REVIEW

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Telehealth in chronic obstructive pulmonary disease: before, during, and after the coronavirus disease 2019 pandemic

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Purpose of review

Many healthcare systems rapidly implemented telehealth as a substitute for in-person care during the coronavirus disease 2019 (COVID-19) pandemic. The purpose of this review is to describe the evidence base supporting the use of telehealth for chronic obstructive pulmonary disease (COPD) prior to the COVID-19 pandemic, discuss the barriers to implementing telehealth during the pandemic, and share our opinion about the future of telehealth in COPD.

Recent findings

The evidence from randomized clinical trials in COPD completed prior to the COVID-19 pandemic indicate that the effectiveness of telehealth interventions compared to in-person usual care on clinical outcomes is inconclusive. Recent experience during the COVID-19 pandemic indicates that telehealth may increase access to healthcare and satisfaction with care when delivered in addition to usual in-person care. While some reimbursement-related barriers to telehealth have been alleviated during the COVID-19 pandemic, several patient, provider, and health-system barriers to implementation remain.

Summary

There is a need to further evaluate the delivery of telehealth services as an adjunct to traditional in-person models of COPD care. Standardization and reporting of core clinical, satisfaction, accessibility, and quality of care outcomes are needed to promote cross-study learning and more rapid translation of research evidence into practice.

Keywords

chronic obstructive pulmonary disease, human-centered design, implementation science, pandemic, telehealth

INTRODUCTION

Telehealth is a broad term referring to the delivery of healthcare services where patients and their healthcare providers are separated by distance (Table 1). This review describes the use of telehealth for the care of people with chronic obstructive pulmonary disease (COPD) at various points before and after the start of the coronavirus disease 2019 (COVID-19) pandemic. We describe the evidence base supporting the use of telehealth, discuss the barriers and facilitators of telehealth, and share our opinion about the future of telehealth for COPD. For more information about equipment, privacy concerns, and reimbursement for providing telehealth services, we refer readers to previous publications [1,2].

EFFECTIVENESS OF TELEHEALTH IN CHRONIC OBSTRUCTIVE PULMONARY DISEASE: EVIDENCE FROM PREPANDEMIC STUDIES

Telehealth can support various aspects of healthcare in COPD, including diagnosis, treatment, monitoring, education, and prevention strategies. Numerous studies have examined telehealth for COPD care prior to the COVID-19 pandemic. We provide below a description of three clinical trials in COPD to illustrate the range of telehealth interventions that have been evaluated and then discuss findings from a recently completed systematic review of clinical trials completed prior to the pandemic. In a single-center clinical trial of 168 adults with COPD in primary care, one study examined asynchronous remote monitoring only vs. usual care [3].

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KEY POINTS

- In the early days of the coronavirus disease 2019 (COVID-19) pandemic, many healthcare systems had to rapidly adapt chronic obstructive pulmonary disease (COPD) care to be delivered via telehealth rather than in person.
- The evidence for the effectiveness of telehealth interventions in COPD is inconclusive.
- While several barriers exist for patients, providers and health systems, other barriers have been alleviated due to policy changes amid the COVID-19 pandemic, and both patients and providers report satisfaction with telehealth offerings.
- Researchers and those responsible for care delivery can look to implementation science and human-centered design to ensure that telehealth services are designed and implemented such that they are a good fit for relevant stakeholders.
- Realizing telehealth's greater potential will require expanding current definitions of healthcare delivery to include new, technology-enabled offerings.

Participants in the intervention group received a daily automated phone call or text message that asked them about their breathing compared to the day before. Participants who responded they were worse than the previous day triggered an alert for the primary care office to contact the participant for further evaluation and management ('active monitoring and provider feedback'). Compared to usual care, the asynchronous monitoring group had a significantly lower risk of hospitalization (95% confidence interval 0.18–0.98), though the confidence interval was very wide and approached no difference.

Two studies evaluated telehealth as part of a multicomponent intervention (remote monitoring or remote consultation or both integrated with other interventions) with usual care vs. usual care alone. In a single-center study, 40 participants in the intervention group received disease-specific education; teaching about self-management; enhanced communication with a respiratory therapist (remote consultation); and remote home monitoring of symptoms, oxygen saturation, forced expired volume in one second, and steps in a six-minute walk distance [4]. Over a 3-month period, the multicomponent intervention improved quality of life (primary outcome) compared to usual care alone (St. George's Respiratory Questionnaire score −10.3 vs. −0.3, $P = 0.018$). The small sample size (40 participants) and single-center study design raise questions about the external validity of study findings. In another single-center study using telehealth as part of a multicomponent intervention, 511 adults hospitalized with COPD ($n = 132$) or heart failure ($n = 346$) expected to be discharged to home were enrolled in a 3-month randomized clinical trial [5]. In the group assigned to the multicomponent intervention, remote monitoring and consultation were integrated with an in-person visit by a care transition nurse prior to hospital discharge. During the in-person visit by a care transition nurse, motivational interviewing was used to identify and address patient and caregiver goals (e.g., medication self-management, identifying warning signs, follow-up visit with a primary care or specialist) and participants received training on the use of an interactive voice response (IVR) system. The IVR system (remote monitor) was used to identify clinical 'red flags' (e.g., escalating symptoms, insufficient clinical follow-up), provide customized patient education and motivation, and alert the care transition nurse when patient responses indicated red flags daily to every 3 days for 28 days after hospital discharge. In response to red flags, the care transition nurse would contact the patient to offer telephone coaching to support patient self-management (remote consultation). In analyses that combined

Table 1. Terminology for telehealth

Remote monitoring	Personal health (e.g., respiratory symptoms) and medical (e.g., heart rate, respiratory rate, oxygen saturation) data from an individual in one location that is transmitted electronically to a healthcare provider in a different location
Asynchronous	Does not require live interaction between a healthcare provider and a patient; data files are sent via telephone or secure encrypted internet connections from the patient to a healthcare provider
Synchronous	Real-time monitoring of physiologic data (e.g., heart rate, oxygen saturation), live-streaming of medical images, or video consultations.
Telemedicine	Subset of telehealth and refers specifically to providing clinical services remotely through synchronous patient–provider interactions

Telehealth relies on technology to exchange information (e.g., voice, images, breath sounds, or physiologic parameters) with healthcare providers and can be asynchronous (a time lag of hours to days between transmission of information by the patient and when the healthcare provider responds) or synchronous (a real-time exchange).

participants hospitalized for COPD or heart failure, there was insufficient data to conclude whether the 30-day risk of re-hospitalization (primary outcome) in the multicomponent intervention compared to usual care was higher, same, or lower (i.e., the 95% confidence interval: 0.60–1.49 was wide). There was also no significant difference in re-hospitalization in analyses stratified by diagnosis (COPD or heart failure).

A recently completed systematic review of telehealth in COPD examined 29 clinical trials published through April 2020 (i.e., prepandemic), including the three studies described above [6▪▪]. The systematic review examined the relative effects of remote monitoring or consultation or both in combination with usual care vs. usual care alone in the management of people with COPD. Eight studies ($n = 1033$ participants) compared remote monitoring plus usual care vs. usual care alone. Ten studies ($n = 2456$ participants) compared remote monitoring alone vs. usual care and 11 studies ($n = 2165$) evaluated telehealth as part of a multicomponent intervention vs. usual care. Meta-analyses of the available literature indicated low to very low-quality evidence about the effects of various telehealth interventions compared to usual care when assessed by the risk of COPD exacerbations, quality of life, hospitalizations, or death. In summary, the evidence about the effectiveness of telehealth on clinical outcomes from randomized clinical trials is inconclusive. There was insufficient information presented in the various component trials to support analyses by COPD severity or other subgroups most likely to benefit or be harmed by telehealth. The measurement and reporting of clinical, satisfaction, accessibility, and quality of care outcomes were inconsistent, precluding a comprehensive evaluation of outcomes across studies. Whether the variation in results across studies reflects differences in study populations, composition of the intervention (remote monitoring, remote consultation, or both), intervention fidelity, usual care practices (which may be context-specific) or the outcomes that were assessed is unclear. Standardized measurement and reporting of core outcomes in clinical trials and studies using qualitative methods may be helpful in identifying specific contexts in which telehealth can benefit patients with COPD.

TELEHEALTH IN CHRONIC OBSTRUCTIVE PULMONARY DISEASE DURING THE FIRST YEAR OF THE COVID-19 PANDEMIC

While telehealth interventions were already widely used for stroke care, psychiatry, and rural care before the COVID-19 pandemic [7], this was not true for COPD care.

Impact on in-person chronic obstructive pulmonary disease care and health

The widespread shortages of personal protective equipment (PPE) and concerns about the risk of transmission of SARS-CoV-2 among staff and patients led healthcare systems to drastically reduce nonemergency in-person care services. This, combined with the fear of contracting COVID-19 by patients with COPD likely led to delays and reductions in routine face-to-face consultations, testing (e.g., spirometry), and use of pulmonary rehabilitation [8–11]. Limited social interactions may also be contributing to stress, insomnia, and mental health disorders [12,13].

Patients with COPD are at higher risk of more severe COVID-19 [14], yet there has been about a 50% reduction in hospitalizations for COPD exacerbations during the COVID-19 pandemic period compared to prepandemic times [15]. The reasons for this reduction in COPD hospitalizations are not precisely known, but may include the salutatory effects of infection control precautions for COVID-19 (e.g., washing hands, masks, physical distancing) on the risk of lower respiratory infections that cause COPD exacerbations, increased caregiver and personal attention on COPD care, and increasing availability of telehealth as a substitute for in-person COPD care.

The rise of telehealth and shifts in care

Healthcare providers who were predominantly providing face-to-face care had to rapidly adapt their care in the early days of the pandemic. Of 202 healthcare professionals from 47 countries who responded to a survey administered between March and April 2020 [16], only 14% reported continuing face-to-face care for all consultations for various health conditions. The rest reported either more or all consultations were being carried out by telephone. A minority of respondents highlighted the use of video consultations through Zoom, Skype, WhatsApp, or Facebook messenger. In a separate study conducted by the COPD Foundation between April 26 and May 31, 2020, the authors reported that more than half of healthcare providers (157 of 244, 64%) started using telemedicine in 2020 for COPD care [17]. To respond to these shifts in the U.S., Medicare began reimbursing telemedicine visits at the same rate as in-person visits for the duration of the COVID-19 public health emergency and several (but not all) private payers subsequently adopted similar policies [18,19]. This enabled health systems to resume providing important revenue-generating services for patients, particularly in the outpatient setting.

Table 2. Early pandemic barriers to implementation of telehealth services

Patient-level	Provider-level	Health system-level
Inadequate language translation service	Inadequacy for some types of visits (e.g., need for physical exam or procedures)	Staffing limitations due to state licensure and practice laws, credentialing and liability
Lack of access to reliable technology and broadband	Lack of telehealth equipment needed for measuring weight, some vital signs (e.g., SpO_2), or to support lung auscultation	Costs of telehealth equipment
Inability to use technology	Adequacy of reimbursement	Scheduling templates requiring changes to accommodate telehealth visits
Privacy concerns	Training in use of telehealth equipment	Billing systems requiring changes to include telehealth encounters
Cognitive impairment		Needing to reconfigure space for telehealth encounters for some patients and in-person visits for others
Hearing impairment		

In the early stages of the pandemic, there were several barriers at the patient, provider, and health system level that slowed the implementation of telehealth for people with COPD. Differential access to connectivity via the internet and other barriers can exacerbate disparities by age, sex, race, ethnicity, income, and education.

Barriers to the use of telehealth during pandemic

As healthcare providers rapidly implemented telehealth programs in response to the COVID-19 pandemic, several patient-, provider-, and health system-level barriers to implementation were identified (Table 2) [20,21]. Some provider-level financial barriers that limited the use of telehealth prepandemic were removed when state and federal authorities required telehealth services to be covered by insurers. At present, health insurance issuers only cover professional fees (cost of the physician's professional services). Further growth in the use of telehealth will be limited if technical fees (cost of equipment, facilities, nonphysician medical staff, supplies) are not reimbursed for consultation provided via telehealth.

Patient and provider satisfaction with telehealth

Both patients and providers seem to report overall satisfaction with telehealth services for COPD and other conditions [22–25]. This supports further exploration and development for use in COPD care. Reduced effort and increased clinician-patient engagement have been seen as primary benefits to telehealth in general. Patients have reported appreciating the time and soft cost saved (e.g., onsite parking) by telehealth appointments vs. traveling to in-person visits. Repeated reference to convenience suggests that patients experience telehealth appointments as patient-centered and user-friendly. Clinicians also cited acceleration of workflows, reduced no-shows, and freeing up time as additional benefits. Telehealth was deemed appropriate for many types of follow-up appointments: conversations and discussions, results reviews, some aspects of chronic disease management, certain types of talk therapy, and for regular check-in with established patients. Patients recognized that telehealth was not a replacement for all types of outpatient visits or when a physical exam is required.

FROM REACTIVE TO PROACTIVE USE OF TELEHEALTH IN YEAR TWO OF THE PANDEMIC AND BEYOND

Telehealth as a strategy

Healthcare systems are considering how telehealth might become a permanent feature of their operations (Fig. 1) to augment what is possible through in-person outpatient care. For example, telehealth may be helpful in supporting health and wellness between in-person clinic visits, such discussions about the updated recommendations for COVID-19 boosters and influenza vaccinations [26], reviewing patients' respiratory inhaler technique and providing education to correct misuse [27], and evaluating the adequacy of a patient's home oxygen equipment in meeting everyday needs [28]. Telehealth may also offer personalized solutions to persistent challenges like supporting access to care for residents with transportation barriers or other socioeconomic barriers to in-person care. However, differential access of connectivity to the internet and smartphones that allow audio and video telehealth services can also exacerbate disparities by age, sex, race, ethnicity, income, and education [29]. The promise of telehealth in reducing health disparities requires careful attention to the needs of vulnerable

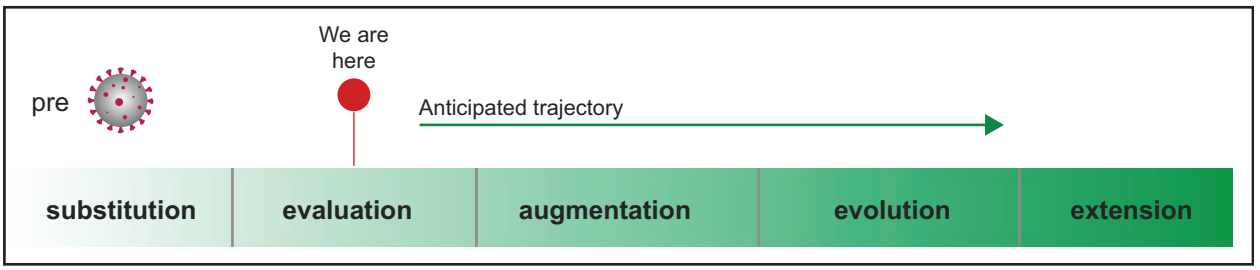

FIGURE 1. Telehealth for COPD timeline – prepandemic and into the future. Even though the effectiveness of telehealth as a substitute for traditional models of in-person care is poorly understood, healthcare systems had little choice but to rapidly implement telehealth as the only option for routine COPD care during the early stages of the pandemic. COPD care is currently delivered through a hybrid of in-person care and telehealth, and current evaluative efforts are focused on the role of telehealth to augment what occurs during in-person encounters. As new technologies that enable remote monitoring become more accessible and pervasive, we expect telehealth to reshape patient-provider interactions and extend them from episodic visits to continuous care.

populations who may not have the necessary resources or who may be reluctant to engage in remote healthcare services.

Beyond the pandemic: what role might telehealth play moving forward?

Implementation science [30,31] and human-centered design [32,33] offer frameworks that could help us to understand the role of telehealth in healthcare over the next several years. Implementation science is the study of methods to promote the integration of research findings and evidence-based interventions into healthcare practice and policies. Rather than addressing whether or to what extent healthcare interventions work, implementation science focus on how, where, and why interventions impact healthcare, considering a broad range of contexts including participants, processes, and places. Implementation science leverages early and continuous stakeholder involvement and the use of conceptual frameworks (i.e., models to systematize the conduct of studies and standardize the communication of findings).

Human-centered design, also called 'design thinking', is an established approach to developing solutions that are optimized for end-user needs (including patients, providers, health systems, and other stakeholders). A complement to implementation science, this approach involves examining the real-world context and behaviors of individuals, engaging stakeholders, and rapidly prototyping and testing solutions [34▪]. A growing number of health systems, including the University of Illinois Hospital & Health Sciences System, Mayo Clinic, and Cleveland Clinic, are applying human-centered design methods to improve care delivery. One way health systems may benefit from human-centered design is using its' practical methods for rapidly operationalizing the strategies identified through implementation science.

For now, telephone and video telehealth are reasonably filling the gap left by reduced face-to-face consultations where no physical exam is needed. However, if only framed within the context of existing models of healthcare delivery, telehealth's value will remain limited. Realizing telehealth's greater potential will require expanding current definitions of healthcare delivery to include new, technology-enabled offerings. Monitoring technologies such as those that continuously measure breathing, heart rate, oxygenation level are already producing insights not possible through episodic measurements [35–37]. Even though business cases for these new modes of delivery do not yet exist, it is only a matter of time before they do. The role of telehealth needs to evolve beyond substitution for in-person care to augmenting existing models or even creating entirely new models that increase access for underserved populations for more intentional and deliberate assessment and planning if its potential is to be realized. A human-centered design approach could help develop these service offerings in such a way that they are appropriate, acceptable, and adoptable by patients and health systems.

CONCLUSION

In the final analysis, healthcare is not alone in having to adapt to the new reality hastened by the arrival of SARS-CoV-2, the virus that causes COVID-19. Entire industries have had to adapt to survive. For example, the number of new films intended for theaters released via direct-to-video streaming services increased as the result of stay-

at-home orders across the globe. Even now, when going out to a movie theater is possible, the film industry continues to distribute through both channels recognizing that people value seeing new movies in theaters and at home. The emergency created a new channel that brought with it opportunities to generate revenue in new ways. The story of telehealth from this point forward could evolve along similar lines. It will just take thoughtful planning to help it realize ways in which it can do even greater good.

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Conflicts of interest

There are no conflicts of interest.

REFERENCES AND RECOMMENDED READING

Papers of particular interest, published within the annual period of review, have been highlighted as:

- ■ of special interest
- ■■ of outstanding interest

1. Baker J, Stanley A. Telemedicine technology: a review of services, equipment, and other aspects. Curr Allergy Asthma Rep 2018; 18:.
2. Shachar C, Engel J, Elwyn G. Implications for telehealth in a postpandemic future. JAMA 2020; 323:2375.
3. Sink E, Patel K, Groenendyk J, *et al.* Effectiveness of a novel, automated telephone intervention on time to hospitalisation in patients with COPD: a randomised controlled trial. J Telemed Telecare 2018; 26:132–139.
4. Koff PB, Min S-joon. Freitag TJ, *et al.* Impact of proactive integrated care on chronic obstructive pulmonary disease. Chronic Obstr Pulm Dis 2021; 8:100–116.
5. Ritchie CS, Houston TK, Richman JS, *et al.* The E-coach technology-assisted care transition system: a pragmatic randomized trial. Transl Behav Med 2016; 6:428–437.
6. ■■ Janjua S, Carter D, Threapleton C, *et al.* Telehealth interventions: remote monitoring and consultations for people with chronic obstructive pulmonary disease (COPD). Cochrane Database System Rev 2021.

A recently completed comprehensive systematic review of telehealth examined 29 clinical trials published through April 2020 (i.e., prepandemic) in 5654 patients with COPD. Meta-analyses of results from the clinical trials indicated low to very low quality evidence about the effects of various telehealth interventions compared to usual care when assessed by the risk of COPD exacerbations, quality of life, hospitalizations, or death.

7. Dorsey ER, Topol EJ. State of telehealth. N Engl J Med 2016; 375:154–161.
8. Halpin DM, Criner GJ, Papi A, *et al.* Global initiative for the diagnosis, management, and prevention of chronic obstructive lung disease. the 2020 gold science committee report on COVID-19 and chronic obstructive pulmonary disease. Am J Respir Crit Care Med 2021; 203:24–36.
9. Reddy S. The consequences of skipping doctor appointments during the COVID pandemic. Wall Street J 2021. [Accessed 9 October 2021]
10. Kouri A, Gupta S, Yadollahi A, *et al.* Addressing reduced laboratory-based pulmonary function testing during a pandemic. Chest 2020; 158:2502–2510.
11. Tsutsui M, Gerayeli F, Sin DD. Pulmonary rehabilitation in a postCOVID-19 world: telerehabilitation as a new standard in patients with COPD. Int J Chronic Obstr Pulm Dis 2021; 16:379–391.
12. Yohannes AM. COPD patients in a COVID-19 society: depression and anxiety. Expert Rev Respir Med 2020; 15:5–7.
13. Pedrozo-Pupo JC, Campo-Arias A. Depression, perceived stress related to COVID, posttraumatic stress, and insomnia among asthma and COPD patients during the COVID-19 pandemic. Chronic Respir Dis 2020; 17:147997312096280.
14. Alqahtani JS, Oyelade T, Aldhahir AM, *et al.* Prevalence, severity and mortality associated with COPD and smoking in patients with COVID-19: a rapid systematic review and meta-analysis. PLoS One 2020; 15:.
15. Alqahtani JS, Oyelade T, Aldhahir AM, *et al.* Reduction in hospitalised COPD exacerbations during COVID-19: a systematic review and meta-analysis. PLoS One 2021; 16:e0255659.
16. Chudasama YV, Gillies CL, Zaccardi F, *et al.* Impact of COVID-19 on routine care for chronic diseases: a global survey of views from Healthcare Professionals. Diabetes Metabolic Syndr 2020; 14:965–967.
17. Boyce DM, Thomashow BM, Sullivan J, Tal-Singer R. New adopters of telemedicine during the coronavirus-19 pandemic in respondents to an online community survey: the case for access to remote management tools for individuals with chronic obstructive pulmonary disease. Chronic Obstr Pulm Dis 2021; 8:213–218.
18. Fact sheet final policy, payment, and quality provisions changes to the Medicare physician fee schedule for calendar year 2021. CMS. Centers for Medicare and Medicaid Services; 2020 [cited 2021Oct9]. Available at: https://www.cms.gov/newsroom/fact-sheets/final-policy-payment-and-quality-provisions-changes-medicare-physician-fee-schedule-calendar-year-1. [Accessed 9 October 2021]
19. An analysis of private payer telehealth coverage – cchpca.org. Center for Connected Health Policy. Center for Connected Health Policy/Public Health Institute; 2021 [cited 2021Oct09]. Available at: https://www.cchpca.org/2021/04/Private-Payer-Telehealth-Coverage-Reportfinal.pdf. [Accessed 9 October 2021]
20. Traube DE, Cederbaum JA, Taylor A, *et al.* Telehealth training and provider experience of delivering behavioral health services. J Behav Health Serv Res 2020; 48:93–102.
21. Elbeddini A, Tayefehchamani Y. Amid COVID-19 pandemic: challenges with access to care for COPD patients. Res Social Adm Pharm 2021; 17:1934–1937.
22. Phenicie R, Acosta Wright R, Holzberg J. Patient satisfaction with telehealth during COVID-19: experience in a rural county on the United States–Mexico border. Telemed J E Health 2021; 27:859–865.
23. Chen DA, Tran AQ, Dinkin MJ, Lelli GJ. Ophthalmic virtual visit utilization and patient satisfaction during the COVID-19 pandemic. Telemed J E Health 2021. Online ahead of print. [Accessed 9 October 2021]
24. Jang S, Kim Y, Cho W-K. A systematic review and meta-analysis of telemonitoring interventions on severe COPD exacerbations. Int J Environ Res Public Health 2021; 18:6757.
25. Bashir A. Commentary and reflection related to the perspectives of nurses toward telehealth efficacy and quality of Healthcare. Health Serv Res Manag Epidemiol 2018; 5:233339281880054.
26. Who is eligible for a COVID-19 vaccine booster shot?. Centers for Disease Control and Prevention. Centers for Disease Control and Prevention; 2021 [cited 2021Oct9]. Available at: https://www.cdc.gov/coronavirus/2019-ncov/vaccines/booster-shot.html.
27. Locke ER, Thomas RM, Woo DM, *et al.* Using video telehealth to facilitate inhaler training in rural patients with obstructive lung disease. Telemed J E Health 2019; 25:230–236.
28. Jacobs SS, Lederer DJ, Garvey CM, *et al.* Optimizing home oxygen therapy. an official American Thoracic Society Workshop Report. Ann Am Thorac Soc 2018; 15:1369–1381.
29. Telediagnosis for acute care: implications for the quality and safety of diagnosis. Telediagnosis for Acute Care: Implications for the Quality and Safety of Diagnosis. AHRQ; 2020 [cited 2021Oct09]. Available at: https://www.ahrq.gov/patient-safety/reports/issue-briefs/teledx-5.html. [Accessed 9 October 2021]
30. Weiss CH, Krishnan JA, Au DH, *et al.* An official American Thoracic Society Research statement: implementation science in pulmonary, critical care, and sleep medicine. Am J Respir Crit Care Med 2016; 194:1015–1025.
31. Proctor E, Silmere H, Raghavan R, *et al.* Outcomes for implementation research: conceptual distinctions, measurement challenges, and research agenda. Adm Policy Ment Health 2010; 38:65–76.
32. Brown T. Design Thinking. Harvard Business Rev 2008; 84–92.
33. Melles M, Albayrak A, Goossens R. Innovating healthcare: key characteristics of human-centered design. Int J Qual Healthcare 2020; 33(Suppl 1):37–44.
34. ■ Chen E, Neta G, Roberts MC. Complementary approaches to problem solving in healthcare and public health: implementation science and human-centered design. Transl Behav Med 2020; 11:1115–1121.

This paper clarifies the conceptual relationship between implementation science and human-centered design. It clarifies the potential ways each can contribute to the development and implementation of health services such as telehealth.

35. Radin JM, Quer G, Ramos E, *et al.* Assessment of prolonged physiological and behavioral changes associated with covid-19 infection. JAMA Netw Open 2021; 4:e2115959.
36. Polsky MB, Moraveji N. Early identification and treatment of COPD exacerbation using remote respiratory monitoring. Respir Med Case Rep 2021; 34:101475.
37. Desai NR, Diamond EJ. Emerging role of remote patient monitoring in pulmonary care. Chest 2021; 159:477–478.