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COVID-19 and telehealth, education, and research adaptations.

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Since January 2020 Elsevier has created a COVID-19 resource centre with free information in English and Mandarin on the novel coronavirus COVID-19. The COVID-19 resource centre is hosted on Elsevier Connect, the company's public news and information website.

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Review

COVID-19 and telehealth, education, and research adaptations

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Educational aims

The reader will be able to:

- Appreciate the history of telehealth.
- Understand how telehealth has been used during COVID 19 for medical care, medical education and medical research.
- Understand the benefits and barriers of telehealth.
- Explore the opportunities that telehealth will afford all aspects of medicine in the future.

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ABSTRACT

For decades, there have been government funded services to provide healthcare telephonically to remote sites both on the earth and in the air. This capability has evolved into what we now know as telehealth. The use of telehealth dramatically accelerated as a result of concerns for patient and healthcare provider safety during the SARS-CoV2 pandemic. Similarly, concerns regarding transmission of infection have required medical schools to provide robust, easily accessible virtual education options. At short notice, faculties have had to develop new telehealth focused curriculum components. However, telehealth, online education, and internet enabled research should not be simply a new way to do traditional jobs but rather, an opportunity to take advantage of how technology can best be used to develop new and better ways to provide care, educate health care providers, and support research.

INTRODUCTION

On January 1st, 2020, as a new decade dawned, no one could have imagined how drastically the world was about to change. As the COVID-19 pandemic spread across the globe, every sector of society was forced to reimagine, reorder, and restructure. A revolution has been forced upon us by this virus and in almost all instances, technology has been at the heart of our adaptations. Nowhere has this been more pronounced than in the practice of medicine. Telehealth has, by necessity, been at the center of the medical field's response to this pandemic [1]. As telehealth becomes more widespread, we must rigorously evaluate and study its effects on patients and physicians to ensure that it is developed and used wisely and appropriately. While telehealth is not a panacea, it does provide an unprecedented opportunity to protect and improve the health of our patients and our communities during the COVID-19 pandemic and beyond.

"Telehealth" encompasses all forms of health care, health education, and health research that is conducted remotely (Table 1). *For the purpose of this article, we use the term telehealth to avoid confusion.*

A BRIEF HISTORY OF TELEHEALTH

Telehealth may be unfamiliar to some medical providers but it is not novel. The use of remote care using pedal radios dates back to the 1920s with the "Royal Flying Doctor" service in Australia. NASA accelerated the growth of telehealth by funding research to develop creative ways to provide medical care to astronauts in space and for in flight medical care for commercial airlines. From 1960 to 2000 telehealth was increasingly adopted to provide

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Table 1
Definitions of terms associated with telehealth.

	Definition
Telehealth	Telehealth is defined as the use of electronic information and telecommunication technologies to support long-distance clinical health care, patient and professional health-related education, public health, and health administration. Technologies include video conferencing, the internet, store-and-forward imaging, streaming media, and terrestrial and wireless communications [18]
Telemedicine	Use of electronic technology or media, including interactive video conferencing technologies, for the purpose of diagnosing or treating a patient, providing remote patient monitoring services, or consulting with other health care providers regarding a patient's diagnosis or treatment [19]
Remote Patient Monitoring	Remote patient monitoring (RPM) uses digital technologies to collect medical and other forms of health data from individuals in one location and electronically transmit that information securely to health care providers in a different location for assessment and recommendations [20]
Store and Forward	Store-and-forward technologies allow for the electronic transmission of medical information, such as digital images, documents, and pre-recorded videos through secure email communication [21]
eConsults	Electronic consultations ("e-consults") as asynchronous, consultative, provider-to-provider communications within a shared electronic health record (EHR) or web-based platform [22]
eVisit	E-Visits broadly defined are electronic exchanges between a medical provider and their patients for delivery of health-care. This has taken many forms during it's evolution from secure e-mail or messaging between provider and patient to electronic communications via a secure portal from a provider's website [23]
mHealth	mHealth or mobile health as medical and public health practice supported by mobile devices, such as mobile phones, patient monitoring devices, personal digital assistants (PDAs), and other wireless devices [24]
Tele-education	The process of teaching and learning mediated by telehealth technologies, where teachers and students are separated [25]

healthcare to populations in underserved and difficult to access areas of the world such as rural/village populations, prison populations, etc. [2]. Then, in the past 2 decades, as internet access and digital devices became ubiquitous in parallel with a growing need for more convenient, accessible, and cost-effective health care the growth of telehealth began to burgeon. A few healthcare systems like Kaiser Permanente have led the way in telehealth use. Since 2015 more than 50% of all outpatient encounters within the Kaiser system have been via telehealth [3]. Yet, Kaiser has been the exception. The global growth in telehealth has been steady but much slower than expected. This slower than anticipated adoption of telehealth has primarily been due to the lack of sustainable reimbursement models along with the inertia of our healthcare systems. However, when COVID-19 hit, the stage was well set for the telehealth revolution we are now experiencing.

TELEHEALTH AND COVID-19

As much of the world moved into "lockdown" in an effort to limit the spread of the virus, the potential benefits of telehealth came into sharp focus. In an effort to quarantine patients at home while still offering access to necessary medical care organizations and governments, including the CDC, encouraged health systems to provide virtual medical care whenever possible [1]. Health systems responded swiftly and dramatically.

The experience at VCU Hospital System (VCUHS), an academic tertiary care center in Richmond, Virginia, is illustrative of the extraordinary shift to telehealth. In early March, as part of a coordinated effort to flatten the COVID-19 curve, VCUHS rapidly converted all elective ambulatory and low acuity urgent care visits to telehealth. This included all follow-up visits, chronic care visits, and any visits where patients were deemed to be physically and mentally stable. Within 2 weeks, volumes of virtual visits at VCUHS skyrocketed from 25–30 to 1700 per day representing a greater than 5000% increase. This expansion has been sustained with telehealth appointments at VCUHS continuing to average 1500 per day and comprising 62% of total outpatient visits for the period from 3/29/20 to 5/2/20. Similar rapid upscaling of video consultations have also been described by others [4,5].

This shift to telehealth has simultaneously decreased exposure for patients and providers and has kept medical staff who are serving on the front lines less exposed and thus available for in person care when needed. Furthermore, telehealth has allowed providers who are COVID-19 positive with mild symptoms and providers who are in the "high risk" population for COVID-19 to remain at home while still contributing to the care of patients. This dual benefit of flattening the curve and maintaining capacity in the healthcare system during the COVID-19 crisis cannot be overstated.

CLINICAL MEDICINE AND TELEHEALTH

While telehealth has proven to be an invaluable tool in responding to COVID-19, the clinical benefits of telehealth beyond COVID-19 have also become plain. However, many of these benefits come with their own unique barriers and challenges that must be addressed as we move into a future in which telehealth will increasingly become a cornerstone of medical practice [3]. Table 2 delineates some of the key benefits and barriers of telehealth to clinical medicine.

Two additional regulatory challenges, not addressed in Table 2, will require special attention as the telehealth revolution unfolds [3]. One is the challenge of information security specifically as it relates to protected patient information on telehealth platforms. Another is the impact of telehealth on the practice of medicine across state and international borders. Since telehealth removes all geographic boundaries between providers and patients medical licensing laws that have historically been tied to geographical borders will need significant reform. Telehealth expansion will require substantial restructuring of laws and regulations in order to protect both patients and providers.

As telehealth develops and expands research assessing the effects of telehealth in pediatric medicine on patient and provider satisfaction, patient outcomes and cost effectiveness must be prioritized. Currently, the research is extremely thin. Studies reveal that although overall satisfaction with telehealth encounters is high in patients, a significant minority still prefer face to face consultations [5–7]. There is early evidence showing that telehealth care is as effective as in person care when treating chronic conditions like childhood asthma [8,9]. While telehealth technology is rapidly improving technological limitations still lead to suboptimal and frustrating provider-patient telehealth interactions [6,7]. Research evaluating the effectiveness, limitations, and hazards of telehealth must guide our adoption and practice as we move into the future.

Table 2
Clinical medicine and telehealth: benefits, challenges and opportunities.

	Benefits	Barriers/challenges
Convenience	– Patient centered: Patients are able to see their provider from home, school or work. This means no transportation time and no waiting room time – Provider centered: Providers can see patients whenever is most convenient for them.	– Exacerbates existing health disparities since some patient populations do not have robust internet access or digital devices – Creates new challenges for patients and providers who are less tech savvy – Take longer than face to face consultations – Technical difficulties rule rather than exception, leading to halting patient-physician communication – Lack of live personal contact hampers exchange of difficult and emotional information
Cost Savings	– Overhead costs decrease – Decrease in higher cost services (urgent care and ER visits) due to improved access to PCPs and specialists	– Potential overuse of medical services by patients since access to care is so easy and efficient – Need for new work flows – Need for different ancillary staff with different skills and training – Need for new reimbursement models that include telehealth services
Improved Access	– Less limitations of access to care based on geographic location of patient or based on patient's physical limitations/handicaps – Increased slots for providers to see patients since physical clinic space is not a limitation – Creates space in clinics for those patients who really need to be seen "in-person"	– Since providers can provide care from anywhere at any time – creating boundaries around work becomes more challenging
Multidisciplinary visits	– Much easier to coordinate and can include specialists from different geographic locations	– Potential overuse of these services when not needed
Provider to Provider Consults	– Easier to coordinate and can be implemented in real time	– Potential overuse of these services when not needed
Infection control	– Fewer patients and staff present in waiting rooms and clinic buildings unnecessarily	– None
Diagnosing, Treating and Triaging Patients	– Since access is improved, patients can be seen by a provider sooner and therefor diagnosed, treated or triaged more rapidly	– Potential for misdiagnoses – Potential for overprescribing of medicines – especially antibiotics

EDUCATION AND TELEHEALTH

Medical education has been equally transformed in a matter of months by the telehealth revolution and medical educators are only beginning to explore the different possibilities telehealth affords our leaners. Telehealth has allowed medical learners to observe and actively participate in the care of patients remotely during the COVID-19 crisis [10,11]. The experience of teaching and learning via telehealth has placed a renewed emphasis on the importance of a discerning medical history along with a perceptive observation based exam – tools that were perhaps becoming a lost art. Students and residents have been given the opportunity to quickly learn the fundamentals of telehealth care and, in some instances have made valuable suggestions from their perspective as digital natives [12]. Undoubtedly, telehealth will be a significant part of these learners' clinical practices in the future.

Additionally, thanks to telehealth, medical learners have been able to learn from local and world experts on topics of interest as many medical societies have made online lectures and webinars (with accompanying CME credits) broadly available and often free to access. The first pediatric respiratory conference to go completely online was the King's College *John Price paediatric respiratory conference*, scheduled to take place in London in early April, 2020 (http://www.paediatricrespiratory.com/). The ATS and ERS conferences followed suit later. Online conferencing lends itself well for traditional teaching formats like lectures followed by Q&A, but more interactive teaching formats like workshops, round table discussions and poster group discussions have thus far proved challenging in an online environment.

Furthermore, telehealth tools have allowed global experts to collaborate on the care of critically ill COVID-19 patients as they work together to understand how this virus works and what the best interventions might be. Certainly, this experience of telehealth based collaborative learning is already inspiring the world of medical education to reimagine itself as we look beyond the COVID-19 pandemic.

RESEARCH/TECHNOLOGY AND TELEHEALTH

Technology and internet-based research has been well established and extremely sophisticated for many years, primarily for marketing and consumer or opinion surveys. There are college majors and careers focused on this type of research. Similarly, epidemiology research increasingly depends upon data collection, data mining, and data analysis and relies on specialized software and computer training. As SARS-CoV-2 safety considerations closed traditional clinical and basic science research at many academic institutions, investigators redirected their focus toward what work *could* be done during this pandemic.

Traditional clinical research, the randomized clinical trial, usually requires that subjects have a physical examination and lab testing before enrollment. During the pandemic, these activities posed an unacceptable risk to investigators and subjects. However, screening subjects for potential inclusion in a trial, obtaining informed consent, and clinical follow up of enrolled subjects not needing labs or physical examination can all be done effectively using remote technology. This has proven to be most useful for identifying and screening potential study subjects. As investigators demand additional monitoring tools to remotely gather important

data from study subjects, we will undoubtedly see the development of remote monitoring tools for things like blood glucose, pulmonary function, and electrocardiography.

Basic science research has been more difficult to transition to remote computer technology although this could encourage the further development of computer models, increased use of data mining, and computational biology. Many bench scientists have used this time to develop grants and protocols; in some cases, reaching out to colleagues around the world who are facing the same challenges.

PROJECT ECHO: THE TELEHEALTH REVOLUTION IN ACTION

Project ECHO and other similar innovative models of care are seeking to use telehealth to revolutionize medicine as we know it [13–15]. Originally developed in 2003 at the University of New Mexico to help primary care providers manage Hepatitis C, the model's success has led to rapid expansion [13]. Project Echo now operates more than 220 hubs for more than 100 diseases and conditions in 34 countries [16]. Using the power and potential of telehealth, Project Echo seeks to simultaneously improve care, increase access, decrease cost, educate providers, and expand opportunities for research [16].

The model uses a hub-and-spoke knowledge-sharing network model to provide best practice medical teaching and care to providers and patients where they live [13]. The expert team at an academic medical center (“the hub”) uses telehealth multipoint videoconferencing to conduct virtual clinics with community providers (“the spokes”). Every clinic involves a short didactic session given by an expert in the group followed by case based discussions of de-identified real cases presented by practitioners in the community. The case discussion involves conversation, suggestions, and consultation around the patient cases. Through virtual access to experts, community providers receive evidence based recommendations and learn to provide more specialized care. The goal of the Project Echo model is to improve access, quality and cost of care for patients with chronic and complex health conditions by educating and empowering primary care providers.

While early evidence supporting Project Echo (and similar models) appears promising it is important to recognize that the studies to date are relatively weak as they are all retrospective, non-experimental and subject to various types of biases [17]. The limited evidence we do have suggests that provider related outcomes such as provider satisfaction, knowledge and confidence are favorably impacted [16,17]. Studies evaluating patient related outcomes indicate that Project Echo is most effective for the management of chronic illnesses like hepatitis C, chronic pain, or type 2 diabetes [16,17]. Moving forward, we must rigorously evaluate models like Project Echo using randomized controlled trials or big data technology to determine if such models truly improve patient and provider related outcomes while also improving access and cost.

THE FUTURE AND TELEHEALTH

COVID 19 has accelerated the telehealth revolution. As we move into the future, innovative and collaborative models of care (like Project Echo) must be scrupulously evaluated and if proven should be improved upon and expanded. Telehealth “home visits” will likely become the norm. Telehealth online consultations with local, regional and national experts will be standard. New handheld telemedicine kits, smart phone add-ons and apps including virtual stethoscopes, otoscopes, ophthalmoscopes, pulse oximeters, blood pressure monitors, ECGs, glucometers, spirometers, and various other tools will allow providers to gather more vital information during a telehealth encounter before making a medical plan together with the patient. Medical research will increasingly involve virtual recruiting, screening and monitoring. Virtual learning for students will progressively become standard while medical schools and residency programs are simultaneously adjusting curriculums to include robust telehealth training as a central component of medical education.

The future of healthcare will increasingly be built around telehealth. Health care systems and providers are reimagining how we do our work; where we do our work and when we do our work. Our current system is a provider centric, reactive model of medical care that rewards intervention over prevention, is not conducive to collaborative care and is prohibitively expensive. COVID-19 has forced us to reimagine everything. Now we have a unique opportunity for health care to move towards something we all desire: a more patient centered, preventative, collaborative and cost effective model of care. Telehealth, like any medical tool or intervention, must be meticulously studied, wisely developed and thoughtfully implemented in order to minimize its risks and maximize its potential - for patients and providers alike.

DIRECTIONS FOR FUTURE RESEARCH

- To evaluate the effects of telehealth on patient and physician satisfaction, patient outcomes and healthcare costs.
- To assess whether telehealth will lead to overreliance upon investigations at the cost of clinical reasoning supported by physical examination findings.
- To determine the feasibility and cost effectiveness of broader telehealth based collaborative learning locally, nationally and internationally.
- To determine how technology and remote learning can be leveraged to improve teaching, learning, and assessment.

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