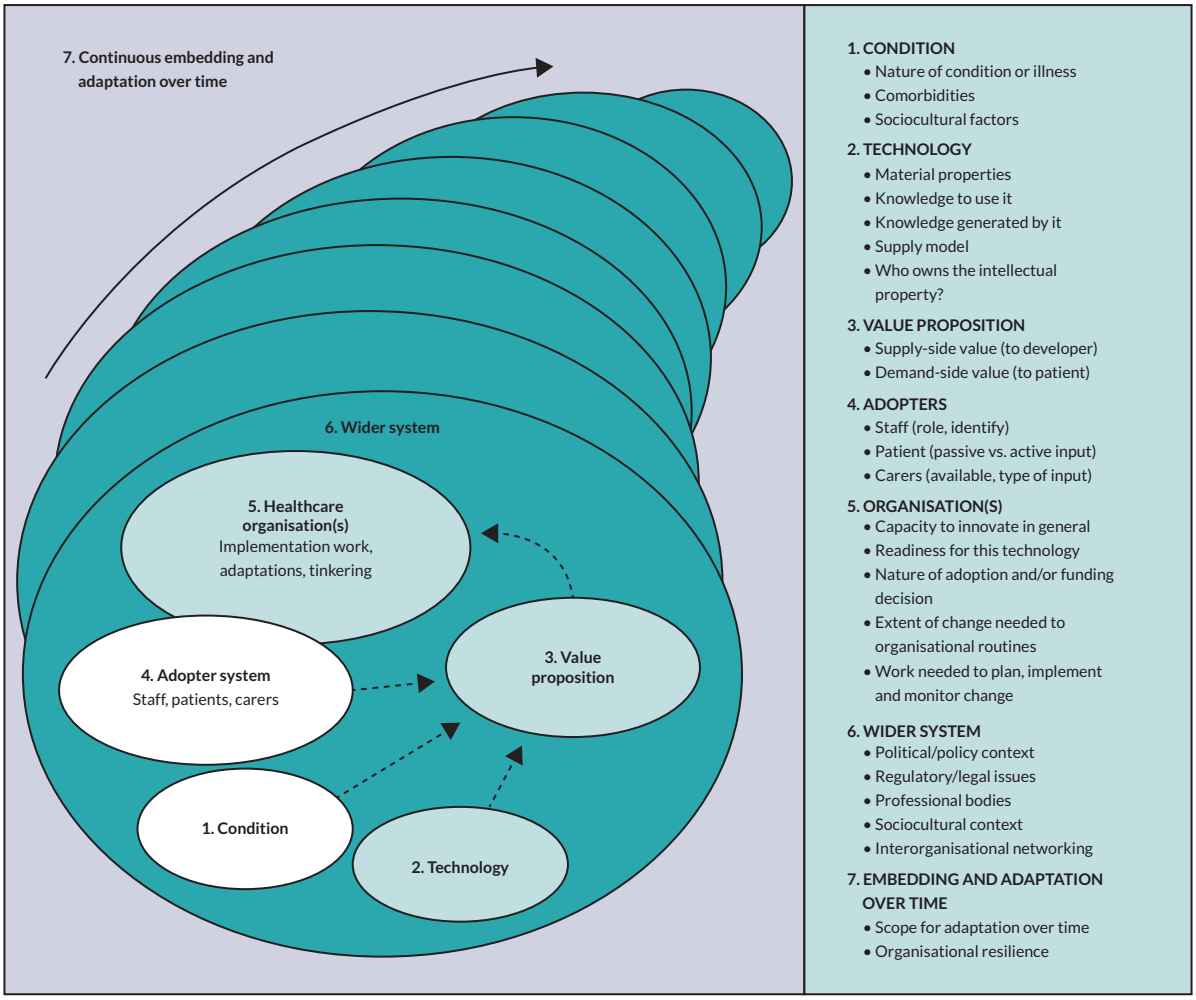

FIGURE 2 The NASSS framework for considering influences on the nonadoption, abandonment, and challenges to spread, scale-up, and sustainability of technologies. Reproduced from Greenhalgh *et al*.[30] This is an Open Access article distributed in accordance with the terms of the Creative Commons Attribution (CC BY 4.0) licence, which permits others to distribute, remix, adapt and build upon this work, for commercial use, provided the original work is properly cited. See: https://creativecommons.org/licenses/by/4.0/. The figure includes minor additions and formatting changes to the original text.

Participants were recruited via a combination of targeted invitation and snowball sampling and included national and regional decision-makers and service providers. Workshop participants considered barriers and enablers to implementation, potential short- and medium-term solutions; organisational and peer support for staff, and resources needed by COPD patients.

All interviews were recorded and transcribed with consent. When interviews could not be recorded, detailed contemporaneous notes were taken. Notes were taken during the workshop.

Data analysis

Our primary analytic focus was on case study data, informed by thematic and constant comparative analysis.[32] We developed familiarisation documents for each site (see *Appendix 1*), synthesising different data sources and updating as new insights accrued. Our analysis was informed by the NASSS framework,[30] condensing the seven interacting domains (see *Figure 2*) to focus on the definition and purpose of TERM, the health system and workforce, patients, and embedding and adapting over time.

The scoping interviews were used to develop an initial understanding of the remote monitoring landscape and to inform the subsequent analytical approach. The findings presented in the Results section are based on the case study and service user interview data. Further detail is available in the appendices. Given the rapid context, analysis drew on pragmatic approaches to qualitative analysis[33,34] (e.g. developing coded summaries immediately post-interview in lieu of transcription). Four team members were directly involved in coding the data and team discussion helped to refine familiarisation documents and synthesise an overarching narrative of cross-cutting themes. Our early engagement with case study data often focused on the

TABLE 1 Overview of data structure and analysis

Data source	Data collected	Contribution to findings
Scoping interviews	• Accounts of 29 stakeholders (national and regional decision-makers, providers, technology suppliers, those supporting innovation and evaluation and patient representatives) involved in developing, commissioning, implementing, delivering and receiving remote monitoring technologies in the context of COPD care pathways	• Understanding of broader remote monitoring context
	• Review of websites and online information (e.g. NHS Respiratory Digital Playbook) describing current approaches to TERM of COPD in the UK	• Understanding of priorities for key stakeholders, sharpening focus of the rapid evaluation
		• Identification of four case sites
Case studies	• Accounts of 19 staff (17 females and 2 males) across 4 case study sites (business managers, clinical leads and nursing staff, call handlers, project and programme managers, Chief Information Officers)	• Insights about the perceived value proposition of remote monitoring technologies in each site
	North Town (NT): 7	• Understanding about the purpose of use of these technologies and motivation/s for their implementation
	City South (CS): 5	• Overview of key organisational strategies, processes, enablers and barriers and how/if these change over time
	Rural Care (RS): 4	• Staff experiences of the development, design, safety and success of remote monitoring technologies
	River Valley (RV): 3	• Staff perceptions of patient experience
	• 18 service documents (e.g. business cases, protocols) plus researcher field notes about people, technologies and processes involved in remote monitoring of COPD	
Stakeholder workshop	• Online workshop with 23 participants (national and regional decision-makers and service providers, including representatives from the 4 case sites and policy partners)	• Refinement of emerging findings, particularly relating to remote monitoring as a service; a continuum which patients can 'cycle' up and down
	• Participants considered barriers and enablers to implementation, potential short- and medium-term solutions; organisational and peer support for staff, and resources needed by COPD patients	• Relevance and need for codesigned patient resources: peer stories; information and reassurance; clarity about service provided
Service user interviews	• Accounts of six service users (respiratory patients, two associated with case sites)	• Understanding of patients' values and experiences with remote monitoring services and allied technologies
	• Use of remote monitoring technology not a prerequisite	• Overview of patients' needs relating to how TERM needs to be integrated into a wider service with clear touch points and regular clinical feedback
		• Service user experiences and concerns about digital inequalities
Service user PPIE workshop	• Online workshop with nine participants (eight respiratory patients and one carer)	
	• Experiences of living with a chronic respiratory condition, codesign of a guide to support the use of TERM services	

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affordances of the technologies then, as we explored the narrative surrounding implementation across technology-enabled remote monitoring services and engaged with wider sociotechnical literature,[35–37] the technology became less foregrounded and we developed a theoretically-informed, emergent explanation of how, where, why and by whom TERM is being used in the specific context of the COPD care pathway. Data from interviews with respiratory patients and the stakeholder workshop provided contextual information that aided interpretation. While our understanding of patient views and experiences was largely informed by analysis of staff interviews and documents, equity and accessibility of services were sensitising concepts throughout.

Findings are presented below. Data collection directly with COPD patients was limited; hence, while we thread the patient voice throughout the findings we do so with clear indication of attribution (i.e. direct quotation or staff interpretation of patient experience). To protect identities, patients are referred to by number, we use pseudonyms for sites and the technologies they used (see *Tables 1* and *2*). Given the small number of sites and interviewees we refer to interview numbers, de-couple these from site information where there is a risk of identification, and use pronouns interchangeably.

Patient and public involvement

Meaningful involvement of patients and the public underpinned evaluation from the outset. Preliminary discussion with the DECIDE User Advisory Group, NHSE Patient and Public representatives and PPI representative from National Voices (part of a dedicated project advisory group) guided focus on issues of equity of access. This informed evaluation design, sampling and conduct. It also led to co-design of resources with and for COPD patients (see *Figure 1*), involving an online workshop in September 2024 with nine participants (eight respiratory patients and one carer) to share and refine findings, discuss experiences of living with a chronic respiratory condition, and codesign a guide to support the use of TERM services for people living with COPD. Five of the nine workshop participants had also taken part in interviews. All patients received a voucher for their time.

Results

The implementation of technology programmes in health care has a chequered history.[37–40] This was reflected in our data, with many of the known barriers to implementation [e.g. legacy IT systems, complex and inconsistent infrastructure and commissioning models, a (valid) prioritisation of patient safety, reactive rather than preventative care models] apparent. Such barriers present challenges to the design, implementation and evaluation of TERM for COPD. In this section we focus specifically on the value proposition of such services for patients and staff; motivation and purpose of TERM approaches; components of a TERM care pathway; organisational, staff and patient experiences; and implementation challenges.

The findings are structured thematically to reflect key dimensions of the research focus, rather than being organised strictly by research question. However, the themes collectively address the research questions: the first three sections primarily respond to Questions 1 and 2 by exploring the purpose, users and design of TERM services. The following sections address Questions 3 and 4, examining implementation processes, staff and patient experiences, and system-level enablers and challenges. Together, the themes present a coherent narrative of how technology-enabled remote monitoring services for COPD are developed, experienced, and sustained in practice.

Who technology-enabled remote monitoring for chronic obstructive pulmonary disease is for

Chronic obstructive pulmonary disease services can target diverse patient cohorts, and are grounded in a desire to prevent deterioration. Living with COPD can be challenging. People often experience shortness of breath, persistent coughing and fatigue, even during simple tasks:

> *When I have a shower, if I go for a walk, I'll probably have to stop and get my breath even on the flat after a few minutes*
>
> *Patient-1*

Over time symptoms typically worsen, requiring lifestyle adjustments and ongoing medical support.

There is a constant need to manage symptoms, relying on inhalers, oxygen therapy, or medication. Ability to perform daily activities may become limited, potentially leading to frustration and anxiety. As one patient put it: 'you feel very isolated when you're terribly ill' (Patient-3).

Some TERM services for COPD are aimed at patients who are severely unwell (see *Table 2*), many of whom will have had a recent exacerbation and hospital admission. Some patients may have received care via virtual wards and be familiar with remote monitoring, hence suited to being stepped down to a TERM service:

TABLE 2 Overview of case studies and TERM services

Site (pseudonym)	Patient cohort offered TERM (*n*)	Technology being used	Organisation and staffing	Service set-up and duration
River Valley Primary Care Network[a]	Patients with severe to very severe COPD (*n* = 30)	Smart inhaler and Respirio app	Primary care staff (GP and practice nurse) support patients with technology and follow-up	Set up in 2024 as part of 3-month study
Rural Care Integrated Care System[a]	All COPD patients (*n* = 3295)	Respirio app	Primary care support for patients (annual review, ad hoc), plus PCN digital care coordinator support for patients and staff	Set up in 2017 with pause and adaptation from April 2024
City South Integrated Care System[b]	Severe-very severe (*n* = 300) + all COPD patients (*n* = 28,000)	TERM-COPD box and Respirio app	TERM-COPD clinical team supports patients; with community respiratory team supporting more severe end of patient care	Set up in 2024 as a 6-month pilot
North Town Hospital providing acute, specialist and community care	Moderate-severe-very severe (*n* ≥ 6500)	GenieOx app plus 24/7 telephone support	COPD24 service staffed by NHS clinical staff and administrative personnel	Digital Care Hub set up in 2011, COPD24 following in 2019

GP, general practitioner; PCN, Primary Care Network.
a Group of GP practices working together, aligned to other health and social care staff and organisations, providing integrated services to their local population.
b Local partnerships bringing health and care organisations together to develop shared plans and joined-up services.

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> *So they have a box delivered which some of them are familiar with because it's identical to the box that we use in the NHS@Home [virtual ward] service … it is familiar to them.*
>
> *CS-4*

Other patients have limited, if any, experience of remote care and restricted access to devices and data.

Provision of TERM services with a 'step-up' and 'step-down' function was considered important in three of the four sites as a means of keeping the most unwell patients out of hospital (RC-1,3; CS-3–5; NT-1). City South and North Town actively targeted severely unwell patients throughout the year to relieve pressure on stretched services (CS-3,4; NT-1,4). COPD patients with lesser immediate clinical need were also sometimes included in TERM services. For instance, North Town received referrals from health professionals based on worry about a patient's clinical instability, despite them not 'fitting' the service's eligibility criteria:

> *I think we've started to introduce people that are moderate and mild because we know that [our] support's there, and that education on diagnosis is just not there.*
>
> *NT-4*

The value proposition and motivations for technology-enabled remote monitoring for chronic obstructive pulmonary disease

Chronic obstructive pulmonary disease patients may benefit from TERM due to improved health outcomes and care experience, and healthcare professionals may benefit in terms of enabling high quality care and managing demand. Staff and patients reported that COPD patients appreciate the support, increased contact with healthcare providers and easier access to care that such services can enable (RC-1,3,4; CS-2–5; NT-1,3,5–7). Staff told us that patients typically find TERM technologies straightforward to use (RC-3; CS-2,4; NT-1,4,6,7), but they can overwhelm or cause confusion for some (CS-3,4; NT-1,5). Some patients agreed (Patient-1,5–7) but also described a sense of empowerment, active engagement in their own care, and positive habit formation:

> *I find it quite empowering (…) it backs up some of the things you're feeling in your own body, and it's data you know that shows trends that you can't argue with (…) it just makes you feel more part of the process.*
>
> *Patient-1*

The value proposition of TERM for staff reflected potential clinical, patient-related and operational benefits related to workload impact and service affordability. For instance, interviewees in management roles saw potential system-wide benefits related to the introduction of TERM services (e.g. reduced bed days and non-elective emergency admissions). Furthermore, for some staff, TERM added value by providing opportunities for meaningful collaboration with colleagues and connection to patients (CS-2–4; NT-2–7).

Improved patient care was a primary goal across sites although it was widely acknowledged that technology-enabled remote monitoring services fundamentally needed to be aligned with (and evaluated by) additional quantifiable outcomes attached to wider policy and financial objectives (e.g. cost-effectiveness) (RC-1,3; CS-3–5; NT-1–4). This was echoed by external evaluators who acknowledged that: 'ultimately, is it going to be cost-effective and are there resource savings?' (RV-1). While acknowledging the need for cost savings, participants in all sites emphasised that TERM is about adding value to an existing service and managing demand for care (RC-1,3; CS-3,4; NT-1–4; RV-1,3).

Staff described the motivations underpinning technology-enabled remote monitoring services using terms such as *empowerment*, *compliance*, *behaviour change*, *prevention*, *consistency*, *supporting help-seeking*, *following the plan*, *self-efficacy*, *reinforced learning*, *self-awareness* and, crucially, *reassurance*. The degree to which patient reassurance was considered a valid purpose of TERM services was at times contested by staff. While staff appreciated the high prevalence of comorbid anxiety among COPD patients, many did not view remote monitoring services as being about providing 'comfort' per se (CS-3–5). This stood in contrast to the North Town model, which provided 24-hour TERM designed to make the patient feel like 'they are the only person that matters (…) by listening to them and really honing in what on what their needs are' (NT-3).

For most sites, the impetus for TERM followed increased use of virtual wards (also known as hospital at home) following the COVID-9 pandemic, which unlocked infrastructure, financial and governance barriers:

> *Obviously virtual wards became the buzzword for the NHS and from there other pathways sort of … came into place.*
>
> *NT-4*

All remote monitoring services were driven (albeit variably) by a commitment to provide equitable access to care and reduce health inequalities. City South defined a user group of interest as 'complex' patients in need of more than 'just' remote monitoring (CS-3). Three sites included areas of high deprivation coupled with above average COPD prevalence, described by one manager as 'a pandemic of COPD' (NT-4). Rurality and dispersed patient populations were a concern in two sites. Interviewees talked about 'offering a new way of engaging with the system' (CS-3) or 'opening a bit of a door for people that have felt that door is closed for quite a long time' (CS-2). Three sites had processes in place to provide hardware and data access to patients. Two sites had introduced new roles to support patient onboarding. Rural Care was keen to broaden access to TERM services through better promotion via text message to all COPD patients. There were assumptions across all sites (and embedded in technologies and wider services) about who would be willing or able to engage with TERM services (e.g. less likely to suit older patients, or those with physical disability or cognitive impairment).

Defining a technology-enabled remote monitoring care pathway for chronic obstructive pulmonary disease

'Technology-enabled remote monitoring' is an umbrella phrase, capturing a range of approaches, of varied scope and intensity of monitoring and associated support. Four types of TERM for COPD were reflected in our data, ranging from self-management through to proactive monitoring at scale (*Figure 3*).

Across sites, use of terminology varied and definitions and scope of TERM pathways for COPD shaped patient recruitment, staff and patient engagement, and future funding.

Technology-enabled remote monitoring occurs along a continuum and varies in its intensity and intention. Staff described TERM services as ranging from *self-management + routine review* in which a patient might track personal data and use it to inform routine care, through to *proactive remote monitoring + clinician-initiated follow-up*, where patients can self-escalate, a data dashboard is continually monitored, and care escalated by clinical staff in response to alerts triggered by provision of 'abnormal' readings. *Self-management with supported follow-up* approaches rely on patient-initiated follow-up (PIFU) to access care, and *active remote monitoring* approaches combine PIFU with a degree of proactive remote monitoring, especially for the most severely unwell patients.

There is nuance in understanding and local articulation of the scope of TERM and what constitutes *management*, *monitoring*, *active* and *proactive*. A shared terminology and understanding of these terms is vital for enabling shared learning across different settings.

> *Going forward, it will be important to clarify terminology across sites because remote monitoring currently can mean a whole array of different technologies and approaches to care.*
>
> *CS-3*

There can also be differences in how a service is described or intended to be implemented and how it is operationalised: real-life *practice* may be more fluid. For example, the technology used by Rural Care allowed for active clinical monitoring through a tech 'backdoor' which some clinicians used on an ad hoc basis, even though the primary intention of was to support self-management:

> *[P]atients can self-monitor … and we can support them to do that, and we might have a little look at their scores over time.*
>
> *RC-4*

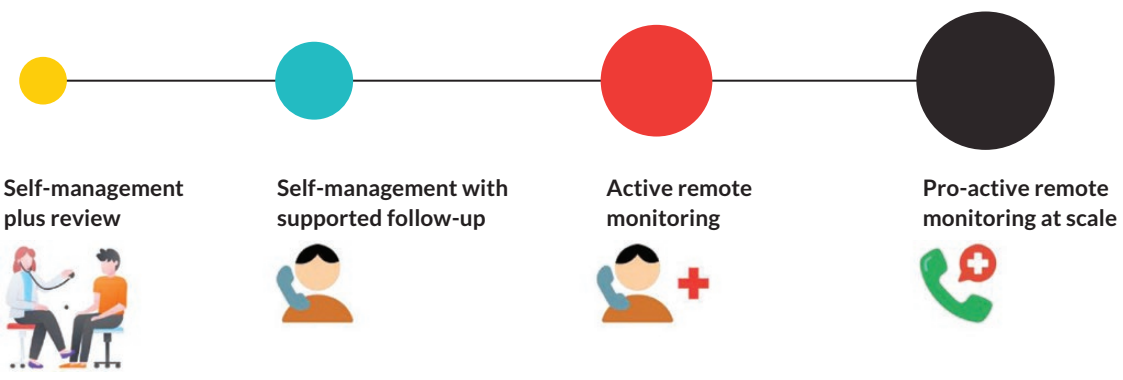

FIGURE 3 Continuum of approaches to TERM, ranging for self-management through to proactive monitoring.

However, there was widespread agreement across sites on what the core components of an overarching technology-enabled remote monitoring care *pathway* included: (1) identification of suitable patients, (2) onboarding, (3) delivery of remote monitoring and information, and a cross-cutting element of (4) provision of support for patients and staff. Approaches to identification, referral, onboarding and monitoring processes differed widely (see *Appendix 1*). Despite indication from some staff that monitoring could and should be time bound (CS-3,4), long-term monitoring was an implicit strategy in some sites and offboarding or re-onboarding protocols not well described. Technology-enabled remote monitoring services were introduced at different points in the care pathway, in a variety of clinical and community settings and by a wide range of teams and professionals.

Across sites, TERM technology sat within a larger service ecosystem of analogue processes and materials (leaflets, phone calls and home visits). Additional 'kit' was offered to patients by all four sites: three sites (RV, RC, CS) offered the same mobile phone application which could be used in conjunction with other equipment required for collecting physiological data; one site (NT) offered a different application with similar tracking functionality. Functionalities varied (e.g. tracking of symptoms, education, access to pulmonary rehabilitation, information about local air quality) depending on the overarching service objectives. Some sites took advantage of strong relationships and '*cultural fit*' (NT-1) with technology teams to develop bespoke modules and measures, develop new care pathways (City South), evolve the service and extend interoperability (Rural Care). This reflected a recognition across sites and some patients of the need to provide 'joined up' TERM services:

> *It strikes me that none of these things are useful in isolation. We need to have an integrated care programme.*
>
> *Patient-6*

There was variation among staff in terms of for whom (degree of clinical severity) and how (e.g. daily, weekly, at onset of deterioration) TERM should be used. Health behaviour interventions tend to come with normative ideas about how a service or intervention 'should' be used by patients.[41,42] Yet staff described variation in usage within the same service, from sporadic to patients using it 'religiously' (RC-1,3,4). Some staff thought it was acceptable for patients to use TERM long term (RC-1,3,4), while others thought of it as a short-term educational tool which is 'supposed to go away' (NT-5) when patients were sufficiently 'well-educated and prepared for how they self-manage going forwards because we don't want to create dependence on the service' (NT-4).

How severity of condition influences TERM usage by patients is unclear. Some staff recognised that some clinically stable patients may be less inclined to monitor (RC-4; CS-4; NT-7). According to some interviewees, 'infrequent but informed' self-tracking when a patient is stable was not in itself problematic, *as long* as this was coupled with a pick-up in use with the onset of exacerbation (NT-6). One staff member pointed to the importance of appropriate rather than frequent monitoring and the need for evaluations not to conflate frequency and appropriateness in performance assessments:

> *The data actually artificially makes it look as though it's the app is not terribly effective because people's symptoms are worsening in you know, December, January, etcetera, but actually what it demonstrates for us is that there's a need for this because people want to use it, they're going to find it more reassuring and helpful when their symptoms are actually at their worst.*
>
> *RC-3*

Implementing and delivering technology-enabled remote monitoring for chronic obstructive pulmonary disease

All four sites had adopted TERM at the time of evaluation, albeit at different stages (see *Table 2*). The extent to which sites were able to effectively TERM in the COPD pathway was underpinned by diverse factors, related to technology functionalities, organisational and workforce capabilities and capacities, staffing approaches and roles, organisation of workforce and workload, clarity of purpose and value proposition, staff buy-in, data and IT platform interoperability, support for patients in using the service safely and appropriately, financial resourcing, clear policy incentives and approach to scaling, as well as ongoing learning.

The way in which a service was introduced, funded, governed and delivered influenced the ways TERM was adopted and, in some cases, subsequently spread and scaled (or not). For example, a TERM pilot study based at River Valley was grounded in primary care oversight and delivery of the service and supported by short-term funding which supported the technology developer to gather feasibility data and the practice to gather evidence relating to the technology-enabled remote monitoring service. However, interviews suggested further clarity was needed in terms of lines of accountability at a Primary

Care Network (PCN) level, which might also boost clinical staff engagement. This is in contrast to the system-wide planning and integrated service design and provision seen in City South or North Town in which adoption and transition to TERM were underpinned by an approach which incorporated multidisciplinary collaboration, system-level commitment to timely clinical response, and longer-term evaluation.

Navigating the transition to TERM services

Navigating the transition to TERM means that while some services may experience relief, such as reduced ambulance conveyance and less strain on primary care (NT-1–3), other areas face increased demand (CS-3,4; NT-1–3). This was particularly true for sites which provided active/proactive monitoring (City South and North Town). Staff at City South described a brief period of intense monitoring at the point of patient onboarding, requiring a short-term increase in provision of support and reassurance for patients, support from technology suppliers, assistance with digital onboarding and navigation and additional administrative support. A transition period was observed where existing routines overlapped with new ones. During the early stages of service implementation, staff often experienced increased workload (e.g. manual entering of data) as they adjusted to new processes (CS-1,4). The success of this transition depended on staff buy-in: for example, one clinician described inconsistent referral to the service, attributed to 'staff members treating it as an optional, add-on service' (RC-1).

Staff highlighted the importance of de-implementing outdated or duplicated practices (RC-2,3). Rural Care, for instance, paused their TERM service due to burden associated with staff and patients duplicating data into multiple systems to access care and information (RC-1–3). Staff across sites reiterated the importance of investing time and financial resources to develop the infrastructure necessary to support the transition to TERM, specifically in staff induction, fostering buy-in from the workforce, building strong relationships with technology development teams, and onboarding patients effectively (RC-2,3; NT-1–4).

Staff experiences of delivering technology-enabled remote monitoring services

Staff experiences of delivering TERM were mixed. Most staff described an overall positive experience (CS-2–4; NT-2,4), with many valuing the immediacy of patient interaction:

> *As a clinician, I've enjoyed the work … I like the opportunity to have a conversation with patients and set their agenda (…) you know, what matters to you.*
>
> *CS-3*

Many staff described professional satisfaction from working as part of TERM services. Increased collaboration with colleagues and deeper connection with patients via TERM enhanced people's sense of professional achievement.

> *You just you can feel (…) how much people care and how lovely they are when they speak to patients.*
>
> *NT-3*

However, challenges were also voiced. Some staff described notable increases in workload and the difficulties of managing this (CS-1,3–5; NT-4,6). Increases were sometimes attributed to overly complex systems which afforded multiple capabilities, providing too much data. According to a clinical participant from City South, this could lead to unnecessary work or over-investigation:

> *As soon as you have data, you have a duty of care to respond to that data (…). And the more you do, the more you find. There's a lot of risk that it (…) creates noise, but not value.*
>
> *CS-3*

In addition, a lack of interoperability between remote monitoring data platforms and existing systems proved challenging to TERM implementation at some sites (CS-1–5), creating additional manual input demands, which led to an increased administrative burden on clinical staff (CS-1,3–5). Job security was a concern in an uncertain commissioning environment (NT-1–3). Others questioned staff buy in regarding the merits of digital care (RC-1,2).

> *It's (…) perceived as being not (…) the gold standard in terms of delivery, even though it might be a patient's choice to do it that way.*
>
> *RC-1*

There were no descriptions of overt non-adoption in our data. However, inconsistent implementation was present and attributed to a lack of sufficient support, awareness or understanding regarding the purpose and limitations of the technology and services (RC-1–3). That said, staff did not describe needing TERM -specific training. Rather, they talked about the importance of developing specific

competencies, including strong communication skills around lived experience of learning to use technology (RC-4; NT-1,4,6,7). Instead of retraining existing respiratory staff, participants described the benefits of building and evolving TERM services by drawing on existing staff, teams, or intermediaries beyond the immediate scope of respiratory care (RC-1,4; NT-1,4,6). A call handler from North Town, which drew on a pool of people working across three clinical care lines in its digital hub described how 'we're all trained to do each other's stuff' (NT-6). Other sites had gone one step further and introduced new roles into the service, such as digital care coordinators (Rural Care), who acted as *a digital advocate* and supported staff and patients in implementing and using digital services. Teams also drew on voluntary services and auxiliary staff (e.g. health coaches, social prescribers) to address a wider range of needs.

Digital and communication skills were viewed as key to the role of delivering TERM services (RC-2,3; NT-1,6,7) but some staff felt they lacked digital literacy (RC-4; CS-1; NT-6), with one describing themselves as a '*dinosaur*' (NT-6). These individuals relied heavily on leadership and training to successfully adopt and implement TERM services, and address digital hesitancy:

> *When [this call handler] first came to us in the hub at the start of this implementation, he couldn't turn a computer on. Now he can get somebody onto the app over the phone.*
>
> *NT-4*

Peer support within and across sites was informal and ad hoc. Highly valued by staff, it was a key strategy used by staff to navigate TERM implementation and adoption, both within and between organisations (RC-2–4; CS-3,4; NT-1,6).

Navigating out of technology-enabled remote monitoring services

Two sites were conducting pilot studies (River Valley and City South), one service was paused (Rural Care) and the North Town service was in the process of being partially decommissioned after a period of 4 years. Staff at City South talked about the challenge of offering – and then withdrawing – a service at the end of a 6-month research period, and reflected on the importance of clear communication (CS-1–5). City South and North Town staff reflected on the need to frame business cases for TERM services carefully to secure funding, but that this was no guarantee of future security. Indeed, many staff talked about how the process of reallocating resources or decommissioning services imposed a significant burden – professionally and personally – on teams. Such burden was exacerbated when short-term research projects or unclear commissioning decisions created uncertainty around job security and professional identity:

> *Well, the service was cut completely. We managed to get a bit obviously to keep it going in the local place for a period of time, but they gave us two weeks' notice to let the staff go and end the whole service for 6000 plus patients.*

Unintended consequences of technology-enabled remote monitoring, and their potential impact on quality and safety

Patients and staff also described potential unintended consequences arising from the implementation of TERM services. These related to management of (patient) expectations, poor service delivery, exacerbation of health anxiety, the potential for scope creep and managing perceived clinical burden (RC-1,3; CS-1,3,4; NT-1–4; Patient-4).

Instability in service sustainability or delivery can impact negatively on patient experience. One North Town patient described being 'devastated' (Patient-6) at the service ending and staff at City South described managing patients' expectations about whether the technology-enabled remote monitoring service might be delivered, post-pilot. Conversely, staff at Rural Care, which had paused its technology-supported COPD service while exploring other technological options, reported no patient dissatisfaction, attributed to patients' having been given lifetime access to the app (RC-1,3). Patients needed to feel that they were receiving the service they were expecting: Patient-3 talked about the lack of engagement in remote monitoring by his healthcare team and the redundancy of 'just (…) handing somebody an app, it's completely useless really, and feeding this data into thin air'. Unmotivated by the lack of feedback, he ultimately stopped using the remote technology and declined further TERM services. While TERM may offer valuable insights into health for some patients, it may cause anxiety for others, according to the professionals from three sites. Constant monitoring may lead to over-reliance on the technology or increased stress as patients become overly focused on their health metrics. Staff had discharged patients from TERM services because of this:

> *The burden of surveillance is not warranted.*
>
> *CS-3*

Furthermore, over-reliance on the technology can be highly problematic when data does not correspond with subjective experience. One patient spoke of the distress caused by clinicians' persistent refusal to assist her mother whose data looked 'normal' despite her visibly deteriorating (Patient-9).

Services grounded in 'softer' principles of reassurance might inadvertently suffer from scope creep over time in which PIFU becomes less about self-management of COPD and more about patient use of the service as a one-stop shop for all healthcare needs. North Town staff described how usage slipped into calls requesting support in accessing primary care appointments and repeat prescriptions, which some staff acted on while others did not (NT-1,5–7).

City South staff described the clinical burden associated with subjective interpretation of TERM protocols, particularly around responding to alerts which were based on algorithms not calibrated to the individual patient, setting off app-based, rather than person-based, threshold breach alarms (CS-1,3,4). Balancing clinical judgment with app-based thresholds at speed could be stressful and generated questions around clinical accountability (CS-1,4).

Embedding and adapting technology-enabled remote monitoring over time

The process of implementing, embedding, and adapting remote monitoring services is inherently complex, dynamic and emergent, with components interacting, requiring constant adaptation over time.[29] The success of TERM services relies on being able to navigate and respond to this complexity as policy frameworks, funding mechanisms, technology advances and patients' conditions evolve. Some technologies, care pathways and staff roles are more amenable to change and adaptation than others.

Readiness and capacity for change

Each of the four sites had its own set of antecedent conditions that influenced how effectively new technologies and services could be implemented. Factors such as existing resources and infrastructure, the extent to which new technologies were interoperable with existing data platforms, pre-existing relationships with technology developers, a data-driven understanding of local needs, a long-term fiscal plan, and clarity of purpose all played crucial roles in shaping readiness (RC-1–4; CS-3–5, NT-1–4). Inconsistent and non-standardised evaluation metrics and processes across Integrated Care Boards (ICBs) and funding bodies were repeatedly raised as a direct barrier to innovation (NT-1–3). Interviews with staff illustrated how the scope of service implementation, adaptation and sustainability depends on getting the basics right from the outset. These included defining data-driven purpose, utilising existing resources, having strong team buy-in [rather than leaning on enthusiastic individuals 'like clinical advisors who will have their own kind of pet projects' (RV-1)], learning from existing models, and considering long term evaluation from the start (NT-3).

Maintaining and sustaining technology-enabled remote monitoring services

Maintaining and sustaining TERM services depends on a range of factors related to funding availability, a long-term approach, clear lines of responsibility, adaptability over time, and maintenance of data infrastructure. The resilience of an organisation to maintain and sustain TERM services relies on *reflexive monitoring*,[43] that is, the collective willingness and ability to make sense of what the service does, what it does well and to identify and respond to critical events through coordinated action.[44] This sustained focus on 'doing the right thing' and prioritising patients' holistic needs supported embedding TERM through efforts to provide a 'person-centred' service in some sites (RS-3; NT-1–4).[45] For instance, staff at Rural Care had paused their service, having been through an intensive pilot, introducing new support roles, and revising their overall approach to the virtual delivery of COPD care. Drawing on this new infrastructure, staff talked about their ambition of initiating a 'one citizen' approach, in which a person's multiple needs would be addressed through accessing one, interoperable digital doorway (RC-3).

The provision of person-centred care can be tempered by commissioning and funding realities that emphasise efficiencies and fiscal benefit, which can impede the extent to which patient-centredness is achievable. Indeed, the challenge of modelling the business case for TERM COPD was described by one participant as being perhaps the biggest barrier to scale and spread of TERM services:

> *Things cost money to set up and to do differently, and we're pretty sure we're decreasing pressure across the system, but we can't prove it because there's not the data.*
>
> *NT-2*

To enable TERM services to become more routinised in COPD pathways, staff spoke of the need for (additional/diverted) budget over and above the cost of technology (CS-3,4; NT-2), knowing and making clear the interdependencies between organisations (NT-1–3), and the importance of taking a long-term approach to evaluation to allow for return on investment and for behaviour change and adjusted use of health services to embed (NT-2). The value proposition of the service (see above) needs to be clear in terms of benefits to patients, for staff and in the business case to developers and commissioners. Staff understood, especially in sites with more established technology-enabled remote monitoring services, that this can emerge over time as services respond flexibly to changes in demand and service delivery (RC-1–3; NT-1).

Discussion

We set out to address four research questions relating to the use of TERM for COPD and reflect on each in turn:

1. How, where, why and by whom is TERM being used in the COPD care pathway, who is it for and how does it help to provide care to patients?

Technology-enabled remote monitoring services for COPD were employed in a variety of NHS service settings, with different patient groups, at different points in the care pathway, and for different purposes. While all models included some kind of information exchange between patient and healthcare professional, there was variation in the intensity and degree of exchange and in (staff and patient) perception of usage. Variation was also seen in referral pathways, onboarding approaches and escalation protocols. Multiple types of technology were in use within and between sites, and technologies were often bespoke versions adapted to meet local needs. It is striking that much of the variation is locally driven and based on perceptions of local decision-makers as to the type of service that is needed and that can be afforded. It is less clear on what evidence base service design decisions are made and research is needed on the themes of warranted versus unwarranted variation.

2. What can we learn from implementation of TERM in different patient populations?

Appetite for services which could provide timelier access to care accelerated in direct response to the COVID-19 pandemic and subsequent roll out of virtual wards as part of the remote monitoring 'ecosystem'. Indeed, analysis surfaced a continuum of TERM services on offer, varying in intensity, purpose, scope and scale. Mature sites drew on existing infrastructure and recognition of legacy systems when transitioning to TERM and experience across all four sites illustrates the importance of ensuring that new systems do not simply layer over old ones but work with them in an effort to move towards efficiency, care quality and user experience. Equally, systems have to be able to communicate with one another effectively. As technology-enabled services continue to evolve, interoperability and the supporting infrastructure must remain key strategic priorities, revisited regularly to ensure alignment with broader goals.

Staff and patient participants by and large described positive experiences of using TERM services for COPD, attributed to a clear value proposition, staff and patient buy-in, and suitable technologies provided as part of a wider service. However, challenges were also apparent and were attributed to poor communication of service purpose, poor service delivery and service decommissioning (patients), and increased workload, poor interoperability and service sustainability (staff). These influences point to the sociotechnical nature of technology-enabled remote monitoring COPD pathways and the need to balance tensions in perceived value and purpose. Staff expressed pessimism around the commitment of regional and national bodies' approaches towards resourcing and endorsing TERM for COPD, pointing to the importance of sustainable service models in supporting patient engagement and staff buy-in, and realising health and economic outcomes.

3. What are understood to be the key mechanisms of action in TERM for COPD: for example, measurement of physiological data, patient education?

Rather than focusing on the granularity of the technological offering, this study surfaced key insights into the ways in which patients and staff engaged with remote monitoring services, and our data illustrated the multiple contextual factors which may be leveraged in order to support effective implementation. Recognition that these services influence care provision on a system level is key, as is clarity of purpose and value proposition to patients and staff alike. Stakeholders may have different (and implicit) conceptualisations of the meaning of 'value': a shared understanding is crucial for buy-in from all stakeholders. Using or building on existing services with

a focus on platform interoperability allows services to address contextual clinical need safely while maintaining a sustainable workload.

4. What can we learn from implementation and use of existing TERM (by patients and clinicians) that can inform potential rapid take up and use in the context of winter planning, and beyond?

Fifteen years ago, Norris and colleagues argued that 'The ubiquity of the [mobile] technology meant that its introduction into the healthcare mainstream was inevitable and that barriers would gradually dissolve as the technology advanced and the benefits became more apparent and commonly available' (p. 249).[46] This remains enormously optimistic. While technology is increasingly accessible, our findings affirm that it is by no means 'commonly available' but rather accessible to those with the knowledge, skills and resources to access and use it.[47] While we acknowledge the limited patient voices within our evaluation, our analysis across the data set suggests that embedding and adaptation of TERM services for COPD depends on the acknowledgment of digital exclusion and hesitancy. The technologies adopted by all four sites hold potential to facilitate access to COPD-related care; however, there is a risk of exacerbating existing inequalities if the needs of diverse types of patients are not considered and addressed.

For example, we found that patients' suitability for remote monitoring services was evaluated by sites based on clinical eligibility and technological readiness (e.g. smartphone ownership, internet access). However, this approach can overlook significant barriers to engagement, including cognitive, physical, cultural, and literacy challenges. Many patients face multiple disadvantages that intersect to further impact their ability to navigate and use technology-enabled services. All patients should have an equal opportunity to learn about and access TERM services. This means that multiple recruitment and onboarding approaches are essential, designed with diverse patient needs in mind. To that end, we have worked with patients to co-design patient-facing resources to be used by TERM service sites alongside existing materials [to be reported at a later date].

There remain significant challenges for widespread adoption and implementation of TERM services. Our findings add to existing evidence about the limited focus on sense-making and co-production of buy-in on value propositions, understanding purpose and benefit, establishing value, impact on roles and responsibilities and ways in which implementation might be reconfigured by using contextual knowledge and insight.

Equality, diversity and inclusion

Participant representation

The DECIDE programme is underpinned by considerations of inequality (Shaw *et al.*, forthcoming). The study was grounded in qualitative methods seeking breadth of representation. While the rapidity of the project placed boundaries around the scope and scale of evaluation, this meant we were able to (a) surface how, where and with whom TERM services are being used *in practice*, (b) explore how this is perceived and valued by clinical, commissioning, and administrative professionals and patients, (c) capture varied lived experiences of managing a respiratory condition and (d) ensure patient/service user narratives informed the design of research and patient-facing materials.

Representation in the research team

The research team bring varied disciplinary backgrounds and areas of expertise including (but not limited to) qualitative and participatory approaches to health service evaluation, digital innovation, patient experiences and equity. We ensured a wide range of voices with input from the DECIDE User Advisory Group and project steering group.

Strengths and limitations

This rapid evaluation is small-scale and conducted over a period of 6 months. Interviews with staff provided a snapshot of experiences. We did not gather data from people unable to access TERM services; we heard about inequity of access from advocates, professionals and other patients. We are limited in our ability to foreground service user experience of TERM for COPD. Service evaluations of implementation of technologies typically require a mixed methods analysis of data regarding costs and impact but this was limited. However, our study design allowed us to collect qualitative data about TERM services, which centred on interpretations of situated experiences from a range of sites describing a breadth of models and views. Recruitment to the interviews and workshops utilised a snowball sampling approach, which allowed us to access key service providers in a complex system and to give voice to otherwise hard to reach patient participants. That said, participants were overwhelmingly female, and rapidity of the evaluation did not allow for collection of additional demographic data, potentially limiting transferability. Scoping work conducted prior to the main study sharpened the

focus of the rapid evaluation. Interviews with patients provided insight into the lived experience of managing chronic respiratory health conditions and supported the development of patient facing resources.

Future research

Future research into TERM requires evidence-based approaches and mechanisms for shared learning. Establishing a community of practice may help facilitate ongoing evaluation and knowledge exchange, fostering continuous improvement. Current data on the adoption, use, and impact of TERM in COPD is limited, highlighting the need for creative, mixed-method evaluation approaches that combine qualitative and quantitative data, including both formative (process-focused) and summative (outcome-focused) assessments. Such approaches would strengthen an understanding of key mechanisms of action in such services and how they 'work', for whom and which contexts. Our exploratory research is a crucial first step toward understanding their impact. However, future evaluations require robust data collection infrastructure focused on patient outcomes, healthcare utilisation and cost-effectiveness. Furthermore, an in-depth analysis of workplace culture from a social science perspective would provide valuable insights. Future research should also move beyond individual pilot evaluations to comparative studies that offer broader insights. However, these evaluations must be flexible enough to account for the diverse, context-specific nature of TERM services across different healthcare settings – there is no one-size-fits-all approach. Patient and caregiver voices must be central to TERM research: incorporating their feedback will ensure TERM interventions are responsive to real-world needs. Finally, understanding and influencing policy drivers is essential for scaling TERM initiatives: aligning TERM with broader healthcare goals will support sustainable implementation and drive meaningful improvements in COPD management.

Conclusions

Technology-enabled remote monitoring for COPD occurs along a continuum of scope and scale. Technology-enabled care pathways have some common overarching features, but there is significant variation across contexts and patient cohorts. Implementation is underpinned by complex tensions between technology functionalities, perceived value and purpose, and organisational capabilities and capacities. To enable contextualised understanding of the implementation and use of TERM services in a range of settings we set out recommendations (see *Appendix 2*) for policy-makers and commissioners, healthcare providers and supporting workforce, patients, and those designing and conducting future evaluation of such services. Future embedding and adaptation of TERM services for COPD will require that patients have an equal opportunity to learn about and access TERM services.

Additional information

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Data-sharing statement

All data requests should be submitted to the corresponding author for consideration. Access to anonymised data may be granted following review.

Ethics statement

This rapid evaluation was reviewed by the Oxford Joint Research Office classification committee, which determined that it is service evaluation on 8 May 2024. The study was conducted in accordance with the World Medical Association Declaration of Helsinki.

Information governance statement

The University of Oxford is committed to handling all personal information in line with the UK Data Protection Act (2018) and the General Data Protection Regulation (EU GDPR) 2016/679. Under the Data Protection legislation, The University of Oxford is the Data Controller, and you can find out more about how we handle personal data, including how to exercise your individual rights and the contact details for our Data Protection Officer here: https://compliance.admin.ox.ac.uk/data-protection-policy

Disclosure of interests

Full disclosure of interests: Completed ICMJE forms for all authors, including all related interests, are available in the toolkit on the NIHR Journals Library report publication page at https://doi.org/10.3310/GJSS1422.

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About this article

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List of supplementary material

Report Supplementary Material 1
Decide COPD Rapid Evaluation Final Report

Supplementary material can be found on the NIHR Journals Library report page (https://doi.org/10.3310/10.3310/GJSS1422).

Supplementary material has been provided by the authors to support the report and any files provided at submission will have been seen by peer reviewers, but not extensively reviewed. Any supplementary material provided at a later stage in the process may not have been peer reviewed.

The supplementary materials (which include but are not limited to related publications, patient information leaflets and questionnaires) are provided to support and contextualise the publication. Every effort has been made to obtain the necessary permissions for reproduction, to credit original sources appropriately, and to respect copyright requirements. However, despite our diligence, we acknowledge the possibility of unintentional omissions or errors and we welcome notifications of any concerns regarding copyright or permissions.

List of abbreviations

A&E	accident and emergency
CLD	chronic lung disease
CNS	Clinical Nurse Specialist
COPD	chronic obstructive pulmonary disease
DAP	Digital Access Point
DCH	Digital Care Hub
DECIDE	Digitally Enabled Care in Diverse Environments
ED	emergency department
EVA	Early Value Assessment
GP	general practitioner
ICB	Integrated Care Board
NASSS	non-adoption, abandonment and challenges to scale-up, spread and sustainability
NICE	National Institute for Health and Care Excellence
PIFU	patient-initiated follow-up
PPIE	patient and public involvement and engagement
TERM	technology-enabled remote monitoring

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Appendix 1 Detailed case studies of participating sites using technology-enabled remote monitoring to support chronic obstructive pulmonary disease patients

This appendix presents detailed case studies relating to four sites in England that were included in the NIHR-funded rapid evaluation of TERM of COPD. It accompanies the journal paper [https://doi.org/10.3310/GJSS1422] reporting key findings from the study.

The four case studies presented here are summarised in *Table 2* in the main findings paper. Case study write-ups stem from data collection conducted in June–July 2024, which included interviews with 19 clinical and non-clinical staff (3–7 per site) along with analysis of 18 documents (e.g. evaluation plans/reports, protocols). Interviewees included members of staff in a variety of roles relating to management and delivery of the service, as well as team members involved in external evaluations of the services.

This appendix presents initial thematic analysis focused on how, where, why and by whom TERM is being used in the COPD care pathway in each of the four sites, and what can we learn from implementation and use of TERM about what works well and what gets in the way. Further analysis and synthesis of learning across sites was then guided by the NASSS framework,[30] focused on what we can learn from implementation and use of TERM across the four sites and is presented in the main paper.

Given the small number of sites and focused data collection, and in the interests of anonymity all sites, technologies and individuals and their roles have been de-identified. We use pseudonyms for case study sites and technologies, and attribute data extracts from interviews by interview number. While we draw on diverse local documents (e.g. district planning, public health reports) to provide context for each case study site, in the interests of anonymity have elected not to reference these.

To aid understanding, we present case studies below in the order in which they are referred to in the main findings paper, and particularly in *Table 2*:

- North Town NHS Foundation Trust COPD24 service
- City South Integrated Care System technology-enabled remote monitoring pilot
- NHS Rural Care planned shift from remote self-management to remote monitoring
- River Valley Primary Care Network smart inhaler technology pilot.

North Town NHS Foundation Trust COPD24 Service

Background and origins of the remote monitoring service

North Town NHS Foundation Trust ('North Town') is an integrated NHS hospital and community services trust providing acute, elective, specialist and community care in Northeast England. COPD is a significant problem in this area, with 2.03% of the population living with a formal diagnosis of the condition (the national average is 1.87%), 4.5% of people over the age of 40 living with COPD, and 1145 COPD unplanned admissions in the area (2022–23) with 25% of those patients readmitted within 30 days. More than 150 languages are spoken across the area, 12% of people do not use English as their main language.

In October 2020, the COVID-19 pandemic prompted development of a proactive model of care for 50 COPD patients in the locality, who had a history of accident and emergency (A&E) attendances and admissions. It offered remote monitoring and 24/7 direct access to a clinical (NHS) telephone helpline should patient and carers need advice, support or reassurance at any time. The full service was established in 2021 and funded via a combination of central (NHSE) digital transformation funds and local healthcare partnership funding until 31 March 2024. The COPD24 service targets patients living at home with severe or very severe COPD with the aim of:

- improving patient experiences of care, reducing patient hospitalisations and A&E attendances
- empowering patients to have more control over and ability to manage and understand their condition, educate themselves in how to look after their health via lifestyle changes and identify deterioration in their condition in advance of exacerbation
- providing 24/7 clinical support (NHS) via telephone and app interactions; and
- improving operational efficiency and costs of care.

The remote monitoring service built on a pre-existing Digital Care Hub (DCH), established in 2011 and delivering several remote services (e.g. the COVID Virtual Ward and

COPD pneumonia Virtual Ward). The COPD24 service is aimed at patients with moderate to very severe COPD, and is provided by staff operating out of the DCH, all of whom are employed by North Town NHS Foundation Trust.

Core components of the remote monitoring pathway and how, when and by whom technology is used

Overview of the service and technology

The COPD24 service is a collaboration between the North Town NHS Foundation Trust DCH and GenieOx, a European company (with offices in the UK) specialising in digitally enabled monitoring via a smartphone. The service comprises two modes of service delivery, a paper diary method or the use of the GenieOx app. For the technology-enabled service (i.e. app-based), users record oximeter readings measuring blood oxygen saturation levels and pulse rate readings into the app. Data entered into the app is automatically transmitted to the DCH and monitored by Band 6 Clinical Assessors. Abnormal readings trigger an alert and prompt follow-up with the patient. All patients can also telephone the service for support and advice at any time. The app and information pack (provided alongside the app) both contain educational and self-care materials to help patients understand and improve the management of their condition and recognise and act on early signs of an exacerbation. The app is available in eight languages, with additional language barriers addressed by staff who speak some European and South Asian languages, use of a professional interpreting service, or support from an English-speaking relative (NT-4, NT-6). Patients who are deemed eligible but who do not have access to smartphones, SIM cards or reliable Wi-Fi have been supported in the past through initiatives to provide connectivity with local companies, such as Tesco and Morrisons (NT-4).

Identifying suitable patients

The COPD24 service is aimed at patients with moderate to very severe COPD. Eligible patients are identified in various ways, including: review of spirometry results (pulmonary function breathing test) or of the Medical Research Council breathlessness score completed in their general practitioner (GP) practice and recorded in the patient's electronic patient record, via GP referral based on a health professional's clinical judgement of being suitable for the service, through emergency department (ED) attendance or through hospital admissions data. Self-referral is also permitted. Primary care providers sometimes refer patients based on a patient's clinical history. It appears that some patients with mild COPD are being referred to the service by GPs due to perceived value in being able to access 24/7 support which diverts them away from general practice (NT-4). This has a knock-on effect for the service, with some people registered who do not require clinical support of this nature, and others using the COPD24 hub as a proxy for general practice, contacting the service for support in accessing medications for conditions other than COPD for example (NT-1, NT-4–6).

The COPD24 service supports community teams in facilitating patient discharge and early discharge from secondary care. Patients discharged from secondary care with moderate or severe COPD are offered remote monitoring of their condition at home. Clinical Nurse Specialist (CNS) Respiratory Teams handling the discharge and members of the DCH visit the patient in hospital to explain the remote monitoring service and demonstrate how to use the app or the paper diary method. The hope is that this face-to-face guidance encourages otherwise-unsure patients or their carers to choose the app method for self-monitoring. Once discharged, patients are visited by Respiratory CNS or Community Matrons who provide further support with onboarding.

Onboarding to the service

Patients joining the service initially receive an introductory telephone call from a healthcare assistant (Band 3), who explains the service and asks the patient whether they wish to use the digital or paper version. Those selecting the digital option are sent a pack containing a pulse oximeter and instructions on how to use it; receive a leaflet about how they would recognise being unwell (with the aim of supporting patients to understand their 'normal' range of oximeter readings and experience of symptoms); and have a follow-up call with the healthcare assistant 2 weeks later with further support and information offered including how to download and set up the app. On-boarding takes 30–45 minutes by phone, plus the follow-up call.

Staff acknowledge that on-boarding is critical for understanding patients and their needs, but that it requires strong communications skills and lived experience of learning to use technology (NT-1, NT-4, NT-5). Information packs sent to patients are useful although it is recognised that not all patients can understand them and others do not engage with them at all (NT-5). Furthermore, on-boarding can involve cold-calling people who have either forgotten that they would be contacted by the COPD24 team or were not aware that they had been referred to the service (NT-1).

An average of 130 patients per month have been onboarded to COPD24 since August 2021, with an

active caseload of 3754 in October 2023. Patients using the digital service tend to be elderly (over 70), often male, and living in more deprived areas. The local Joint Strategic Needs Assessment Report indicates that many of the people with COPD from more deprived and minority ethnic communities in particular are less likely to present to the health service until they are hospitalised. This reinforces the importance of increasing referrals for these communities from ED and ward-based teams (currently 22% of referrals) as a means of ensuring equity and supporting patients who may have previously been unknown to primary care.

To date, around half the caseload of patients who have been recommended to use the COPD24 service have activated the app. In addition, many accounts have been created but are still to be activated, suggesting a cohort of patients with a degree of digital confidence and desire to engage via the technology-enabled service, but who may need additional support to do so (NT-4). To accelerate on-boarding, the service began messaging patients (using a dedicated messaging platform) in September 2023, with 1100 messages sent to patients on the waiting list providing details of how to access the GenieOx app, and 200 patients then successfully self-onboarded (NT-1). Plans are for this approach to continue, with the on-boarding administrator supporting patients who are less digitally able or reluctant to engage.

Technology-enabled remote monitoring care pathway

Patients who choose the TERM service receive hyperlinked instructions by e-mail or text on how to download the app to their smartphone and how to enter readings. The individual patient's normal oximeter thresholds are pre-set within the app and oximeter readings inputted into the app are sent electronically to a dashboard accessed by the DCH clinical team. Other measurements input into the app include completion of a bespoke questionnaire inviting the patient to self-report a 'Know Your Normal' score, and further measures relating to extra medication, sputum, oedema, and temperature. Patients can enter these as and when required. If a patient's readings are outside their normal thresholds, alerts are received on the digital dashboard at the DCH:

- Red alert – a text is sent telling the patient that that DCH staff are aware of the results and will call within the next 5 minutes (therefore, not to call 999).
- Amber alert – a text is sent requesting the patient or their carer to call the DCH for clinical support 24/7, if needed.

Real-time monitoring of patient-reported data is strongly perceived as supporting quick decision-making. According to all staff we interviewed (clinical and non-clinical), the personal calibration of individual-level algorithms and connection to the patient's medication record means that individuals can be assessed quickly and supported appropriately, often as an exacerbation is starting and preventing hospital admission. The service now handles over 1000 telephone consultations and over 1000 'red' app alerts a month – at the time of the evaluation, 90% required no onward referral and 1% required an ambulance. The majority of app alerts relate to oxygen saturation levels (58%), sputum (16%) and medication (14%), which are early indicators of exacerbation risk, and which are followed up via message in the app or telephone. Monthly multidisciplinary clinical governance meetings between the DCH manager, DCH clinical lead, GPs, respiratory consultants, and respiratory specialist nurses involve examining a list of patients who are either 'high alerters' or ringing in frequently for DCH support. This meeting triggers proactive calls from DCH staff to check in with these patients and assess whether they need changes in their medication, support with their breathing techniques, assessment for home oxygen support, reassurance, palliative care, community care support or escalation to GPs or ED. Risk stratification, improvement of clinical consultation templates and the introduction of electronic prompts for less urgent alerts have been implemented, which allow staff to respond more quickly to highest risk alerts (NT-1, NT-2). DCH staff have access to patient records via the underlying clinical computer system, which enables staff to view patient interactions with primary, community and secondary care. While this provides opportunities for real time audit and supports clinical decision-making and care coordination, the clinical system is not interoperable with other healthcare provider networks in the adjacent geographical area.

It is notable that once set up on the system, all patients are able to access the same service, regardless of health status. Although the service is grounded in principles of proactive remote monitoring and 'just-in-time' support, in reality, many patients' day-to-day experience of the service is one of supported self-management, due to minimal clinical need. Indeed, many patients do not actively use the service at all for long periods of time (i.e. inputting data or contacting the service by telephone) until they perceive a deterioration in their health (NT-5). Therefore, the same patient can cycle through the service as supported self-management *and* proactive remote monitoring and back to supported self-management within a short time frame. The service is provided with the expectation that COPD patients will access it

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long term, due to the fluctuating and seasonal nature of the condition. As a result, patients are not actively offboarded or removed from the digital version of the remote monitoring service unless the patient themselves requests this. Some patients may choose to use the paper-based version instead (NT-7).

Workforce and staff experiences of the remote monitoring pathway and technology

The DCH is made up of approximately 50 staff including: DCH Leadership and Management, a Clinical Consultant Lead, Band 3 Health Care Assistants responsible for onboarding patients, Band 3 Healthcare Assistants who take the first line calls into the hub and manage or escalate calls to Band 6 and 7 Clinical Assessors, paramedics and administrative staff. All staff work across the telephone support lines in the hub but may have particular expertise in one area (e.g. palliative or COPD care). All DCH staff have a 6-week induction process. The service is supported and promoted in the community by a respiratory nurse and community matrons, GPs and GP support staff, and ED clinicians.

Skilled and motivated staff support

Digital Care Hub staff describe bringing extensive clinical skills to the role (most have a background working in emergency service call centres, as community matrons or specialist staff in palliative or respiratory care), and strong interpersonal skills (NT-5–7). There appears to be high professional satisfaction (despite recent disinvestment – see below), with positive descriptions of working in the hub (NT-2), low staff turnover; and good working relationships with adjacent teams (e.g. ambulance teams) (NT-4). Staff describe feeling motivated by regular positive feedback from leadership of the service, and by the wider showcasing of the COPD24 service (NT-2–4).

Sustaining sufficient staff capacity

Workforce and staffing challenges include susceptibility to staff absence. While there is some flexibility in filling gaps in personnel day to day (e.g. given knowledge of roles and ability to backfill roles as needed), this is a specialised service requiring training and the service is therefore unable to draw on bank services. This is challenging given the current backlog of patients (est, 4000) who cannot currently be onboarded due to staff shortages.

Reported user engagement with the remote monitoring pathway and technology

Key themes on patient (and carer) engagement with, and use of the service, are highlighted below – these are drawn from an external mixed methods evaluation of the service (conducted in 2023), and analysis of interviews with staff.

Immediacy of care

Patients have described positive perceptions of the immediacy with which support can be accessed and the sense of security this provides. For example, receiving a text message asking them to retake oximeter readings, which is then followed up by a person on the phone if a deterioration is detected. Patients can access the service by telephone and have described the importance of being able to do this at times of heightened anxiety. This is described in the external evaluation and was raised spontaneously across staff interviews in this rapid evaluation.

Reassurance

Anxiety is a significant comorbidity of COPD that exacerbates symptoms and breathlessness and is often worse at night: people have described the value of being 'calmed down' by a real person at the end of the phone (when all but emergency services are otherwise unavailable), reassured and supported to manage the situation without the need for an ambulance should an emergency arise (regardless of time of day), people also feel reassured of a rapid response and 'knowing someone is there' (NT-INT-5,6). The immediacy and proactivity of response are especially valued by those living alone.

Psychosocial support

Patients have also talked about the importance of receiving psychosocial support which goes beyond clinical care: the North Town service supports engagement with social services, befriending services, carer support, charities, and hospice support; it also connects people to community organisations and charities that help people with a wide range of financial problems including paying bills, buying food, heating their homes, and organising home repairs (NT-1). Indeed, the external evaluation specifically highlighted the emotional and social benefits of the service, stating that perceived support calms and comforts patients and directly influences their sense of well-being and control of their COPD.

Improved self-management

In interviews, staff relayed how patients benefit from being supported to understand what is 'normal' for them in managing their COPD. In particular, understanding the difference between a fluctuation in symptoms and an imminent exacerbation reduces anxiety and use of the remote monitoring service itself. Getting to the point where a patient 'knows their own normal' can take time and may involve increased use of the system while new

behaviour and self-management beds in. People describe how important it is to be able to talk to a person about this process and how the North Town telephone service supports this.

'Good usage' of the service

The nature of the service means that patients may reach out to the DCH team for support in accessing prescriptions or primary care appointments. Patients like this aspect of the service; however, DCH staff indicate that this is something they feel compelled to do but do not always feel is an appropriate use of the service (NT-5–7). Given the nature of the service, and breadth of patients, there are differing ideas about what 'good' use of the service looks like. Staff relay how some patients feel compelled to record their symptoms in the app every day and this can cause stress to patients (NT-6); while others become reliant on the readings for understanding their health. Some DCH staff believe and communicate that optimal use of the system involves daily recording of symptoms while others believe the system should only be used at the point when exacerbation is detected by the patient.

Understanding what the service is for (what is in and what is out of scope of intended use)

The way in which the service is used is closely linked to patients' and staff's understanding of service purpose and parameters. Patients do not always understand what the service is for (and not for), what it involves, and why they have been invited to join it. Onboarding calls can be met with confusion (or outright scepticism, with some patients fearing they are being scammed) (NT-1, NT-4). Patients have described how they agreed to register with the service because it seemed to be a good alternative to trying to access primary care appointments.

Digital exclusion and hesitancy

The area around North Town hospital includes pockets of high deprivation, low literacy (digital and health), unpredictable access to technology and wide cultural variation (NT-4). Although the COPD24 service provides reactive and proactive monitoring, this model only works if the patient wishes, and is able, to engage with self-monitoring and self-care. Therefore, not only do patients need to have access to technology and data, but a degree of engagement and compliance is crucial. This kind of engagement on the part of patients is highly dependent on the provision of clear, acceptable and accessible information. Language, physical and literacy challenges have made it more difficult for some patients to understand verbal or written information; people with particular needs might require more interaction during the on-boarding process to ensure they understand the purpose of the COPD24 service.

Impact, evaluation and opportunities

Findings from this rapid evaluation indicate that there are significant foundations on which to build: implementation of a range of remote monitoring technologies across clinical domains; extensive understanding of remote monitoring technologies by staff involved in delivering the TERM COPD service [including a good relationship with GenieOx, described by staff as having a good '*cultural fit*' with the COPD24 service (NT-1)]; supportive and embedded staffing and IT infrastructure; established workforce with deep specialist knowledge and competencies around clinical and non-clinical aspects of remote monitoring and allied technologies; and established culture and leadership for implementation and adaptive development of remote monitoring. The external evaluation referenced above indicates that in the 3 months following referral into the COPD24 service, patients experienced a 47% decrease in non-elective admissions for COPD. Local data show the same cohort experienced 33% fewer A&E attendances linked to 'airways/breathing' in the same time frame. Benefits continue over time, albeit at a lower level, indicating the importance of ongoing and proactive engagement with the caseload, and perhaps reflecting the progressive nature of the disease. External qualitative evaluation indicates the service is highly valued by patients and healthcare professionals and has the greatest impact for those within its mainly elderly patient cohort who engage digitally via the App (rather than via the paper-based service). External evaluation did not include an economic element, though there is strong indication that COPD24 reduces significant demand and associated costs across numerous services (including for COPD) (NT-2,3).

The external evaluation strongly suggests that the service has been highly rated by patients and healthcare professionals and is showing financial impact (e.g. on cost of non-elective admissions). However, there are questions over the future of the service, particularly beyond North Town. This has come about in the context of financial pressures in the wider health and care system, and a strategic decision by the ICB to invest funds elsewhere. This has resulted in a reduced COPD24 service from April 2024, with patients outside of North Town offboarded. The ICB System, Finance and Performance committee requested additional information relating to urgent care data, about why impact falls over time, how the service

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addresses co-morbidity, potential synergies with Virtual Wards, and alternative options for continuing a scaled back service (NT-1, NT-2).

City South Integrated Care System technology-enabled remote monitoring pilot

Background and origins of the remote monitoring service

City South Integrated Care System has one of the highest COPD emergency admission rates and hospital presentations in the UK, with one in five admissions for respiratory illness reported as due to COPD between 2020–1 and 2022–3. Over half the premature mortality reported due to respiratory illness is caused by COPD. The highest rates of COPD-related hospitalisation are reported for people living in the most deprived communities. The remote monitoring pilot focuses on monitoring COPD patients needing most support. The pilot was introduced following the success of acute virtual wards (CS-1), with three main goals:

- providing preventative care/reducing secondary care admissions (CS-1,3,4)
- increasing patient empowerment (CS-2–4)
- reducing health inequalities (CS-1–5).

While there was overwhelming support for these aims from interviewees, there appear to be varying perceptions among staff about which is/are most important, how they influence each other, and how that translates to wider impact (CS-3–5).

Running between February and July 2024 (with a 1-month extension for selected patients), the pilot was funded by NHS England's Health Technology Adoption and Accelerator Fund. It involved TERM4COPD as the existing provider of virtual wards in the Integrated Care System, along with the Community Respiratory Team. The patient cohort was split into four tiers: patients that had three or more A&E admissions for COPD exacerbations within the last 12 months were placed in Tier 4 and offered remote monitoring, following an initial in-person assessment by the local Community Respiratory Team. Patients who experienced one to two admissions within the last 12 months were placed in Tier 3 and offered remote monitoring, with overarching clinical responsibility provided remotely by a respiratory clinician. Patients in Tiers 1 and 2 were offered an app to support self-management.

According to interviewees, the pilot was conceived with external funding requirements in mind, which shaped the way the service was then designed, delivered and evaluated (CS-3,5). On the latter, the pilot is being evaluated by the ICB according to the funder requirements including a focus on outcome measures relating to reduction of non-elective admissions, reduction in ED attendances and a lack of increase in GP appointments (CS-5).

Core components of the remote monitoring pathway and how, when and by whom technology is used

Overview of the service and technology

Tier 1 and 2 patients were not expected to need active support and monitoring and were instead provided with access to the Respirio app to manage their condition independently at home (CS-1). The app provides access to educational materials about COPD, videos on correct inhaler technique, pulmonary rehabilitation resources, symptom tracking capabilities, and more general health and well-being advice. Tier 3 patients received a TERM4COPD box with a tablet (including a SIM card with Internet data) and pulse oximeter and were offered remote monitoring provided by an in-house TERM4COPD clinical team. TERM4COPD is a remote monitoring tech provider company. Tier 4 patients were sent a TERM4COPD box with more observation equipment than Tier 3 patients. This was because of the expectation that they will at some point likely need to be stepped up to a virtual ward set up, which they could do using the same kit (CS-2). The TERM4COPD box for Tier 4 patients provided: a phone or tablet, along with a SIM card with Internet data, Bluetooth-enabled observation equipment including pulse oximeter, blood pressure machine and thermometer.

Given the focus on reducing health inequality, several adjustments were made by the TERM4COPD team to support patients and enable access to the technology-enabled service. Adjustments included:

- provision of technology needed to submit readings, including a SIM card with Internet data (to ensure access for patients without WiFi at home)
- an option to receive a daily phone call from TERM4COPD to record the readings, rather than inputting the information into the app to help with addressing digital literacy or health literacy challenges
- access to the website linked to the technology in the five languages most common in the area
- instant translation service embedded in the remote monitoring software
- the ability to video call deaf patients and communicate through sign language.

Prior to rolling out the remote monitoring service, the TERM4COPD clinical team provided 2-day in person training to respiratory specialists. This was combined with regular in-house training and discussions with Community Respiratory Team that helped build knowledge among staff on how to engage with the remote monitoring technology and how to embed it into the patient care pathway (CS-2). The Community Respiratory Team did not receive any formal training before the pilot, but shared best practice internally, for example with the most experienced member of the team giving a talk on integrating remote monitoring to caring for patients with COPD to other staff (CS-4).

Identifying suitable patients

The selection of patients who were offered the remote monitoring pilot was done through review of secondary care data, against eligibility criteria relating to four Tiers (CS-1, CS-3–5). This automated process for identifying and selecting patients saved time in the beginning. However, errors in the data led to some ineligible patients being onboarded, including some patients who did not have COPD (CS-1). Feedback from staff involved in the pilot highlighted that additional work is needed to better assess patient suitability for programme, for example combining population health eligibility with subsequent desktop review of patient notes (CS-3).

Patients in Tiers 1 and 2 (around 9000 in total) were offered the Respirio app for self-management, with access for life (CS-1). Patients who were expected to need additional support were placed in Tier 3 (around 165 patients). Selection criteria for this cohort included having experienced up to two admissions within the last 12 months. A total of 150 patients that were considered at high risk of experiencing an exacerbation, having had three or more A&E admissions for COPD exacerbations within the last 12 months, were placed in Tier 4. Patients with dementia or receiving end of life palliative care were excluded from Tier 3 and 4 (CS-2).

While it was not possible to comment on addressing wider health inequalities (see planned evaluation in section below), interviewees reported that 19% of patients onboarded to the remote monitoring pilot came from the most deprived areas in the locality (CS-2).

Onboarding to the service

Tier 1 and 2 patients were provided with access to the Respirio app. Patients identified for Tier 3 and 4 were offered the remote monitoring service by a text message in the first instance, followed up by a phone call if they did not respond to the text message. After consenting to participate, TERM4COPD staff would onboard Tier 3 and Tier 4 patients on the phone (CS-2). This initial phone call would take up to an hour, enabling the TERM4COPD team to walk patients through how to log in, what the submission process is like, what to click and when, and to ensure patients are really on board with the process (CS-2).

Once TERM4COPD staff had onboarded Tier 4 patients, they would e-mail the Community Respiratory Team informing them of the new patient. The Community Respiratory Team then scheduled an appointment with the patient to visit them at home for an in-person assessment – a 'deep dive', involving the team assessing the patients' entire respiratory history and medications and checking whether anything could be optimised (CS-1,4).

Technology-enabled remote monitoring care pathway

Tier 1 and 2 patients self-manage using the Respirio app. At the time of writing, it is unclear if any patients in Tier 2 were stepped up into Tier 3 to receive active remote monitoring.

After the initial assessment for Tier 3 and 4 patients, the TERM4COPD team would take over monitoring the patients and providing support when needed. Sometimes this support was more technical in nature (e.g. if a pulse oximeter did not give correct reading) and the TERM4COPD team would provide advice and support for the patient (CS-2). In terms of remote monitoring, Tier 3 and 4 patients submitted their oxygen saturation and short questionnaire each day between Monday and Friday at 9 a.m. (CS-2). Overall clinical responsibility for these patients lay with a respiratory clinician employed by TERM4COPD on a bank contract for 2 hours per day (CS-2). This approach was based on the assumption that Tier 3 patients would mainly need remote clinical support, predominantly in the form of prescriptions. Staff noted that it was helpful to have one clinician assigned for this cohort of patients, ensuring continuity of care (CS-2). Similarly, Tier 4 patients were offered daily remote monitoring between Monday and Friday: every day at 11 a.m. patients submitted completed oxygen saturation measurements, sputum colour and production, a completed breathlessness questionnaire and the EuroQol-5 Dimensions, five-level version to indicate how they are feeling overall (CS-2). While the Community Respiratory Team held overall clinical responsibility for Tier 4 patients, it was TERM4COPD's in-house clinical team that managed the day-to-day monitoring service, escalating patient cases to the Community Respiratory Team when needed (CS-1). The Community Respiratory Team made decisions about how to handle the more complex or difficult cases and visited patients in person when needed (CS-4). If Tier 4 patients became unwell, they were offered a weekly health coaching session (CS-2).

Patients were notified by text message at 5 p.m. each day that the service was closed for the day (CS-2).

In addition to recording symptoms, patients also had the option to send text messages to the TERM4COPD team, which the TERM4COPD team then needed to reply to. It was reported in interviews that the TERM4COPD clinical team tended to get about 10 text messages a day, which tended to be questions, for example about medications, or equipment (e.g. needing a new thermometer) (CS-2). Patients also had the option of opting into a call from the TERM4COPD clinical team – the last question in questionnaire was 'would you like a call with a clinician?'. In these cases, even if submitted readings appeared fine, the TERM4COPD team would talk with the patients about concerns they may have (CS-2).

The remote monitoring of Tier 3 and 4 patients required the TERM4COPD clinical team to assess data submitted electronically, which would then be automatically classified as red, amber or green (CS-2). For Tier 4, if the patient was fine and their results displayed in green, they did not need to take any action except acknowledging their results. If the alerting system flagged a patient as amber, the TERM4COPD clinical team needed to reach a decision on whether to close the case or to escalate the problem to the Community Respiratory Team (a red alert would automatically lead to an escalation to the team).

TERM4COPD's decision-making process typically involved calling the patient in the first instance. This appeared to be due to the information recorded electronically not being sufficient to make a clinical judgement about next steps (CS-2). The TERM4COPD clinical staff member would then record the information regarding how the alert was dealt with in the patient notes, which was saved on the TERM4COPD system. In more complex cases, TERM4COPD clinicians sought input from the Community Respiratory Team (as respiratory specialists) who carried the overall clinical responsibility for Tier 4 patients (CS-1).

Once the patient case reached the Community Respiratory Team, the assigned clinical team member would decide on the next course of action. This included deciding whether to call an ambulance immediately or, alternatively, redirect them to primary care (CS-4). Community Respiratory Team members also made many referrals to other care providers such as pulmonary rehabilitation, as well as getting the patient to use the Respirio app more often, where they could do their rehabilitation virtually. They also facilitated smoking cessation referrals, informed patients about vaccinations, encouraged them to do self-referrals for drug and alcohol rehabilitation, or to occupational therapists. Community Respiratory Team clinical staff also referred patients to a fatigue and breathlessness course at their local hospice (CS-4). In some cases, Community Respiratory Team staff would link patients back with TERM4COPD for health coaching to assist with various social needs, such as accessing benefits or making blue badge applications (CS-4).

If a patient needed to be stepped up, the Community Respiratory Team members could do that by referring them to a virtual ward, where they would be monitored more closely for a week or two before being stepped back down to Tier 4 (CS-INT4). Both the Community Respiratory Team and TERM4COPD clinical teams involved in the remote monitoring pilot agreed that one of the biggest benefits of the programme was the ability to step patients up to the virtual ward and back down as needed (CS-1–5). Community Respiratory Team and TERM4COPD clinical teams met three times a week to discuss patient cases (CS-1,4).

Offboarding

For Tier 3 and 4 patients, once their condition stabilised, they were stepped down within the monitoring system. After patients are discharged from Tier 3, TERM4COPD arranged the collection of the box (CS-2). Patients continued to use Respirio for self-management. All patients were to be discharged from the service by the end of August 2024 but were to retain access to the Respirio app (CS-1,4).

During the pilot a few patients asked to be discharged from the service because they did not want to be called so frequently (staff reported that this was typically due to work or other activity that meant they were busy) (CS-2). A few patients asked to be discharged due to the intensity of the service or with the technology (CS-4). In cases where patients had health anxiety, interviewees relayed how the clinical team felt the level of needed surveillance was not warranted (CS-3).

There was a recognition by staff that if the remote monitoring service was to be offered longer term, it would be very difficult to know when to step-down, with some patients expected to be going through periodic phases of stability and instability (CS-1,4). If the service was to be offered longer term, interviewees indicated that clear step-down procedures would need to be put in place there was a sense that PIFU could be beneficial (CS-1,4).

Workforce experiences of the remote monitoring pathway and technology

The experience of providing remote monitoring by health service staff has been varied. Key themes relate to the following areas.

Collaboration across clinical teams

TERM4COPD and the Community Respiratory Team played different roles throughout the pilot, also differing significantly with regard to who they relied on for running the service internally. Day-to-day monitoring was provided by the TERM4COPD team, which consisted of two senior nurse leads, around four remote monitoring clinicians, three health coaches doing calls, and a senior respiratory clinician with overarching clinical responsibility for Tier 3 patients (CS-2). The two TERM4COPD-based senior clinical leads made overarching clinical decisions day-to-day, escalating to the senior respiratory clinician for Tier 3 patients. This meant that on any given day, the TERM4COPD clinical team supporting the pilot could range between eight and eleven people (CS-2). The difference in numbers reflected the fact that once patients' condition stabilised, they were only required to submit their readings two or three times a week. This meant that certain days were busier than others and required more TERM4COPD staff on board. While flexible in numbers, the TERM4COPD clinical team remained roughly the same throughout the pilot (CS-2).

For the Community Respiratory Team, the remote monitoring service was overseen by five senior clinicians. Interviewees explained that the team was small given that this was only a pilot service (CS-4). Senior clinicians were selected because of the level of complexity of Tier 4 patients, requiring the team to make difficult decisions on how to best support their most complex patients and to mitigate some of the risks associated with remote care (CS-3,4). The Community Respiratory Team was originally trying to recruit a respiratory consultant to head this work, but that proved very difficult, and they ended up running the pilot themselves (CS-3,4). As a result of the high volume of pilot-related work, the Community Respiratory Team initially tried to swap responsibilities for remote monitoring between themselves, meaning that they wanted to rotate responsibility for the pilot each day, that way preserving more time for their regular tasks (CS-1). This proved to be challenging given that if TERM4COPD needed to escalate a patient, they would simply speak to whoever happened to be available (CS-1). Interviewees noted that TERM4COPD sometimes escalated up to 30 patients at the same time, meaning that multiple members of the Community Respiratory Team needed to attend to that patient load. In other instances, various members of the Community Respiratory Team would still need to respond to escalations of patients because they needed to be visited in person within their specific geographical areas of responsibility (CS-1).

The escalation process between the Community Respiratory Team and TERM4COPD was something that both teams took time to adjust to (CS-1–4). The Community Respiratory Team clinical members noted that sometimes they would receive cases that they felt they did not need to address, while other times cases were not escalated when and staff felt they could have been (CS-1). Many of these issues related to the pilot being very protocol driven, meaning that clinical judgement was sometimes overpowered by numerical data (CS-1,3,4). Interviewees talked about how this smoothed out as the two teams learned about each other's working styles and decision-making processes (CS-2–4).

Balancing access and dependence

Healthcare staff that we interviewed agreed that remote monitoring for COPD patients needing most support, including access to holistic care, has multiple benefits linked to the intensity of engagement with them (CS-1–4). From the ability to engage patients who would typically be lost in follow-up, to being able to form a relationship of trust with a patient cohort that had perhaps struggled to engage with mainstream healthcare system; and to ensure not only the intensity and duration of care, but its specialist nature (CS-2–4). This meant that there was significant work generated by remote monitoring, not least given the complexity of the patient population (CS-3). Staff were also aware that the intensity of the service also brought risks of creating over-dependence on the service, talked about the fine line between 'caring' and 'over-caring', and the service having perhaps providing too much data and subsequent engagement (CS-3,4). This could lead to additional work and over-investigation, as well as patient reliance on the scores and numbers recorded (CS-3). In interviews, two staff members reflected on how the pilot exposed the limitations of the current healthcare system in processing and responding to vast amounts of patient data (CS-3,4). Additionally, these same staff members noted that some patients may perceive this level of health surveillance overwhelming (CS-3,4).

Administrative workload

There appeared to be more administrative work during the pilot than originally anticipated (CS-1,3,4). Systems were not synchronised to manage the patient load (CS-1–5). Instead, the onboarding and the escalation processes relied on TERM4COPD team members emailing Community Respiratory Team with a list of patients that required an initial (post-onboarding) or additional (post-escalation)

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assessment. For initial in-person assessments, Community Respiratory Team members needed to add that information to their own spreadsheet, including the patient's name, post code and which clinician is assigned to them, followed by scheduling an appointment by cross-checking staff availability against their internal rota (CS-1). Once all that was done, the Community Respiratory Team needed to then call the patient and offer them the slot. This way of organising work meant that if staff members were too busy to manage their inbox in a timely manner, the whole process become delayed (CS-1). Part of the problem was access, given that not everyone was allowed to see the data they input into the spreadsheet (CS-1). Ideally, all those systems would be able to talk to each other, enabling a searchable diary system with potential initial and follow-up assessment slots, but this was not set up because of how quickly the pilot started.

Patient escalations also added to the existing workload of Community Respiratory Team and, at times, put pressure on staffing and delayed assessing newly onboarded patients (CS-4). Interviewees noted that the pilot-related workload was managed on top of their existing duties. As a result, it was agreed that they would be allowed to carry a longer waiting list for their home oxygen follow-up reviews, meaning that they now have a backlog to work through after the completion of the pilot (CS-4).

Data collected through the remote monitoring pilot sat with TERM4COPD (CS-2). While Community Respiratory Team had access to TERM4COPD's dashboard and could edit the information there, they needed to copy and paste that information over into their EMIS system for the completeness of their patient records (CS-4).

Reported user engagement with the remote monitoring pathway and technology

As reported by staff, most patients with COPD had a positive experience with self-management and remote monitoring via the technology-enabled service (CS-1–5). Key themes on patient (and carer) engagement with, and use of the service, are highlighted below – these are drawn from analysis of interviews with staff.

Use of technology

Patients largely did not report problems and appeared to find it easy to use (CS-4). Early adjustments (e.g. large text in the tablet) seemed to help with this (CS-1). There were some minor tech-related complaints raised by patients (e.g. prefer to use the TERM4COPD app on iPhone over an Android powered device, or that the tablet locked after 30 seconds of not being touched) (CS-1). According to interviewed staff, a small number (exact information not available) of patients found the tech challenging and were discharged before engaging with the service (CS-1,4).

Encouraging self-management

Some staff members acknowledged that self-management is particularly important and, simultaneously, particularly challenging given the complexity of the patient cohort (CS-1,3,4). While agreeing that the increase in patient empowerment is an important and central goal of the pilot, there was a suggestion from staff that this can only be achieved through a period of intensive support for and sustained engagement with patients (i.e. enabling self-management well, also needs support and work) (CS-2–4).

Relations of TERM with wider service delivery pathways

According to interviewed staff, patients generally appeared to understand the mechanics of the remote monitoring service, but sometimes struggled to understand where it sits within the wider pathway (e.g. with GP care) (CS-5). Patients were described by interviewed staff as appreciative of the service, the access enabled by it, and the wide range of support that was available to them (e.g. health coaching) (CS-2).

Temporary nature of a pilot service

Interviewees noted that despite messaging that this was only a 6-month pilot, some patients appeared to have either not fully appreciated the temporary nature of the service or were worried about the remote monitoring ending (CS-1–5). One staff member indicated that they may try to maintain some form of monitoring for some of their patients through other programmes, such as home oxygen (CS-4).

Impact, evaluation and opportunities

A local evaluation has been running alongside the pilot from the start. It includes patient surveys tailored to tiers, patient feedback about the onboarding and offboarding process, how they changed behaviour and if they think the behaviours will be retained after the pilot. The evaluation includes a survey of GPs and patients, and in-depth interviews with the Community Respiratory Team staff (CS-5). There will also be some profiling work on onboarded patients to inform the extent to which they addressed inequalities through the pilot. To date evaluation findings suggest that the approach taken in the pilot was effective for minimising admissions, but maybe not support long-term behaviour change (CS-5). The evaluation is ongoing and there is not yet enough data to make definitive statements with certainty (CS-5).

At the time of writing, the Community Respiratory Team was developing a plan for winter months and making decisions about whether to run a similar programme again in the future or not, for COPD and other conditions. Key considerations are summarised below:

- *Offering remote monitoring to the 'right' patient cohort*. Interviewed staff members highlighted that an important consideration is making sure that remote monitoring is offered to patients for whom it is most useful, ensuring that patients are eligible to participate in the first place, and then onboarded at the right time, (i.e. when they are motivated, but not too ill to participate) (CS-3,5). It is also important to target people who have been admitted to hospital multiple times and ensuring that they could be monitored safely at home with support (CS-5). Supporting high-risk patients during the 90-day readmission period is something that local teams are currently thinking about more (CS-3). This includes considerations around introducing self-referral processes (CS-4).
- *Revaluating what makes for appropriate triggers in a red alert system*. Interviewees noted that the red alert system created many challenges, including a high volume of escalations and disproportionate attention to numerical data for patients (CS-1,3,4). Its relative usefulness in its current form may need re-evaluation, perhaps to include additional subjective measures, such as additional questions to obtain information, for example about breathlessness, to aid clinical judgement and decision-making (CS-1).
- *Remote monitoring design in light of health system and staff and patient needs*. Currently, the way technology is used is determined by what is possible within the wider system, and there are limits in terms of how it can be personalised to specific patient needs (CS-1). Addressing this would require potential co-design work, integrating patient voices into the planning process (CS-5). There was some suggestion that the design of the pilot was perhaps overly complex for their needs (e.g. Tiers 3 and 4 were reported to not be that different in terms of complexity or acuity), which made it challenging to embed within the existing healthcare system (CS-3).

National Health Service Rural Care planned shift from remote self-management to remote monitoring

Background and origins of the remote monitoring service

The Rural Care region has a higher-than-average ageing population, with 29% of residents aged 65 and over (compared to 19% in England). Around 50% of residents live in rural and 50% in urban areas, with 11 (of 219) areas in the region in the top 20% most deprived areas nationally. COPD is a significant problem (with 2.1% of the population diagnosed with COPD in comparison to the national average of 1.9%), and over 6000 emergency hospital admissions for respiratory disease (including COPD) in 2020–1. Underdiagnosis and delays in diagnosing patients have been attributed to limited staff capacity and skills in dyspnoea (shortness of breath) scale performance, and spirometry, combined with less than hoped for uptake of annual respiratory reviews. To support its ageing population, NHS Rural Care has been investing in TERM interventions to help people self-manage COPD (and other conditions) at home, and to reduce wider pressure on services. The decision to provide digital support for COPD patients drew on analysis of local data which indicated a need for improved ways of supporting patients with COPD (ability to pool data from general practice, community, mental health, and acute care databases, as well as police and fire departments, enables a good understanding of who the highest intensity users of their healthcare services are, with respiratory patients being one of the top five groups of users).

Funding from the Estates Technology Transformation Fund allowed NHS Rural Care to introduce remote monitoring services for cardiac, respiratory and diabetic patients in 2017. At this time NHS Rural Care worked with DigiRural, a company providing digital therapeutics for long-term conditions to develop a remote monitoring offer. Patients with COPD were offered the Respirio app as part of that offer. During the pandemic, NHS Rural Care received additional funding for 5000 DigiRural licences as part of COVID-19 response, which could be used for any of the apps offered by DigiRural. The service ran until April 2024, with a total 3295 users registered for Respirio from 2017 until then. In 2024, NHS Rural Care made a strategic decision to develop more tailored remote monitoring services and sought a new supplier.

Core components of the remote monitoring pathway and how, when and by whom technology is used

Overview of the service and technology

The central element of the remote monitoring COPD pathway in NHS Rural Care was the Respirio app, which offers symptom tracking, information/educational resources, and support for patients in terms of administrative needs associated with managing their condition and flagging situations which may need health professional intervention (e.g. appointment and medication management) – see *Box 1*. Use of the Respirio

app is focused on patient self-management. For NHS Rural Care the aim was to give patients a tool for managing their condition independently (D-INT1–4) and prevent exacerbations leading to emergency admissions and reduce pulmonary rehabilitation waiting lists (D-INT1).

BOX 1 Overview of features within the Respirio app

- ***Symptom tracking*:** allows patients to self-report on patient-reported outcome measures (PROM) data and COPD Assessment Test (CAT) scores.
- ***Information and educational resources:*** offers access to standardised educational materials (e.g. videos) on COPD, healthy lifestyle, mental health, and correct inhaler techniques; enables access to pulmonary rehabilitation videos; provides additional information (e.g. about the air quality on a given day).
- ***Support for patient navigation of needed interactions with healthcare system:*** supports patients with administrative tasks associated with a long-term condition, such as managing appointments, medications and prescriptions. Additionally, the app notifies the patient to contact a doctor if their symptoms deteriorate.
- **Allows access to patient data** by health professionals via back-end dashboard: includes capabilities for actively monitoring patient data.

Interviewees stressed that when rolling out the service, the idea was that any symptoms recorded by patients through the app were not intended to be actively monitored by a healthcare professional; the service was intended to focus on self-management (RC-1–4). PIFU was key and largely depended on patients taking the responsibility for reaching out to healthcare professionals when needed and/or ensuring that data from the app was considered during any regular interactions with the health system (e.g. annual reviews) (RC-4). Respirio was promoted as a self-management tool in NHS Rural Care. Healthcare professionals were not encouraged to actively monitor patient data through their dashboard; however, some chose to do so (RC-1,4).

Identifying suitable patients

All patients with COPD within the NHS Rural Care area were eligible for the Respirio app. The app was typically offered through a primary care-initiated text message. It was left up to primary care teams to decide which of their COPD patients to inform about the option (D-INT3). The central Digital Access Point (DAP) team provided a template for texts that could be personalised enabling primary care teams to reach out to eligible patients. Some patients were also informed about Respirio directly by a nurse or other member of the primary care team – this direct approach was reported by interviewees to lead to higher levels of uptake (RC-1–4). Secondary care providers did not actively participate in recruitment, but some offered it if they were aware of the service (RC-3). Conversations highlighted the desire of the DAP team to promote the service more specifically to COPD patients who would consider themselves sufficiently digitally literate, digitally confident and with access to technology (RC-1). Rather than focusing on limitations of digital literacy as a primary barrier to access, the DAP team proposed that more COPD patients might access the self-management service if they were simply more aware of it and its potential benefits (RC-1).

Onboarding to the service

Most patients received an offer of the Respirio service via a text message, which provided links to information about accessing and using the Respirio app. One interviewee noted that the assumption was that patients could download the app independently by clicking the link in the text message, allowing them to immediately start using it (in some cases, digital care coordinators assisted patients in this process) (RC-3). The DAP team could then track the level of engagement, measured by how many people clicked the link in the message and signed up to the service. Uptake of the service was reported at 30–40% of those patients who were offered it (RC-3).

There was no specific training for patients who wished to use the Respirio app (RC-3). However, COPD patients had access to support via dedicated Digital Care Coordinators – a dedicated role created by NHS Rural Care to facilitate and support greater take-up of a range of digital tools (including Respirio). There are currently 14–16 Digital Care Coordinators (Band 4) employed at the PCN level, who are responsible for supporting patients in accessing digital tools and enhancing digital health literacy (RC-4). They also support staff, for example cascading knowledge and understanding to the health coaches and social prescribers, who are employed either by GP practices or at PCN level. While Digital Care Coordinators support patients and clinical teams in taking up digital tools, the implementation of new digital services is led by advanced PCN-level nurse practitioners with a clinical caseload (RC-4).

Technology-enabled remote monitoring care pathway

Interviewees agreed that use of the technology by COPD patients was oriented to self-management rather than active monitoring (RC-1–4). In terms of interactions with the healthcare system, when a patient was notified via the app that they should speak to a clinician, they were typically asked to contact their primary care provider in the first instance, that is their GP, practice nurse, nurse practitioners or paramedic (RC-4). Clinical staff then discussed patient care needs, making sure that the patients' self-management plan was up to date

and checking whether medications needed changing. Interview data (with staff) suggested that patients using the app felt empowered and reassured that their condition was under control – the notification function informed the patient (on the basis of their recorded symptoms) they should contact their clinical team offering reassurance about when to reach out to primary care providers and/or when to call an ambulance (RC-3,4).

In addition to this PIFU, the information collected through the app was used to inform discussions patients had with healthcare professionals during regular reviews (e.g. annual reviews) (RC-4). It is unclear if this was formalised or not. Given the functionality of Respirio (see *Box 1*), staff could check their back-end dashboard before reviews to gain a picture of patient use, engagement with educational modules, record of symptoms in the tracker, and CAT scores (RC-4). This involved clinical staff proactively logging into their profile on the Respirio platform and accessing the dashboard. On some occasions, this happened without patient-initiated contact (RC-4).

While clinicians were able to review patient data through their dashboard, the use of this data for remote monitoring was discouraged by the DAP team who, given the focus on self-management, did not want to raise patient expectations of active/remote clinical engagement with the data submitted (RC-2). Respirio was also not integrated with other systems (e.g. the NHS App) presenting challenges with active remote management (RC-1).

Offboarding

Patients accessing the remote service prior to April 2024 were given lifelong access to the app (RC-1). Given the focus on self-management, none were actively offboarded. However, as of April 2024, no new patients were offered the service.

The Respirio offer via NHS Rural Care did not allow stepping up and down of patients (RC-1,3).

Workforce experiences of the remote monitoring pathway and technology

To date the experience of using Respirio by health service staff in Rural Care is reported to have been varied. Respirio has been used in pulmonary rehabilitation services for about 6 years, though, according to one interviewee, it has not yet shown at-scale impacts on reducing waiting lists for rehabilitation services (RC-1). Strong clinical leadership has been important, which is why implementation was led by advanced PCN-level nurse practitioners with a clinical caseload in NHS Rural Care (RC-1). However, the service/technology has reportedly been offered inconsistently – some clinical staff offered it widely and others perceived it as more of an add-on service (RC-1). This was attributed by one interviewee to varied attitudes to the seriousness of COPD and to the perceived value of digital technology offers (RC-1). There has been some outreach to raise awareness about the Respirio offer (RC-3). This appears to have had a positive effect, with increased clinical buy-in, but there was still work to be done on awareness and buy in to TERM for COPD (RC-3).

In addition to the need to work on more consistent approaches to offering the service, other challenges included limited staff training for this app and technology-enabled services more generally (RC-2). One interviewee emphasised that clinical teams need to understand the population and problem at hand, to be supported with insights from data and analytics teams; and have a good appreciation of digital risk management and digital clinical safety (RC-1). Training for clinical staff across NHS Rural Care is currently being set up to address this need (RC-2). To date, the speed of adoption and spread of the TERM COPD service overall as a whole has been somewhat slower than anticipated (RC-2).

Reported user engagement with the remote monitoring pathway and technology

Key themes on patient (and carer) engagement with, and use of, the service are highlighted below – these are drawn from analysis of interviews with staff. Patient experience of using Respirio has been described by staff as largely positive, though with some challenges identified as well. Key themes related to:

Challenges to uptake and engagement: while many patients registered with the service initially, an estimated third of these patients did not then go on to use the app (RC-3). Staff reported that some patients perceived the app as an (unwelcome) attempt to manage demand (particularly for GP services) (RC-3).

Desire for direct engagement with, and monitoring by, a clinician: on the one hand, patients appeared to value the ease of being able to contact the appropriate clinical team, particularly the notification function, which informs the patient when their recorded symptoms suggest that they should contact their clinical team and appeared to offer a level of reassurance (RC-3,4). On the other, there was a desire to be able to more actively share the data they captured with their clinical team, and experience something more akin to remote monitoring, rather than self-management (RC-3).

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Equity, patient access and digital literacy: while in theory Respirio was available for any COPD patient, and there was support from Digital Care Coordinators, in reality the technology appeared to work best for patients who have the digital ability and cognitive function to use it, as well as knowledge and skills to proactively self-manage (RC-1). Men were reported to be willing to take up the service slightly quicker than women (RC-1). The DAP team reported that the app was taken up in higher numbers in areas of most deprivation, and this was hypothesised by one interviewee as potentially due to patients perceiving it as a helpful adjunct to usual care, which was often difficult to access (RC-1). All interviewees noted that the patients that did use the app had very positive feedback.

Diversity and adaptability in use of Respirio: patients appeared to have used the app at varying times and in varying ways, from sporadic use to 'super-use' (RC-3). Patients who paused or stopped using the service appeared to return to using it after an exacerbation (RC-4). There was noticeable seasonal variation, with many more patients using it during winter (RC-1,3).

Impact, evaluation and opportunities

The service described above was paused in April 2024 as NHS Rural Care shifted to appoint a new digital service supplier who could provide remote monitoring for COPD patients (RC-1). This search for a new provider was described by interviewees as related to a broader desire to implement digital services in the Rural Care region, for COPD and other conditions (RC-3). The aim is to introduce more widespread access to remote monitoring services, enable patients to be stepped up and down in care as needed and for clinicians to more actively use remote monitoring data to inform decisions about whether they need to see the patient (RC-3).

To date, the implementation and use of technology to support self-management and PIFU more broadly have been welcomed by NHS Rural Care leadership. This has enabled significant learning on the adoption and uptake of technology-enabled support. The focus now is on extending this, developing a 'one citizen' approach that stretches across the system (and with interoperability critical), and includes a range of digitally enabled services, aligning remote management and remote monitoring under one banner (RC-3). In practice, this means developing an offer that would enable all services – from a more light-touch management tools, to remote monitoring, all the way to virtual wards – through one provider (RC-1). This 'one citizen' approach also places patients at the centre, recognising that they potentially have multiple conditions that need to be managed simultaneously, and need all tools in one place for them to access easily (RC-3). The procurement process for this was ongoing at the time of data collection. As one interviewee explained, their vision is to work with a supplier who can manage the technology throughout the duration of any future contract, with the capacity to make changes to the system quickly and efficiently and be flexible in their approach to accommodate changes in the care pathway (RC-1). Adherence to national guidelines and relevant digital health regulation remains central in guiding NHS Rural Care's approach to the selection of a new tech provider (RC-2).

River Valley Primary Care Network smart inhaler technology pilot

Background and origins of the remote monitoring service

River Valley is one of eight PCNs in a region of central England, providing care for around 50,000 patients. COPD prevalence is lower than the national average but remains a strategic priority given impact on the wider health systems, particularly regarding emergency hospital admissions. Since 2022, primary care in the area is targeting anticipatory care to support vulnerable COPD patients to stay healthy at home during the winter months.

The use of smart inhaler technology to support patients with COPD to self-manage is a collaboration between SmartInhale (a digital smart inhaler company), Pentagon Health (a medical technology development company), Low Peak Practice staff and the NHSE Lung Health @Home team. Low Peak practice sits within the River Valley PCN and serves around 1800 patients. It is a small practice with three full time doctors, one practice nurse, one healthcare assistant, two reception staff and one practice manager. They have recently taken on a number of patients after offering an extended weekend service, which has resulted in some patients attending from other practices. One of the practice partners is the Clinical Director of River Valley PCN.

Following the completion by the surgery of a pilot study establishing the feasibility and acceptability of introducing smart inhaler technology into the paediatric asthma population (aged 5–16), the practice received NHSE funding to become a 'Fast Follower' site, testing out the Lung Heath @Home care pathway and introducing the technology into the COPD care pathway. Additional funding is provided by the Office for Life Sciences. The focus is on building the knowledge, skills and confidence of

people with COPD to play an active, equal role in their own care and well-being; enabling patients to understand what good inhaler use looks like through use of digital inhaler; augmenting the benefits of pulmonary rehabilitation by providing daily support with digital health; improving access to services and support; and enabling improved access for priority patient groups. It remains unclear at the time of writing how this relates to the immediate needs of the local population.

At the time of writing, this work has been subject to delay and is planned, not current. As such, understanding of the TERM service and any potential learning to be derived from the pilot are limited.

Core components of the remote monitoring pathway and how, when and by whom technology is used

Overview of the service and technology

The focus of the service is on self-management. Low Peak Practice wish to discover whether a smart-enabled care pathway in high-risk adults with chronic lung disease (CLD) can be implemented in primary care, is acceptable to patients, improves adherence to controller medication, and reduces use of short acting bronchodilators and unscheduled care. Additional objectives include increasing access to pulmonary rehabilitation and embedding behaviour change from the start of diagnosis/managing it in real time over a targeted period.

The technology involves a 'smart inhaler' used in conjunction with the Respirio app. A small electronic device attaches to a compatible inhaler and sensors connect to a smartphone via Bluetooth, providing medication reminders with varying frequencies based on usage, shake detection, orientation and duration guidance, inhalation flow rate, information relating to volume and duration. The platform then provides an overview of prescription and doses taken, adherence review (per day, month, year), and red/amber/green 'traffic light' inhalation insights to communicate the relative success of the inhalation. All data from the smart digital sensors are synced with the patients' app and, in theory, can be monitored by clinical staff at the practice in real-time using a web portal (though it appears that this function will not be used in practice during the pilot).

The pilot service was expected to run from July 2024 for a period of 3 months, with allied evaluation focused on the proportion of patients who have had regular COPD reviews, the proportion of patients participating in smart inhaler monitoring, whether digital smart inhalers improve CLD control, whether digital smart inhalers improve mediation compliance, whether digital pulmonary rehabilitation is an acceptable adjunct to in-person pulmonary rehabilitation, and whether digital pulmonary rehabilitation improved CLD control.

Identifying suitable patients

The pilot study will include 30 patients drawn from the pool of 70 patients with severe or very severe COPD from across the PCN. Promoted as a self-management tool with supported follow-up, patients will be invited to use the smart inhaler in conjunction with the Respirio app for a period of 3 months at which point they will attend a routine face-to-face follow-up appointment with a GP in the practice, which will include a review of the data gathered by the smart inhaler.

Using the search and stratification tool developed by the Lung Health @home team in collaboration with a Health Innovation Network, the pilot focuses on identifying and prioritising patients who are: (1) waiting to start pulmonary rehabilitation, (2) for whom pulmonary rehabilitation is likely to be an appropriate intervention but had not yet been referred, or (3) who require further assessment to determine whether pulmonary rehabilitation or another intervention is appropriate. Patients are to be stratified into groups based on diagnosis of chronic lung condition, and indicators of instability or exacerbation risk. There are plans for the search tool to be revised at the end of 2024 or in early 2025, enabling more detailed information within the search return (i.e. not only a list of patient IDs), so it is easier for the staff to focus on patients who match local priorities (e.g. health inequalities) without accessing the detail via patient records.

At the time of writing, the site had identified an unexpected compatibility issue between the prescribed inhalers and the smart inhaler device being piloted, which does not currently work with the preferred inhaler treatment for the pilot study target user group. The search criteria outlined above is being expanded to include group 2 of the Lung health @home search tool and will review these patients to determine whether there are sufficient numbers of people with compatible inhalers to recruit.

Onboarding to the service

Patients will be invited by letter and follow-up phone call to attend a dedicated clinic with the Low Peak specialist respiratory nurse where they will be provided with information about the service and an opportunity to ask questions. This collective meeting is intended to mirror the way in which the service would be implemented in real life, post-pilot. Patients who agree to take part will

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then attend an appointment with the respiratory nurse who will: obtain consent to participate in the study for a duration of 3 months, complete a spirometry or FeNo test (or 'fractional exhaled nitric oxide' test which measures the levels of nitric oxide in your breath), review inhaler technique, suggest a change of inhaler (if appropriate) based on the requirements of the patient and availability of compatible smart digital monitoring sensors, prescribe the suggested inhaler for 3 months, assess whether patients have sufficient ability to use digital technology, and complete a CLD control questionnaire and record all required study data.

All data will then be reviewed by a Low Peak practice GP. Inhaler-matched digital monitoring sensors will be ordered based on the prescribed inhaler. Patients will have a follow-up appointment where they will be introduced to their device, offered support to ensure that they are confident with method of use and introduced to the monitoring app for the smart inhaler, to be installed on their smartphone or tablet, and to the Respirio app and referred for (virtual) pulmonary rehabilitation if appropriate.

Technology-enabled remote monitoring care pathway

The focus here is on self-management. Technology is being used to drive treatment changes over time, to focus routine in-person review, and to ensure the optimal care pathway is achieved. Day-to-day adherence data are therefore not of primary interest. After 3 months, patients will have an in-person follow-up appointment with the respiratory nurse, at which time the digital diary will be reviewed for adherence, inhaler technique will be reviewed and reinforced, the prescribed dose will be reviewed and amended if necessary; and the nurse will complete a CLD control questionnaire and record all required study data. Where required, patients will be referred to additional services (e.g. social prescribers). Data will be reviewed at 52 weeks to explore long-term impact on overall CLD control and metrics relating to unscheduled access of care.

Offboarding

There are no current plans to offboard patients other than at completion of the pilot.

Workforce experiences of the remote monitoring pathway and technology

As the pilot is yet to start, there is no available feedback relating to staff experiences of implementing the remote monitoring technology. A practice nurse and GP will be wholly responsible for recruitment, onboarding and patient follow-up. The expected value (for staff or patients) of implementing the remote monitoring technology appears to relate to future improvement in medication adherence. It is not (yet) clear whether or how the introduction of this technology would support the workforce or system within which it operates, and digital health solutions do not appear to be a routine offering in the practice (RV-1–3). Discussions with practice staff highlighted a clear motivation to explore the potential of technology to support patients living with COPD, born out of participation in a similar study hosted by the practice focused on a paediatric asthma cohort. Clinical staff responsible for the current pilot are reliant on trusted senior colleagues to provide training on how to implement the smart inhaler and use of digital pulmonary rehabilitation.

Reported user engagement with the remote monitoring pathway and technology

As the pilot has yet to start, there is no current feedback or data relating to patient engagement and experience. It is worth noting that site has received funding to be able to offer one-off personal health budgets to increase engagement in pulmonary rehabilitation.

Impact, evaluation and opportunities

As part of the Fast Follower scheme, the site is being concurrently evaluated. The focus of the evaluation is on access, engagement, patient outcomes and system outcomes, and working with the site to understand what that means in the context of their change idea. No patient feedback is currently being sought during the pilot.

In addition to the ongoing compatibility complications (see above), one of the main problems that the team foresee with using the smart inhaler is that it is not currently within the formulary, thereby limiting procurement. At the moment the team are accessing the inhaler via a discount from Pentagon Health who are actively working the 'formulary pathway' and developing a business case to facilitate the addition of the smart inhaler to the procurement list.

Appendix 2 Recommendations

This appendix sets out recommendations drawn from findings from the evidence review and analysis of data from the qualitative evaluation. Our findings contribute to what is known about TERM services for COPD in several important ways, which we present as a series of eight recommendations.

Understand that the technology is one element of the service

The technology is not the service but needs to be embedded in the COPD pathway and align with service needs in cost-effective ways and with proportionate regulation: consider which aspects of the technology are essential versus 'nice to have' and how they can be effectively embedded. Those designing and implementing TERM COPD care pathways need to consider how the technology will fit with NHS care pathways and what roles, responsibilities, capabilities, capacities, infrastructure and funding need to be in place to support technology implementation and cost-effective service delivery. There is no one-size-fits-all approach to TERM for COPD – it is crucial to ensure the technology aligns with local conditions and readiness. The technology should complement existing processes, with essential features prioritised over non-critical ones. Successful implementation requires integrating digital tools with traditional methods like printed materials, phone calls, and home visits. Improving procurement processes and formulary pathways is vital to ensure practical access to appropriate technologies while avoiding introducing tools that may be unavailable or unnecessary.

Appreciate that TERM for COPD occurs along a continuum

It is important to clearly communicate what TERM COPD is and consists of, in a way that accounts for it encompassing a continuum of intervention levels that can support both different types of patients and the same patient in different stages of COPD complexity. The phrase 'technology-enabled remote monitoring' is an umbrella term with multiple applications. Local assumptions underlying this phrase need to be made explicit from the outset.

There is no 'optimal point' at which TERM for COPD should be introduced into the care pathway

A COPD TERM service should introduce the appropriate level of intervention based on patient needs, which can vary across different types of patients and for the same patient over time. Different types of patients may also have different support needs in terms of onboarding and engagement. It is important not to assume who will engage with TERM; all eligible patients should be invited, using simple methods like text messages, and enabled to self-onboard where possible. Early follow-up should be conducted by a person to support engagement. While many services focus on severely ill patients, lighter-touch monitoring for lower-risk patients may be an effective way to introduce TERM. Patients may fluctuate in disease complexity, requiring different levels of service, may need to need to 'cycle' up and down the TERM continuum, and should be informed of how to access these services. Some patients may feel overwhelmed by frequent monitoring and disengage, but efforts should be made to offer and support re-engagement.

TERM for COPD impacts on the workforce in multiple ways

When implementing TERM for COPD, it is crucial to allocate time and budget for workforce and administrative support, and clear role definitions. TERM affects the broader care system, potentially shifting demands across services and requiring a transition period as new and old routines overlap. Staff workload may increase, particularly if there are issues with interoperability between monitoring data and existing systems, leading to manual data entry. Administrative support can help ease this burden. Many clinical staff may lack confidence in using digital health tools, so ongoing support is essential, especially since patients are more likely to engage with services when introduced by well-trained staff with strong communication skills. Ensuring staff are comfortable

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with the technology improves patient engagement and service integration.

Account for evidence gaps when making the case for services

Those planning, funding and delivering services should be aware that, currently, models are grounded in accumulating but not yet conclusive evidence. Remote monitoring shows potential to improve care and prevent exacerbations across various stages of the disease, including chronic management and acute episodes, as well as during treatments like oxygen therapy and pulmonary rehabilitation. Multiple aspects of COPD care, such as symptom tracking and patient education, are being incorporated into different technologies, though the mechanisms of action are not yet fully understood. Key evidence gaps still exist around the optimal use of remote monitoring, its impact on clinical roles, access equity, target populations and overall cost-effectiveness of the service. Continued research is needed to determine the best practices for integrating these technologies into COPD care pathways.

Enable ongoing evaluation and shared learning

The adoption, implementation and spread of TERM for COPD must be supported by strong evidence and mechanisms for shared learning. Although there are significant gaps in the evidence base for TERM in COPD care, efforts to model business cases and evaluations should rely on available 'hard evidence' and acknowledge uncertainties around uptake, use, and impact. There is inconsistency in how evaluation data is valued across commissioning structures, particularly in terms of patient experience, and standardising evaluation processes would improve outcomes. Informal peer support between TERM sites is emerging but remains inconsistent, highlighting the need for formalised communities of practice to facilitate shared learning and improvement across sites.

Focus on clarity, stability and certainty in policy incentives and sustainable funding commitments for services

The unintended consequences of over-reliance on short-term pilots and uncertainty in service stability can have lasting impacts on staff commitment to innovation in service delivery, trust in their efforts bearing fruit as well as impact on patient experience. Furthermore, decision-makers need to work together to ensure clarity in the terminology used to make sense of what TERM is and what it consists of, to support effective landing of TERM service transformation efforts, clarity of purpose, and clarity on scope and eligibility.

Recognise that the technology will call for adaptation of the system in as much as the system will shape the needs from technology suppliers

Plan for co-evolution of technology and system. The functionalities of technology impact on how the workforce and health system delivers term, including through introduction of new roles and governance mechanisms, new upskilling needs, and adaptations in workforce responsibilities and the nature of the workload. The health system impacts on how technology evolves and adapts to meet staff and patient needs. Decisions to scale and spread TERM have to recognise the evolutionary nature of technology and health system interactions.