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Implementation of Artificial Intelligence Technology in Tele Medicine

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Abstract

The practice of medicine across locations by the prudent application of information and communication technology is known as telemedicine. As a result of the COVID-19 epidemic, telemedicine has experienced exponential growth on a global scale. Artificial intelligence has the potential to enhance and broaden the scope of telemedicine, opening countless opportunities for creating solutions for medical need. AI in telemedicine has the potential to significantly aid in the implementation of the healthcare continuum and, where required, encourage and facilitate increased access to integrated healthcare. Four emerging themes may be used to identify the potential influence of AI in telemedicine: collaborative information analysis, intelligent aid and diagnosis, healthcare information technology, and patient monitoring. Healthcare implementation is fraught with issues related to safety, ethics, efficacy, efficiency, regulations, and finances. If doctors act as informed, helpful mentors and leaders in the process, their uptake will rise. For the medical community and patients to embrace AI, the benefits of the technology must be sufficiently shown. AI can assist doctors make better decisions and complete certain activities to enhance the quality of healthcare. AI in telemedicine has the potential to significantly aid in the continuum of healthcare's adoption. Throughout a citizen's life, they may encourage and enable more access to integrated healthcare as and when needed. For example, the treatment of chronic illnesses requires ongoing, interdisciplinary care that is coordinated. AI can assist in meeting this demand by facilitating intelligent communication and information exchange between medical practitioners and by offering a knowledge basis for patient care.

Keywords: Artificial intelligence (AI), telemedicine, teleophthalmology, tele-dermatology, tele-stroke, healthcare information technology, advantages, challenges

INTRODUCTION

Telemedicine is regarded as one of the most significant advancements in the medical field. In addition to improving the standard of medical treatment and organizational effectiveness, it makes healthcare services more accessible [1].

By adding artificial intelligence (AI) to telemedicine, its capabilities may be enhanced and expanded, opening countless opportunities for the creation of solutions for requirements. They can both help doctors give patients higher-quality medical treatment. AI and telemedicine together can lead to better health results and a better patient experience. Along with improving and expediting illness screening and diagnosis, they can also decrease in-person patient visits and increase the precision and personalization of diagnosis [2].

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Telemedicine is the use of interactive digital communication to transport medical information to conduct medical examinations and treatments, consultations, and professional collaborations from a distance [3]. Telemedicine is frequently emphasized as a "science that is open and

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continuously changing as it responds to and adjusts to the shifting health demands and settings of societies while incorporating new technological developments" [4]. Reducing delays and logistical costs while addressing the accessibility and communication gaps in the medical industry are the primary goals of telemedicine.

Over the past ten years, wireless technology has been used to sensors and used in case studies pertaining to electronic patient records and home monitoring. These studies have included ones that examine the technology's cost-effectiveness and medical community's acceptance of it [4]. Teleradiology, which transmits digital radiological images (such as X-ray images) from one location to another; telepathology, which transmits digital pathological results; tele-dermatology, which transmits medical information about skin conditions; and telepsychiatry, which provides psychiatric evaluations and/or consultation via video and telephony, are the four fields to which it was primarily founded to provide services using information and communication technologies (ICT) [5].

The practice of telemedicine can be either synchronous or asynchronous (store-and-forward). The following are a few of its modalities:

- *Tele triage:* Evaluation of symptoms to recommend the patient to the appropriate care.
- *Teleconsultation:* Doctor-to-physician communication or direct consultation.
- *Telediagnosis:* Sending and registering a patient's supplementary tests for expert interpretation.
- *Telemonitoring:* Ongoing physiological parameter collection sent to a provider for treatment and diagnosis.

Each country has its own definitions and usage of these phrases. Through electronic systems, remote patient monitoring (telemonitoring) involves medical management, transmission, registration, and processing of bodily parameters. Wearable or implanted sensors and wireless devices can be used for this. Depending on the patient's demands, it can be synchronous or asynchronous and enables ongoing support and management of chronic illnesses.

THE BASICS OF TELEMEDICINE

In order to improve the health of people and their communities, the World Health Organization defined telemedicine as "the delivery of healthcare services, where distance is a critical factor, by all healthcare professionals using information and communication technologies for the exchange of valid information for diagnosis, treatment, and prevention of disease and injuries, research and evaluation, and for the continuing education of healthcare providers."

This definition is still in use although it was written around 22 years ago, and some of its elements, like "where distance is a critical factor," may need to be revisited. Even patients who live close to medical facilities can benefit from telemedicine, as evidenced by its use and experienced by physicians, patients, and health services. People's care in their homes is increasingly valued because of the comfort and security they provide, particularly during the SARS-CoV-2 pandemic [6].

This research paper offers a more straightforward but equally effective definition of telemedicine: "Telemedicine is the practice of medicine, between different places, through the responsible use of information and communication technologies." Responsible use means that telemedicine must be practiced in a way that is moral (similar to the practice of face-to-face care), safe, with privacy and confidentiality (for patient protection), and with quality (seeking the best possible patient outcomes).

Several new words are being introduced to introduce a more comprehensive and all-encompassing perspective on people's health in a digital age, including virtual health, eHealth, and care, linked health, and linked care. They may differ slightly in what they mean. Thus, ought to be comprehended within the contexts of which they are employed for. It is possible to think of telemedicine as being included into these denominations.

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The simplest definition of digital health is the application of digital technology to healthcare. It includes cutting-edge computer sciences in artificial intelligence with large data. Health on the go "The use of mobile wireless technologies for health" is the definition of Health [7].

The scientific and practical literature provides a wealth of evidence supporting the cost-efficiency, safety, and effectiveness of telemedicine [6–8]. The following are the primary advantages:

- Increases access and brings people.
- Contributes to the digital transformation strategy.
- Expands access and brings citizens closer to health services.
- Enhances clinical outcomes.
- Improves patient involvement and self-care.
- Strengthens care coordination.
- Helps address social and geographic.
- Health disparities, permits ongoing and clear communication between various levels of care.
- Helps organize health systems.
- Lowers health costs.
- Increases healthcare efficacy and effectiveness.

THE INTEGRATION OF ARTIFICIAL INTELLIGENCE IN TELEMEDICINE

Two of the most widely accepted definitions of AI are as follows: (1) Computer programs that carry out operations that often call for human intelligence and (2) artificial intelligence (AI) as "augmented intelligence," which refers to computer algorithms created to improve the skills of highly skilled experts.

AI in medicine is anticipated to help with the significant number of preventable medical mistakes as well as the inefficiencies in workflow and delivery that come with modern healthcare delivery [9–13].

Four emerging trends – patient monitoring, healthcare information technology, intelligent diagnosis and help, and information analysis collaboration – can be used to identify the possible effects of AI in telemedicine.

In some circumstances, artificial intelligence (AI) may be able to recognize traits that humans are unable to. But one cannot assume that algorithms would be able to take the place of doctors' comprehensive function [14].

When additional patient data becomes available, doctors are taught to respond quickly and to make dynamic judgments about new diagnoses and treatments. AI makes decisions based on "engineered" data, and its initial judgment is disconnected from the patients' subsequent outcomes, raising the possibility of blunders [15]. The rationale behind the AI-proposed diagnosis must be understood by doctors to anticipate any potential repercussions or unexpected adverse effects [16, 17].

AI can help doctors with some duties and decision-making to enhance the delivery of healthcare. Since a doctor spends almost half of their time working on electronic health records [18], it is also extremely helpful in that, as it uses intelligent algorithms to automate administrative activities, freeing up important time that may be devoted to providing direct patient care [17]. Speech recognition technology has the potential to assist doctors by displacing the need for keyboards for information entry and retrieval.

When making an initial diagnosis of a patient's health issue, obtaining their medical history is more important than doing a physical examination. According to certain research, history accounts for 76% of the contribution, whereas examination accounts for 11% [19].

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When it comes to analytical thinking and problem-solving, AI may be quite helpful, especially when dealing with big data sets. But AI shouldn't be overused at the expense of doctors' essential medical abilities [19]. AI cannot completely comprehend and understand contextual information or distinguish between information that is pertinent and irrelevant. Healthcare emergencies are something that doctors must handle. According to evidence-based management principles, an AI-powered system should put the performance and general welfare first [17].

Regulatory agencies work to advise payers and users on new technologies, but they face difficulties due to the quick evolution of AI and its application in telemedicine. Adoption of AI requires further clarification on its legal implications.

According to the American Medical Association (AMA), developers of autonomous AI systems should assume responsibility and keep their own medical liability insurance with their customers in the event of a system failure or incorrect diagnosis.

Another possible deterrent to adoption is the price of AI integrated with telemedicine. One of the main obstacles to its practical application is the diversity of insurance policies and medicolegal restrictions.

TELEMEDICINE AND ARTIFICIAL INTELLIGENCE

Teleophthalmology and AI

It is necessary for people with diabetes mellitus to have yearly retinal screenings to detect and cure diabetic retinopathy. Diabetic retinopathy is becoming more common, and the burden of sight-threatening conditions can be lessened with early detection and prompt treatment. Ophthalmologists do fundus examinations for this type of screening, or traditional fundus cameras are used for colour fundus photography [2]. Digital retinal pictures from teleophthalmology programs are transmitted to a centralized reading centre so that they may be evaluated for the existence of DR.

By providing an automated imaging system, the shortage of qualified personnel in relation to patient demand for this examination might be addressed. Using AI (Artificial Intelligence in Telemedicine 5) and machine learning (a kind of AI), teleophthalmology can diagnose patients' disease with technologies that are easily accessible to them. Artificial intelligence (AI) tools incorporated into the screening procedure might evaluate retinal pictures and compare them to earlier samples to ascertain the diabetic retinopathy stage [12].

But since the sensitivity and specificity of the automated imaging methods and equipment now on the market are still around 90%, false-positive and false-negative findings might happen. The most effective screening method is still the dilated eye exam [15].

Telestroke and AI

One of the leading causes of death and disability in the globe is stroke. Numerous studies have demonstrated that stroke has a significant worldwide impact and a significant financial cost to patients and their families as well as to health and care services [3]. Approximately 85% of strokes occur in low- and middle-income nations, with one-third affecting the economically active population. Stroke mortality varies significantly depending on social and economic development. The impact of stroke will be exacerbated by the demographic shift towards an older population that is taking place in most emerging nations [9].

Treatment and diagnostic delays raise the danger of dying and a dismal outlook. Due to the lack of neurologists with expertise in managing strokes and the diagnosis and treatment window, telemedicine has become a means for providing easily accessible neurological care. It has been demonstrated that teleneurology is a secure, economical and effective method of enhancing results of stroke [6]. The telestroke's accuracy has been shown to be comparable to bedside assessments in the diagnosis of acute stroke [10].

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AI algorithms that use machine learning to automate the reading and categorization of radiologic images have been included into telestroke systems. The care quality and efficiency rely on the quick analysis of brain imaging and clinical data. Location, categorization, and identification of the stroke management may be directly impacted by severity choices [18].

Platforms that offer automated data on different aspects of the acute stroke triage route and clinical workflow are used by telestroke programs. They provide quick and precise analysis to maximize stroke treatment delivery in hospitals [19].

Machine learning techniques for the detection of ischemia infarction on computed tomography (CT) or magnetic resonance imaging (MR) diffusion-weighted imaging can be used to quickly identify acute stroke patient candidates for thrombolysis. AI has been useful in detecting big artery occlusion and core infarct sizes on MR DWI, which are crucial for choosing individuals who could benefit from mechanical thrombectomy [4].

Another neuroimaging program that gathers and examines CT perfusion scan data is called RapidAI. With a quantifiable value of the amount of brain tissue that is irreparably damaged and the volume of tissue that can be recovered if blood flow can be promptly restored, it offers a real-time perspective of brain perfusion.

Future research confirming AI approaches is required to enable its wider usage, since the existing deployment of AI in the telestroke sector has significantly improved treatment decisions and clinical results.

Teledermatology and AI

Recently, teledermatology has been revolutionizing healthcare. Teledermatology's accuracy, cost-effectiveness, and potential to increase access to the expert are all supported by the available data. Most diagnoses in dermatology are based on the detection of visual patterns, and morphological traits constitute the primary basis for diagnosis. Clinical diagnosis of skin disorders has benefited greatly from the use of skin imaging technologies, and TD is one of the telemedicine domains where AI image recognition skills for aided diagnosis have been thoroughly investigated. AI-integrated TD might potentially be a useful screening tool. There are restrictions, though, as a recent systematic review of the teledermatology smartphone applications that are now on the market found that previous research used highly skewed patient samples, which limited the findings about the effectiveness of these automated diagnosis methods [13].

AI-driven image diagnosis system for skin malignancies has been compared to dermatologist diagnostic performance in several studies, and the results indicate that it is as accurate as dermatologists with training.

Both in-person and teledermatology, dermatology might be disrupted by deep learning technologies. However, research employing this technology has revealed a drawback for illnesses other than skin cancer. For these diseases, low specificity and specificity have been discovered, indicating that they are imprecise enough to be relied upon only on AI-driven picture analysis [16]. A patient with a certain dermatological problem can receive a false positive for a condition that looks similar if the ailment is not included in the AI model's database.

When lesions that were judged worthy of being photographed or biopsied turn out not to be representative of the lesion type, bias may also be introduced. Therefore, the sensitivity of a clinician's diagnosis while using photos from datasets may be lower than in a typical clinic.

TELEMEDICINE, ARTIFICIAL INTELLIGENCE, AND EDUCATION

Providing top-notch instruction and training for medical students, residents, and doctors is crucial for the appropriate (ethical, safe, and high-quality) use of emerging technologies like telemedicine and

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artificial intelligence. There is still a significant deficiency in knowledge and instruction in this area, despite initiatives and the recent expansion of telemedicine instruction at medical schools. In the foreseeable future, the use of telemedicine knowledge and practice to help people in need of high-quality medical treatment will only increase [18].

A curriculum that incorporates telemedicine training into medical school should be competency-based, outcomes-oriented, and include a variety of instructional modalities. Asynchronous lectures, faculty-supervised standardized patient telehealth encounters, discussions on applications, ethics, safety, etiquette, and patient considerations, and hands-on diagnostic or therapeutic procedures using telehealth tools, like live video, the store-and-forward method, remote patient monitoring, and mobile health, are some examples of the latter [15].

These courses ought to teach students how to preserve a solid patient-doctor relationship, safeguard patient privacy, advance treatment and access equality, pursue the best results, and understand the advantages and disadvantages of telemedicine.

Globally, the usage of telemedicine has increased exponentially because of the COVID-19 epidemic. Medical students' comprehension of the intricate ethical, legal, and regulatory concerns surrounding the use of these technologies will also improve when telemedicine and AI education are included into the curriculum [2]. Access to treatment, cost-effectiveness, patient experience, and physician experience might be the primary topics of such a program [19].

Additionally, practicing physicians should receive more training in AI and telemedicine. Medical specialty organizations and boards are advised by the American Medical Association to think about creating AI-related teaching modules tailored to their specialties [7]. The American Medical Association also emphasizes the necessity of ongoing medical education with relation to the evaluation, comprehension, and use of data in patient care.

These days, doctors should be able to interact with electronic health records and comprehend the full potential of emerging technology. To apply AI as clinical decision support, they need be able to oversee AI applications and handle data.

It is not necessary for doctors to become AI specialists; instead, they should be sufficiently aware of the potential and constraints of AI algorithms to enable them to utilize them to their full potential. But it's crucial to make sure that the humanism ingrained in medical practice and the patient-physician interaction is not harmed using AI and telemedicine [5].

PATIENT MONITORING

One of the earliest and most popular uses of telemedicine is patient monitoring. This makes it possible to perform routine doctor-to-patient consultations more quickly and affordably while evaluating the patient's present condition and clinical outcomes remotely. Through video conferencing and the connection of digital medical equipment to collect and record the patient's clinical data, this has been created to mimic in-person consultations. In contrast to physical patient monitoring, this movement aims to give accessibility, convenience, efficiency, and cost savings [17].

Recent telepresence robot designs are made to walk about rooms and corridors on their own by being controlled remotely using a software interface that connects the user to the robot over Wi-Fi [3]. Recently, this idea has been expanded to include the use of vision and artificial intelligence systems in tandem for obstacle detection and navigation. The Dr. Rho Medical Telepresence Robot, which consists of a mobile body and a screen for patient-doctor contact, is an illustration of this. It has a micro-projector for group exams and procedures, as well as an intelligent vision system that tells the cameras to follow the doctor's motions and gestures [7]. Numerous hospitals have already implemented this robot and other telepresence robot designs.

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HEALTHCARE INFORMATION TECHNOLOGY

The trend of using AI to systematize data analysis and retrieval also tackles the challenges associated with healthcare processes. According to an American College of Physicians survey, doctors devote half of their time on desk work and EHRs, which is how remedy was created. By substituting the laborious procedure of reviewing the patient's vitals with a chat interface questionnaire, storing the findings, and forwarding them to the physician, this system efficiently handles patient records [18]. Because the patient may submit images or videos for review, medications and other information can be sent to them more quickly.

Utilizing cloud computing to address electronic infrastructure problems, such as bandwidth constraints in some regions and implementation challenges, is another trend in the evolution of patient monitoring. By implementing the services in datacentres and utilizing distant servers to store and handle the data, this initiative seeks to increase the effectiveness of gathering and disseminating patient information. This has been used in a study called "A Cloud Computing Based Telemedicine Service" to speed up medical analysis by sending ECG wave impulses across the cloud to many places, including a mobile phone [19].

INTELLIGENT ASSISTANCE AND DIAGNOSIS

The incorporation of assistive mechanical components and the utilization of gathered medical data and outcomes for intelligent diagnosis are two more emerging trends in robotic technology. The purpose of both characteristics is to help patients either physically or by examining preliminary patient assessments to support the existing healthcare system. These technologies can function through the preprogrammed use of machine learning and neural networks. Existing technologies are introducing the use of intelligent diagnosis in a variety of software programs and smartphone applications for telehealth self-diagnosis (Figure 1) [3].

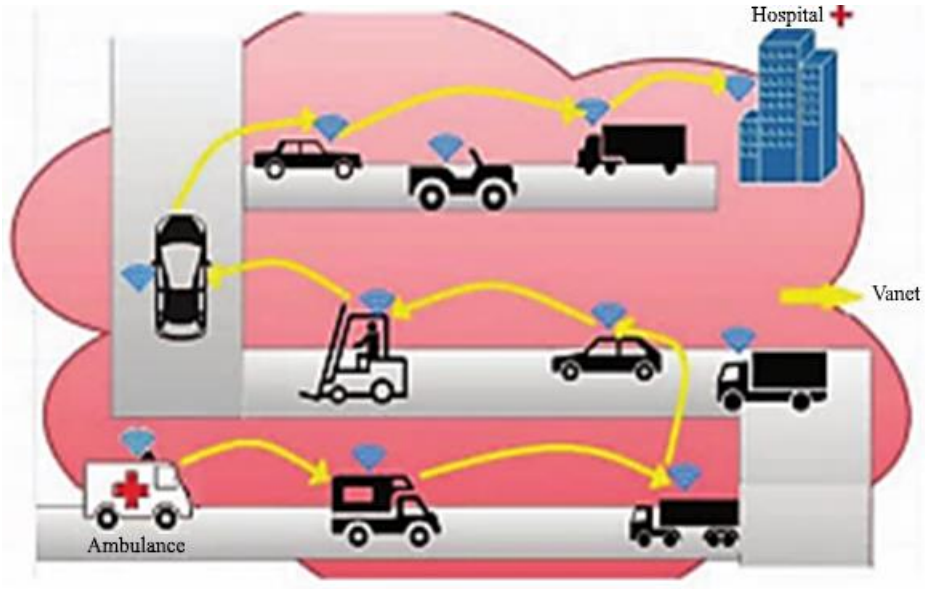

Figure 1. Architectural diagram of the telemedicine system and the types of vehicular ad-hoc networks used [20].

Self-diagnosing applications and devices for rapid assessments of vital signs, like respiration, heart rate, pulse, and the like, have emerged in the market because of the well-known trend in medical technology. One such instance is Lemonaid Health, a startup that created an AI model for patient screening and assessment using a questionnaire and meeting certain criteria [8]. Following screening, the patient will be classified according to the case's complexity. Physicians will assess the case appropriately and may advise over the phone or provide immediate prescriptions.

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CHALLENGES IN IMPLEMENTATION

The expense is one of the biggest obstacles to the adoption of telemedicine programs and equipment. Even if cost-effective models have been developed, hospitals and institutions will need to spend money and time on training and installation before they can fully utilize them [3]. The connection status or bandwidth is another problem since it could be necessary to adjust the infrastructure, which is highly challenging to do, particularly in remote or undeveloped facilities, to construct a rapid and steady delivery of high-quality telemedicine information [11]. Because of the existing issues with healthcare information security and confidentiality when conducting telemedicine consultations and operations, there has been a wide range of future instructions for artificial intelligence in this field.

Since research on this issue has not yet been thoroughly developed, it could take some time before telemedicine technology is really used.

The malpractice concerns have resulted in the need for training and licensing to use telemedicine equipment appropriately, just like they have for other medical procedures and technologies. Implementing facilities may be hampered by this as it increases the cost and completion time. Malpractice and lack of knowledge can also influence patients' preferences and consistency, which may lead them to dismiss the advancement or application of technology [15].

DISCUSSION

AI integration in healthcare has enormous potential to transform patient outcomes and treatment. Clinical laboratory testing and illness detection may be made more accurate, efficient, and economical with AI-driven predictive analytics. AI may also help set guidelines and manage population health by optimizing pharmaceutical choices and delivering accurate, real-time information. There is potential for better patient care with the integration of AI in virtual health and mental health assistance. To guarantee the fair and efficient application of AI, it is crucial to solve constraints like prejudice and a lack of customization.

Combining telemedicine and artificial intelligence (AI) has the potential to revolutionize healthcare delivery by increasing patient access, boosting diagnosis accuracy, and improving treatment outcomes. Ensuring that these developments are used ethically and that careful research and evaluation are done to verify their safety and effectiveness is vital. Doctors don't have to become AI experts to take full use of AI algorithms; they only need to understand their strengths and weaknesses. In summary, artificial intelligence (AI) has the potential to greatly improve the quality of care delivered through telemedicine, particularly during emergencies like the COVID-19 epidemic.

Telemedicine screening needs to be well planned and eventually customized for the intended audience to benefit from all that digital technology has to offer. Using the following methodology (appendix) is suggested for evaluating new digital technologies. Determine the disease's prevalence first, then specify the context for usage (such as resource-rich versus resource-constraint settings in this study). The second step is to choose the appropriate health economic model; several models may be pertinent. Third, choose deployment strategies and screening criteria after assessing the new technology's diagnostic performance. Finally, assess the expenses.

CONCLUSIONS

In conclusion, computer intelligence is a technology that has advanced to the point where it can significantly improve upon human processes and even current technologies. This technology's ease of application made it extremely useful in a variety of sectors, and this study highlights how crucial its use is to the medical industry. Telemedicine is a flexible process with countless opportunities for advancement. Its use might involve adding more patients or figuring out the best way to perform a medical operation that will have a significant influence on many lives. Although telemedicine may have been able to keep up with the latest developments in artificial intelligence, there are still some issues that need to be resolved. The most significant contribution from these studies will be their

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implementation, therefore, it's also critical to start looking at ways to lower the cost of this technology so that it may be utilized in poor healthcare facilities and rural regions.

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