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COVID-19 Compels Medical Practitioners and Governments to Promote Telemedicine Practices – A Systematic Review

Areeba TARIQ[1], Osama Asif AZIZ[1], Faiza Khadim ARAIN[2*], Muhammad Wasim MUNIR[1,3*]

[1] Department of Biomedical Engineering, Salim Habib University, Karachi, Pakistan
[2] DIHPE, Dow University of Health Sciences, Karachi, Pakistan
[3] Biomedical Sciences and Engineering, Tampere University, Finland
E-mail(s): f17bme01@shu.edu.pk; f17bme02@shu.edu.pk; faiza.khadim@duhs.edu.pk; wasim.munir@shu.edu.pk

* Author to whom correspondence should be addressed; Tel.: +92-21-111-248-338

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Abstract
Telemedicine integrates communication technologies with medicine, which allows healthcare professionals to monitor and treat patients remotely. During the coronavirus disease 2019 (COVID-19) pandemic, telemedicine has emerged as the most effective tool in the fight against such infectious diseases. Rapid advances have helped governments realize the flaws in current healthcare systems and have sparked a revolution in how these systems are managed and operated. The present work studies the changes realized within healthcare systems around the world, new regulations advocating these changes, and the barriers to widespread integration of telemedicine with current healthcare delivery systems. The Google Scholar, ScienceDirect and PubMed databases were used to find articles related to the aims of this study. In this systematic review based on the PRISMA guideline, we reviewed 61 studies to analyze the shift in trends within the telemedicine field due to the onset of the COVID-19 pandemic. Remote consultations, teleconferencing, and remote patient monitoring have experienced a significant increase in use and acceptance as a result of the pandemic. Furthermore, governments around the world have started to develop policies to expedite the integration of information and communication technologies with healthcare. The findings suggest that while a lot of progress has been made in terms of adopting such technology for healthcare delivery, several barriers, such as lack of legal framework and patient-physician acceptance in developing countries, still exist before telemedicine can be fully integrated with existing healthcare systems.

Keywords: Telemedicine; Coronavirus disease 2019 (COVID-19); Regulatory affairs; Patient-physician acceptance; Information and communication technology (ICT)

Introduction

Conventionally telemedicine delivers medical assistance with the help of information and communication technology (ICT). This enables patients to access specialized healthcare opportunities from remote locations via various telecommunication alternatives. Ranging from a simple phone call to the more complex use of sophisticated equipment, telemedicine offers multiple strategies to access healthcare facilities [1]. As ICT gains ground, the telemedicine sector is also evolving and working towards imaginative ideas to meet the primary objectives of telemedicine. Recent developments in ICT (i.e. electronic health records, smartphones, 4G speed) has led to the

growth of the software development industry [2]. Nowadays, software developers are focusing on designing mobile applications related to healthcare, subject to mobile health (mhealth) [2].

Coronavirus disease 2019 (COVID-19) has created a pandemic situation which has led to a scarcity of medical resources within healthcare institutions. The most obvious example is that healthcare institutions no longer have vacant beds to facilitate patients due to the extraordinary influx of patients. This means that healthcare institutions resort to telemedicine, which is evident in self-quarantine by patients outside the healthcare institutions [3]. Patients in self-isolation have been receiving medical guidance and treatment through telemedicine. Telemedicine has been playing an important role throughout the pandemic situation and has proven to be advantageous over other forms of healthcare delivery by minimizing the interaction between healthcare personnel and patients. Telemedicine has provided more feasible and simple solutions which helped control the spread of the virus, and improve the safety of both the patient and healthcare personnel. Additionally, patients have been able to keep up with medical expenses during one of the largest economic shocks as telemedicine visits cost cheaper than office visits [4].

Consequently, the above advantages have contributed to raising awareness regarding telemedicine amongst the general population. Moreover, developed and underdeveloped nations have also realized the need for an organized telemedicine network throughout the country but a major drawback for most is the huge initial investment [5]. However, the implementation of telemedicine services requires a proper legal framework to be established by the government. The legal framework for such a network would be able to deal with cybercrime and allow insurance companies to develop policies related to telemedicine [6]. Furthermore, there is still a significant amount of conflict between patients and healthcare personnel regarding the ethical use of technology to promote healthcare delivery [7]. These legal and social concerns serve as barriers to the widespread integration of telemedicine with current healthcare systems.

The purpose of this review was to study the extent to which telemedicine has been implemented in response to the COVID-19 pandemic while also addressing the existing legal and social issues which serve as barriers to long-term integration of such technologies. Various studies have been considered to analyze the changes made to healthcare systems to accommodate telemedicine and the impact it has had on the delivery of healthcare services. Moreover, the changes in policies of health insurance companies and those of hospitals have also been studied to gain insights into the evolving legal frameworks relating to the widespread practice of telemedicine for patients around the world.

Material and Method

As illustrated in Figure 1, the updated PRISMA guideline [8] was followed for the systematic review. A summary of the research protocol is presented in Table 1.

The search was conducted for four months (September 2020 – December 2020). A list of search terms was used to find relevant articles focused on the growth of telemedicine over the past year and its legal implications.

While reviewing articles during the selection process, articles were screened three times. The first screening was conducted based on article titles and abstracts; all authors were involved in this screening stage. Since the search criteria for this study were relatively broad, only a couple of articles were excluded in this stage. However, during the full-text screening and data extraction phases, two of the authors agreed upon the exclusion of several articles from this study. The results of the excluded articles were narrowly focused on a certain type of technology or a very small group of people that could not be generalized. As a result of this selection process, a total of 17 articles are excluded from this study.

Table 1. Research protocol in accordance with PRISMA guidelines

Criterion	Explanation
Review Questions	"To what extent was telemedicine implemented before the onset of the COVID-19 pandemic?" , "How has COVID-19 affected the growth of telemedicine?" , "In what ways has telemedicine improved healthcare during the pandemic?" , "What telemedicine-based initiatives were taken in response to the pandemic?" , "How have government policies changed as a result?" , "Which barriers to the widespread integration of telemedicine still exist?"
Literature Search	*Sources:* Google Scholar, PubMed, Science Direct
	Search Term: ("coronavirus" OR "COVID-19" OR "pandemic") AND ("telemedicine" OR "tele-health" OR "mhealth") AND ("regulations" OR "policies") AND ("barriers" OR "patient acceptance" OR "physician acceptance")
Filter Criteria	*Type of work:* All type of publications *Years:* 2018-2021
Exclusions	*By title:* Analysis of titles based on search terms, exclusion of publications which did not include any of the relevant search terms
	By abstract: Exclusion of articles that did not answer any of the review questions mentioned above
Evaluation	*Full-text assessment:* Inclusion of articles which answered the review questions and whose results were easily generalized for the purpose of this study

Following is the inclusion criteria:

- Research published within the past two years
- Applications of telemedicine before and/or after COVID-19 which varied in type, services, and country
- Research that tracked the growth of telemedicine
- Research discussing COVID-specific initiatives
- Research evaluating government policies in response to the pandemic
- Research highlighting the existing barriers of widespread telemedicine use in healthcare

Following is the exclusion criteria:

- Research published over two years ago
- Research that is overly generalized
- Research that does not include data regarding post-COVID-19 growth, government policies, or current implementation barriers
- Research that could not be generalized for the purpose of this study

As there was high variability in study objectives, information extracted was primarily focused on the shift in the trends of telemedicine due to COVID-19 and the response of governments to facilitate the shift. Some variables considered include the type of technology used, country setting, and facilities available before the pandemic, and the response of governments, physicians, and patients.

Results

The study framework is presented in Figure 1.

As is evident from the PRISMA flow chart, the following steps were taken:

- *Identification*. During this step, the duplicates were removed from the pool of records found. This resulted in 78 articles remaining for the screening process.
- *Screening*. This was a two-step process. First, the articles were screened on the basis of their title and abstract. This resulted in the removal of two articles. Second, the remaining publications were then assessed by reading through the full text. A total of 15 studied were excluded.

- *Inclusion*. Finally, 61 articles passed the screening to be included in this review. These were grouped into the following sections: i) Telemedicine before COVID-19 ii) The growth of telemedicine during COVID-19 iii) Impact of COVID-19 on government policies iv) Barriers to the adoption of COVID-19.

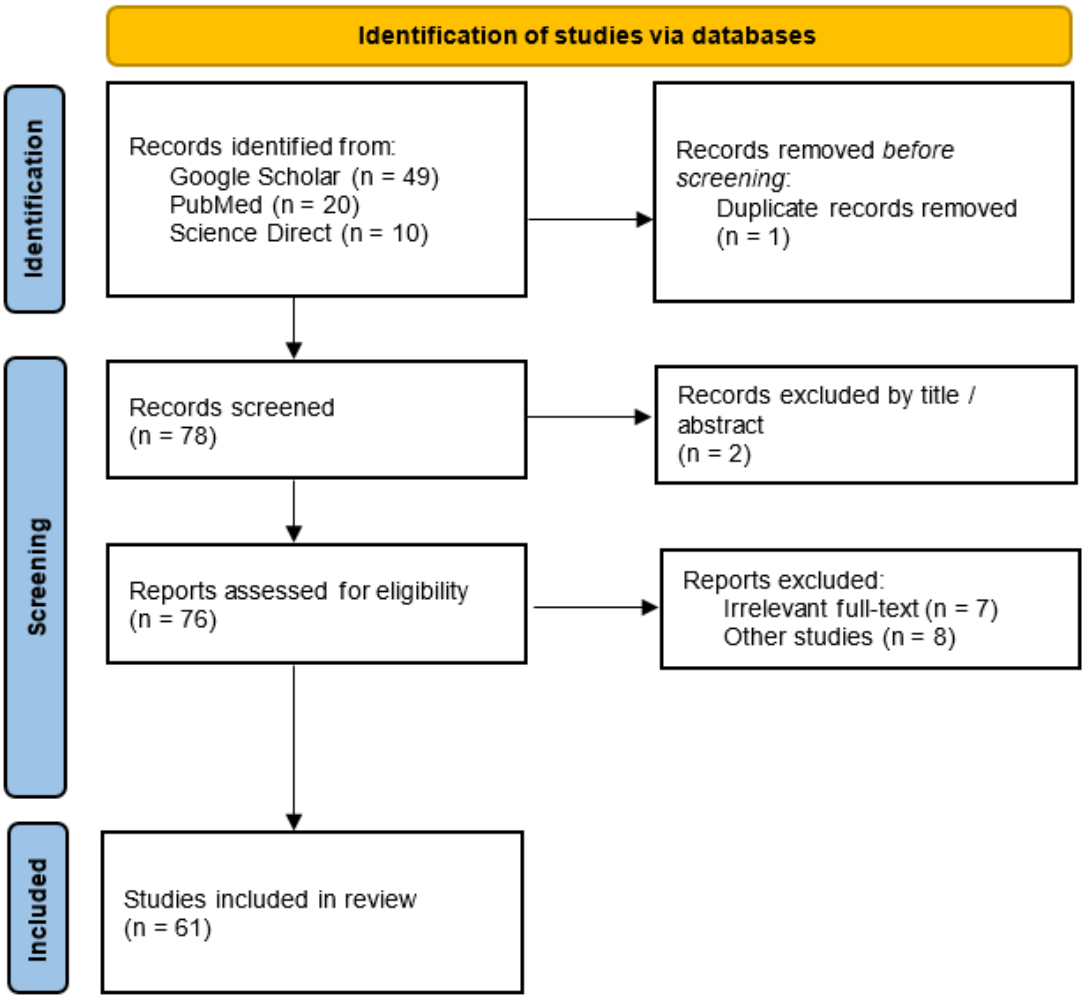

Figure 1. PRISMA flow chart

Telemedicine before COVID-19

While the first time telecommunication was used for healthcare delivery dates back to the 1950s [9], modern telemedicine was not adopted until the 1990s [10]. Advancements in technology during the 90s gave rise to a form of tele-diagnostics for infectious diseases in which physicians remotely viewed and interpreted samples under a microscope operated by technicians [11]. Since then, research in telemedicine has grown exponentially (from 6 publications by the end of 2002 to 117 by 2018), the majority of which originated from the United States and focused on cardiovascular diseases [10]. However, due to patients' and physicians' reluctance to telemedicine, in-person visits were not replaced, but rather supplemented with telemedicine [12].

While advances in technology such as the development of software-defined wide area networks (SD-WAN), 4G/5G internet services, and fiber connections providing speeds of up to 1GB per second [13] promote the growth of telemedicine, only 24% of healthcare organizations within the

United States established a telehealth program by January 2020 [14]. The incremental growth of telemedicine can be attributed to limited reimbursements, patient and provider discomfort with telemedicine technologies, and lack of cases requiring replacement of in-person care outside of rural areas [15]. Moreover, a survey conducted in 2019 confirmed that while the most Americans showed interest in virtual healthcare, it was only accessible by 17% [16]. As a result, face-to-face visits remained the most popular form of healthcare delivery for outpatients before the pandemic [17]. Some examples of telemedicine initiatives pre-COVID are described in Table 2.

On the other hand, some countries including Saudi Arabia [21] and Italy [22] failed to integrate telemedicine within their healthcare practices before the onset of the pandemic. This is in part due to the fact that there is a lack of understanding of the potential of digital devices within the healthcare section [21] and also the need for a regulatory framework to permit, incorporate, and recompense telemedicine services [22]. While their healthcare systems had made progress, the lack of telemedicine solutions frequently resulted in long waiting lists, errors, and high rates of infections following hospitalizations [21]. Other countries like Pakistan and Nigeria suffer from a shortage of specialized healthcare facilities and clinicians [21,23]. In response, Pakistan's National Health Vision 2016-2025 initiative aims to identify gaps in the healthcare sector and improve healthcare through telemedicine [21]. However, Nigeria and Pakistan both face challenges in adopting telemedicine due to low ICT proficiency, interrupted electricity, unreliable internet connections, social acceptance, legal concerns, and financial barriers [23].

Table 2. Telemedicine initiatives pre-COVID

Telemedicine Service	Country	Year Initiated	Services Offered	Benefits	Ref.
HealthPartners	United States	2018	Virtual intensive care unit, after-hours medical admissions, cross coverage, and disaster management	Support patients, protect clinicians, and conserve resources	[18]
Project ETHAN (Emergency Telehealth and Navigation)	United States	2015	Advanced triage system in ambulances to assess the patient to determine whether he/she requires emergency or primary care	Reduced unnecessary ambulance transports and prevented overcrowding of the Emergency Department in Houston hospitals	[19]
eSexual Health Clinic	United Kingdom	2017	Web portal for online consultations, test results, health promotion, prescriptions, helpline, surveillance,etc.	Reduced stigma around sexual diseases, convenient, and improved confidentiality.	[11]
Toulouse Telemedical Assistance Service (TMAS)	France	2015	24-hour emergency physician consultation service for ships	Manage patients at sea remotely	[20]

The Growth of Telemedicine during COVID-19

The onset of the COVID-19 pandemic has strained even the best and most established healthcare systems around the world. Italy, with a ratio of 3.2 hospital beds per 1,000 individuals, and the United States, with a 2.8 to 1,000 ratio of hospital beds to persons, have struggled to accommodate the needs of the rapidly increasing number of ill patients [24]. Moreover, fear of acquiring the disease has prevented many patients from seeking medical care at hospitals and clinics, viewing such settings as

a last resort [25]. The most popular resolution to such issues has led many to adopt telemedicine practices. As a result, many countries have witnessed an increase in phone [17,25–30] and video [26,28–33] visits. A study conducted at NYU Langone Health noted a drastic decrease in in-person visits accompanied by a corresponding increase in virtual visits for both urgent and non-urgent care [15]. In countries like the U.S., home peripherals are being used to facilitate virtual consultations for patients with chronic illnesses [32].

The pandemic has brought to light the importance of telemedicine in the healthcare sector and has led to rapid developments in the field [34]. The new, developing technologies focus on various aspects of telemedicine such as virtual visits, remote patient monitoring, and chatbots for screening and triage [35]. Several technologies have been identified and integrated with telemedicine in response to COVID-19. These include artificial intelligence for outbreak predictions, internet of things for surveillance, big data for analysis, virtual reality for communication and collaboration, holography for conferences and live events, cloud computing for services offered by Zoom and other companies, autonomous robots as patrol, 3D scanning for thoracic chest scanning, 3D printing for the production of masks, and biosensors for monitoring patient health [36]. As Table 3 shows, the pandemic has resulted in widespread use of telemedicine technologies in several medical specialties in which it was previously scant.

Table 3. Telemedicine implementation in various medical specialties

Type of telemedicine	Medical Specialties	
	Before COVID-19	**After COVID-19**
Remote consultations	Psychotherapy [27], Cardiovascular [31]	Urology [37], Hematology [38], Neurology [29], Pediatric Bowel Disease [28], Pregnancy [39], Pharmacies [29]
Teleconferencing	Cardiovascular [31]	Hematology [38]
Remote Patient Monitoring	Diabetes [40], Cardiovascular [16,31], Psychiatry [43]	Peritoneal Dialysis [41], Prenatal Care [39], Urology [37], Dentistry [42], Intensive Care Units [32], Rehabilitation [16]

Remote consultation, teleconferencing, and remote patient monitoring have become the most common forms of telemedicine practices during the pandemic (Table 3). Specialties such as urology, hematology, dentistry, and rehabilitation previously depended entirely on clinical visits; however, with COVID-19 sanctions preventing patients from visiting clinical care settings, remote forms of healthcare delivery have risen [37, 38, 42, 43]. Moreover, pharmacies have also changed their methods of operation by providing remote consultations for over-the-counter medication and home delivery options for both prescribed and non-prescribed drugs [29].

In addition to the adoption of telemedicine in existing medical practices, many COVID-specific initiatives have also been taken to prevent the spread of the virus. The initiatives are commonly grouped into five categories - tracking, screening, contact tracing, quarantine and self-isolation, and clinical management [44] as illustrated in Table 4.

The COVID-19 tracking applications are mostly web-based and provide live counts for the number of cases within each country. These tools are being used by governments, media, and the general public to keep track of the spread of the virus on a global and national level. In addition to tracking, a lot of emphasis has been placed on COVID-19 screening. Mandatory screenings are being conducted in almost every major location including universities, hospitals, and airports [45]. People at home also have access to free apps and websites which conduct pre-diagnostics and refer users to doctors if deemed at risk. Such screenings, in combination with contact screening, quarantine and self-isolation and clinical management, have played a major role in controlling the spread of COVID-

19. Contact tracing has been implemented by several large countries and organizations such as the European Union and the U.S. Center for Disease Control [46]. Through this initiative, people are notified of their exposure to the disease and advised to the keep track of their symptoms. Moreover, the initiatives under the category of quarantine and self-isolation have contributed significantly to the advancements in social robots. Robots are being used in replacement to humans for services which increase the risk of exposure (i.e. surface disinfecting, delivery, and hospital staff) [45]. Not only is this protecting the workforce, it is also leading to early advancements and acceptance of such technologies. Lastly, clinical management directly relates to how the exposure front-line workers in being minimized. This is the area where telemedicine has gained the most attention and is considered to be the best way of providing healthcare services in times of COVID-19. While the focus of these initiatives vary from mobile hospitals to computerization of health data and remote patient monitoring, the core purpose of these solutions is to reduce patient-doctor interaction as a means of controlling the spread of the virus. Since healthcare workers are constantly at high risk of exposure, such initiatives are required to protect them so that they may play their part in the fight against COVID-19.

Table 4. COVID-specific initiatives

Category	Applications	Country
Tracking	coronatracker.com	Worldwide
	covid.gov.pk	Pakistan and International
Screening	maladiecoronavirus.fr [35]	France
	beatcovid19now.org [35]	Australia
	robots measure body temperature in public transportation systems [45]	China
Contact Tracing	Apps such as Exposure Notification System by Apple and Google [46]	USA, Singapore, Austria, Australia, etc.
Quarantine and Self-isolation	Drones remind people of social distancing measures in public spaces [45]	USA
	delivery robots [45]	China, Japan, USA
Clinical Management	mobile cabin hospitals [24]	China
	Molecule Transformer-Drug Target Interaction (MT-DTI) identifies molecules currently in markets that could potentially be used against the COVID-19 [24]	South Korea
	Robots for surface disinfection using UV [45]	China, UK, USA, Rwanda, Greece, etc.
	Robot named "Tommy" reduces direct patient-doctor contact [45]	Italy
	Wuhan Hongshan Stadium turned into a robot-run hospital [45]	China
	Full computerization of NHS practices (appointment booking, prescription ordering, medical records viewing) [30]	England
	Various smartwatches and apps used for remote patient monitoring [47]	USA

Impact of COVID-19 on Government Policies

The response of governments worldwide to the COVID-19 pandemic has remained relatively the same concerning financial incentives and program initiatives for the wide integration of telemedicine

in existing healthcare systems. In addition, lockdowns have been the most popular form of controlling the transmission of the virus in many countries, including the United States, United Kingdom, Germany, Italy, Spain, France, India, Rwanda, Nigeria, and South Africa [48].

In the United States, the Center for Disease Control is encouraging the use of telemedicine to protect healthcare professionals and patients from acquiring COVID-19 [49]. As a result, the COVID-19 Preparedness and Response Supplemental Appropriations Act was approved by the U.S. government to promote the use of audio and video technologies in the healthcare sector [50]. Moreover, financial incentives have been placed for both providers and patients. Health insurance companies have expanded their coverage plans to include all telemedicine visits [15]; for example, Humana has waived the costs for urgent care visits while Aetna is allowing eHealth visits without copays for prenatal care and other concerns [39]. The U.S. Department of Health and Human Services has also waived the enforcement of laws preventing consumers from using telecommunication for doctor visits [15]. At the same time, doctors are being ensured reimbursements by the Centers of Medicare and Medicaid Services for providing nontraditional services [29,50,51] regardless of previous geographic restrictions [18,32] at the same rates as traditional visits [49]. Pharmacies are also allowed to prescribe drugs without an in-person assessment, as stated by the Drug Enforcement Administration [51] and the provisional suspension of the Ryan Haight Online Pharmacy Consumer Protection Act of 2008 [50].

In addition to financial incentives, the U.S. government has also temporarily amended laws regarding licenses and patient privacy. States now allow patients to receive care from doctors anywhere in the U.S. [15,51], while Medicare and Medicaid have both removed their licensure requirements for practicing providers [29,49]. These relaxed laws have extended into the pharmacy industry, where pharmacists can now work remotely outside the licensed pharmacies [50]. Furthermore, the Health Insurance Portability and Accountability Act (HIPAA) penalties are being waived [29,50] and non-compliant platforms such as FaceTime, Zoom, and Skype have been approved for healthcare use [50]. Lastly, the Food and Drug Administration has adopted alternate pathways for the permittance of new medical devices and home monitoring equipment to expedite their introduction in the market [46].

Similar measures have been put in place by the governments of other countries as well. England's response to the pandemic includes the implementation of home visiting services for patients who are unable to take advantage of the "primary care COVID-19 hubs" located throughout the country [30]. Data sharing laws and other regulations have also been relaxed to ensure efficient clinical management [30]. In France, the Ministry of Health has approved reimbursements for teleconsultations for COVID-19 patients and is also temporarily funding remote consultations conducted by midwives and speech therapists [22]. Medicare at home services are funded by the Australian government [50] while the Dutch government has guaranteed reimbursements for extra services and staff in an effort to prevent hospital bankruptcy [52]. Although individual countries' health ministries (i.e., Germany) are taking the first step towards a digitized healthcare system [35], large-scale organizations like the European Union are also working towards establishing international standards, interoperability, laws promoting telemedicine usage, increasing the research conducted in the field, and ethical guidelines [14].

Countries with outdated healthcare systems have taken drastic measures in response to COVID-19. The Indian government, for example, has exponentially increased the use of telemedicine [29] by increasing its budget for the healthcare sector and launching a mandatory tele-consultation service on a national level [34]. In Africa, the severely underfunded systems of South Africa, Rwanda, and Burundi have adopted the Universal Health Coverage to provide access to healthcare during these difficult times [48]. Middle Eastern countries like Israel compensate the costs of telemedicine visits and in-person visits equally [26], while Saudi Arabia has initiated its National Transformation Program 2020 which aims to successfully integrate telemedicine into existing healthcare systems nationwide [21].

Barriers to the Adoption of Telemedicine

Two major factors have decelerated widespread adoption of telemedicine practices, the first being implementation [21,53] and the other acceptance [17,27,54,55]. Implementation of telemedicine has proven to be challenging since insurers are yet to define policies regarding the coverage of tele-visits [56]. Other barriers include cybersecurity threats [56], training of healthcare personnel [14,57] and patients [14], the presence of a digital divide amongst populations [33,39,58], high costs [35], fear of litigations [29], infrastructural requirements [35,44,59], invasion of privacy and infringement of civil liberties [44], licensure requirements [60], lack of standardized legalities [53], and physician malpractice and liabilities [53]. Moreover, developers of telemedicine solutions should be more considerate of user-product interaction and alter the design to increase accessibility across all populations [46]. Barriers that are commonly ignored are accessibility for the disabled population [46] and language [14,46,50] for those living in countries where the populations are very diverse (i.e. the United States). Also, patients and doctors must receive training on the usage of telemedicine technologies so that they may overcome usability barriers [14]. Financial barriers are a major roadblock for low- and middle-income countries (LMIC) [50,55] since these countries lack the infrastructure, equipment, and technology to implement telemedicine on a large scale [55]. Contrastly, in the U.S. specifically, two notables' barriers to widespread telemedicine adoption were related to HIPAA compliance and regulatory burdens in terms of reimbursements [15,60] and interstate licensure requirements [60]. In addition, there are not many compelling reasons for the replacement of in-person care outside of rural areas when disregarding the pandemic [15].

Similarly, existing barriers to the acceptance of telemedicine are present for both physicians and patients. The major reasons behind acceptance are patient hesitation [56], patients' views of tele-visits being inferior to in-person visits [27], shifting from a hospital-centric to a patient-centric model [61], and limitations for conditions that require detailed physical exams [55]. On the other hand, physicians resisted adopting telemedicine practices as they found it difficult to diagnose patients remotely [26] accurately and inability to charge for consultations conducted in such a manner [55]. Another factor leading to unacceptance of such technologies is the lack of ethical guidelines [50]. Patients and doctors may not be comfortable [15] providing others access to their personal lives. While video calls, location sharing, and other forms of monitoring provide convenience, they also disrupt the professionalism of a patient-doctor relationship. Therefore, training would be required in addition to guidelines to ensure the ethical and safe use of telemedicine technologies [14].

Discussion

The results of this study show that there has been an overall significant increase in the adoption of remote patient monitoring and teleconsultation practices following the onset of the COVID-19 pandemic. However, several countries, including Pakistan, Bangladesh, Nigeria, and other African countries, have not witnessed this change due to a lack of infrastructure and trained personnel [25,48]. Although acceptance of such practices differed among patients and providers [17], patients that have embraced telemedicine have been satisfied with the results [11,34,39,62]. However, some providers view telemedicine as a temporary practice and remain steadfast in believing that in-person visits cannot be replaced [26].

According to the results of this review, the existing limitations of telemedicine applications in the healthcare sector is due to lack of government, physician and patient support. Advancements during the COVID-19 pandemic have been many in number but short-lived; more permanent approaches to current healthcare shortcomings are required to further improve the quality of patient care. A proper set of established guidelines and professional training is needed to promote the use of ICT in all aspects of the medical field. In addition, the threat to patient privacy must be eliminated by instilling proper protocol measures to ensure patient data security outside of hospitals. Furthermore, the infrastructural requirements in developing countries must be met either by developing low-cost alternatives or increasing public healthcare funds. Such obstacles can easily be solved with an international collaboration dedicated to improving the global healthcare system as a whole.

However, some limitations for this study should be noted. First, the study was constrained to the use of the Google Scholar, PubMed and Science Direct databases; no other database was used during the search and therefore, it is possible that important researches have been left out of this review. Second, the number of papers consulted in the development of this review is comparatively low as reviews usually consist of 70+ research papers. Third, the inaccessibility to some subscription-based journals has prevented some large-scale studies to be excluded from this review. Lastly, this review does not address all parts of the world. Countries such as Australia and those in Central and South America are not included since research papers found specifically addressing these countries were scarce. As a result, the results of this review are limited in scope and future work is required to evaluate the use of telemedicine in not only the U.S., Canada, UK, Africa and China, but in other parts of the world as well.

Conflict of Interest

The authors declare that they have no conflict of interest.

References

1. Al-Kassab MHA, Dongming L, Yunhe P. Facilities provided by ISDN for telemedicine. J Syst Eng Electron 1999;10:7–14.
2. Abdel-Massih RC, Mellors JW. Telemedicine and Infectious Diseases Practice: A Leap Forward or a Step Back? Open Forum Infect Dis 2019;6.
3. Omboni S. Telemedicine During the COVID-19 in Italy: A Missed Opportunity? Telemed J E-Health Off J Am Telemed Assoc 2020;26:973–5.
4. Leite H, Hodgkinson IR, Gruber T. New development: 'Healing at a distance'—telemedicine and COVID-19. Public Money Manag 2020;40:483–5.
5. Mekonnen WT. A Framework for Evaluating Telemedicine-based Healthcare Inequality Reduction in Ethiopia: A Grounded Theory Approach [PhD thesis]. University of South Africa; 2019. [cited 2021 March 20] Available from: http://hdl.handle.net/10500/26333
6. Becker CD, Dandy K, Gaujean M, Fusaro M, Scurlock C. Legal Perspectives on Telemedicine Part 1: Legal and Regulatory Issues. Perm J [Internet]. 2019 [cited 2021 March 01];23:18-293. Available from: https://www.ncbi.nlm.nih.gov/pmc/articles/PMC6636526/
7. Biswas P, Batra S. Commentary: Telemedicine: The unsung corona warrior. Indian J Ophthalmol 2020;68:1012–3.
8. Page MJ, McKenzie JE, Bossuyt PM, Boutron I, Hoffmann TC, Mulrow CD, Shamseer L, Tetzlaff JM, Moher D. Updating guidance for reporting systematic reviews: development of the PRISMA 2020 statement. J Clin Epidemiol. 2021;134:103-112.
9. Picot J. Telemedicine and telehealth in Canada: forty years of change in the use of information and communications technologies in a publicly administered health care system. Telemed J Off J Am Telemed Assoc 1998;4:199–205.
10. Farias FAC de, Dagostini CM, Bicca Y de A, Falavigna VF, Falavigna A. Remote Patient Monitoring: A Systematic Review. Telemed J E-Health Off J Am Telemed Assoc 2020;26:576–83.
11. Coombes CE, Gregory ME. The Current and Future Use of Telemedicine in Infectious Diseases Practice. Curr Infect Dis Rep 2019;21:41. doi: 10.1007/s11908-019-0697-2
12. Wallis CJD, Catto JWF, Finelli A, Glaser AW, Gore JL, Loeb S, et al. The Impact of the COVID-19 Pandemic on Genitourinary Cancer Care: Re-envisioning the Future. Eur Urol 2020;78:731–42.
13. Baker J, Stanley A. Telemedicine Technology: a Review of Services, Equipment, and Other Aspects. Curr Allergy Asthma Rep 2018;18:60. doi: 10.1007/s11882-018-0814-6

14. Kaplan B. Revisting Health Information Technology Ethical, Legal, and Social Issues and Evaluation: Telehealth/Telemedicine and COVID-19. Int J Med Inf 2020;143:104239. doi: 10.1016/j.ijmedinf.2020.104239
15. Mann DM, Chen J, Chunara R, Testa PA, Nov O. COVID-19 transforms health care through telemedicine: Evidence from the field. J Am Med Inform Assoc JAMIA 2020;27:1132–5.
16. Jumreornvong O, Yang E, Race J, Appel J. Telemedicine and Medical Education in the Age of COVID-19. Acad Med. 2020;95(12):1838–43.
17. Heyworth L, Kirsh S, Zulman D, Ferguson JM, Kizer KW. Expanding Access through Virtual Care: The VA's Early Experience with Covid-19. NEJM Catal Innov Care Deliv [Internet]. 2020 [cited 2021 March 02];1(4). doi: 10.1056/CAT.20.0327
18. Doshi A, Platt Y, Dressen JR, Mathews BK, Siy JC. Keep Calm and Log On: Telemedicine for COVID-19 Pandemic Response. J Hosp Med 2020;15:302–4.
19. Hollander JE, Carr BG. Virtually perfect? Telemedicine for COVID-19. NEJM. N Engl J Med. 2020;382(18):1679–81. doi: 10.1056/nejmp2003539
20. Dehours E, Balen F, Saccavini A, Roux P, Houze-Cerfon CH. COVID-19 and French Medical Maritime Teleconsultation. Telemedicine and e-Health [Internet]. 2021 [cited 2021 March 04];27(4):397-401.doi: 10.1089/tmj.2020.0296
21. Aldahmash AM, Ahmed Z, Qadri FR, Thapa S, AlMuammar AM. Implementing a connected health intervention for remote patient monitoring in Saudi Arabia and Pakistan: explaining 'the what' and 'the how.' Glob Health 2019;15:20. doi: 10.1186/s12992-019-0462-1
22. Ohannessian R, Duong TA, Odone A. Global Telemedicine Implementation and Integration Within Health Systems to Fight the COVID-19 Pandemic: A Call to Action. JMIR Public Health Surveill 2020;6:e18810. doi: 10.2196/18810
23. Adenuga KI, Iahad NA, Miskon S. Telemedicine system: service adoption and implementation issues in Nigeria. Indian J Sci Technol 2020;13:1321–7.
24. Ciotti M, Ciccozzi, M, Terrinoni, A, Jiang, W-C, Wang C-B, Bernardini S. The COVID-19 pandemic. Crit Rev Clin Lab Sci 2020;57:365–88.
25. Ahmed SAKS, Ajisola M, Azeem K, Bakibinga P, Chen YF, Choudhury NN, Fayehun O, Griffiths F, Harris B, Kibe P, Lilford RJ. Impact of the societal response to COVID-19 on access to healthcare for non-COVID-19 health issues in slum communities of Bangladesh, Kenya, Nigeria and Pakistan: results of pre-COVID and COVID-19 lockdown stakeholder engagements. BMJ Glob Health. 2020;5(8):e003042.
26. Grossman Z, Chodick G, Reingold SM, Chapnick G, Ashkenazi S. The future of telemedicine visits after COVID-19: perceptions of primary care pediatricians. Isr J Health Policy Res. 2020;9(1):53. doi: 10.1186/s13584-020-00414-0
27. Probst T, Stippl P, Pieh C. Changes in provision of psychotherapy in the early weeks of the COVID-19 lockdown in Austria. Int J Environ Res Public Health [Internet]. 2020 [cited 2021 March 10];17(11):3815. doi: 10.3390/ijerph17113815
28. Ashton JJ, Kammermeier J, Spray C, Russell RK, Hansen R, Howarth LJ, et al. Impact of COVID-19 on diagnosis and management of paediatric inflammatory bowel disease during lockdown: a UK nationwide study. Arch Dis Child 2020;105:1186–91.
29. Ganapathy K. Telemedicine and Neurological Practice in the COVID-19 Era. Neurol India 2020;68:555–9.
30. Majeed A, Maile EJ, Bindman AB. The primary care response to COVID-19 in England's National Health Service - Azeem Majeed, Edward John Maile, Andrew B Bindman, 2020. J R Soc Med 2020;113:208–10.
31. Sayer G, Horn EM, Farr MA, Axsom K, Kleet A, Gjerde C, Latif F, Sobol I, Kelley N, Lancet E, Halik C. Transition of a large tertiary heart failure program in response to the COVID-19 pandemic: changes that will endure. Circ Heart Fail. 2020;13(9):e007516. doi: 10.1161/CIRCHEARTFAILURE.120.007516
32. Wosik J, Fudim M, Cameron B, Gellad ZF, Cho A, Phinney D, Curtis S, Roman M, Poon EG, Ferranti J, Katz JN. Telehealth transformation: COVID-19 and the rise of virtual care. J Am Med Inform Assoc. 2020;27(6):957–62. doi: 10.1093/jamia/ocaa067

33. Moazzami B, Razavi-Khorasani N, Moghadam AD, Farokhi E, Rezaei N. COVID-19 and telemedicine: Immediate action required for maintaining healthcare providers well-being. J Clin Virol. 2020;126:104345. doi: 10.1016/j.jcv.2020.104345
34. Iyengar K, Mabrouk A, Jain VK, Venkatesan A, Vaishya R. Learning opportunities from COVID-19 and future effects on health care system. Diabetes Metab Syndr Clin Res Rev 2020;14:943–6.
35. Fagherazzi G, Goetzinger C, Rashid MA, Aguayo GA, Huiart L. Digital health strategies to fight COVID-19 worldwide: challenges, recommendations, and a call for papers. J Med Internet Res. 2020;22(6):e19284. doi: 10.2196/19284
36. Javaid M, Haleem A, Vaishya R, Bahl S, Suman R, Vaish A. Industry 4.0 technologies and their applications in fighting COVID-19 pandemic. Diabetes Metab Syndr 2020;14:419–22.
37. Novara G, Checcucci E, Crestani A, Abrate A, Esperto F, Pavan N, et al. Telehealth in Urology: A Systematic Review of the Literature. How Much Can Telemedicine Be Useful During and After the COVID-19 Pandemic? Eur Urol 2020;78:786–811.
38. Willan J, King AJ, Djebbari F, Turner GDH, Royston DJ, Pavord S, et al. Assessing the impact of lockdown: Fresh challenges for the care of haematology patients in the COVID-19 pandemic. Br J Haematol 2020;189:e224–7.
39. Khilnani A, Schulz J, Robinson L. The COVID-19 pandemic: new concerns and connections between eHealth and digital inequalities. J Inf Commun Ethics Soc 2020;18:393–403.
40. Galindo RJ, Aleppo G, Klonoff DC, Spanakis EK, Agarwal S, Vellanki P, et al. Implementation of Continuous Glucose Monitoring in the Hospital: Emergent Considerations for Remote Glucose Monitoring During the COVID-19 Pandemic. J Diabetes Sci Technol 2020;14:822–32.
41. Ronco C, Manani SM, Giuliani A, Tantillo I, Reis T, Brown EA. Remote patient management of peritoneal dialysis during COVID-19 pandemic. Perit Dial Int J Int Soc Perit Dial 2020;40:363–7.
42. Maspero C, Abate A, Cavagnetto D, El Morsi M, Fama A, Farronato M. Available Technologies, Applications and Benefits of Teleorthodontics. A Literature Review and Possible Applications during the COVID-19 Pandemic. J Clin Med. 2020;9(6):1891. doi: 10.3390/jcm9061891
43. Longpré-Poirier C, Desbeaumes Jodoin V, Miron J-P, Lespérance P. "Remote Monitoring of Intranasal Ketamine Self-Administration as Maintenance Therapy in Treatment-Resistant Depression (TRD): A Novel Strategy for Vulnerable and At-Risk Populations to COVID-19?" Am J Geriatr Psychiatry 2020;28:892–3.
44. Whitelaw S, Mamas MA, Topol E, Van Spall HGC. Applications of digital technology in COVID-19 pandemic planning and response. Lancet Digit Health 2020;2:e435–40.
45. Zeng Z, Chen P-J, Lew AA. From high-touch to high-tech: COVID-19 drives robotics adoption. Tour Geogr 2020;22:724–34.
46. Gerke S, Shachar C, Chai PR, Cohen IG. Regulatory, safety, and privacy concerns of home monitoring technologies during COVID-19. Nat Med 2020;26:1176–82.
47. Seshadri DR, Davies EV, Harlow ER, Hsu JJ, Knighton SC, Walker TA, Voos JE, Drummond CK. Wearable Sensors for COVID-19: A Call to Action to Harness Our Digital Infrastructure for Remote Patient Monitoring and Virtual Assessments. Front Digit Health. 2020;23(2):8. doi: 10.3389/fdgth.2020.00008
48. Ogbolosingha AJ, Singh A. COVID-19 pandemic: Review of impediments to public health measures in Sub-Saharan Africa. Am J Prev Med Public Health 2020;6:68–75.
49. Rogers LC, Lavery LA, Joseph WS, Armstrong DG. All Feet On Deck-The Role of Podiatry During the COVID-19 Pandemic: Preventing hospitalizations in an overburdened healthcare system, reducing amputation and death in people with diabetes. J Am Podiatr Med Assoc. 2020;25:1-11. doi: 10.7547/20-051
50. Jnr BA. Use of Telemedicine and Virtual Care for Remote Treatment in Response to COVID-19 Pandemic. J Med Syst. 2020;44(7):1-9. doi: 10.1007/s10916-020-01596-5
51. Calton B, Abedini N, Fratkin M. Telemedicine in the Time of Coronavirus. J Pain Symptom Manage 2020;60:e12–4.

52. Lapid MI, Koopmans R, Sampson EL, Van den Block L, Peisah C. Providing quality end-of-life care to older people in the era of COVID-19: perspectives from five countries. Int Psychogeriatr 2020:1–8. doi: 10.1017/S1041610220000836
53. Nittari G, Khuman R, Baldoni S, Pallotta G, Battineni G, Sirignano A, Amenta F, Ricci G. Telemedicine Practice: Review of the Current Ethical and Legal Challenges. Telemed E-Health. 2020;26(12):1427-37. doi: 10.1089/tmj.2019.0158
54. Liu F, Jiang Y, Xu G, Ding Z. Effectiveness of Telemedicine Intervention for Chronic Obstructive Pulmonary Disease in China: A Systematic Review and Meta-Analysis. Telemed J E-Health Off J Am Telemed Assoc 2020;26:1075–92.
55. Miller BJ. Telemedicine after COVID: An unanticipated benefit to a pandemic. J Pak Orthop Assoc 2020;32:53–5.
56. Lim MA, Pranata R. Teleorthopedic: A Promising Option During and After the Coronavirus Disease 2019 (COVID-19) Pandemic. Front Surg 2020;7:62. doi: 10.3389/fsurg.2020.00062
57. Das AV, Rani PK, Vaddavalli PK. Tele-consultations and electronic medical records driven remote patient care: Responding to the COVID-19 lockdown in India. Indian J Ophthalmol 2020;68:1007–12.
58. Barnes SJ. Information management research and practice in the post-COVID-19 world. Int J Inf Manag. 2020;55:102175. doi: 10.1016/j.ijinfomgt.2020.102175
59. David KB, Solomon JK, Yunusa I, Lawal BK, Marshal CS, Okereke M, Ozuluoha CC. Telemedicine: an imperative concept during COVID-19 pandemic in Africa. Pan Afr Med J. 2020;35:129. doi: 10.11604/pamj.supp.2020.35.25281
60. Betancourt JA, Rosenberg MA, Zevallos A, Brown JR, Mileski M. The Impact of COVID-19 on Telemedicine Utilization Across Multiple Service Lines in the United States. Healthcare 2020;8:380. doi: 10.3390/healthcare8040380
61. Liu N, Huang R, Baldacchino T, Sud A, Sud K, Khadra M, Kim J. Telehealth for Noncritical Patients with Chronic Diseases During the COVID-19 Pandemic. J Med Internet Res. 2020;22(8):e19493. doi: 10.2196/19493
62. Holtz BE. Patients Perceptions of Telemedicine Visits Before and After the Coronavirus Disease 2019 Pandemic. Telemed E-Health. 2021;27(1):107–12. doi: 10.1089/tmj.2020.0168