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BRIEF COMMUNICATION

Digital Response to the COVID-19 in Korea: Lessons for the Next Infectious Disease Outbreak

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The digital response is an excellent infection prevention and control measure to minimize person-to-person contact when a respiratory infectious disease is rapidly spreading. However, few studies have explored the reasons for the development and utilization of these technologies. Here, we analyze documents by the Korean government, existing research, and news articles to provide a qualitative review of the digital response, and new concepts explored by Korea during coronavirus disease 2019, to apply them for the next infectious disease outbreak.

Keywords: COVID-19; Pandemic; Korea; Digital technology

INTRODUCTION

Although vaccines and treatments against coronavirus disease 2019 (COVID-19) have been developed, the pandemic has not ended, and nonpharmaceutical means are still being employed. Korea has shifted paradigms, from COVID-19 testing, tracking, and treatment processes to applying digital technologies for infection prevention and control (IPC). IPC measures based on nonpharmaceutical means has been effective in suppressing the virus [1-3]. Severe acute respiratory syndrome coronavirus 2 is transmitted through droplets discharged by coughs, sneezing, and breathing, as well as by physical contact [4], but digital technology may provide a powerful and effective means to break these routes between confirmed cases and uninfected individuals. Information and communication technology (ICT) infrastructure, including mobile applications, artificial intelligence (AI), cloud computing, and mobile application have been used in screening, reservation for testing, tracing, quarantine measures, social distancing techniques, remote monitoring, and treatment [5-9]. Examples of the contactless, nonpharmaceutical, and digital technology-based responses used in Korea include AI robots that provide room service in hotels [10], and drones that sanitize infected areas [11]. AI dramatically decreased the time needed to develop test kits, and person under investigation (PUI) were monitored, and X-ray images were read remotely via could [12,13]. The method related to customer registration was largely developed in April 2020. A blockchain-based vaccination certificate was introduced in March 2021 [14]. Digital response that was mostly developed in February and March 2020 have continued to be used until now, as a growing number of people preferred contactless services.

In a report published in May 2021, the World Health Organization (WHO) Independent Panel for Pandemic Preparedness and Response prompted humankind to develop and apply various nonpharmaceutical interventions (NPIs), including digital technology-based responses, in preparing for future pandemics and controlling new viruses [15]. Since February 2020, Korea has focused on the development of NPIs including digital response at various levels (Figure 1). Korea's response to COVID-19 was developed based on experiences with severe acute respiratory syndrome and Middle East respiratory syndrome (MERS), when disease prevention paradigms shifted from analog technologies to digital methods [16,17]. This study summarizes the digital response focused NPI measures employed in Korea during the

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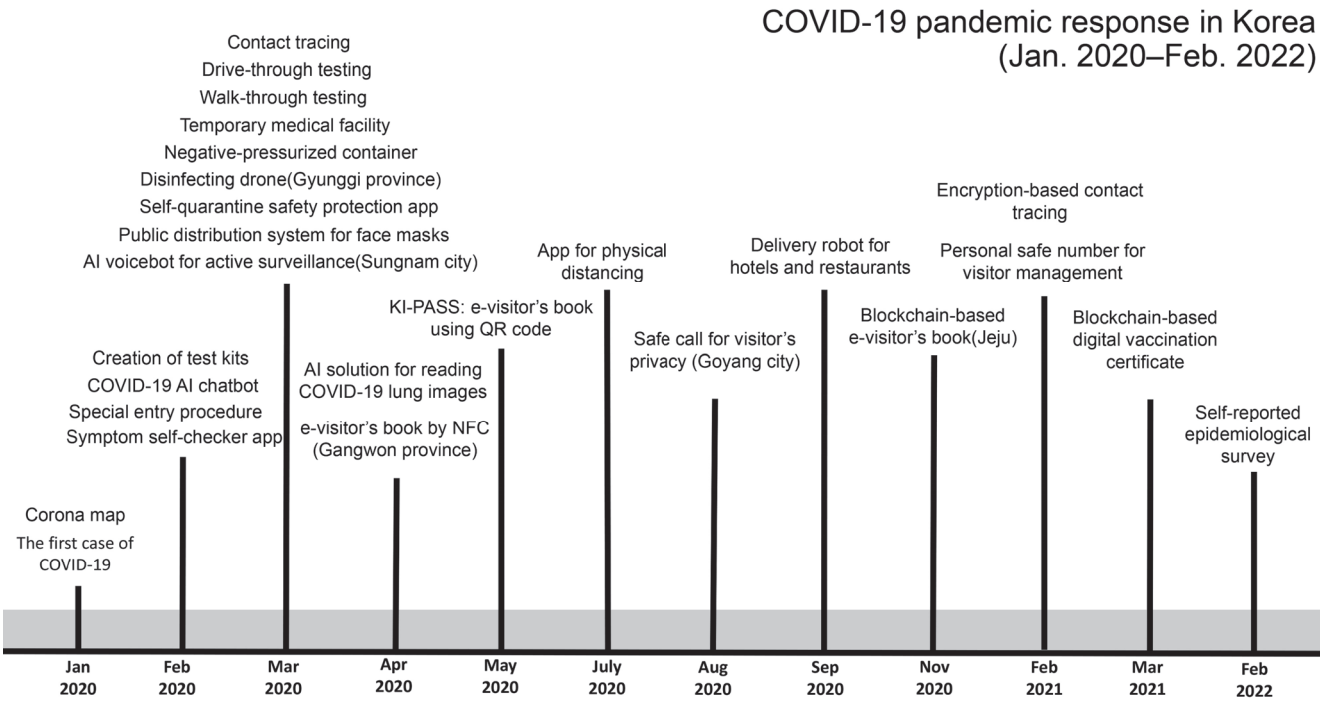

Figure 1. Overview of coronavirus disease 2019 (COVID-19) response in Korea. AI, artificial intelligence; CT, computed tomography; NFC, near-field communication; KI-PASS, Korea Internet Pass; QR code, quick response code.

COVID-19 pandemic and suggests directions for further development. The information included in this report may be pivotal for this as well as future global pandemic.

DIGITAL RESPONSE

The pandemic has placed an enormous amount of pressure on countries, paralyzing public health systems and creating shortages of personal protective equipment, hospital beds, and healthcare personnel. Digital response methods in Korea used for overcoming those crises are further detailed in the following sections.

1. Artificial intelligence

1) AI call for surveillance

AI calls were initiated twice daily to monitor the symptoms of PUI who required active surveillance due to exposure of confirmed cases in Seongnam City. According to the city, only 10 minutes was required for the AI to call 364 people at once and obtain information based on the established protocol. A total of 5 hours and 40 minutes were required when health center personnel made each call individually [18]. In other words, 5 hours and 30 minutes were saved, drastically improving the quarantine process.

2) AI consultation

An AI company distributed a free service that provided diagnose within minutes by analyzing the X-ray or computed tomography images that medical staff uploaded to the cloud [19] (Figure 2). This service was primarily utilized by hospital medical staff. However, a residential treatment center, that was dedicated to the treatment of confirmed cases with mild symptoms of COVID-19 also used the service, in a case in which an X-ray image was remotely sent to the hospital information system [20]. The results were analyzed and followed-up by the medical staff at the hospital.

2. Contact tracing

Epidemiological investigations were conducted based on objective data, including information extracted from the global positioning sys-

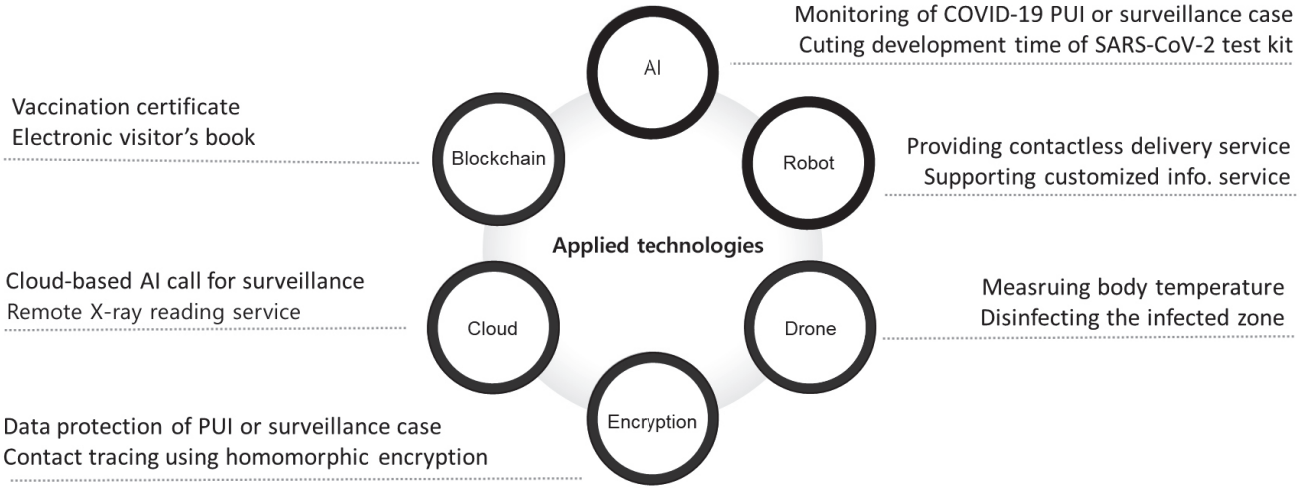

Figure 2. Applied technologies against coronavirus disease 2019 (COVID-19) in Korea. AI, artificial intelligence; PUI, person under investigation; SARS-CoV-2, severe acute respiratory syndrome coronavirus 2.

tem, drug utilization review (DUR), and credit card transaction logs [21]. Strong information protection policies accompanied the process of obtaining information related to the personal location and movement tracking of individuals. During the pandemic, the primary issue faced by many countries was minimizing the conflict between public and private interests and maintaining privacy and security while processing the information of confirmed cases [22]. Korea met the personal information protection level required by the European Union General Data Protection Act (GDPR) and ultimately passed the "EU GDPR" adequacy review in December 2021 [23].

3. Electronic access directory management

During the MERS outbreak in 2015, 39 people died in South Korea. At that time, the Korea–WHO MERS joint mission team had recommended that the spread of the secondary infection was most likely because of the culture of having several friends and family members accompany or visit inpatients [24,25]. During the COVID-19 pandemic, the visitation of patients with weakened immunity at nursing hospitals was prohibited. Before the MERS outbreak, there were no systems in place for managing non-patient access, but now most hospitals keep track of visitors using quick response (QR) codes. Considering Korea's traditional patient visiting culture, this is a revolutionary change.

4. National health information system

The Health Insurance Review and Assessment Service (HIRA) reviews the costs and adequacy of medical care. The DUR is a drug safety inspection system that checks a patient's medical history via the HIRA. Through the DUR, information regarding infectious diseases brought by travelers from overseas as well as information regarding travelers coming from countries with infectious disease outbreaks and COVID-19 confirmed cases in hospitals and pharmacies was recorded. The immigration offices or the Ministry of Foreign Affairs provide information to the Korea Centers for Disease Control and Prevention (currently Korea Disease Control and Prevention Agency) regarding overseas travelers entering from regions with infectious disease outbreaks, and the data were transferred real-time to the HIRA. Additionally, an upgraded International Traveler Information System was developed in 2018 and installed in the DUR system [26]; allowing healthcare organizations to be informed regarding a cross-border traveler's travel history.

5. Public communication

Public communication, which addresses the information gap between the public health authorities and citizens, is a means for drawing in the participation of citizens. Public health authorities have secured diverse, citizen-friendly means of communication. In February 2020, the Korea Disease Control and Prevention Agency endeavored to de-

liver accurate information on COVID-19 to citizens by using a COVID-19 AI chatbot [27]. As fake news was spreading around the Internet about the origin of COVID-19 and its clinical course [28], communication was implemented to eliminate excessive fear and lack of understanding. When the number of confirmed cases dramatically increase, the Korean government sent text messages to provide information about the emergence of confirmed cases to those in relevant areas. In addition, the COVID-19 map was popular at that time, as it showed the movement routes of confirmed cases.

DISCUSSION

1. Digital technologies allow for practices of social distancing

WHO has recommended, avoiding the "3C" in architecture, space, culture, and lifestyle to prevent of infectious disease. The "3C" represents crowded places, close contact settings, and closed spaces, which can be avoided with the use of digital devices. In the future, smartphones may be equipped with functions for detecting viruses by olfactory or tactile sensors or may provide alarms or alerts when the number of people in an area is over a certain limit. Currently, samples may be taken by healthcare workers at screening stations. However, individuals may utilize self-test kits for polymerase chain reaction test at home or worksites, and robotic AIs may carry out parts of patient treatment in the future.

2. Strengthening measures to protect privacy and security

Digital technologies also allow for easy transmission and sharing of necessary data and information through ICT, minimizing infection by avoiding face-to-face procedures and maintaining physical distance. These technologies allow for the implementation of remote healthcare services, which allows hospitals to secure more beds and reduce medical workforce use. However, efforts should be made to protect personal and human rights. In the early stages of COVID-19, there were issues of privacy infringement, with movement routes of confirmed patients being disclosed together with the places and brand names. Despite the uniqueness of the pandemic situation, the issue highlighted the need for attention to that privacy considerations in the policy-making process.

3. Consideration of 'digital divide'

Additionally, the digitalization of disease prevention activities has created a digitally disadvantaged class. Those with impaired mobility or the elderly may have difficulties carrying out the actions required by various disease prevention policies. Therefore, in addition to digital disease prevention, alternative means, in consideration of those who are digitally disadvantaged, are necessary. For instance, a manual customer register may be placed with a QR code-based digital register.

4. Necessity of effective international collaboration through the World Health Organization

As previously described, the patient-visiting culture of Korea was significantly changed based on WHO recommendations, and this change eventually helped the country to better respond to COVID-19. Each country has its own unique policies and traditions, but a comparison of the systems and cultures through the WHO can help countries successfully learn from successes. The WHO established the International Health Regulations in 2005 and distributed various infection management guidelines, based on contribution by member states, and in 2021, published investigation results in preparation for the next pandemic. The WHO was blamed not successful in responding to COVID-19. However, with the target deadline of May 2024, the organization is now preparing negotiations to create new rules for responding to a pandemic, with the goal of prepare a treaty that would be adopted by 194 member states. New pathogens can cause infections. Therefore, the world should unite to establish standards protocols and reinforce protective strategies [29].

Digital technologies can be effective channels for delivering primary health care and contactless patient monitoring [30]. A limitation of the present study is that the discussion was largely focused on digital disease prevention approaches in Korea. Further studies investigating the disease prevention effects of each digital response method may be necessary.

CONFLICT OF INTEREST

No potential conflict of interest relevant to this article was reported.

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