Application of Modern Technologies on Fighting COVID-19: A Systematic and Bibliometric Analysis

Irsa Azam and Muhammad Usman

Abstract COVID-19 pandemic drastically increased the demand for essential medical healthcare equipment’s, medicines along with the strict lockdown conditions to prevent disease transmission. As a result it becomes challenging for healthcare professionals to provide In-person treatment. This poses pressure to perform medical practices besides taking care of the spread of the novel coronavirus. Studies have declared that information technologies have the potential to fulfill customized requirements of COVID-19 pandemic. Thinking about advance technologies and its benefits, this study is going to provide a through literature about the application of advance technologies in real-time. The study also highlights that Telemedicine and Telehealth are the most widely used technological term in the COVID-19 research literature. The first aspect of the study is to search the literature that allowed us to understand the series of advance technologies emerging recently and how they are helpful during this pandemic? The second stream of literature focused on classifying the top 12 technologies under different scenarios as an outcome of the current situation. Study mapped the literature by selecting the final 83 articles to understand the benefits and application of these technologies in different areas of healthcare system.

Keywords COVID-19 · Telehealth · Telemedicine · Artificial intelligence · Internet of things · Pandemic · Robotics
1 Introduction

The world is witnessing the deadly coronavirus (COVID-19) outbreak. To date, the center for disease control and prevention (CDC) reported 1.7 million cases of COVID-19 with 104,396 deaths [1]. The WHO (World Health Organization) declared this outbreak a pandemic on the date of March 11, 2020. Moreover, WHO also called for mutual support for the health sector to prepare them to fight against this pandemic [2, 3]. Similarly likely, on March 13, 2020 the executive officer of the president of US indicate this pandemic a global emergency. As the growth of the incidents of COVID-19 continues to rise, the healthcare system is struggling to prepare and fulfill the increasing clinical demands [3, 4].

COVID-19 has dramatically affected healthcare facilities and treatment systems worldwide [2]. The Healthcare system is under great pressure to provide primary healthcare services to patients. In order to fulfill the growing demands of healthcare equipment’s and to mitigate the spread of coronavirus, hospitals need to improve the efficiency of their medical system [5]. In this global health emergency, medical personnel and scientific researchers are looking for ways to address the challenges of this deadly virus in more efficient way [6]. In this emergency situation, science and technology are playing a key role [7]. Studies also examined that this pandemic has not just impacted on physical health but it also severely impacting the mental health of people. In the presence of the fear of this deadly virus people are choosing to stay at home and practice social distancing [8].

Researchers are continuously suggesting that advanced technology has the potential to mitigate the disease by naturally controlling the disaster [9]. Despite the fact that some countries are not accepting latest technologies, it the only option to fight with this pandemic [10–12]. Countries are trying to adopt innovative technologies almost in all the department of the healthcare system to get relief from this emergency situation [13, 14]. This alarming situation raised one question in everyone’s mind, about how public healthcare services are immediately responding to infectious disease with the help of latest technologies. Therefore, this present study focus on the ways of utilizing modern technologies by the healthcare system and the practical benefits of these technologies in fight against the pandemic. This study will provide a thorough review of the application of advanced technologies used by different healthcare systems in different departments. The study will not only provide insight into the application of technologies but also it will provide a deep understanding of their reaction to coronavirus pandemics.

2 Methodology

For this systematic search, the study developed a search strategy to identify relevant literature. This search strategy was tailored to Scopus database. A Boolean operator keyword technique is utilized by using “COVID-19” AND Technologies, “COVID-19” AND industry 4.0 to collect data. Study included journal articles
published in English only. The selection criteria were based on the Fig. 1 PRISMA Statement [15]. The research mainly focused on the mapping existing literature on COVID-19 in the field of technological innovation in healthcare system. Therefore all the other articles targeting other areas are excluded. A total of 78 articles were excluded at this stage. The studies of 172 records were extracted at this stage. For maintaining the quality of the review all duplications of the articles were checked deeply. A careful evaluation of each research paper was carried out and 89 articles were removed at a later stages. Finally, a total of 83 articles were selected for final conducting the study. These 83 articles were fulfilled all the basic criteria of the study.

3 Results

COVID-19 teaches us many lessons on becoming resilient in future with the supply of resources [16]. The study found many advanced technologies which is successfully utilized in healthcare system of different countries. These technologies can help in the proper control and management of COVID-19 pandemic [17, 18]. All
these technologies discussed in this paper can also help in the detection and diagnosis of COVID patients and also rectify other health-related problems.

### 3.1 Telemedicine and Telehealth Service During COVID-19

The concept of telemedicine can be defined as the process of providing care to a patient by a physician or other healthcare professional at a different venue [19]. It is the Use of Information Technology platforms, including voice, audio, text and digital data exchange as help to diagnosis, prescription and follow up evaluation [20]. Researchers are continuously trying to suggest the measures to overcome the possible pitfalls of telemedicine [21, 22].

Globally, the existing healthcare system has severely challenged by COVID-19 pandemic. The transmission speed of the virus makes the hospital to avoid face to face consultation with patients [23]. Therefore, many routine checkups including dental procedures, neurologic examination, and cardiology monitoring have been suspended and only emergency surgeries are allowed to perform. All over the world, government-imposed serious restriction on social interactions and travel and proposed remote working concept [24]. The concept of telemedicine is not new, some countries were already adopting the practices of telehealth especially palliative care for seriously ill patients. Research evidence declared that those patients who were receiving palliative care at their homes were very much satisfied with time saving and convenient virtual care [25]. The emergence of COVID-19 makes the telemedicine critically essential tool to mitigate the spread of coronavirus and save personal protection equipment [25].

After reviewing the literature and performing bibliometric analysis, the study found that telemedicine and telehealth are most widely used terms in COVID-19 research shown in Fig. 2. A large number of studies have been conducted in this area as compared to any other technological terms. This clearly indicate the important role being played by telemedicine and telehealth in healthcare service. Telemedicine research is conducted in almost all the departments of healthcare systems including Dentistry, Neurology, Orthopedic, Cardiologist, Dermatologist and eye care [26] (Table 1).

### 3.2 3D Printing Technology

The world is facing a huge shortage of personal protection equipment (PPE) during COVID-19. Countries are looking for creative solutions to fulfill this shortage [27]. 3D printing is appearing to be the best solution for this problem. It is playing huge role by making low-cost face shields and changing full-face snorkel masks [28]. The 3D printable adopter, having a transparent face shield is used as an effective barrier against infection. The Polylactic Acid material used for making adopters is
cost-effective, available at a very cheap price. The front transparent sheet is made with the help of polyester and used for laser printing [27]. The facemask produced with the help of 3D printing technology can be used to test a large number of people in just 30 min. Previously used face masks including surgical and N95 were considered unfriendly for the environment. However, these masks are made with NanoHack 3D which is environment friendly and can be reused [2].

3.3 Artificial Intelligence (AI)

Researchers identified that Artificial Intelligence (AI) is also one of the powerful tool to fight against COVID-19. AI has the capacity to accurately predict the outbreak and also helps in minimizing the spread of Coronavirus. It can also guide about the COVID patient future health condition, which one is going to develop the severe respiratory disease [29]. If the wrong information is circulating in social
| Implementation of technology | Area | Functions | References |
|-------------------------------|------|-----------|------------|
| Telemedicine [44–46]          | Teledentistry, Teledermatology, Digital Orthopedics, Telecardiologist, Telehealth eyecare | Remote dental screening, making diagnosis, providing consultation and proposing treatment plan, Virtual neurologic examinations by using well established robust information technology, WebEx virtual conference call system to perform daily telemedicine rounds, Close communication with patients, Delivering care in the most appropriate venue, whether that be at home, the clinic, or the hospital, Use video communication software and implanted devices for remote cardiology monitoring, Triage for anterior eye, enhancing compliance, subjective reflection and visual acuity, imaging, contact lens fitting, Blood pressure and oxygen saturation | [23] [19, 47] [48] [49–52] [53, 54] [24, 55, 56] |
| 3D-Printing Technology        | COVID-19 intensive care unit (ICU) | Doctor use the headlight to protect themselves from respiratory droplets, blood, sputum and other fluids. Useful for ENT clinic, emergency room, operating room, ENT ward | [27, 57–59] |
| 5G, 6G Mobile Data            | Wireless awareness, Forecasting, Connectivity, Health Status Code | Facilitate the scientists in forecasting the next global epidemic from the recent epidemic, Role of B5G or 6G in delivering faster download speeds, Future possibilities of speeds up to one terabit per second, Patient data including state of health, travel history, and number of contacted people is used to tell a person about requirement of quarantine or not, Code is assigned by giving red, yellow or green color | [35, 60, 61] |

(continued)
| Implementation of technology  | Area | Functions                                                                 | References                                      |
|-----------------------------|------|---------------------------------------------------------------------------|------------------------------------------------|
| **Telehealth** [62–65]     | Zoom, Microsoft Teams Palliative care Cisco WebEx virtual conference call Remote non-clinical services | Provide additional visual information, diagnostic clues and therapeutic presence Remote assessments of patients presenting COVID-19, Provision of proper care to patient Use to Perform daily telemedicine rounds via a store and forward consultative service Provision of training, administrative meetings and continuing medical education | [66–68] [25, 69–71] [72–75] |
| **Artificial Intelligence** | 2D Deep Convolutional Neural Network 3-Dimensional Deep Learning Model Smartphone Applications Business Intelligence | Disease tracking Prediction outcome of patient’s health condition Computational Biology and Medicines perspective, Protein structure predictions Prevention and follow-up for COVID-19 patients BI can provide real-time data on how the epidemic is spreading and where are the clusters Use of first aid calls to identify the place of contagion occurring | [29, 66, 76, 77] |
| **Internet of Thing (IoT)** | Internet of healthcare thing (IoHT)/Internet of medical thing (IoMT) Mobile Applications | Alerts and tracks any types of diseases to improve the safety of the patient Digitally captures the data and information of the patient without any human interaction Biometric measurements like blood pressure, heartbeat and glucose level Facilitates the use of patient medical information without the physical manipulation of patient records | [78, 79] [80, 81] |
| **Robotics**               | Robots | Hospital used robots to deliver medicines, food and measure the temperature of coronavirus patients | [34, 82] |
| **Drone technology**       | Remote Areas | Transportation of COVID-19 test samples to laboratory centers The autonomous drones are used to haul samples taken from suspected persons in the remote | [40] |
| Implementation of technology | Area | Functions | References |
|------------------------------|------|-----------|------------|
| Automatic Machine           | Solar-powered automated hand washing machine | The machine, which uses solar and minimalizes the risk of self-contamination when washing hands | [40] |
| GPS, Wifi, Bluetooth        | Digital Contact Tracing App Infected Patient Contact Tracing Digitized security controls | Use of electronic information to identify exposures of an individual to infection Identification of close contact for giving instructions about patient (self-quarantine, respiratory hygiene/cough etiquette) Advice for receiving early care patient develop symptoms Hospital used digitalized administrative processes such as using infrared thermometer to detect temperature without body contact | [41, 83] |
| 5G cloud partnership        | CT and X-ray synchronization system ECG data monitoring and ultrasonic images 5G cloud-based smart robot 5G IT-based infrared temperature monitoring Surveillance System Honghu Hybrid System (HHS) | accurate detection of CT and other images in the screening of alleged COVID-19 incidents Enhancing the medical treatment potential for urgent and serious cases Conduct remote health care, body temperature monitoring, sanitization, washing, and medication distribution Used in traffic centers to track passenger conditions in a variety of cities. Monitor social distancing, mask wearing, and body temperature Information on symptoms, psychological status, contact history, social behavior, and the physical environment | [36] |
| Wearable Biosensor          | Patient Arm | physiological parameters for monitoring patients, detecting disease progression, skin temperature, heart rate, respiratory rate, oxygen saturation, perspiration and activity of ambulatory subjects in a 24/7 basis | [23, 32] |
media AI can automatically detect them and delete them. AI is also used in developing Robots which further helps in performing an online examination of people and sanitization job. CT scan is produced with the help of this technology which healthcare system used for the detection of pneumonia caused by a virus [30, 31].

Many countries have started different quarantine measures for restricting the movement of asymptomatic individuals having COVID-19 exposure to the community. These individual needs to stay at home with quarantine facilities. Moreover, they were also asked to perform symptom surveillance and fever during those 14 days. However, studies reported that there are 50% infected people who had no fever until the development of full-blown disease [4]. So relying on body temperature only is not sufficient. Therefore, the development of AI-based wearable technology (Biosensors) is used for the continuous monitoring of COVID-19 patient. This topic is not much discussed in the literature but this measure can enhance patient compliance with the monitoring system [32, 33].

3.4 Robotics

The outbreak of COVID-19 made caused a severe workload on medical staff of hospitals. Robotics are good alternatives for providing similar care as a doctor does. According to [34] China had placed 14 Robots into their hospital, which were used to clean and disinfect, deliver medicine and food, measure patient temperature, and also provides entertainment to patients. It is a great alternative to use and decrease the direct interaction between patients and doctors. They can perform the assigned tasks very carefully. They can perform daily work, assist doctors with remote diagnosis, and reduce the fear of spreading disease [34].

During the lockdown, a police Robot placed in different patrolling areas can carefully examine that people are following the orders of lockdown or not. Similarly likely embedded Robots in hospitals looks after the work of doctors. They used to make sure that doctors are performing their duties without any disruption. This technology is very helpful in decreasing the spread of the deadly virus [2].

3.5 Mobile Data (5G, 6G) and Cloud Partnership

For dealing with fast-growing coronavirus, Wuhan builds cabin hospital in its most difficult time. That hospital was built to deal with emergency patients, confirmed with mild symptoms. The main purpose of cabin hospitals is to check patients with oral medicine, mobile computed tomography, and CT scanning and some other functions. The basic purpose of the hospital is to build a wireless medical healthcare management system where services will be provided remotely. Therefore, hospital worked on 5G wireless network system. The wireless router consists of local
network unit was configured to get access the internet, address the need of internet access, reports different types of data and also the share of a file between cabin hospital and outside of hospital. They found that 5G network signals are more stable without packet drop, having bandwidth speed 10 time faster than 4G, and intranet bandwidth exceed 50 M and efficiently able to meet the demands placed on the network. The role of B5G or 6G is significant, in delivering faster download speeds, with future possibilities of speeds up to one terabit per second [35].

### 3.6 Cloud Partnership

Studies indicate that hospitals can use 5G based portal for free diagnosis of COVID-19 and efficient medical care. If there is any limitation in this portal (lack of radiologist), it can be addressed by using CT scan and X-ray with the focus on 5G cloud partnership. 5G cloud partnership is helpful in using the accurate detection of CT and other image during COVID-19 alleged screening. A 5G cloud based smart robots can also be developed for performing some medical tasks. Some cities are already practicing 5G IT based infrared temperature monitoring in different traffic centers for tracking passenger condition [36].

### 3.7 Internet of Things (IoT)

This advance technology helps in making sure that all the coronavirus infected patients are quarantine. It is also used for proper monitoring of quarantine patients. If a patient found to be at high risk, it can quickly be tackled by using an internet based network. This technology can also help in the reduction of the workload of the medical staff and ultimately their efficiency also improves. Patients can enjoy the benefits of superior treatment services with a small number of mistakes. IoT is considered to be most widely used technology in almost all sectors including health, education and business [37, 38]. This platform is useful to identify a person who is going to contact COVID patient [39]

### 3.8 Drone Technology

Drone technology can be used to check the proper implementation of quarantine and mask-wearing. Ghana became the very first country in the world who make the use of drone technology for the transfers of COVID-19 test samples to laboratory centers. The process includes the transportation of haul sample taken from the suspected person of remote area into the testing centers of two major cities [40]. Then the results of the test are delivered through short Message Service. This
technology makes the haulage of medical supplies to remote clinics possible by decreasing the transportation cost.

### 3.9 Solar-Powered Automated Handwashing Machine

The continuous pressure of washing hands with soap under running water makes the Ghanaian inventor able to invent hand washing machine. This automated handwashing machine uses solar energy and reduces the risk of self-contamination. This innovation got a certificate from the standard authority for starting mass production. The machine used a remote sensor that allows for a 15 s gap before between the discharge of handwashing soap and water to hands into the barrel. A single machine can be used by a minimum 150 people before refill [40].

### 3.10 GPS, WiFi and Bluetooth

Many countries including Australia, Canada, Germany, France and United Kingdom have changed the traditional contact tracing system and adopted digital tracing. GPS and WiFi sensors are used to identify the location of the app users and that geolocation information is utilized to dictate the proximity to an infected person. Barcoding is also used for contact tracing these days. China is using this technology for tracking information. Another strategy is the use of Wi-Fi fingerprints which make use of the received signal strength of each Wi-Fi network to create a fingerprint for each location [41, 42].

### 4 Conclusion

The study provides a thorough insight on the list of technologies which the healthcare system is utilizing in performing multiple tasks. The results are relevant with [43] study. Health sector is using this technology in making customized face masks, gloves and also used them in collecting information about the proper treatment of COVID patients. The study discussed 12 advance technologies which is applied in different areas of healthcare system and which provide relief during the war against the deadly virus. The application of these technologies can give updates on daily basis, about specific region in a specific given time of epidemic. The proper application of advance technologies can provide a lot of innovative ideas and solutions in order to better deal with this virus. Each technology contains its specific characteristics. The generalizability of telemedicine and telehealth made them the most popular term found in the bibliometric analysis of the literature given in Fig. 2. The proper application examples of these technologies can encourage those
who are still depending on face to face treatment in this difficult time. The study can also provide a guideline to practitioners on the benefits and application areas of these technologies.

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