Telemedicine and virtual respiratory care in the era of COVID-19

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Shareable abstract (@ERSpublications)
The #COVID19 pandemic has forced a dramatic shift to remote care and accelerated multiple telemedicine initiatives. As they evolve into the new norm, these initiatives must accommodate preferences and address the risk of increasing the digital divide. https://bit.ly/3sj5WYL

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Abstract

The World Health Organization defines telemedicine as "an interaction between a healthcare provider and a patient when the two are separated by distance". The coronavirus disease 2019 (COVID-19) pandemic has forced a dramatic shift to telephone and video consulting for follow-up and routine ambulatory care for reasons of infection control. Short message service ("text") messaging has proved a useful adjunct to remote consulting, allowing the transfer of photographs and documents. Maintaining the care of noncommunicable diseases is a core component of pandemic preparedness and telemedicine has developed to enable (for example) remote monitoring of sleep apnoea, telemonitoring of COPD, digital support for asthma self-management and remote delivery of pulmonary rehabilitation. There are multiple exemplars of telehealth instigated rapidly to provide care for people with COVID-19, to manage the spread of the pandemic or to maintain safe routine diagnostic or treatment services.
Despite many positive examples of equivalent functionality and safety, there remain questions about the impact of remote delivery of care on rapport and the longer term impact on patient/professional relationships. Although telehealth has the potential to contribute to universal health coverage by providing cost-effective accessible care, there is a risk of increasing social health inequalities if the "digital divide" excludes those most in need of care. As we emerge from the pandemic, the balance of remote *versus* face-to-face consulting, and the specific role of digital health in different clinical and healthcare contexts will evolve. What is clear is that telemedicine in one form or another will be part of the "new norm".

Introduction

The World Health Organization (WHO) defines telemedicine (or telehealth; the WHO uses the terms interchangeably) as "an interaction between a healthcare provider and a patient when the two are separated by distance" [1], adding that this communication may be synchronous (as in telephone or video consultations) or asynchronous (when data, queries and responses are exchanged by email or short message service (SMS)) with the aim of providing clinical support and improving health outcomes [2]. Teleconsultations, telemonitoring, mobile health and remote delivery of interventions are all facets of digital healthcare that have been thrust into mainstream service by the requirement for social distancing in a pandemic, and are now a core focus of professional societies (for example, the European Respiratory Society [3]).

Telehealth is promoted as having the potential to contribute to universal health coverage by providing cost-effective accessible care [4], including for vulnerable and ageing populations and those living in remote areas [1]. Others have pointed to inequities arising from the "digital divide", as the people most in need may be those least able to use, or without access to, essential technology [5]. In addition to enforcing remote clinical care, the coronavirus disease 2019 (COVID-19) pandemic has demonstrated the enormous value to public health and policy of the "big data" generated by digital health, although the need for confidence in how personal data are protected and used remains a priority for the public [4]. Artificial intelligence (AI) can support respiratory care; for example, interpreting chest radiographs and sleep studies [6, 7], predicting acute exacerbations of COPD [8] and answering questions from people with lung cancer with chatbots [9]. However, effective implementation strategies are poorly developed [10], and the potential for AI to replace (as opposed to support) clinical decision-making [11] currently outstrips the trust of many patients and professionals [12, 13].

While we are mindful of this wider perspective, in this clinical review we focus on selected examples to provide an expert perspective on the potential of telemedicine to deliver virtual respiratory care. We consider how the COVID-19 pandemic has had a major influence on this story, promoting implementation

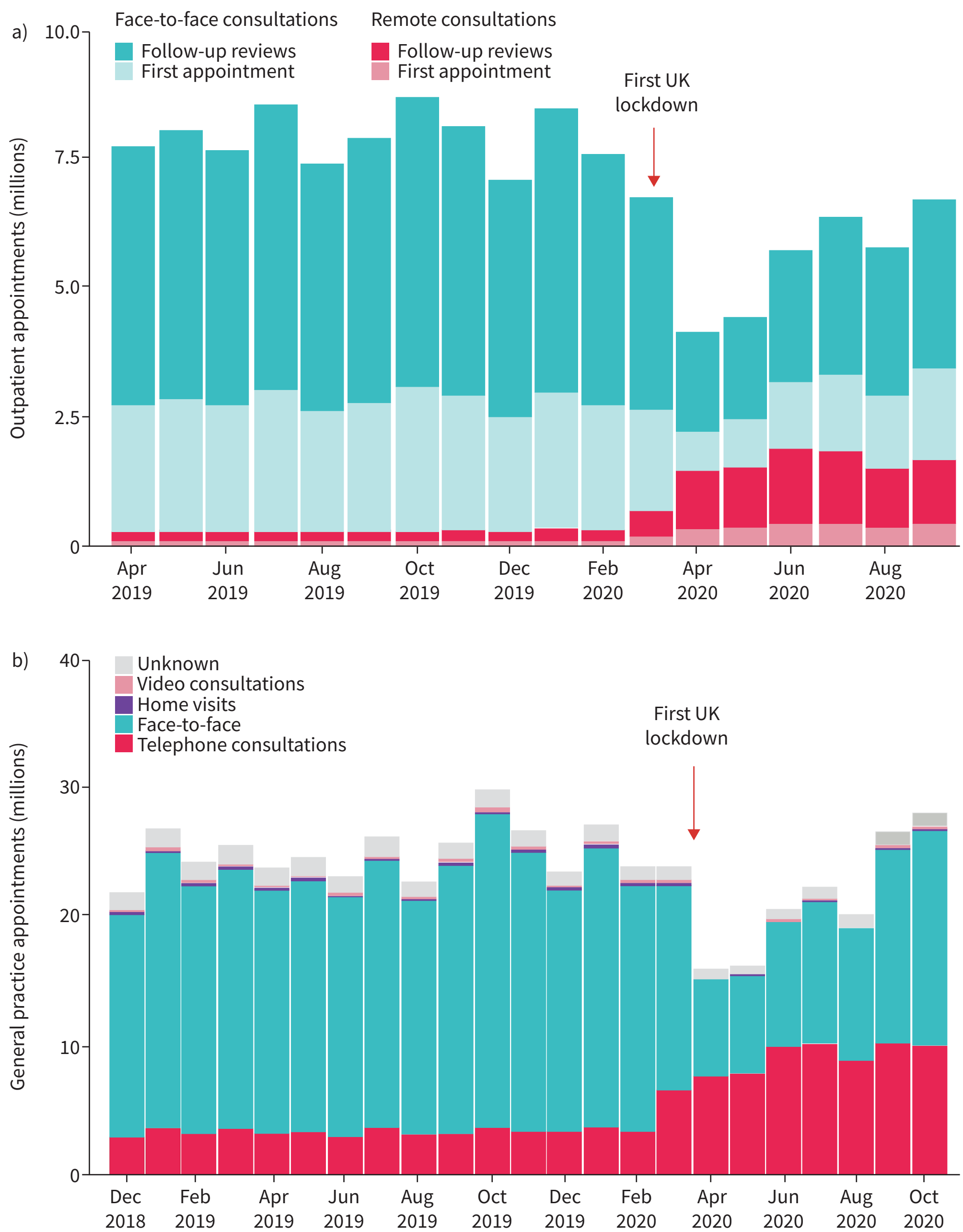

FIGURE 1 Shift to remote consulting in hospitals and primary care in the United Kingdom (UK) in response to the coronavirus disease 2019 pandemic. a) Hospital outpatient consultations; b) general practice consultations. Reproduced and modified from [22] with permission.

of remote ways to monitor the progress of COVID in people at risk [14–18], highlighting the potential of safely maintaining the care of people with noncommunicable respiratory diseases [19, 20] and of supporting self-management during times of lockdown [21]. The imperative to contain the spread of infection resulted in an overnight shift to remote consulting (figure 1) [22, 23]; as COVID-19 gradually moves to endemic rather than pandemic status, we will discuss the "new norm" and the legacy that the pandemic has given to telemedicine.

Remote access to consultations

Remote consulting is not new. The medical literature of the late 19th century contains a number of reports of innovative practice using the recently invented telephone to (for example) listen to a child's breath sounds and reassure a mother that their child did not have croup, enable transmission and amplification of heart sounds to a remote specialist, facilitate organisation of rural general practices and to communicate within and between hospitals [24]. Some of the barriers that have held back widespread adoption of telephone (and other remote) consulting were being described in letters to the editor of *The Lancet* 100 years ago [24], including inadequate fees in comparison to face-to-face consultations [25–27] and the fear of being swamped by anxious patients. In contrast to the pandemic role of remote consulting in supporting infection control, an early scare was the risk of contracting infection from unhygienic public telephones [24].

Telephone consulting for acute problems

A century later, the telephone had become the norm for providing access to acute medical advice with out-of-hours services in many countries reporting that the majority of calls could be managed safely without the need for a face-to-face consultation [28–31]. Respiratory infections are one of the commonest reasons for out-of-hours and primary care same-day contacts [32–34], so (even pre-COVID-19) telephone consultations were a core component of front-line respiratory care. Whether "telephone triage" is an efficient strategy for managing acute demand in routine practice is unclear [35]. Although some [31, 36, 37], but not all [38], studies have shown that telephone triage reduces professional time and costs on the day of the request, there is evidence that consultation rates increase over the 4 weeks after the index call [31, 38–43]. Compensating for lack of confidence in decisions made in remote consultations has been suggested as a reason for increased rates of follow-up [31]. However, safety evidence is reassuring, with systematic reviews demonstrating no significant increase in poor outcomes such as emergency department visits, hospitalisations or deaths [39, 41–43].

Another possibility is a qualitative difference in telephone consultations compared to those undertaken face-to-face. Analysis of the content of consultations shows that telephone consultations are shorter, mainly because they only address one problem (typically at least half of primary care face-to-face consultations deal with two or more presenting problems [44]), suggesting that additional problems are deferred in focused telephone calls. Several studies have concluded that doctors undertaking telephone consultations devote less time to rapport building, data gathering, provision of education and counselling and provide less opportunistic healthcare [44–47]. Reassuringly, patients' recall of important advice (such as treatment instructions, or safety-netting advice) does not appear to be compromised by remote modes of communication [48].

Telephone consulting for routine review of known conditions

A recurring theme (from patients [49] and healthcare professionals [50]) is that remote consulting may be particularly appropriate for the review of known problems, when there is no requirement to make a diagnosis [50], and potentially a relationship already exists between the patient and healthcare professional [51].

20 years before the COVID pandemic forced remote consultations, several trials investigated the potential of telephone reviews for asthma [52, 53]. A key aim of these primary care studies was to increase the (historically low [54]) proportion of people with asthma who received at least an annual review. Reassured by a randomised controlled trial (RCT) that showed that telephone reviews could be cost-effectively substituted for traditional face-to-face reviews with no loss of control [52, 55], different strategies have been tested to implement this in routine practice. Using proactive telephone calls to triage the need for a face-to-face review increased review rate from 64% to 87%, with no between-group difference in control or use of healthcare resources [53]. Incorporating the offer of a telephone review (about a fifth of patients chose review by telephone) and opportunistically calling nonresponders increased the proportion reviewed from 54% to 66% [56]. A Cochrane review in 2016 (six studies) concluded that offering telephone consultations could increase the proportion of people with asthma who received a review, with no evidence

of harm in terms of asthma control, although impact on unscheduled care was uncertain because these events were uncommon in primary care populations [57].

Similarly, there was already evidence that remote consulting, informed by usage data, was effective and more convenient than traditional face-to-face consulting for reviewing obstructive sleep apnoea and hypopnoea syndrome (OSAHS) [58]. With the COVID-19 pandemic, remote consulting became the norm for routine reviews of most long-term conditions [59].

Telephone consulting for hospital outpatients

While historically less widely adopted in hospitals than primary care practice (until the pandemic mandated a move to remote consulting), observational studies have shown the potential utility of telephone calls to replace face-to-face follow-up consultations [60, 61], and also as a preliminary contact to streamline future hospital consultations [62]. A telephone call to take a history and arrange necessary investigations prior to the first respiratory outpatient attendance reduced the need for follow-up appointments [62]. Post-discharge telephone follow-up has been tried in a range of conditions (although not specifically in respiratory conditions), but while appreciated by patients, benefits in terms of reduced complications or readmissions have not been demonstrated clearly [63]. About a third of respiratory outpatient follow-up appointments were considered suitable for telephone reviews because there was no need for a physical examination or hospital-based tests [60, 61].

Video consulting

Video consultations offer the potential to overcome some of the limitations of telephone reviews by enabling visual communication [64], but in contrast to telephone consulting were rarely part of routine practice until COVID-19 forced social distancing [65, 66]. While supporting the feasibility of video consultations [67], the pre-COVID-19 evidence base is therefore limited with respect to effectiveness, safety and cost [68, 69]. Anticipated benefits compared to telephone consultations are the ability to pick up nonverbal clues, avoid misunderstandings and improve rapport [70]. More specifically, in the respiratory context there was already interest in the potential to observe and demonstrate inhaler technique [70], improve adherence to tuberculosis therapy with remote directly observed therapy [71], deliver breathlessness training for COPD [72], share completion of an asthma action plan [73], undertake remote spirometry [74], provide supportive and palliative care in cancer [75] and follow-up OSAHS [59].

Early exploratory work highlighted that the perceived benefits of having a visual component were tempered by practical problems with the technical infrastructure, as either the patient or the clinician had inadequate bandwidth, or an unstable connection, and sometimes just a lack of basic equipment such as a webcam [66, 70, 75–78]. Although many of technical hitches were minor (such as failure to "unmute" or "enable video"), "technical talk" occupied a significant proportion of video consultations [25, 26, 68, 75, 76], which disrupted the flow of the conversation and in the context of a busy clinical environment could be prohibitive [26, 78, 79].

The dramatic increase in video consultations during the first few months of the pandemic was particularly evident and maintained in secondary care [77, 80–82] (figure 2). Reports from a range of clinical settings and healthcare systems emphasise the significant organisational changes that were needed to establish a practical and safe outpatient video-consulting service [83], typically including upgrading infrastructure, revising billing arrangements and service workflow, ensuring suitable consulting space and staff training, developing processes for appointment handling (including identifying patients for whom remote consulting was inappropriate) and allowing additional time to resolve technical problems [25, 70, 76–79, 82, 84]. Pandemic changes to global and local policies promoted acquisition of necessary infrastructure, facilitated the development and approval of hardware and software systems for managing video calls and e-consultations [81] and promoted the organisational changes required to implement "digital-first" healthcare systems [27, 81, 82, 85].

Asynchronous consulting: SMS, e-consultations and automated telephone calls

A decade ago, qualitative interviews with patients [64] and general practitioners [86], and a survey of practice managers [87] revealed that email and SMS text messaging were perceived as useful for sending appointment reminders and sharing specific information (such as results of investigations), but were not acceptable alternatives to face-to-face consultations. A Cochrane review (132 studies) concluded that automated telephone calls could increase uptake of immunisation and screening, reduce nonattendance at appointments and promote adherence to medications or tests, although evidence of health benefits in specific respiratory conditions (asthma, COPD, sleep apnoea and nicotine dependence) was inconclusive [88].

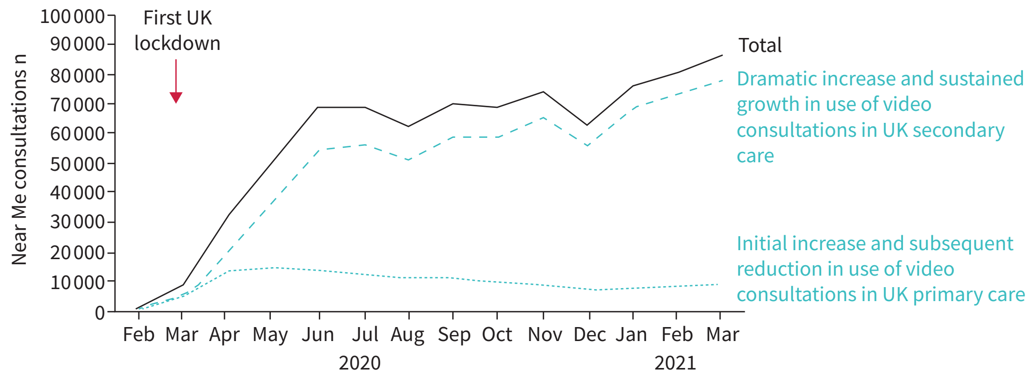

FIGURE 2 Growth in use of a United Kingdom (UK) National Health Service video-conferencing platform (Near Me) at the beginning of the coronavirus disease 2019 pandemic. Reproduced and modified from [81] with permission.

A systematic review including 57 primary/community care studies from a range of countries concluded that e-consultations were convenient and valued for routine queries on nonserious conditions [89]. Despite this, pre-pandemic use of e-consultations was very low and largely used for administrative requests (certification or prescription requests; test results) [90]. Although seen by early adopters as an "inevitable" innovation in a digital era, dealing with e-consultations was not necessarily time efficient [91], despite the potential to divert requests to appropriate members of the team. Approximately two-thirds of clinical e-contacts were converted to a telephone or face-to-face consultation, especially when the query related to a new problem [91], and, echoing the findings of acute telephone consultations, a quarter of online consulters had further consultations in the following month [90]. A Cochrane review in 2012 (nine studies) found insufficient evidence of the impact of e-consultations on resource use, and quality of communication [92].

E-consultations typically use a template to structure the clinical history and ensure relevant information is collected [91]. These may be generic templates for acute consultations, potentially interactive depending on initial choices, or may be tailored to disease-specific follow-up. For example, the template may request standardised information such as completion of control questionnaires in reviews of asthma or COPD (https://www.ardens.org.uk/). While offering convenience for patients with clearly defined problems, concerns have been raised about how "empathy" and "emotional work" are marginalised by asynchronous e-consultations [91].

In the context of the pandemic, the facility of attaching photographs and documents has been widely used to avoid face-to-face contact. Enabled by bespoke software linked to the electronic health record (https://www.accurx.com/who-we-support/general-practice/), photographs of rashes or other visible problems can be requested by SMS to supplement a telephone consultation, or documents can be sent to the patient reinforcing information [93]. Medicolegal concerns about confidentiality, timelines for responding to e-consultations or the risk of missing an important diagnosis are ongoing concerns in the context of communication reliant on written information with no auditory or visual clues [87, 89].

Training and advice for remote consulting

Given the dramatic rise in use of remote consulting during the pandemic, it is unsurprising that numerous articles have been published with advice on consulting in the context of the COVID-19 pandemic [59, 68, 94, 95]. While telephone consultations are relatively well practised [51, 96], advice on video consulting often include detailed "checklists" for clinicians of organisational, technical and medicolegal tasks, "video-conference etiquette", generic consultation skills to build rapport, establish trust and safety-net [68, 94, 95], even before specific clinical tasks are considered. Home monitoring devices are increasingly available, or can be lent to monitor an acute illness or for a specific task [94]. An important priority during the pandemic was assessing breathlessness remotely without access to measurements [95]. Despite much discussion [97], most clinicians continued to use the pragmatic approach of asking the patients if they felt more breathless than usual combined with listening for evidence of shortness of breath as the patient was speaking.

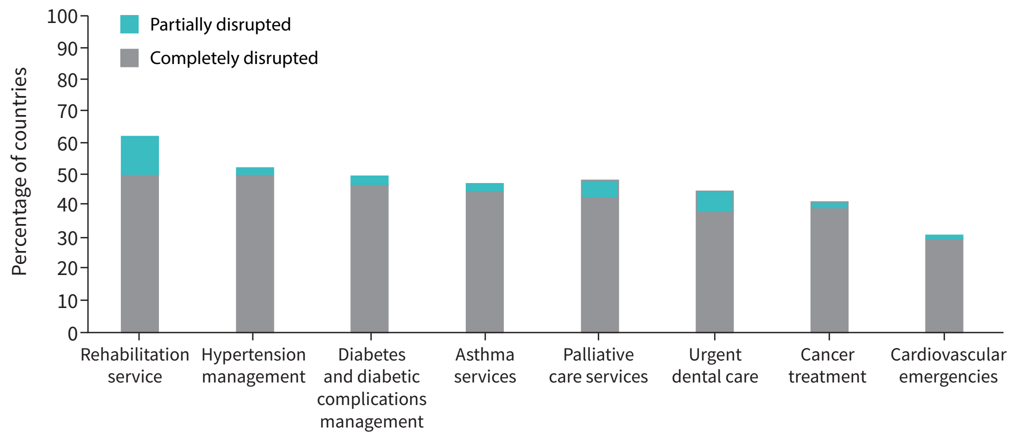

FIGURE 3 Percentage of countries reporting disruption to noncommunicable disease (NCD) services during the pandemic. This "snapshot" of the disruption to NCD care from a World Health Organization survey of 163 countries worldwide was conducted in June 2020, so represents the early impact of the pandemic. Reproduced from [19] under the Creative Commons Attribution ShareAlike 3.0 InterGovernmental Organization licence.

Video conferencing became a norm for many people to maintain social contact during the pandemic, but patients may still benefit from advice about using the medium for consultations [68]. In particular, ensuring a suitable setting (private, well lit, quiet and with adequate internet connection) is important advice [68].

Maintaining care for respiratory noncommunicable diseases

Maintaining the care of noncommunicable diseases (NCDs) is a core component of pandemic preparedness, although a global WHO survey revealed significant disruption of NCD-related care in many countries, including a number of respiratory services (figure 3) [19]. A survey of 39 European countries revealed the potential of remote solutions for maintaining access to prescription drugs and other essential services [98], despite restricted outpatient and primary care consultations in 90% of countries [20]. Interactive telemedicine has been advocated to support the care of a broad range of NCDs with an extensive (and often positive) evidence base in the context of heart failure, diabetes and hypertension [99]. We here consider five diverse exemplars of remote care for respiratory NCDs. These are selected as being relatively common respiratory challenges with an evidence base that can inform delivery of care.

Monitoring to support remote consulting in OSAHS

OSAHS affects an estimated billion people globally and optimised diagnostic and treatment pathways are necessary to deliver cost-effective healthcare and reduce health impacts [100]. Remote consultations have been an option for people with OSAHS who are using continuous positive airway pressure (CPAP) therapy for more than two decades [101]. People can be seen at distance from the main sleep centre, with discussions informed by telemonitoring data from their CPAP devices viewed on cloud-based platforms that allow adjustment of prescribed settings if issues such as poor adherence or high mask leaks are identified [102]. There is increasing evidence that this approach is at least as effective as face-to-face reviews and may enable more timely management. In terms of service delivery, telemonitoring has been deemed feasible in a range of healthcare systems [103–106], facilitating access to CPAP initiation [103], promoting timely titration of therapy [104, 107, 108] and troubleshooting of technical problems [104, 109]. A meta-analysis (11 RCTs; 1440 patients) concluded that overall telemedicine improved adherence compared to centre-based care [110]. Clinical outcomes (*e.g.* Epworth Sleepiness Scale score) were generally reported as similar between groups [58, 103, 107, 111], and there is evidence that telehealth is more cost-effective than traditional in-person follow-up [106, 108, 111, 112].

Telemonitoring and video consultations (figure 4) are generally well accepted by patients using CPAP therapy [101, 105–108, 112–114]. The time savings reduce the impact on work productivity and the reduced travel and fuel consumption costs are valued as environmentally friendly [58].

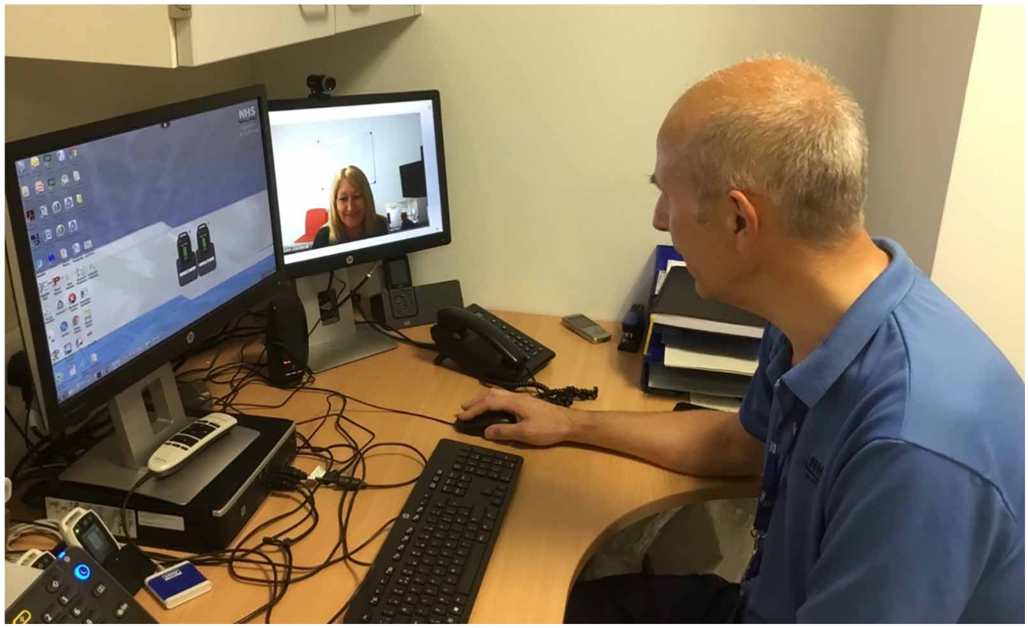

FIGURE 4 Remote consulting in a sleep apnoea service (Dumfries and Galloway, UK).

Remote monitoring to reduce exacerbations of COPD

Key objectives of COPD telemonitoring are to reduce exacerbations (especially severe exacerbations resulting in distressing and costly admissions) and improve quality of life. It is therefore disappointing that a Cochrane review in 2021 (29 studies from 11 countries) concluded that remote monitoring is ineffective at reducing exacerbations, admissions and deaths even when provided as part of a multifaceted intervention [115]. For example, in a meta-analysis of three studies (400 participants) comparing telemonitoring supported by usual care with usual care alone, there was no significant reduction in hospital admissions or improvement in quality of life at 6 months [115]. The trials included in this meta-analysis were heterogeneous, and the review authors suggest that the intensity of clinical contact associated with the intervention may have been a factor in determining effectiveness.

These interventions are typically monitored asynchronously by healthcare professionals at a substantial resource cost to healthcare systems [116, 117]. Although there was no evidence of benefit from telehealth, importantly there was no evidence of harm [115], and there may be clinical, social, geographic and (especially in a pandemic) infection control reasons for providing telemonitoring to some individuals.

The reasons for this disappointing lack of effect in COPD are likely to be multifactorial, but a key factor is that there are no clear predictors of exacerbations [118]. Symptom scores are poorly predictive [119], reflecting the difficulty many people with COPD have in differentiating early exacerbations from day-to-day fluctuations in symptoms [120]. Similarly, background variation in physiological measures (oxygen saturation, heart rate and respiratory rate) make it difficult to detect small changes associated with exacerbations [121–123]. Innovative biomarkers that could change the utility of telemonitoring are yet to be translated into clinical practice [124].

Rather than involving healthcare professionals in regular monitoring of telehealth data, there is some evidence that digitally supported self-management may improve breathlessness and (at least in the short term) quality of life [125–127].

Digital support for asthma self-management

Supported self-management of asthma is an effective complex intervention that reduces acute attacks and improves asthma control [128, 129]. Peaks in prescribing of inhaled steroids and emergency packs of steroids immediately prior to the first lockdown, suggests that an increased focus on self-management may have contributed to the reduction in asthma attacks and emergency department attendances observed during the pandemic [130]. Novel strategies for supporting self-management became important as both acute consultations and routine reviews shifted to remote delivery [59].

Support for people living with asthma encompasses clinical, practical, information and social support [131], much of which can be delivered remotely [21]. From a clinical perspective, the key component is the self-management discussion summarised in an agreed action plan. Integrated within ubiquitous mobile technology, digital action plans can be available whenever and wherever timely action is needed. In addition, sharing of logged data could facilitate remote medical advice in the event of an attack [132].

A Cochrane review (18 studies) comparing telemonitoring interventions with usual care, showed that health outcomes (acute attacks, healthcare resource use, asthma control) were similar in both groups [133], although a review of interactive telehealth concluded that there may be a small improvement in quality of life in adults [134]. Multifaceted interventions using combinations of remote case management, telemonitoring, teleconsultations, reminders and education may be effective [135]. Other systematic reviews echo these findings, emphasising that while telemonitoring may not be consistently more effective than usual care, there was no evidence of harm [99, 136–139]. The decision on their use might therefore be based on patient preference and organisational routines.

Most asthma applications (apps) are monitoring devices, with few apps including an interactive action plan that responds to asthma status by prompting the user to follow their healthcare professional's personalised advice [140]. Existing algorithms are based on symptoms and peak flows [141], but as patient and professional trust in artificial intelligence grows [12], digital action plans will be able to incorporate data from novel wearables and environmental sensors into personalised "living with asthma" action plans.

Remote delivery of pulmonary rehabilitation

Telerehabilitation is the delivery of rehabilitation services at a distance, using technology to provide exercise training, self-management education and information regarding disease management remotely [142]. Telerehabilitation can incorporate a number of technological modalities including telephone (audio calls; text messaging), web-based platforms, mobile applications or interactive video-conferencing. Importantly, participation may depend on patients having an appropriate device (*e.g.* telephone, smartphone, tablet or computer).

Several studies have investigated the feasibility and efficacy of telerehabilitation delivered *via* different modes of delivery. One option is group exercise *via* a videoconference software system installed on a tablet or personal computer. Patients watch the on-screen instructor and use their own minimal equipment at home to exercise [143]. Other approaches allow patients to access an interactive web-based programme that includes home exercises, an individualised action plan and education material. Patients interact with the healthcare professionals by entering information on the dedicated webpage for asynchronous review by the professional [144]. Another option installs exercise videos and educational material onto a tablet as a resource for patients exercising at home. Telemonitoring, often *via* wearable technology, may complement telerehabilitation by enabling patients to monitor vital signs using Bluetooth-enabled wearables that transmit data to a cloud-based platform *via* an app installed on the tablet. The healthcare professional reviews vital signs and patient-reported outcomes and provides feedback to the patient (figure 5) [145].

A recent Cochrane review [146] compared telerehabilitation to centre-based rehabilitation in patients with chronic respiratory diseases, concluding that there was "probably little or no difference" (moderate-certainty evidence) between the modes of delivery in their effect on exercise capacity (6-min walk distance, incremental shuttle walk test, cycling tests). Similarly, there was no between-group difference in dyspnoea or quality of life, although anxiety (but not depression) favoured telerehabilitation [146]. Adverse effects were similar in both delivery modes. Importantly, participants were more likely to complete a programme of telerehabilitation compared to centre-based rehabilitation (completion rate 93% compared to 70%). The review concluded that telerehabilitation could provide a clinically effective and safe alternative to centre-based pulmonary rehabilitation [146].

Telephone delivery of psychosocial interventions for lung cancer

A Cochrane review (32 studies) of telephone support for cancer care concluded that telephone reviews were convenient for patients, but the impact on symptom control varied [147]. Three of the studies in this review recruited people with lung cancer with variable outcomes [148, 149]. A psychosocial intervention delivered in four telephone calls did not improve symptom management or caregiver burden [148], although a six-session intervention designed specifically for people with advanced lung cancer improved depression, anxiety and caregiver burden [149]. Caregiver support provided in 14 telephone calls not only reduced anxiety and improved the self-efficacy of the caregivers, but also improved patient outcomes (pain, depression, quality of life) [150]. These studies tested specific interventions in addition to routine

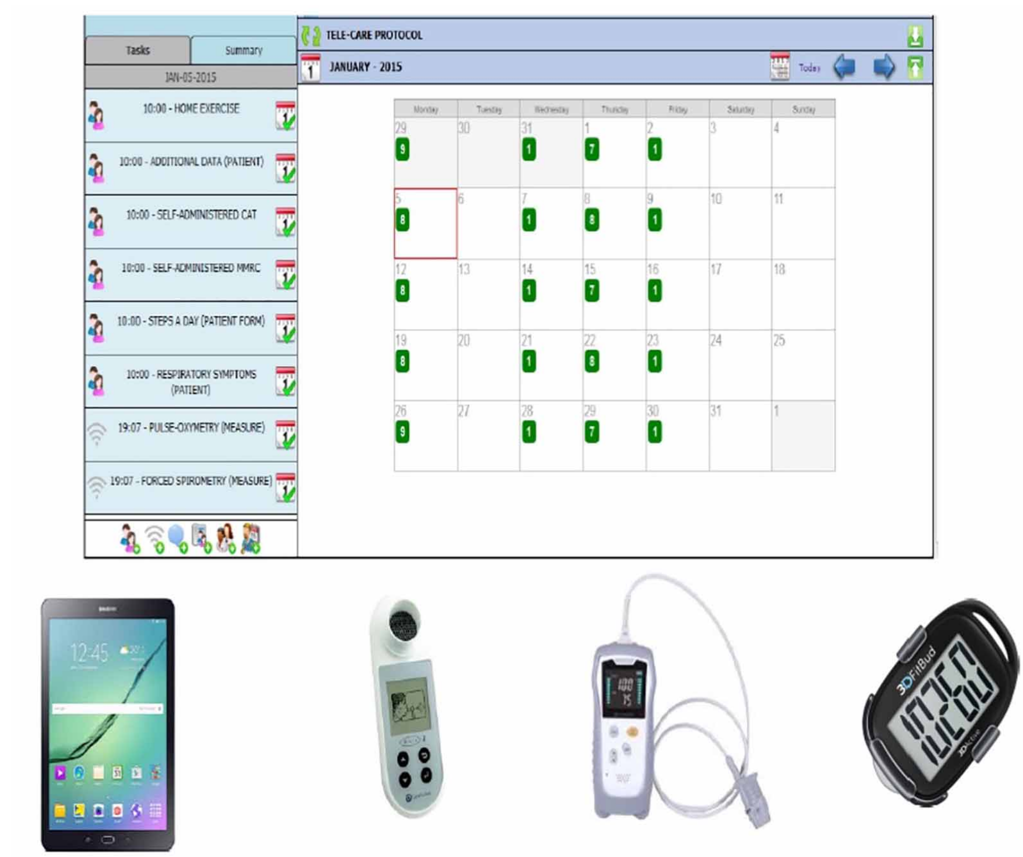

FIGURE 5 Telerehabilitation. Patients monitor vital signs using Bluetooth-enabled wearable monitors that transmit data to a cloud-based platform *via* an application installed onto the tablet. Health professionals can log in and see if the patient has uploaded data, and provide feedback [145].

respiratory/oncology follow-up; none pre-empted the pandemic context in which traditional face-to-face follow-up was replaced by remote consulting [76].

Digital innovation to manage COVID-19 infections

Qualitative data from eight European countries described the central role of telephone triage in providing safe access to primary care in the context of the pandemic, and specifically highlighted the challenge of managing respiratory infections remotely with no (or very limited) access to COVID-19 testing [151]. Patients generally accepted the need for remote consulting, even if some would have preferred a face-to-face appointment, and had confidence in their primary care professional's advice, especially if there was a pre-existing relationship. The professionals described the uncomfortable tension of needing to avoid face-to-face contact to prevent spread of infection and wanting a physical examination to provide reassurance. Ensuring clear safety-netting and making arrangements for review if things deteriorated was a priority. Supporting the social consequences of the pandemic (loss of income, fears of essential workers of being unable to isolate, comforting the bereaved unable to attend funerals) were core roles for primary care during the pandemic, which general practitioners and nurses felt was made more difficult because of the lack of "touch" in remote consultations [151].

Telehealth support for community management of COVID-19

There are multiple examples of telehealth, instigated rapidly to provide care for people with COVID-19, to manage the spread of the pandemic, or to maintain services.

Community-based telemonitoring of symptoms scores, temperature, oximetry and blood pressure supported by self-management information and/or remote monitoring proved to be a cost-effective alternative to hospitalisation [15, 16, 18, 152–156]. Although a rapid systematic review was unable to confirm safety due to lack of standardised reporting [18], mixed-method evaluation of individual programmes concluded that they were reassuring to patients (especially the oximetry) [15, 153, 156], acceptable to clinicians [15, 152, 156], able to detect signs of deterioration [15, 156, 157] and a safe approach for selected high-risk patients with mild-to-moderate COVID-19 [15, 16, 18, 155–157]. Economic analysis was limited to reporting resources used and the amount spent per patient monitored [18].

Contact tracing smartphone-based applications potentially helped control the spread of COVID-19, but the effectiveness of this technology depended on high levels of adoption among the population [158]. Different age groups had different perceptions of contact tracing technologies: older people were motivated by their concern about health risks, but less convinced about using an app; middle-aged adults were concerned about security and privacy of health data; younger generations were motivated by attachment to their community and were influenced by social media [159, 160].

Maintaining allied health professional services (physiotherapy, dietetics, occupational therapy, psychology, speech therapy, social care) required rapid implementation of telehealth that was generally positively received, although some patients preferred a blended model of telehealth and in-person care [161]. Substantial administrative staff support was required to manage the demand for telehealth [161]. The COVID-19 pandemic accelerated the implementation of electronic mental health services to address pandemic-related stress (including post-COVID traumatic stress) and problems of social isolation, as well as a range of specific mental health disorders [162].

AI techniques have been applied to COVID-related epidemiology, therapeutics (drug discovery), clinical research (predictive modelling), social and behavioural studies [163]. Specific examples include development of automated tools for interpreting computed tomography scans, chest radiographs and lung ultrasound diagnostics [164–168], although clinical trials to establish the benefits and safety of image analysis in clinical practice are awaited [169].

Perspectives on empathy and developing rapport in remote consultations

Concerns about the potential loss of empathy when healthcare professionals and patients cannot see and "feel" each other (maybe akin to the "laying on of hands" of traditional images of medical consultations) has been the subject of discussion for many years [102, 170], and remains a theme in current research [151, 171]. One physician observed in the context of breaking bad news, that "you can't offer a tissue in a remote consultation" [70], and others have commented on the lack of touch and smell [93], and the loss of "human-ness" in e-consultations [172]. A common observation was that remote consulting "worked better" when the patient and clinician knew each other and the interaction was building on an existing relationship [25, 173]. Communication skills, such listening, encouraging questioning, emphasising choice and investing time in developing rapport may help develop relationships in remote consultations [102, 173], and the increased use of video consulting may overcome some of these "distance" problems [102, 174].

Concerns about digital inequities

The WHO highlights the potential of telehealth to contribute to universal health coverage by providing cost-effective accessible care [1, 4], but there are concerns about the risk of increasing social health inequalities [5]. Although video consultations have been promoted as improving access for the housebound or those living at a distance from healthcare facilities [69], an inflexible policy of remote consulting excludes those who cannot afford [89], or do not have the skills to use required technology [28, 65, 81]. Most studies are conducted in high-income countries, with a paucity of evidence from deprived communities or low and middle-income countries (LMICs), heightening concerns about increasing the digital divide [99]. For example, provision of wearable connected devices and cloud-based technologies are suggested as improving access to diagnostics [147], and providing remote access to pulmonary rehabilitation [146], but insecure electricity and technology infrastructure mean this is unlikely to benefit rural communities in LMICs [175], or those from deprived communities whose use of technology is, of necessity, "frugal" [176]. "Digital-by-default" policies, accelerated during the pandemic, risk leaving behind the most marginalised [176]. In addition, in many LMICs, there is a significant gender gap in mobile ownership, so that women with respiratory disease may not have access to remote pulmonary rehabilitation or support for their asthma self-management, for example [177].

Language barriers in ethnic minority groups are a significant barrier to remote consulting [64, 65]. Ethics frameworks recommend that all digital innovation should address "fairness" as an overarching principle (along with transparency and accountability) [178]. Suggested approaches to reducing "unfairness" include ensuring access to the required infrastructure, and engaging populations at risk of being excluded by virtue of limited e-health literacy or for cultural reasons in the development of digital health initiatives [5].

Older age is often cited as a barrier to use of telehealth, although older patients with reduced mobility may appreciate the ease of telephone access [32], and with appropriately designed interfaces telehealth has been acceptable to people with COPD and associated multimorbidity [116, 179]. Familiarity with video-conferencing software has increased dramatically during the pandemic as families relied on video calls to keep in contact with vulnerable parents and grandparents, which may facilitate telemedicine in the future [180].

People with multimorbidity or general frailty benefit from holistic approaches that may be more appropriately conducted face-to-face [181]. Observational studies suggest that clinicians tend to triage older patients to face-to-face consultations [89, 182], reflecting awareness of the severity or complexity of their healthcare problems [31, 171].

Conclusions and perspectives on the new post-COVID-19 norm

The COVID-19 pandemic has resulted in a major change in perceptions of telemedicine. In many situations, remote consulting has been the only safe option [14, 22]. Incentives and resources have enabled rapid scaling-up of telehealth capacity; "light touch" regulation has enabled practical and perceptual barriers to be overridden [26, 81]. Policy, clinical and research questions arise about how this will evolve post-COVID-19, with tightening of regulations and the imperative to address digital inequalities [81], and e-health literacy [183]. Remote consultations can improve access, reduce costs and travel [27] and offer environmental benefits [82], and are likely to persist as a flexible option, but (patient and professional) preference will become an increasing consideration when choice is not over-ridden by infection control requirements [184]. Evidence-based guidance will be needed on what is clinically safe for remote consulting [65, 82], and the acceptability of an increasing role of AI in interpreting investigations, identifying risk, informing clinical decisions and advising patients on self-management actions [11].

While the exact balance of remote *versus* face-to-face consulting, and the specific role of digital health in different clinical and healthcare contexts will evolve as we emerge from the pandemic, what is clear is that telemedicine in one form or another will be part of the new norm.

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