Telehealth and Artificial Intelligence during the COVID-19 Pandemic

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Telemedicine enables clinical services to use information technology, video imaging, and telecommunication links to deliver healthcare services at a distance. In contrast to telemedicine, which is defined as the provision of medical services at a distance by a physician, telehealth is an umbrella word that encompasses telemedicine as well as a number of nonphysician services such as telenursing and telepharmacy. Telemedicine is often used for controlling chronic diseases such as cardiovascular diseases, diabetes mellitus, cancer, and mental disorders.

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1. Introduction

The coronavirus disease (COVID-19) pandemic has affected the environment, and people's health lifestyle globally [1][2]. Digital health offers a valuable opportunity to handle epidemics such that real-time results continuously emerge. Recent cases of Severe Acute Respiratory Syndrome (SARS), influenza A virus subtype H1N1, and Ebola Virus Disease have taught many lessons about the usefulness of digital health in public health crises. Those lessons can also be applied to improve the reaction to the coronavirus disease 2019 (COVID-19) pandemic caused by severe acute respiratory syndrome coronavirus 2 (SARS-CoV-2) through innovative and productive techniques [3][4][5]. In 1980, the Veterans Health Information Systems and Technology Architecture (VisTA) was deployed for the first time; this is considered the beginning of what is now referred to as digital medicine, leading to the first generation of the Electronic Health Record (EHR). The successful implementation of the computerized patient record system was another milestone in 2000. The VisTA user interface allows providers to analyze and edit the EHR of patients, which was the beginning of medical information technology [6].

The launch of the first iPhone in 2007 contributed to developing an ecosystem that enables real-world monitoring and clinical/research-level health data collection through mobile systems. Today's social, mobile, computational, and cloud integration creates a society of customers immersed in technology. The third technological revolution (digital technology) has already taken place and has given rise to significant developments in the medical world, but the subsequent fourth medical revolution will have a significant impact on healthcare [7][8][9]. The fourth medical revolution began with technologies such as the Medical Internet of Things (MIoT), artificial intelligence (AI), advanced robots, biosensors and so on. These innovations have digitized services for the medical sector to enhance healthcare services [10][11][12]. Hence, the goal of the fourth medical revolution is to plan and build an

intelligent healthcare system to function effectively and efficiently and create a better technology platform for virtualization, decision making, and real-time capability [13][14].

Telehealth has a broader scope of remote healthcare services than telemedicine. Different terminologies are used to refer to telemedicine or telehealth—for instance, digital health, electronic health, mHealth (Mobile Health), teleconsultation, and tele-triage. In addition, there are some terms that mention specialties, for example, teleneurology, telecardiology, and telepsychiatry [15]. Telemedicine has been used since the early 1960s by the military and space technology departments. Nowadays, telemedicine is available for everyone at digital stores, and mHealth apps can be used on smartphones, tablets, and computers [16]. These apps provide accessible remote communication between healthcare professionals and their patients [17].

Telemedicine has some disadvantages, such as the need for network stability, good battery life, data security, and privacy. Some critics of telemedicine argue that using these apps is unethical in terms of privacy, equity, and patients' rights [17][18]. Additionally, mHealth apps may increase the spread of inaccurate information due to the absence of face-to-face communication. A limited number of studies have reviewed this issue, but it remains a safety concern that should be addressed [19][20]. It was investigated the role of telehealth and AI in combating the COVID-19 outbreak through identifying hotspots in digital health during COVID-19. It was also reported the data privacy and security challenges that researchers must be aware of and explore the available tools and techniques to minimize the risks.

2. Telemedicine, Telehealth, and Mobile Health (mHealth)

Telemedicine enables clinical services to use information technology, video imaging, and telecommunication links to deliver healthcare services at a distance. In contrast to telemedicine, which is defined as the provision of medical services at a distance by a physician, telehealth is an umbrella word that encompasses telemedicine as well as a number of nonphysician services such as telenursing and telepharmacy [21].

Telemedicine is often used for controlling chronic diseases such as cardiovascular diseases, diabetes mellitus, cancer, and mental disorders. Telemedicine might be a safe and effective alternative for older people who suffer from these diseases. It is easy for patients to follow up on their cases via mHealth apps, especially those living in rural areas [22].

Digital psychotherapy is considered one of the most successful roles of telehealth. It makes it easy for patients to communicate with their psychiatrists anytime and anywhere. Telepsychiatry costs less than regular visits to therapists. Due to the severe shortage of mental health professionals in rural areas, digital psychotherapy has developed to help people in the countryside communicate with their psychiatrists in urban areas [23]. Mobile apps could be an effective alternative to telepsychiatry services for patients. People with depression, anxiety, schizophrenia, and other mental illnesses can benefit from technology and be cared for at home using their smartphones [24].

Cancer is the leading cause of death worldwide. Most cancer patients need regular monitoring to control their health. Cancer is a chronic disease, and the patient's family has a vital role in improving the patient's quality of life. The family's contribution to the patient's care at home is essential. Palliative care programs are based on the family's responsibility for care at home. Family members face challenges providing care at home, and telemedicine provides them with information and knowledge. Mobile apps can facilitate communication between cancer patients and their healthcare providers [25].

3. Telehealthcare's Role during COVID-19 Pandemic

The importance of telemedicine has garnered more attention since the COVID-19 pandemic. Teleconsultation is a safe and effective way to diagnose, control, and treat diseases [26]. Suspected COVID-19 cases or infected patients (with mild and moderate cases) are advised to stay at home and use mobile apps to follow up with their healthcare providers. Many governments launched telehealth apps to provide online health services for citizens. The Brazilian Board of Medicine published a memorandum on 19 March 2020 to use telemedicine as an exception during the pandemic [27]. The MOH (Ministry of Health) of the Republic of Indonesia encouraged telehealth services for COVID-19 related inquiries or any other medical conditions. The MOH prompted health-tech start-ups to release mobile apps that provide digital health services [28]. In Turkey, Syrian refugees suffer from low quality of life, low socio-economic status, language challenges, and poor health conditions. Hence, telemedicine services are a cost-effective alternative for those refugees to contact healthcare practitioners in Arabic and English [29]. The Indian Space Research Organization, MOH, and Ministry of External Affairs played a significant role in developing telemedicine services in India. The government supports and promotes telemedicine during the COVID-19 pandemic to reduce overcrowding in hospitals and encourage social distancing. During the COVID-19 pandemic, telemedicine can also help with reducing the burden on tertiary hospitals by providing diagnosis and treatment to patients in their own location and reducing the chances of the patient's exposure due to hospital visits [30].

4. Artificial Intelligence in the Healthcare Sector

4.1. AI Types and Subgroups

The term AI was introduced to the world for the first time by McCarthy et al. in the 1950s [31]. The term AI refers to the ability of computer systems to think and take action like humans in comparable situations and predict the outcomes of these reactions. The AI-based algorithms continue to be improved by developers and scientists, taking advantage of the refinement of networks and technology infrastructures, especially in the late 1990s. AI has been classified into seven types based on functionality and technology. AI has two related subgroups: machine learning and deep learning. AI refers to intelligent systems that think and act like humans. Machine learning refers to systems that learn things based on previous experience and provide defined data to make proper decisions, while deep learning refers to systems that can think like human brains using artificial neural networks [32].

4.2. AI Applications

Nowadays, AI has become a useful tool for users in many different fields, including e-commerce (personalized and online shopping), navigation (GPS technology, traffic prediction), robotics (robots powered by AI), healthcare (diagnosis and prognosis of different diseases, and finding the appropriate treatment approach for each case), agriculture (identify defects and nutrient deficiencies in the soil), gaming (creating human-like interactions and predict the human behavior), automobiles (self-driving vehicles), social media (Facebook, Instagram, and Twitter), marketing (delivering targeted, personalized ads), and smartphones (facial recognition) [33].

The spatial distribution of diseases was identified and analyzed by Geospatial Artificial Intelligence (GeoAI). It was used to simulate or predict diseases and track them in research on infectious diseases. Google Flu Trends used big spatial data (weekly forecasts for various cities) from the National Climate Data Centre [34], and deep learning recurrent neural networks (RNNs) were used for predicting influenza outbreaks at provincial and city spatial scales in the USA, assisted by bioinformatics tools like docking and modulation to predict upcoming influenza subtypes that could cause a future pandemic [35]. Using an algorithm tailored to artificial neural networks, geotagged tweets from Twitter and the Centers for Disease Control and Prevention and influenza-like illness datasets were also used to forecast illness in real-time [36]. These geotagged tweets focused on where the user sent the tweet from and allowed for its geographical position to be monitored on the Twitter App. Another study used a machine learning approach to predict the epidemiology of influenza in the USA each season, integrating a predictive method of self-correction with Google Patterns relevant to influenza, cloud-based EHRs, and historical flu trends, in addition to a network-based approach that leverages spatiotemporal trends in historical influenza activity [37].

There are currently various GeoAI strategies for public health uses, and broad attempts to deploy GeoAI and location-based information in precision medicine, such as through mHealth for therapies. Future research will broaden current GeoAI technology to open up new opportunities for research and development in the field of spatial epidemiology and public health, including modeling sites that have not already been documented in high resolution, or analytics for the creation of new spatially extensive data sources [38].

4.3. Artificial Intelligence's Role in COVID-19 Prediction

In hospital emergency departments, COVID-19 patients are in a highly critical situation that requires quick interpretation of symptoms so that physicians can make appropriate decisions. AI-based models have been used to predict the danger of deterioration in COVID-19 patients using the X-ray images of their chests and based on artificial neural networks that are fundamental to deep learning-based algorithms [39]. The AI-based model can learn from physicians' daily reports, and the trained model used data from 3661 patients. The obtained results, which showed an accuracy of 0.786 of the area under the curve (AUC), could be vital in assisting physicians with diagnosis and reporting findings in the emergency department. Another AI-based model was designed to see how well a chest radiograph performs through scoring the severity of COVID-19. The model was integrated with laboratory and clinical evidence to predict the outcomes of COVID-19 for infected patients [40]. The obtained results showed an accuracy of 84% and AUC = 0.82. Two radiologists evaluated the results, confirming the accuracy of the AI-based model findings, which will assist radiologists with chest radiograph reports and predicting COVID-19 patient outcomes in the future.

Moreover, a machine learning-based model has been designed to predict the risk of infection by SARS-CoV-2. The model was tested and trained using data from more than 51,500 patients who were diagnosed with COVID-19. The designed model used eight features collected from the COVID-19 patients, including age, sex, confirmed contact with an infected individual, and five clinical symptoms (cough, fever, sore throat, shortness of breath, and headache). Based on these features, the obtained results showed AUC accuracy with 95% CI: 0.892–0.905 [41]. Overall, the AI models and algorithms had a vital role during the COVID-19 pandemic, as users trust them to make proper decisions about diagnosis and infection outcomes and assist physicians throughout the reporting process to achieve suitable and quick intervention.

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