

Patient and staff experiences of using technology-enabled and analogue models of remote home monitoring for COVID-19 in England: A mixed-method evaluation

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ABSTRACT

Objective: To evaluate patient and staff experiences of using technology-enabled ('tech-enabled') and analogue remote home monitoring models for COVID-19, implemented in England during the pandemic.

Methods: Twenty-eight sites were selected for diversity in a range of criteria (e.g. pre-hospital or early discharge service, mode of patient data submission). Between February and May 2021, we conducted quantitative surveys with patients, carers and staff delivering the service, and interviewed patients, carers, and staff from 17 of the 28 services. Quantitative data were analysed using descriptive statistics and both univariate and multivariate analyses. Qualitative data were interpreted using thematic analysis.

Results: Twenty-one sites adopted mixed models whereby patients could submit their symptoms using either tech-enabled (app, weblink, or automated phone calls) or analogue (phone calls with a health professional) options; seven sites offered analogue-only data submission (phone calls or face-to-face visits with a health professional). Sixty-two patients and carers were interviewed, and 1069 survey responses were received (18 % response rate). Fifty-eight staff were interviewed, and 292 survey responses were received (39 % response rate). Patients who used tech-enabled modes tended to be younger ($p = 0.005$), have a higher level of education ($p = 0.011$), and more likely to identify as White British ($p = 0.043$). Most patients found relaying symptoms easy, regardless of modality, though many received assistance from family or friends. Staff considered the adoption of mixed delivery models beneficial, enabling them to manage large patient numbers and contact patients for further assessment as needed; however, they suggested improvements to the functionality of systems to better fit clinical and operational needs. Human contact was important in all remote home monitoring options.

Conclusions: Organisations implementing tech-enabled remote home monitoring at scale should consider adopting mixed models which can accommodate patients with different needs; focus on the usability and interoperability of tech-enabled platforms; and encourage digital inclusivity for patients.

1. Introduction

In recent years, there has been a shift to adopt remote healthcare

models to reduce the burden on secondary care, resulting from increased demand and difficulties in moving patients efficiently into and out of hospital [1–3]. In England, integrated care systems (partnerships of

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health and care services) have been asked to deliver remote home care capacity equivalent to 40 to 50 virtual ward ‘beds’ per 100,000 population by December 2023 [4]. The COVID-19 pandemic accelerated the need for remote health care delivery [5–6] and the perceived need for patient self-management. Remote home monitoring services were implemented for COVID-19 patients in a number of countries [7–13]. In England, such services aimed to reduce risk of disease transmission, detect patients with low oxygen saturation, more rapidly escalate a response, and reduce unnecessary emergency department attendances where appropriate [10–11,14]. Primary care situated COVID-19 remote home monitoring services were rolled-out across England in November 2020, and in January 2021, similar services were implemented for

patients who had been discharged early from hospital (‘virtual wards’) [10–11,15]. Patients were asked to record oxygen saturation levels and relay readings to services using digital or automated technology (i.e. technology-enabled monitoring) or through telephone calls (i.e. ‘analogue’ monitoring) [10,14] (see Fig. 1).

The effectiveness of remote monitoring services depends on the availability of dependable, high-quality, and clinically useful technology systems with which patients and staff can engage [16–18]. Higher levels of patient engagement with remote monitoring have been associated with better patient outcomes [19]. The benefits of remote health care are not necessarily experienced by all patients. For example, insisting upon digital engagement might exclude patients without home internet

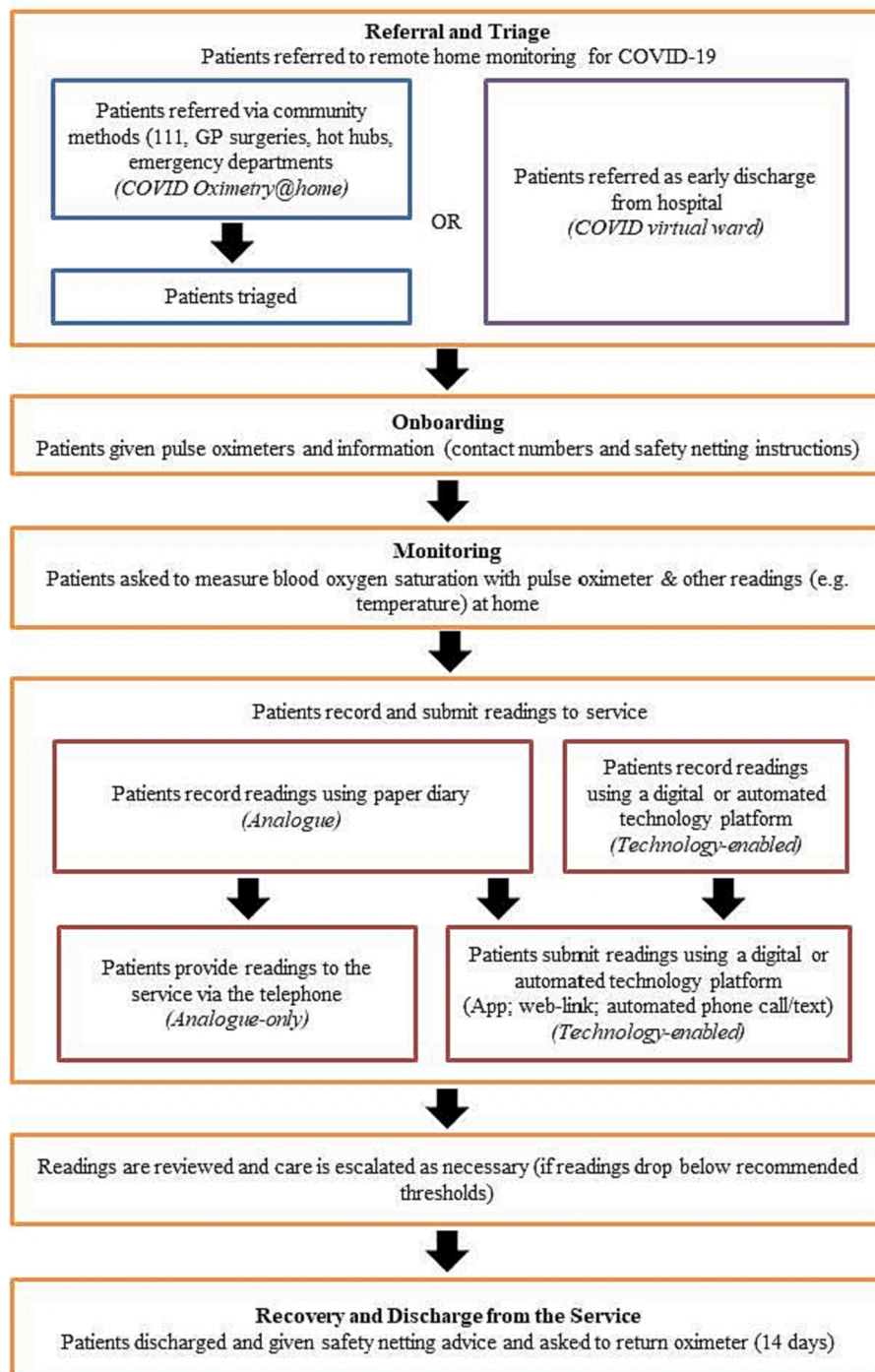


Fig. 1. COVID-19 remote home monitoring service models.

or lacking digital skills from accessing care or reduce the quality of care [20–22]. Patients and staff have emphasised the need to maintain human contact in the clinical relationship to preserve high quality care [23–27]. In our patient experience study of COVID-19 remote monitoring services, most patients reported a positive service experience, though many received help from family and friends to engage with services [28].

While staff can adapt to remote monitoring, positive experiences have been contingent on the technology’s accessibility and functionality for meeting practitioners’ clinical and operational needs, its interoperability with existing data systems, and sufficient staffing for monitoring and responding to data [24,29–31]. However, the benefits of technology can be impeded by technical problems, a lack of digital infrastructure and appropriate workforce training and support [32–33]. Our study of staff experiences of training and delivery of COVID-19 remote monitoring services found that staff received a range of locally specific training and clinical oversight, however, it took time to feel confident in remote clinical decision-making and it could be difficult to integrate monitoring within their existing work practices [34].

This study focuses on patient and staff experiences of carrying out the technology-enabled (‘tech-enabled’ hereafter) and analogue activities of COVID-19 remote monitoring, building on our previous evaluations of patient and staff experience [28]. Understanding the perceptions of patients and staff can help to shape accessible, reliable and high-quality services for the future wide-spread implementation of remote monitoring services. Study objectives were to determine: 1) differences in the characteristics of patients using tech-enabled and analogue modes; 2) patients’ experiences of relaying symptom data using different modes; 3) staff experiences of processing symptom data for large numbers of patients using tech-enabled and analogue models; 4) impact of the use of different models on patients’ and staff experience of the patient-clinician relationship.

2. Methods

2.1. Design and conceptual framework

The study adopted a fully mixed, concurrent, dominant status design [35], with emphasis on the qualitative analysis to explore and describe the breadth and depth of experiences across patients and staff.

Quantitative survey data and qualitative interview data was collected concurrently from patients and staff engaging with COVID-19 remote home monitoring services in England, UK, and analysed concurrently and independently, integrating findings at the results [35–36]. The research questions were answered by both quantitative and qualitative methods (aside from #1 which used quantitative data only). We used the technologies and clinical relationship domains of the Planning and Evaluating Remote Consultation Services (PERCS) as a conceptual framework [16] for the analysis (see Fig. 2), as these domains were closely aligned with the research questions. The technologies domain focuses on the dependability, functionality, and familiarity of the technologies employed in remote consultation and the clinical relationship domain focuses on the clinician’s knowledge of the patient and the development of trust and positive regard.

This study was part of a larger evaluation that was carried out from January – July 2021 [37]. The methods for this study are reported in detail in Appendix A and are summarised below.

2.2. Ethical approval

Staff aspects of the evaluation received ethical approval from the University of Birmingham Humanities and Social Sciences ethics committee (ERN_13-1085AP39) and was categorised as a service evaluation by the Health Research Authority decision tool and UCL/UCLH Joint Research Office. The patient experience elements received approval from the London-Bloomsbury Research ethics committee (REC reference: 21/HRA/0155).

2.3. Sampling and data collection

2.3.1. Selection of sites

Twenty-eight sites (services in different geographic locations) were purposively selected based on a range of criteria, including the type of service (pre-hospital, early discharge, both), sector leading the service (primary, secondary, or combined), and modality for patient data submission (see Appendix A). For a more in-depth analysis of implementation, seventeen services were selected as case study sites using the aforementioned criteria. From this sub-sample, four sites were purposively selected by England’s NHS user experience (NHSX) organisation for an in-depth analysis of the functionality of tech-enabled modes, as

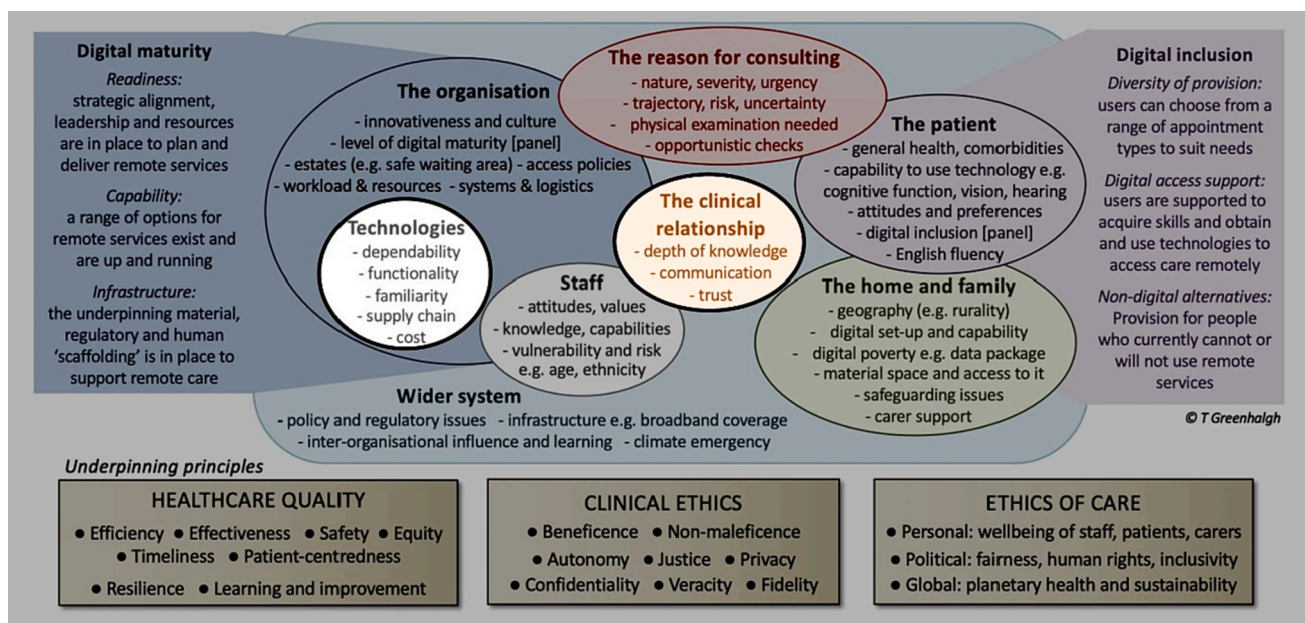


Fig. 2. The Planning and Evaluating Remote Consultation Services framework.

these sites were known to have adopted different tech-enabled platforms.

2.3.2. Patient and staff interviews

Service leads from the 17 case study sites identified a sample of six patients that the research team could contact to invite to participate. Interviews focused on: how patients were referred to the service, how they felt about recording and monitoring their symptoms, how they communicated with the service, and their experience of escalating care (see Appendix B for interview guides).

These same sites identified four staff members to interview (including a clinical/operational lead e.g. a senior nurse; front-line delivery staff; and staff involved in data collection and management, e.g. non-clinical managers). Interviews focused on: the model’s aims, resources and processes, facilitators and barriers of implementation and patient engagement. In the four sites where we conducted an in-depth analysis of tech-enabled platforms, staff interviews were extended to include a ‘think aloud’ section where staff narrated the process of using the platform in situ [38] (see Appendix B).

An informed consent process with participant information sheets and written consent was used for both staff and patient interviews (see Appendix A).

2.3.3. Patient and staff surveys

We conducted a survey of staff delivering the service in 28 sites, and a survey of patients or carers in 25 of the 28 sites; if patients were not able/willing to take part in the survey, they were given the option to ask a carer or family member to complete the survey on their behalf (see Appendix C for staff and patient surveys). Site leads distributed staff and patient surveys; staff received an electronic version and patients and carers received either a paper or electronic version. All surveys were prefaced with information sheets and a consent form. Patient and staff survey questions were reviewed by our clinical advisors and patient and public involvement group and were piloted with two sites.

2.4. Data analysis

For patient and staff interviews, data collection and analysis were carried out in parallel and facilitated through the use of rapid assessment procedure (RAP) sheets [39]. RAP sheets contain a structured template to write key points from interviews in real-time on a-priori categories,

based on questions included in the interview topic guide (with flexibility to add categories as the study continues). They facilitate rapid cross-case comparison. Two RAP sheets were used per site, one for staff interviews and one for patients. The RAP sheets were imported into qualitative analysis software (NVivo12). Data relating to patient experiences of relaying symptom data via analogue or tech-enabled modalities, staff processing data, and interactions between patients and clinicians were coded inductively into themes, using the PERCS domains as a sensitising lens [16].

We analysed patient and staff survey data using SPSS statistical software (v25) to triangulate findings from the interviews. The following patient data were analysed; socio-demographic information, patient reported ease of completing activities as part of their care, frequency and quality of contact with the remote monitoring team, and whether they had received any support from family or friends. We used descriptive statistics and conducted Pearson’s chi-square tests and logistic regression modelling to explore patient characteristics with mode of submission, including the covariates age, education, health status, ethnicity, and employment. Due to non-normal distribution of data we used non-parametric Mann-Whitney U tests to compare patient experiences across service models; survey responses were compared for patients who had reported they had relayed readings via tech-enabled or analogue modes. Data related to experience of relaying and processing data, and the clinical relationship were coded deductively from open-ended survey questions (see Appendix A).

Staff reported on their experience of delivering the service using tech-enabled and analogue modalities and their views of patient engagement with the service. To make comparisons of staff experiences across models we used non-parametric Mann-Whitney U tests; staff were categorised as delivering a mixed model if sites adopted both tech-enabled and analogue data submission options, or an analogue-only model if a tech-enabled platform was not used (see Appendix A for further details).

3. Results

3.1. Site and participant characteristics

Twenty-eight sites were included across England (see Table 1 for site characteristics). Twenty-one sites adopted mixed models whereby patients could submit symptoms using either tech-enabled or analogue

Table 1 Site characteristics.

Domain	Type of remote home monitoring	No. of sites (n = 28)	No. of case study sites (n = 17)	No. of sites for in-depth analysis of tech models (n = 4)
Type of service	CO@h ^a	13	9	2
	Virtual ward ^b	4	1	1
	‘Integrated’ CO@h and virtual ward	11	7	1
Sector leading the service	Primary care/community care	16	11	3
	Secondary care	5	3	1
	Both	5	3	0
	Not specified	2	0	0
Mode of patient data submission	Analogue-only	7	3	0
	Tech-enabled and analogue	21	14	4
Geographic location	South west England	7	3	1
	South east England	5	4	1
	East of England	1	1	0
	Greater London	5	3	0
	East midlands	2	1	1
	North east England	2	1	0
	North west England	5	4	1
	Yorkshire and Humber	1	0	0
	Month service started	Before November 2020	11	7
	In November 2020	13	9	3
	After November 2020	4	1	0

^a pre-hospital model; ^bearly discharge from hospital model.

Table 2
Characteristics of patients using tech-enabled compared to analogue-only modes of monitoring.

	Tech-enabled mode N (%)	Analogue-only mode N (%)	P value of difference*
Gender			0.520
Female	290 (58.9)	241 (56.8)	
Male	202 (41.1)	183 (43.2)	
Total N	492 (100)	424 (100)	
Age			<0.001
< 50 years	126 (25.4)	69 (16.2)	
50 – 65	244 (49.2)	184 (43.2)	
66 – 79	118 (23.8)	138 (32.4)	
>= 80 years	8 (1.6)	35 (8.2)	
Total N	496 (100)	426 (100)	
Ethnicity			0.046
White British, Irish, other white background	459 (93.5)	371 (89.8)	
Other background	32 (6.5)	42 (10.2)	
Total N	491 (100)	413 (100)	
English first language			0.352
Yes	463 (94.1)	386 (92.6)	
No	29 (5.9)	31 (7.4)	
Total N	492 (100)	417 (100)	
Education			<0.001
No formal qualification	55 (13.6)	91 (27.8)	
GCSE/CSE/O level	149 (36.8)	118 (36.1)	
As level, A level, degree level or higher	201 (49.6)	118 (36.1)	
Total N	405 (100)	327 (100)	
Employment			<0.001
Working full time/part time/self-employed	308 (61.5)	205 (47.1)	
Not in work due to poor health/disability	27 (5.4)	38 (8.7)	
Retired	123 (24.6)	153 (35.2)	
Total N	458 (100)	396 (100)	
Health			0.004
Limited a little or a lot	165 (37.1)	180 (47.1)	
Not limited at all	280 (62.9)	202 (52.9)	
Total N	445 (100)	382 (100)	
Deprivation score**			0.249
1–2 (Most deprived)	92 (22.7)	90 (24.9)	
3–4	70 (17.2)	67 (18.6)	
5–6	74 (18.2)	75 (20.8)	
7–8	85 (20.9)	76 (21.1)	
9–10 (Least deprived)	85 (20.9)	53 (14.7)	
Total N	406 (100)	361 (100)	

* P-values derived from Pearson's chi-square tests, bold denotes statistical significance at the $P < 0.05$ level.

** Deprivation by LSOA (Index of Multiple Deprivation decile).

options (app, weblink, automated phone calls, or phone calls with a health professional); seven sites offered analogue-only data submission (phone calls or face-to-face visits with a health professional) (see Appendix D for details of the different models adopted).

Sixty-two patients and carers were interviewed, and we received 1069 survey responses from patients and carers (18 % response rate). Of the total respondents, 936 (87.6 %) were patients, 48 (4.5 %) were carers and in 85 (8 %) cases it was not possible to determine who

Table 3
Logistic regression with patient mode of submitting data as the dependent variable and patient characteristics as independent variables.

Variable	Odds ratio	95 % CI (Lower-upper)	P-value*
Age			0.005
Younger than 50 years	Ref.		
50–64 years	0.68	0.43–1.06	0.091
65–79 years	0.56	0.33–0.97	0.039
80 years and over	0.14	0.05–0.42	<0.001
Education			0.011
No formal qualification	Ref.		
GCSE level or equivalent	1.57	0.98–2.51	0.060
AS level, A level or degree or equivalent	2.02	1.27–3.21	0.003
Health status			0.159
Limited at little or a lot	Ref.		
Not at all limited	1.28	0.91–1.79	
Ethnicity			0.043
White ethnic groups	Ref.		
Minority ethnic groups	0.54	0.29–0.98	
Employment			0.368
Employed (full-time, part-time, self-employed)	Ref.		
Other	1.20	0.81–1.77	

Ref = Reference category.

* Bold denotes significance at the $P < 0.05$ level.

Table 4
Functions of COVID-19 remote home monitoring platforms that staff valued or highlighted as needing improvement.

Valuable functions	Staff views
<i>Interoperability with other data systems</i>	Staff valued tech-enabled platforms that integrated with existing patient health systems, enabling them to view patients GP records, automate referrals from GP practices, update GP practices on patients' care.
<i>Plasticity</i>	Staff liked features that enabled them to change what they viewed according to their needs and add or change patient readings or notes. For example, being able to: <ul style="list-style-type: none"> • Organise their main screen according to their needs, such as to view patients receiving oxygen (see also filtering, ordering and sorting). • Open more than one patient record at the same time • Switch between a patient's readings and their notes. • Easily return to different screens • Change the parameters for alerts in oxygen level saturations for individual patients (e.g. COPD patients who have lower overall levels of saturation). • Add ad hoc readings for patients that have mis-entered their measurements • Add patient notes for additional information, for example, noting any mental health concerns. • Set different levels of permission for what different staff can view or edit.
<i>Filtering, ordering and sorting information</i>	Staff valued platforms that enabled them to filter, order and sort patients according to their clinical needs or the service's operational needs, for example, by traffic light rating, oxygen saturation levels, by staff allocation, by patients yet to be reviewed.
<i>Task management</i>	Task management functions – that is, automated messages from the system relating to allocated tasks – were valued if they fit the service's needs. In some sites, automated tasks to call patients could facilitate work allocation. In others, inappropriately automated tasks became an additional message to remove because oversensitive alerts were raised for patients.
<i>Exact readings</i>	Staff wanted exact readings for patients' measurements (rather than ranges), for example, oxygen saturation levels (essential when patients were weaned off oxygen) and temperature. In one site, inexact readings for patients using oxygen led to staff calling patients for readings they had already provided through the app. In one site, temperature readings were provided in Fahrenheit rather than Celsius and had to be continually converted by staff.
<i>Automated discharge report</i>	One platform produced automated discharge reports that could be shared with patients' GPs, which was valued by staff. A staff member from another site highlighted the potential efficiency gains from automating the discharge process through the platform so that the tech provider and GP could both be notified of a patients' discharge from the service (and the need for equipment to be collected).
<i>Reporting</i>	For most tech-enabled platforms, reports on patients using the service were provided on a daily or weekly basis by the tech provider. However, built-in reporting function would enable staff to view and interrogate the data themselves.
<i>Data dashboard</i>	Staff reported the utility of a data dashboard to have an overview of all patient records, including referral, onboarding, review and discharge dates.
<i>Visibility of information</i>	Staff valued being able to see patients' readings visually, for example, in tables or charts that could be viewed clearly on one page. Including data points for missing data from non-submission was also useful.

completed the survey (see Appendix E for participant characteristics). More patients reported using a tech-enabled mode for data submission (66 % of interviewees and 51 % of survey respondents) than analogue-only modes (31 % of interviewees and 49 % of survey respondents). Of the patients surveyed: 29 % (n = 309) reported providing readings via text (i.e., web-link or automated text), 25 % (n = 264) digital app, and 1 % (n = 15) email.

We found statistically significant differences in patient characteristics across modes of data submission (see Table 2). Fewer patients who used tech-enabled modes reported having a health problem/disability, more patients were in employment, had a higher level of education, were younger, and identified as White British compared to patients using analogue-only modes. Logistic regression analysis found only age, level of education and ethnicity to be related to mode of data submission. Health status and employment were not related to mode of submission after adjustment for other factors (see Table 3).

Fifty-eight staff were interviewed, and we received 292 staff surveys (39 % response rate; 70 service managers or clinical leads and 222 delivery staff). Appendix F contains staff characteristics. More staff reported delivering mixed models of COVID-19 remote home monitoring (81 % of interviewees and 77 % of survey respondents) than analogue-only models (19 % of interviewees and 23 % of survey respondents).

3.2. Patients' experiences of using tech-enabled and analogue modes to relay symptoms

Two key themes related to patients' experiences of relaying symptom data included: allocation of mode, and ease of relaying readings/the functionality of tech-enabled systems.

Most patient interviewees did not recall being given a choice about the mode in which they could submit readings; however, most were happy with the mode given. Staff interviewees across many sites offered phone calls to older patients who might lack digital technology and/or skills or were experiencing cognitive/physical impairments. Some patients opted for phone calls with a health professional over tech-enabled

monitoring so that they could discuss their illness and any feelings of anxiety and/or isolation.

Most patient interviewees across sites reported that it was "easy" or "straightforward" to relay readings whether by tech-enabled or analogue modes. Some patients thought that the simplicity of the tech-enabled systems was its strength; several patients mentioned in interviews that while the first attempt to give readings might take some working out, they quickly got into the habit of submitting them and it became a part of their daily routine. Patients using tech-enabled modes were more likely to report that recording readings (p = 0.009) and providing readings (p = 0.001) to the service were easy compared to patients using analogue-only modes (see Appendix G). However, differences might reflect differing characteristics of the patient groups.

The main barriers (for both modes) reported by patient and staff interviewees to patients submitting readings were feeling too poorly, tired or forgetting. Many patients and staff highlighted that family members or carers had assisted in relaying readings; particularly patients who lacked confidence in their digital skills, patients that were unwell or had communication difficulties.

"In the beginning I found it [entering the information] difficult because I was poorly but then I had a member of my family to help me and then it was just easy to do and I'm not good at things like that. I found it easier to do after a while." Site C, Patient 6.

The functionality of technologies was not discussed in detail by patients: however, several patients and staff reported issues related to monitoring applications ('apps' hereafter), particularly during set-up because they required downloading and remembering log-in details. Two sites offered face-to-face support at onboarding for this. A small number of patient interview and survey respondents suggested improvements to app functionality: easier navigation, being able to access visual charts or tables of all readings entered, improvements in the system parameters (e.g. allowing decimal points for temperature), and the ability to record other symptoms.

3.3. Staff experiences of using the models to process symptom data for large numbers of patients

Two themes key to staff experiences of processing symptom data were: the scalability of the models, and the ease-of-use/functionality of tech-enabled systems.

Mixed models were considered by staff to be more scalable than analogue-only models. Service leads from three sites reported that they had adopted tech-enabled platforms to ensure the service could cope with a high volume of patients, and staff from six tech-enabled sites highlighted efficiency gains from data being entered by patients in real-time and not having to call every patient.

“At the peak we were on I think hundred and ninety-six on the service... and each of them were submitting three or four points of data, three times a day... that’s well over two thousand bits of data coming in a day. There’s just no way manually we would have been able to do that.” Site G, Staff 1

Staff survey findings indicated that 52 % of staff using mixed models reported a positive impact on their workload compared to 35 % using analogue-only ($p = 0.034$). However, service lead perceptions of capacity/resources to deliver the service (as reported in the survey) were not statistically significantly different ($p = 0.554$) across models (although the smaller sample size for this question should be noted; see Appendix G). Additionally, a few staff interviewees reported that phone calls were labour intensive and required a larger workforce and manual data entry. Across sites, regardless of modality of the model, staff found it useful to adopt a traffic light (red, amber, green) system for prioritising care.

Staff reported monitoring patients as statistically significantly easier ($p = 0.005$) for mixed models (77 % staff reported monitoring as easy/very easy) compared to analogue-only models (56 % staff reported monitoring as easy/very easy) (see Appendix G). However, qualitative findings indicated that some staff were frustrated by length of time it took tech providers to make changes to platforms and that tech-enabled platforms could be improved to better support clinical and operational needs (see Table 4).

3.4. Patients’ and staff experiences of the clinical relationship

Three themes emerged relating to patients’ and staff experiences of the patient-clinician relationship: staff knowledge of patients’ condition, reassurance and providing appropriate care, and concordance in the patient-clinician relationship.

Phone calls were essential in both models for staff to gain comprehensive knowledge of their patients’ condition. Staff across sites gathered information on patients’ medical history and social needs at the referral and triage stages, which they referred back to during monitoring. Staff delivering mixed models used the data they received to get an overview of patients’ health and called patients if there were signs of deterioration to conduct a more thorough assessment over the phone or to escalate care (e.g., assessing breathlessness, oxygen saturation after exertion, coherence). Phone calls were useful for gaining information about social circumstances and mental health, sometimes prompting referrals to other services.

“Many of the patients when we come across... live on their own. So, it’s not just their health it’s the... wellbeing of the patients as well... There are many times where I have done the referrals... and provided more support for them, for food and other medications and things like that” Site D, Staff 4

Staff and patients from mixed model sites mentioned that continuity of staff making the calls was valued as staff could build a rapport with patients and better judge their recovery progress. Staff members (across both models) highlighted that on the phone patients were more likely to mention other medical symptoms that might require attention (e.g.,

symptoms of heart failure). Staff from two analogue-only sites reported that depth of knowledge gained from phone calls was a key reason for not adopting tech-enabled platforms.

There was no evidence of a difference ($p = 0.559$) between models in how patients rated contact with the service team (see Appendix G). Staff across all sites reported that the opportunity for patients to discuss symptoms with a clinician reassured them and prevented patients from unnecessarily contacting emergency services or encouraged deteriorating patients to go to hospital when they were afraid.

“So a lot of [patients], when you speak to them, and you say, ‘Actually look, your levels were 92. I’ve exerted you for a minute they’ve dropped down to 89, can you hear yourself gasping on the phone?’ They say, ‘Yes.’ And I say, ‘Well that’s really serious you do need to call an ambulance.’ And then they will come around to it.” Site A, Staff 4

Regardless of the mode ($p = 0.158$), patient survey respondents reported that contacting a health professional was relatively easy. However, seeking further help if they had concerns about their health was significantly easier ($p = 0.006$) for patients using tech-enabled modes (see Appendix G), although, differences might reflect differing characteristics of patients using the modes. Several staff delivering mixed models noted patients using technology should be understood that whilst readings were reviewed frequently, communication was not synchronous, and patients should call emergency services if readings were low. However, patients reported that despite receiving an automatic prompt to escalate their care when readings were low, they preferred to first speak to the service for a more personalised assessment.

Patient interviewees using tech-enabled modes reported that being contacted by staff if they had missed readings gave them a sense of security that someone was watching over them. Yet for staff, managing/chasing non-submitters could be time-consuming, frustrating, and worrying, consuming valuable resources. Services tried to encourage patients to submit readings by setting out service requirements to patients at onboarding.

“What we found initially was that [expectation of submitting twice a day] wasn’t explained fully and then we were having to chase them a lot for readings. So that is really explicit at the start now that... almost like as daft as it sounds like a verbal contract. You know, ‘We will do all of this however, what we expect of you is you know readings twice a day to be compliant’.” Site I, Staff 3

4. Discussion

4.1. Principal results

This is the first national evaluation of patient and staff experiences of the rapid implementation of mixed models and analogue-only models of COVID-19 remote monitoring services across multiple care settings. Overall, patient and staff experiences of tech-enabled remote care were positive, suggesting remote care could feasibly reduce the burden on secondary care for COVID-19 and potentially other conditions where physiological symptoms can be effectively measured and monitored by patients and/or carers. The study also highlighted several features of tech-enabled models that supported clinical decision-making, for example, the use of data dashboards with traffic light systems to prioritise patients. Mixed models were considered more scalable by staff and able to process large volumes of data, as the work of data input was transferred to patients using tech-enabled modes. However, phone calls and establishing relationships with health professionals remained a feature of both mixed and analogue-only models and were important for gathering more detailed information about a patient’s condition and giving patients opportunities to seek advice about whether/how to escalate care. Personal contact was also needed to set-up home monitoring and triage patients, indicating staff resource to establish and deliver services needs to be factored into the operational costs of tech-

enabled models of care, as all models involved some aspects of analogue communication.

The efficiency and likelihood of scaling up tech-enabled models appeared contingent on patients being prepared and able to do this work [28]. Patients using tech-enabled modes of data submission tended to be younger, have a higher level of education and more likely to identify as White British compared to analogue modes. As most patients did not recall being given a choice about the mode they were offered, it may be that staff were attuned to the best option to suit individual patients, or that staff were biased in their selection of which patient groups they thought could manage technology. As remote monitoring services continue to become more common, it is important that patients are informed of tech-enabled options to support their care and are involved in decision-making. Collecting and monitoring data on patients' access to technological infrastructure and skills could inform services' digital inclusion strategies. Older patients, patients with physical or cognitive impairments, patients living alone, and those with communication difficulties may need additional support from services to engage [16,40].

We found that the PERCS framework [16] useful for selecting and placing this study's focus within the wider context of the complexity of evaluation matters related to implementing remote monitoring services. We were not able to explore all the domain's features within this study; the impact of the supply chain and cost of the technologies were not covered as these were related to the experiences of more senior and operational staff (and are reported on elsewhere).

4.2. Comparison with prior work

Our findings extend the literature on remote home monitoring by comparing patient and staff experiences of remote home monitoring implemented rapidly at scale. In our study of staff experiences, we found that training in the delivery of services was mostly on-the-job and for many staff, processes for monitoring were not easily integrated into existing work systems [34]. As with previous studies [24,29,31], staff noted that better functioning systems that fit with work practices would have greatly improved efficiency, highlighting the need to involve clinicians in the design and development of technical platforms. Given the number of tech-enabled models now established, there is a need for service leads to trial different systems and incorporate patient feedback and involvement.

Staff engagement has been explored in previous studies [24,29], but this study extends previous research by considering scalability of services. Staff reported that mixed models were better equipped to manage large patient numbers without jeopardising clinical relationships. However, managing patients who did not relay symptoms was resource-intensive and staff reported that some patients had disengaged from the service because of a preference to self-manage. Consistent with previous research showing staff concerns about patient safety in chronic conditions [29], the acute nature of COVID-19 caused staff anxiety about rapid deterioration. There is a question of whether services' resources could have been better optimised for patients' needs, by: addressing concerns about risk in staff supervision and training, offering lower-risk patients the option to self-monitor, by adapting tech-enabled platforms to offer varying levels of automated contact, and/or following more stringent protocols for managing non-submitters (e.g., discharging patients back to their GP if they missed three data submission points).

Although patients, overall, in our previous study and others of COVID-19 remote monitoring, have found tech-enabled modes of monitoring useful and easy to engage with [8,18,28], some patients were reliant on support from family and friends to engage with technology [28], supporting prior work that some patients have differing support needs [16,23,41] and need to be able to access a health care professional on the phone or in person [25–26]. Improving digital health literacy in the population, and training and supporting the workforce to build digital skills and confidence, could widen participation in digital health care and maximise the benefits of the service [33,40,42]. Co-

designing digital health services with patients to promote better patient engagement may contribute patients' quality of care and outcomes [19,40]. As yet, no firm conclusions can be drawn on whether the introduction of COVID-19 remote home monitoring in England improved patient outcomes relative to pre-implementation, in part due to low coverage of the programme [15,43].

4.3. Limitations

Some patient groups were under-represented in our sample compared with national onboarding data for COVID-19 remote monitoring [44] (e.g. patients age 80+, ethnic minority groups, patients living in the most deprived areas). Our response rates for the patient and staff surveys were low; it may be that patients and staff who were less engaged in the delivery of the service were less likely to respond and consequently findings may not be representative of all patients and staff. Patients for interviews were selected by site leads; it is possible that participants that had more positive views of the service were selected. There was large variation between sites in terms of staffing, resources, and patient populations, making it difficult to assess to what extent differences in staff and patients' experiences were affected by the working conditions in different services or by the model of service adopted. The language and terminology describing technology was unfamiliar to some staff and patients, which at times caused confusion about what technology was provided.

4.4. Conclusions

The results of this evaluation suggest three policy priorities for implementation of remote home monitoring at scale: 1) to adopt mixed models which allow patients to engage in services with technology if they are able to, or through human contact if they are not; 2) to improve the usability and interoperability of tech-enabled platforms for clinicians through co-design and testing; and 3) to encourage digital inclusivity for patients by developing user-friendly platforms through co-design and testing, providing home internet and technology (where needed), and supporting technology skills development through over-the-phone or face-to-face support. Services routinely collecting and monitoring data on patients' access to technological infrastructure/skills could inform digital inclusion strategies for remote home monitoring.

Summary table.

What was already known on the topic

- Studies have shown that patients and staff like remote home monitoring but there can be barriers to delivery and engagement, and it may not be appropriate for all patient groups.
- The implementation of services is affected by the availability of dependable, high-quality, and clinically-useful technology systems for patients and staff.
- Few studies have explored patient and staff experience of COVID-19 remote home monitoring services.

What this study added to our knowledge

- Older patients, patients with a lower level of educational attainment and ethnic minorities were more likely to relay symptoms through phone calls with the service.
- Staff considered mixed tech-enabled and analogue models better equipped to manage large patient numbers; but improvements were needed to improve functionality of technology systems to better fit clinical and operational needs.
- Tech-enabled modes were not a substitute for human contact, as phone calls were used in both mixed models and analogue-only models.

5. Declarations

5.1. Authors' contributions

All authors were responsible for the study conception, design, and data collection throughout the study. LH led the qualitative data analysis

and NC led the survey analysis. LH, NC, and CV drafted the manuscript with contribution from all authors. All authors commented on drafts of the manuscript and approved the final version. NJF was principal investigator for the study.

Declaration of Competing Interest

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

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Appendix A. Supplementary data

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