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Literature Review
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Challenges in Laboratory Data Management for Telemedical Services

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Abstract

Background: The practice of providing clinical care remotely via electronic communications is known as telemedicine.

Objective: To improve patients' health, the World Health Organization (WHO) created the term in the 1970s to describe a legitimate method of exchanging medical information about diagnosing, treating, and preventing illness and injury through information and communication technology.

Result: The notion of telemedicine is not a novel one. In both wealthy and underdeveloped nations, telemedicine is a cutting-edge idea that is expanding. ICT, or information and communication technology, is a significant factor in improving healthcare at the individual and community levels.

Conclusion: Today, "telemedicine"—providing healthcare over long distances—uses ICT systems. Introducing ICT is meant to enable decentralized health services.

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INTRODUCTION

The World Health Organization defines telemedicine as "healing at a distance." This entails overcoming the obstacles caused by travel and improving the quality of care through information and communication technologies[1]. A bidirectional technological method that has existed for a few decades involves interacting with a patient and a healthcare professional, while the patient can get services remotely[2]. The public can quickly and safely consult medical professionals via telemedicine regarding symptoms of infectious diseases, treatment and preventative strategies, psychological disorders, and other concerns[3]. By avoiding the hassle of travel, patients can obtain medical care remotely, lowering their chance of contracting highly contagious diseases. This is especially helpful for older individuals with numerous comorbidities whose movement may be compromised. Telemedicine reduces interaction with ill patients, prevents the spread of bacteria, and protects personal protective equipment (PPE), according to healthcare providers[4]. By adhering to regular learning schedules, telemedicine also maintains a vital place in medical education and resident training [5]. Even with telemedicine's indisputable benefits, its application in routine clinical practice is still rare and largely undeveloped. More specializations can employ telemedicine, and the field has grown due to the technology's increasing affordability and widespread use. Email, wireless tools, smartphones, two-way video, and other gadgets for communication are among the telemedicine services and applications [7]. Group treatment, nurse-patient interactions, teaching and training, community health worker television, and medical image transmission are a few instances of telemedicine programs. Along with teleconsultations, this also covers teledermatology, teleneurology, teleradiology, and telepharmacy[7].

Categories of Telemedicine

The two main subcategories of telemedicine are store-and-forward telemedicine and real-time telemedicine. Store and forward telemedicine, also known asynchronous telemedicine, allows data sharing without requiring both parties to communicate simultaneously. Data can be gathered, arranged, and kept in storage. The data are transmitted to the designated location for examination or diagnosis when possible. One example is when an ECG or skin lesion photograph, along with the patient's information and history, is emailed to a medical professional in the relevant field who works at a different or distant healthcare facility [8]. Real-time telemedicine, also known as synchronous telemedicine, is unique because it requires the patient and the healthcare professional to communicate simultaneously. Live and interactive, synchronous telemedicine includes video conversations supported by visual and aural assessment tools. Electronic stethoscopes and other devices for remote physical assessment can be employed [8].

Benefits of Telemedicine

Telemedicine, like every other new modern service, has generally improved access to healthcare. Observing that telemedicine is expanding quickly, the advantages have undoubtedly helped. Through telemedicine, people can access healthcare services more conveniently and promptly over longer distances. Patients gain from telemedicine

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services, but doctors and other healthcare professionals may quickly connect with patients and colleagues who live far away. Telemedicine also lowers the expenses and travel difficulties. Telemedicine shortens hospital stays for patients and enhances the management of chronic illnesses. In specific disciplines, such as mental health and intensive care unit care, telemedicine offers care that is on par with or even superior to traditional healthcare [7].

Numerous medical specialties use telemedicine; some of the most well-liked telemedicine solution specialties include [9].

Tele-radiology: Through teleradiology, healthcare professionals in one place can safely transmit a patient's X-rays and medical data to a licensed radiologist in another location for a brief consultation regarding the patient's condition.

Tele-psychiatry: Applications of telepsychiatry and telepsychology are widely accepted by both patients and clinicians, and the results of diagnosis and treatment have typically been comparable to those of conventional in-person meetings, because psychiatry frequently does not need the same physical exams as medicine. Telepsychiatry is primarily helpful for addressing behavioral health issues and enables licensed psychiatrists to treat patients remotely[10].

Tele-dermatology: In teledermatology, a general practitioner can share a patient's photo of a skin lesion, such as a rash, mole, or other skin anomaly, for remote diagnosis using store-and-forward technology and live interactive services. With the aid of teledermatology, physicians in remote locations without access to dermatologists can offer specialized services.

Tele-obstetrics: Obstetricians can give prenatal treatment remotely thanks to tele-obstetrics. For instance, taking a baby's heart rate at one place and sending it to an obstetrician at another facility for diagnosis.

Tele-oncology: Patients with cancer may benefit from more convenient and easily accessible care through tele-oncology. It provides live video platforms to enable patient consultations with the oncologist and store-and-forward capabilities to forward photos for diagnosis.

Tele-pathology: Tele-pathology facilitates remote illness diagnosis by enabling pathologists to exchange and transmit high-resolution pictures and videos. Education and research also make use of it. The idea of mobile technology was born out of mobile's swift and continuous development.

Teleclinical microbiology (TCM)

TCM uses information and communication technologies to deliver routine clinical microbiology services by specialists located some distance from the medical laboratory[11]. TCM is a relatively novel telemedicine module for infectious diseases and laboratory medicine [4,5]. The workflow of a standard TCM module includes the preparation and examination of clinical specimens by local staff[12], creation of an electronic file for every clinical case and digitalization of specimen assets (such as glass slides and culture plates)[13], transmitting or granting remote access to the electronic files and results[11], assessment and evaluation of the clinical data and findings by telecon-sultants working remotely[14], providing each clinical

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situation with computerized feed-back[15], and providing the patients with diagnostic reports[16]. Besides providing clinical diagnosis, TCM encourages the implementation of quality assurance programs, improves surveillance and early warning system performance, supports efforts to address antibiotic resistance, and offers a means of knowledge and talent transfer[17–19]. However, there are currently very few experimental TCM initiatives in existence[11]. Wilkowska and Ziefle[20] showed that beneficiaries generally regarded data security and privacy in e-health as very important. The authors concluded that the successful acceptance of medical technology would be mediated by developing practical answers to these problems. A scoping study on the effects and difficulties of telepathology's implementation revealed that organizational and legal concerns were not significant for small telepathology networks, like our TCM module[21]. Suren et al.[22] outlined a comprehensive IT infrastructure for coordinating prosthetic joint infection detection, care, and therapy, enhancing their platform's capacity to support real-time communications, improved cooperation effectiveness, and reduced information loss. Expert studies support the practical use of advanced informatics tools, such as specialist laboratory information systems, decision support algorithms, biochemical reaction databases, profile matching software, and automated image analysis tools, as a crucial step in maximizing and expanding the capacity of TCM modules[23]. Similarly, the detection of malaria parasites and the prediction of antibiotic resistance patterns have been accomplished with the help of digital imaging and machine learning[24,25]. The potential of incorporating artificial intelligence and machine learning systems into practical contexts has also been highlighted by experts [26,27]. To encourage the adoption of digital pathology modules, several pathology community members in the UK emphasized the significance of obtaining funding for early gear and software and paying staff compensation[28].

METHODS

The literature survey for this review was conducted through the archives of Google Scholar, PubMed, and SpringerLink, and these were published between 2015 and 2023. The study did not require human participation according to the principles of Preferred Reporting Items for Systematic Reviews and Meta-Analysis guidelines.

The papers were initially selected by reading the titles and abstracts. The final selection was completed after reading the full text. Furthermore, some web pages about CP organizations were used to complete the information for this review. Only English-written RCTs, controlled and uncontrolled trials, case studies, cohort studies, and pilot studies were considered—an in-depth search of electronic databases obtained scientific articles.

RESULTS

Advantages and disadvantages of the application of telemedicine technologies

Researchers from many nations are interested in utilizing telemedicine during the COVID-19 pandemic, reassessing its advantages and

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disadvantages, and examining the state-of-the-art electronic infrastructure. Therefore, telemedicine has proven successful in treating diabetes mellitus, cardiovascular illnesses, and other medical conditions, enabling high-quality remote care[29,30]. Time-saving and frictionless communication are two of its key benefits. As a result, telemedicine is quickly taking the lead in lowering the spread of COVID-19. It is crucial to address the shortcomings of telemedicine technology while acknowledging its necessity during the COVID-19 pandemic. Before the pandemic, studies indicated that the primary obstacles to the extensive use of internet solutions in medicine are implementation costs and return on investment uncertainties[31,32]. Among other challenges, it is essential to highlight the traits that are exclusive to specific demographic groupings. Thus, the advantages of current digital technologies are diminished by advanced age, low educational attainment, and inexperience (for instance, older adults are most susceptible to COVID-19). Negative legal factors include, for example, the lack of laws defining the extent of accountability in the event of health harm or, in the case of unlawful activity, issues about confidentiality and personal information[33]. This does not, however, lessen the significance of telemedicine technology during the COVID-19 epidemic or in general. As a result, patients with minor symptoms and a low risk of consequences can remain at home because calls and video chats can be used to manage the disease's symptoms and the healing process.

Medical devices

Given that equipment is a key component of telemedicine, used medical devices require special attention because they communicate directly with patients. Transferable data integrity must never be compromised because doing so could impact the course of therapy. Medical gadgets should be protected from other linked devices to avoid hacking and only receive encrypted data. Regularly inspecting seals is necessary since disassembled equipment could still be compromised, avoiding particular parts of the electronic circuitry.

Several medical devices are from different manufacturers, making it challenging to unify device connections and utilize the same communication and security principles for all. Globalization and further telemedicine development are hindered by the absence of defined protocols, rules, and information formats for information aggregation, transfer, and storage in telemedicine environments[34–36].

The main challenges in terms of the application of IoT in healthcare are the following

Data overload and accuracy, as far as the accumulation of information, are problematic for the utilization of various transmission protocols and standards; integration with multiple devices, as far as the accumulation of different resources, disrupts the execution of IoT in the healthcare field; data safety and confidentiality, as far as IoT resources lack information protocols and standards[37].

Since medical devices are a component of the Internet of Medical Things, security features currently present in IoT systems can offer the required level of protection and create an architecture that meets the requirements of all medical information systems[38].

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Legal and Ethical Concerns

Telemedicine's quick adoption and growth could lead to more contemporary technological issues. These issues could become barriers to the use of telemedicine if they are not resolved. Telemedicine-related issues might range from ethical and confidentiality issues to technical limitations. Technological advancements can address technical restrictions. Moral and legal issues, however, continue to be a barrier that requires consideration. A doctor needs enough medical history and patient information to have a successful remote session with them and provide an appropriate diagnosis. Concerns exist around the accuracy with which the doctor receives this information, as well as the security of the data transfer. When using telecommunication technology, patient confidentiality and consent must be considered. It should be understood, recorded, and authorized how patient personal data is stored and accessed[39]. Even when another clinician is called for advice, the patient is still under the care of the specific referring physician under the traditional method of seeing a healthcare professional. Both clinicians will typically be in the same nation and adhere to the same regulations. However, what guidelines should be followed when a referring physician consults with another via telemedicine across international borders? In cross-border practice, another licensing issue is brought up. It must be decided if the foreign doctor being consulted must be licensed in the patient's home country[40].

Physical examination and diagnostics

Physical examination and diagnosis-related issues were among the major obstacles in telemedicine visits, according to 18 research [29,41–57]. It is challenging to conduct physical examinations remotely[29,41,43–47,49,51,57] because some of its fundamental components, like tracking vital signs (such as blood pressure), cannot be done electronically and, if they can, are imprecise[29,41,54]. Additionally, several diagnostic tests and medical treatments cannot be performed remotely[49]. It was determined that telemedicine visits were insufficient, particularly for surgical specialties[42]. Virtual visits using an ophthalmoscope, flexible laryngoscopy, and otoscopic examination are not suitable[44,55,57]. According to a qualitative study, disagreement exists on a single, accepted method for virtual spine exams[46]. Eichberg *et al.*[50] showed that telemedicine-based neurological examination is lower quality than in-person[51].

Furthermore, there is currently no technology that enables remote palpation[49]. Patients believed in-person physical examinations and ancillary diagnostic procedures were the most complete, accurate, and precise [42,55] and were more inclined to turn down telemedicine appointments[57]. This matches the findings of Eichberg *et al.*[50], who demonstrated that patients needed additional evaluation in 18.5% of failed visits. Murphy et al.[47] discovered that telemedicine visits were more likely to result in incorrect referrals and subpar diagnosis and treatment. Additionally, many diseases still need to be evaluated in person[56], and a physical examination might not be feasible in emergency situations[29]. Telephone interviews were limited to verbal conversation and descriptions, unlike video consul-tations[49].

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CONCLUSION

A remarkable new trend that generally improves medical and health services is telemedicine. Even with telemedicine's quick development and expansion, more is still anticipated, particularly when serving under-developed nations. One excellent illustration of how contemporary technology and medical research may be effectively combined to improve healthcare and establish a paperless healthcare system is telemedicine. The advancement of computing technology, telecommunication networks, and information infrastructure gives us optimism for achieving these objectives. The rapidly expanding array of diverse technological solutions presents opportunities and challenges for telemedicine's future. Since this field is unquestionably becoming more important and prominent in healthcare delivery worldwide, we are calling for further research.

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