The Role of Information and Communication Technology to Combat COVID-19 Pandemic: Emerging Technologies, Recent Developments and Open Challenges

Muhammad Arshad

Deanship of e-Learning and Information Technology,
Jazan University, Jazan, 82812, Kingdom of Saudi Arabia

Summary
The world is facing an unprecedented economic, social and political crisis with the spread of COVID-19. The Corona Virus (COVID-19) and its global spread have resulted in declaring a pandemic by the World Health Organization. The deadly pandemic of 21st century has spread its wings across the globe with an exponential increase in the number of cases in many countries. The developing and underdeveloped countries are struggling hard to counter the rapidly growing and widespread challenge of COVID-19 because it has greatly influenced the global economies whereby the underdeveloped countries are more affected by its devastating impacts, especially the life of the low-income population. Information and Communication Technology (ICT) were particularly useful in spreading key emergency information and helping to maintain extensive social distancing. Updated information and testing results were published on national and local government websites. Mobile devices were used to support early testing and contact tracing. The government provided free smartphone apps that flagged infection hotspots with text alerts on testing and local cases. The purpose of this research work is to provide an in depth overview of emerging technologies and recent ICT developments to combat COVID-19 Pandemic. Finally, the author highlights open challenges in order to give future research directions.
Key words:
COVID-19, Information and Communication Technology, Emerging Technologies, Coronavirus, Pandemic.

1. Introduction

Healthcare facilities are now adapting to COVID-19 by increasingly embracing new tools and innovations such as telemedicine and virtual care that use information and communication technology (ICT) to offer digital or remote healthcare facilities for patient treatment [1]. As the coronavirus pandemic (COVID-19) progresses, in an effort to avoid the spread of the disease, treat patients and take the burden off overworked healthcare staff, technical applications and programs are multiplying while still creating new, reliable vaccines. Digital information and monitoring systems have been unleashed in an unparalleled fashion to gather data and credible facts to help public health decision-making at a moment when everybody wants more information, including infectious outbreak modelers, state agencies, foreign organizations and persons in quarantine or preserving social distance.
To better monitor the outbreak and implement restrictive policies, artificial intelligence, robotics and drones are deployed; while scientists are frantically applying gene editing, synthetic biology and nanotechnologies in an attempt to plan and evaluate possible drugs, therapies and diagnostics. This analysis provides a non-exhaustive summary of the latest ICT technologies in use, outlining their key characteristics and importance in the battle against the coronavirus pandemic, reflecting on how they are used to track and control the accelerated spread of the disease, and ensuring that public health institutions retain their capacity to fulfill the ever-increasing needs caused by the disease [2].

1.1 Research Article Outline

The authors agreed to help humanity combat COVID-19 by researching various implemented technology as well as future technologies that could aid in pandemic containment, and then reporting our findings in the form of a manuscript. The analysts obtained advice from medical and scientific experts, as a result of which the study's topics have been determined.

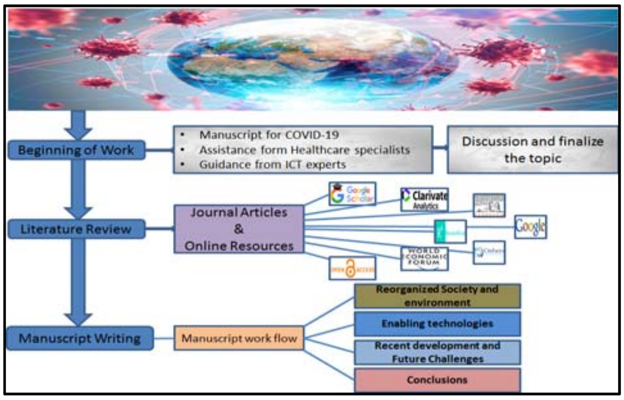

Fig. 1 Research Article Outline.

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To write a manuscript on this novel subject, first to understand what is going on in the world, which necessitates a lengthy survey of online knowledge from reliable sources, as well as a literature review to support the viability of the method disclosed in the online sources. The literature survey is mainly conducted using Google Scholar, Elsevier, IEEE, and Open Access networks. The World Health Organization (WHO), as well as reputable knowledge gathering sites such as the World Economic Forum, ResearchGate, Google, and news reports is the key internet sites from which information is retrieved. The initial screening is achieved by evaluating the title of the work, and then the found work is sorted according to the sections in our research. Furthermore, if the substance of the scrutinized work does not appear to match or the material in the work is already covered in another deemed analysis, the work is eliminated when writing the manuscript. The framework flow method for this manuscript is depicted in Figure 1.

1.2 Life Cycle of Data Analytics for COVID-19

First introduce the life cycle of data analytics for COVID-19 by ICT. Figure 2 shows that the life cycle of data storage for COVID-19 consists of three consecutive stages: 1) Data Acquisition, 2) Data Preprocessing and Storage, 3) Data Analytics.

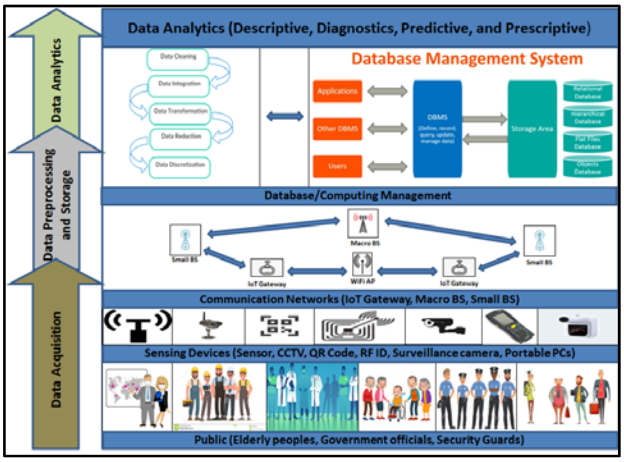

Fig. 2 Life Cycle of Data Analytics for COVID-19 by ICT.

Since this taxonomy can reliably capture the core features of data analytics for COVID-19 by ICT, the authors categorize the life cycle of data analytics for COVID-19 by ICT into three sections [3].

Data processing and transmission are two parts of *data acquisition*. To begin, data collection entails gathering raw data from different peoples within the society using dedicated data collection technologies. For example, wireless/digital thermometers are used to measure the temperature in public places or populated areas. The collected data would then be sent to the data storage system via wired or wireless communication systems.

Data Preprocessing and storage. Because of the large scale, redundancy, and instability features of raw data, it is essential to preprocess it before storing it in data storage systems. Data cleaning, data integration, data extraction, data elimination, and data discretization are examples of popular data preprocessing techniques. The method of maintaining and handling large data sets is referred to as data management. The database/computing management system is divided into two parts: the database management system (DBMS) and the storage area. The infrastructure requires not just the storage devices, but also the network devices that link them together. Data management software, in addition to networked storage devices, is required for the data storage system.

Data Analytics. Various data analytical schemes are used in the data analysis process to derive useful information from the vast COVID-19 data sets. The authors roughly divide data analysis systems into four categories: (i) statistical modeling, (ii) computer visualization, (iii) data processing, (iv) machine learning.

2. Prominent Emerging ICT Technologies to Combat COVID-19

As the COVID-19 pandemic progresses, technical applications and programs are multiplying in an attempt to keep the crisis under control, manage patients effectively, and aid overworked healthcare staff. COVID-19 symptoms can now be detected using emerging technology, removing all ambiguity about the condition and predicting the likelihood of contracting it. With proper monitoring systems, it is helpful to provide day-to-day updates of an infected patient, area-wise, age-wise, and state-wise. A look at the technical future in the sense of COVID-19 reveals that while technology cannot substitute or compensate for other public policy interventions, it is becoming increasingly important in emergency response [4]. These solutions will meet the needs for personalized face masks, gloves, and data collection for healthcare systems in order to effectively monitor and handle COVID-19 patients. The proper application of these innovations would aid in improving public health knowledge and collaboration. These tools have the potential to generate a slew of new concepts and solutions for dealing with local and global medical emergencies. As the first global disease of the twenty-first century, COVID-19 provides an ideal opportunity for policymakers and regulators to consider the legal plausibility, ethical soundness, and feasibility of deploying new innovations under time constraints [5].

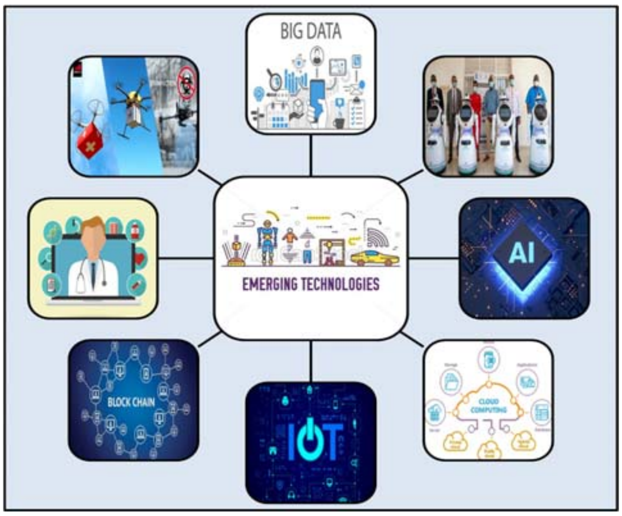

Fig. 3 Emerging ICT Technologies.

2.1 Artificial Intelligence

The World Health Organization (WHO) issued the first warning of a suspected novel coronavirus (COVID-19) in Wuhan on December 31, 2019. More than a week before official information about the outbreak was published by international agencies; Artificial intelligence (AI) systems expressed concerns about the novel coronavirus spreading outside China. Using natural-language recognition and machine learning, a health-monitoring startup accurately forecast the distribution of COVID-19. During outbreaks of this type, decisions must be taken quickly, often amid scientific confusion, anxiety, mistrust, and social and institutional disturbance. Due to a lack of evidence, the use of this technology is currently limited [6].

2.2 Cloud Computing

Cloud computing is a form of digital technology that includes delivering computer system services such as servers, storage, databases, networking, and intelligence over the internet. This technology allows for more rapid innovation and adaptable resources. As a result, the infrastructures' maintenance costs are minimized and its reliability is improved. People have been able to continue their digital lives with the aid of apps like Zoom footage, Slack, and Netflix via providers like Amazon Web Services, Microsoft Azure, and Google Cloud in these periods of social exclusion due to the COVID-19 epidemic [7].

2.3 Internet of Things (IoT)

The Internet of Things (IoT) is an integrated solution that has resulted in massive growth in automated processing, asset management, and other fields. Data collection, conversion, analytics, and storage are all part of it. Sensors used in cell phones, robots, and other devices are used to collect data. The captured data is then submitted to a central cloud server for analysis and decision-making. This technology is becoming more widely accessible for forecasting, combating, and tracking emerging infectious diseases [8].

2.4 Blockchain

In the vital realm of disease prevention, blockchain technology has recently emerged as a core technology. Blockchain implementations may provide a reliable, open, and low-cost way of enabling efficient decision-making, resulting in quicker response times during such emergencies. Blockchain has the capacity to become an important part of the global response to the coronavirus pandemic by monitoring the disease's spread, handling insurance premiums, and ensuring the viability of medical supply chains and donation tracking pathways in the light of this pandemic [4].

2.5 Telehealth Technologies

The disease's accelerated growth poses a serious threat to the whole planet. Health providers and policymakers are struggling when the normal potential for citizen care is surpassed. Social distance interventions are one of the most effective methods for minimizing and preventing the spread of the epidemic; this is where telemedicine can benefit and offer assistance to healthcare services, especially in the fields of public health, prevention, and clinical procedures, as it does in other sectors such as teleworking and support in training and education. Telemedicine can take several different forms in this situation [9].

2.6 Drones

Drones are being used to monitor quarantine measures, promote aerial broadcasting, spray disinfectant, perform aerial thermal sensing, monitor traffic, and provide medical supplies in affected areas during the COVID-19 pandemic. Drone software is being rewritten to acquire a variety of functions as the crisis becomes more urgent, with drones being used to supplement helicopter patrols.

and conventional routine disinfection, as well as for law enforcement and transportation to support disease detection and control in many countries. Drones and other aerial monitoring systems can help enforce containment and social distancing steps in the COVID-19 pandemic, not only by minimizing the number of face-to-face encounters but also by freeing up vital human capital (such as health staff and law enforcement officers) and restricting their exposure to the virus, decreasing the likelihood of contamination [4].

2.7 Big Data

Big data is a field that deals with methods for analyzing, routinely extracting information from, or otherwise dealing with data sets that are too large or complex for standard data-processing program applications to handle. Big data is an analytic tool that is well suited to tracking and controlling the COVID-19 disease global distribution. This technology will store a huge number of virus-infected patients. This technology lays the groundwork for a more rapid and near-real-time assessment of decision-making. It would aid in the saving of lives and the rapid identification of suitable treatments [10].

2.8 Autonomous Robots

The activities are carried out by an autonomous robot that is not influenced by any external entity. It's possible to use it to gather data about the climate. It can be used for a long time without assistance. It is classified as a robotics and artificial intelligence sub technology. It has the power to ignore circumstances that are potentially dangerous to humans. In the battle against the coronavirus pandemic, robots are being used all over the world [4].

3. Recent ICT Developments to Combat COVID-19

The COVID-19 pandemic presents devastating effects worldwide for health and all spheres of life (i.e., the economy, social security, education, and food production), encompassing profound and negative impacts on the enjoyment of economic, social, and cultural rights Information and Communication Technology has proved a useful and necessary tool to help ensure that international, local and regional governments on the frontline of the emergency continue to provide essential public services during the COVID-19 crisis. This section presents an overview of the recent ICT in terms of software, hardware and network based developments to combat COVID-19 pandemic.

3.1 Software Based Developments

In many nations, Big Data and Artificial Intelligence (AI) have helped accelerate COVID-19 preparedness and human monitoring, and hence the spread of infection. Resources such as migration maps that use cell phones, mobile payment apps, and social media to gather real-time data on people's locations have allowed the Chinese authorities to control the movement of people who have visited the Wuhan market, the epicenter of the pandemic. Machine learning models have been developed with these data to forecast the regional propagation dynamics of SARS-CoV-2 and to direct border controls and surveillance [11]. The Internet of Medical Stuff (IoMT), also referred to as the IoT for healthcare, is a combination of medical instruments and software apps that provide integrated healthcare facilities linked to IT programs for healthcare [12]. IoMT has seen a rise in the number of its possible applications in recent years, compared to IoT [13]. This increase is due to the fact that a growing number of mobile devices are now fitted with Near Field Communication (NFC) readers that allow these devices to communicate with IT systems [14]. IoMT uses include 1) tracking patients from a distant area, 2) monitoring prescription orders, and 3) sending clinical information to the health care providers involved via wearables. The health care industry has recognized the revolutionary value of IoMT technologies [15] because of its capacity to effectively capture, interpret, and distribute health data. Several innovators, medical institutions and government agencies are trying to exploit IoMT resources in the wake of the current COVID-19 pandemic to reduce the pressure on healthcare systems.

Forecasting systems based on machine learning (ML) have shown their importance in interpreting perioperative effects to accelerate decision-making on the potential course of action. In several application domains, ML models have long been used to define and prioritize adverse factors for a hazard. To manage forecasting challenges, many prediction approaches are widely used. The authors of [16] show that ML models are capable of predicting the number of possible patients impacted by COVID-19, which is widely known to be a possible danger to humanity. In particular, four standard forecasting models have been used to forecast the threatening factors of COVID-19, such as linear regression (LR), least absolute shrinkage and selection operator (LASSO), support vector machine (SVM), and exponential smoothing (ES). Each of the models makes three forms of forecasts, such as the number of newly infected cases, the number of casualties, and the number of recoveries in the next 10 days. In [17] offers an answer by Artificial Intelligent to fight the virus. To accomplish this purpose, some Deep Learning (DL) techniques have been shown, including Generative Adversarial Networks (GANs), Intense Learning Machine (ELM) and Long/Short Term Memory (LSTM). It outlines an interconnected approach to bioinformatics in which multiple facets of knowledge are gathered from a continuum of organized and unstructured data sources to form user-friendly platforms for doctors and researchers. Accelerating the method of diagnosis and treatment of COVID-19 disease is the primary benefit of these AI-based platforms. In addition, for each device, there are many unique sources, like different data types, such as clinical data and medical imaging, which may enhance the efficiency of the implemented methods in realistic applications for the right responses. The authors of [18] propose the methods of real-time forecasting of COVID-19 inspired by artificial intelligence (AI) to predict the scale, duration and end time of COVID-19 across China. The data was obtained by the WHO between January 11 and February 27, 2020. In the auto-encoder and clustering algorithms, they used the latent variables to group the provinces/cities for the transmission framework inquiry.

Screening for infection: In order to screen and guide people to relevant services, China uses open, web-based and cloud-based instruments. High-performance infrared thermal cameras set up at Taiwanese airports are used to take real-time thermal photographs of patients, identifying people with fever easily. In Singapore, at the exits to offices, schools and public transport, individuals have their temperature measured. Thermometer data is tracked and used for the detection of emerging hot spots and infection clusters where research may be initiated [19]. Iceland has launched systematic monitoring of asymptomatic citizens, unlike most other nations. Iceland gathers patient-reported symptom data using mobile technology and integrates this data with other databases, such as clinical and genomic sequencing data, to reveal knowledge on the pathology and dissemination of the virus. This approach has contributed to the knowledge base of asymptomatic COVID-19 prevalence and transmission. Iceland has had the highest per capita testing rate and the lowest per capita mortality rate for COVID-19 to date [20].

Contact tracing: Using surveillance camera video, facial recognition technologies, bank card information, and global positioning system (GPS) data from vehicles and cell phones, South Korea has introduced aggressive touch tracing software to provide real-time data and accurate timelines of people's movement. South Koreans get emergency text warnings about new cases of COVID-19 in their area, and individuals who may have been in touch with infected persons are urged to report to testing centers and self-isolation centers. South Korea has preserved among the lowest per-capita mortality rates in the world by detecting and isolating pathogens early. A cell phone application that shares short-distance Bluetooth signals while people are close to each other has been introduced in Singapore. These experiences are registered by the program and saved on their respective cell phones for 21 days. When an individual is diagnosed with COVID-19, the Ministry of Health of Singapore accesses the data to identify the infected person's contacts. Singapore, like South Korea, has retained one of the world's lowest per capita COVID-19 mortality rates. Germany has released a smartwatch program to test for symptoms of infectious disease that gathers data on heart, temperature, and sleep habits. The application data was provided on an online interactive map in which officials can determine the risk of COVID-19 occurrence nationally through widespread monitoring and digital health interventions; Germany, despite a high prevalence of cases, has maintained a low per capita mortality rate compared to other countries [21, 22]. Applications for touch tracing are not without drawbacks. Not all contact needs quarantine, such as where the persons exposed are wearing personal protective devices or are isolated by thin walls infiltrated by cell phone signals. In the other hand, where people do not bring their cell phones or are without mobile coverage, relevant exposure might be skipped. Moreover, researchers at Oxford University (UK) have indicated that in order to be a successful prevention technique, 60% of the population of a country would need to use a touch tracing application [23].

3.2 Hardware Based Developments

The use of Information and Communication Technology (ICT) to support and facilitate long-distance medical treatment is telemedicine. Telemedicine encompasses online health care which also requires continued education in health, recruitment of doctors and administrative meetings [31]. It can also require the use of existing programs and channels (such as patient portals) to enable patients to undergo care. While the use of telehealth in hospitals is highly encouraging, its rapid implementation has generated new challenges that could have an effect on current health infrastructure [32]. Obviously, telemedicine and virtual systems have the ability to help resolve large-scale diseases and crises in increasingly unpredictable situations. Findings from [33] indicate that during the COVID-19 pandemic, telemedicine provides an important method of triage, screening, and treatment. In addition, results from [34] show that telemedicine enables a patient's wellbeing to be investigated. It also helps to digitally advise people about improvements in medical tests and signs that should trigger a conversation with their doctors. 5G applies to the fifth generation of internationally supported cellular networking technologies for mobile networks [35]. Compared to 4G, in terms of higher speed, reduced latency, broader spectrum, greater availability, and more stability, 5G is expected to provide improved performance. 5G network infrastructure, along with other similar innovations such as IoT and AI, has the ability to revolutionize the healthcare industry. China's commercialization of 5G technologies has already transformed its response mechanism to the COVID-19 pandemic by supplying frontline personnel with improved assistance and promoting enhanced viral detection, patient reporting, data processing, and analysis [36]. In this section, we address the different ways in which countries can implement 5G to help boost the efficacy of their efforts in resisting the health crisis of COVID-19, citing China as an example.

5G+ Telemedicine: Telemedicine refers to the method of tracking patients remotely. Although the use of drones, smart wearables, and smartphone devices will enhance the telemedicine industry's capabilities, 5G network infrastructure is a must to understand those capabilities. Because of their reduced bandwidth and data transmission speed, existing 4G networks are unable to accommodate high-quality real-time video conferencing, which is an important necessity for seamless teleconferencing consultation. In addition, the linking of IoMT users to cloud services is always disrupted by 4G LTE networks, making them unreliable. To this end, 5G will allow mobile networks to tackle these problems with its features such as ultra-low latency and high-speed data transfer. In addition, 5G can enable immersive implementations of virtual and augmented reality (VR/AR), which can contribute to an integrated telemedicine experience, and equip caregivers with instant knowledge in possible complications and treatment strategies [37].

Internet Hospitals: The global COVID-19 outbreak is a dangerous situation, and epidemic prevention and management is a difficult challenge. Fever clinics for outpatients and hospital beds were seriously overcrowded in some parts of China during the early stages of the outbreak. In view of this, Chinese city governments, health-care agencies, and a number of enterprises are actively leveraging mobile internet and 5G technology to deliver internet health-care services through clinical specialists from around the world. In China, Internet clinics have played a critical role in disease prevention and surveillance [38]. Government officials facilitated the availability of "Internet+" emergency insurance coverage after the COVID-19 epidemic, which has greatly increased public use of Internet hospitals. Both hospital workers and the general population have endured psychiatric issues as a result of the epidemic's dramatic rise in the number of reported cases and deaths, including fear and depression. As a result, remote mental health facilities have begun to be offered through internet hospitals [39]. During the epidemic, internet hospitals' home delivery systems for patients with chronic illnesses are still in high demand.

4. Open Challenges

The world has never been more intertwined, and this health epidemic has global implications. The ICT industry is now losing a significant amount of revenue, and it is unclear whether the situation will stabilize. Despite the volatile situation, many technology sectors will be the center of interest and will begin to appear as strong winners. ICT should not be considered a panacea for a pandemic. Only ICT will provide both sufficient content arrangements and effective coordination of said services, which is needed for a full public health response. Keep that in mind, relying on ICT as a cornerstone of a public health plan comes with a range of short and long term risks that must be considered.

4.1 Big Data Analytics for COVID-19

COVID-19 data has the following characteristics: large volume, diverse data forms, developed in real-time, and carrying significant market and social value. COVID-19 faced big data analytics analysis obstacles due to its special functionality. Data processing, data representation, and data sharing are all problems that data acquisition tackles. COVID-19 data generates the following data preprocessing analysis challenges: data convergence, redundancy removal, data washing, and compression. In data processing and value extraction, data storage is critical. In COVID-19, however, developing an effective and scalable data storage device is difficult. The key problems in data management are reliability and persistency, scalability, and performance. Because of the enormous scale, heterogeneous architectures, and large dimension, big data analytics for COVID-19 is very difficult. The following are the main challenges in this phase: Data temporal and spatial correlation, effective data processing schemes, anonymity, and stability are all concerns that need to be tackled [3].

4.2 Risks of digital technology

Digital health programs will intensify socio-economic inequality and lead to gaps in health care. Usually, new media requires the use of the internet and smart phones. Although 4 billion people around the world used the internet in 2019, usage in high-income areas was disproportionately higher than in low-income and middle-income areas (82 percent in Europe vs 28 percent in Africa). Susceptible communities, such as those in low-income neighborhoods or rural areas, may not have access to wireless signals, tablets, or wearable devices such as smart watches even within high-income countries. Interventions should be targeted to the target areas in order to successfully introduce emerging technologies globally; internet connectivity requires investment by the federal and private sector in technology and infrastructure. Subsidized prepaid phone contracts, loaner smartphones, free Wi-Fi hotspots, and educational programs may offer interim alternatives to these inequalities at the regional level. Automated applications and devices which do not need continuous network connections should be considered in regions lacking connectivity or adequate funds to support cellular and internet coverage. Several digital health initiatives will violate privacy, particularly those that control individuals and implement quarantine, thus raising the risk of people with mental illness or reduced access to food or water. Surveillance and surveillance enforced by the government will instill distrust and endanger civil liberties. In order to balance the need for touch tracing and safety, the European authorities have recommended that data should be maintained for a maximum of just 14 days, a potential viral transmission period, and that non-essential digital measures should be lifted until the pandemic is over. An opt-in mobile monitoring program with anonymized data, no central database and no GPS information is being implemented by some European countries. Relevant privacy and data protection issues are potentially offset by promoting a return to daily routine without infection recovery [21].

4.3 Digital Education

During the Coronavirus pandemic, educational events were especially hard struck, with several seminars, training classes, and postgraduate exams being canceled. However, there has been a need for rapid training of the healthcare workers on how to better handle the respiratory problems that have been experienced, as well as redeployment training for personnel who shift positions during the pandemic management strategy [40]. As a result, creative digital wellness technologies are being used to deliver instructional information and longevity. There is little connection between the learner and the tutor, which is one of the most important problems of digital education. Motivational online learning courses can become tedious after a while, there is no clear exchange of information and no active strategy, in an online-only world, and technical problems are bound to arise, Distractions and time management issues, as well as adjusting to new technologies, can occur [41].

4.4 Patient Management

The accelerated growth and adoption of modern treatment models, aided by digital health innovation, is becoming the most significant digital health transition. These digital interventions arose from a desire to protect vulnerable people from the dangers of visiting the hospital, while also fostering social distances and safeguarding staff. The use of telemedicine referral methods has promoted this in both primary and secondary care. With the accelerated rollout of digital tools and packages, the MedTech industry has seen tremendous creativity and support. The vast majority of clinic visits have shifted to virtual appointment approaches, which range from simple phone consultations to more sophisticated video-conference or App-based telemedicine options. Multidisciplinary team sessions have moved away from in-person attendance and into Zoom and other channels to allow for complicated treatment choices to be taken without placing large numbers of healthcare professionals in danger. The rapid navigation of governance and digital transformation demanded by the introduction of these digital care systems was helped by the immediate need generated by the COVID-19 pandemic. Without it, execution may have taken a long time [42].

4.5 Inclusion for the Poor and Elderly

The coronavirus has a lethality risk of 13.4 percent in patients aged 80 and over, which is more than ten times higher than the general population. Working-class individuals, on the other hand, are disadvantaged because they lack the financial and physical ability to participate in social distancing, which would otherwise buffer them from publicity. While the coronavirus is more likely to affect these susceptible populations, an ICT-based action is often less likely to enter them. Not only because of a lack of familiarity, but also because of physical disability, the elderly are less able to employ any of the equipment that will act as the foundation of an ICT-powered public health program. Visual and auditory disability greatly limits a person's capacity to interact with some kind of electronic system, regardless of its intent, and therefore their ability to completely benefit from e-health systems that depend on these devices. Smartphones, which have increasingly served as primary channels for notification, surveillance, and information distribution since the pandemic, can simply be out of reach for the poor, especially in developing countries. Because of its ability to manage the many different situation, ICT will and can be seen as the foundation of a public health response during a pandemic [43].

4.6 Privacy and Maintaining the Social Contract

The activities of the countries that have been most effective in suppressing the coronavirus have shown that any invasion of privacy and normal liberties is an unavoidable part of a public health solution to a global epidemic. In normal times, data collection between public and private institutions may be seen as an unwelcome invasion of privacy, but during a pandemic, it allows for the efficient dissemination and distribution of public health information about real people to officials and the general public. However, after the crisis has passed, ICT applications for monitoring and regulating population trends and behavior will not only cease to be of public health value, but will have become actively hostile to the cause of equal and free communities. Although such ICT applications have a location, they should be followed by a stringent sunset clause requiring them to terminate after the public health emergency is over [44].

4.7 5G deployment and limited connectivity

These 5G-based systems must be deployed as quickly as possible by network providers. Many countries would face imminent challenges due to the limited rollout of 5G networks and the limited supply of 5G applications. In terms of network access and capacity, the adoption of 5G is expected to be incremental. The complexities and deployment problems of 5G systems, such as power usage due to high-frequency transmissions and multi-band support of upper and lower frequency bands, make handset cost and output more difficult [45].

5. Conclusions

The outbreak of Coronavirus (COVID-19) has widely affected people all over the world and radically changed the routine functions of humanity. Healthcare sectors of the countries were the first to get affected due to the spread of COVID-19 disease, facing numerous challenges. As the countries now have control mechanisms in place to minimize the spread of COVID19, they are reopening the economies so that the public can resume their regular lifestyle. To prevent any “re-emergence” of the disease, healthcare sectors of each country must be equipped with novel solutions to address any emerging challenges effectively.

As a species on this earth, we have to use our gifted intelligence to encounter this novel coronavirus. Using technology, proper governance, healthcare service, coordinated public behavior can help a lot in mitigating the risk. The support of technology in handling this situation is irreplaceable. While the world continues to grapple with the impact of the COVID-19 pandemic, complementary efforts of various emerging technologies, such as IoT, UAVs, AI, blockchain, and 5G, are endeavoring to alleviate its impact. Keeping that as the foundation of this work, we offer some of the latest insights on the COVID-19 pandemic. We dissect the various technological interventions made in the direction of COVID-19 impact management. Primarily, our discussion focuses on the use of emerging technologies such as IoT, drones, AI, blockchain, and 5G in mitigating the impact of the COVID-19 pandemic. Till the time a cure for this disease surfaces, the responsibility to manage and limit its impact rests largely with these technologies.

The emergence of COVID-19 has pushed the limits of the technologies and many alternatives have been proposed to encounter the pandemic. This had accelerated the innovations taking place in technologies in almost every field. The online experience that the people come across during this period might have a long-term influence in online shopping, e-learning, digital payments, telehealth facilities and mobile entertainment. The core technologies that would get a boost include artificial intelligence, machine learning, Internet of Things, location and navigation technologies, augmented and virtual reality, drone technology, robotics, cloud, and entertainment technologies. The situation has caused to search for alternatives and innovative technologies.

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