

Article

The COVID-19 Pandemic Response and Its Impact on Post-Corona Health Emergency and Disaster Risk Management in Republic of Korea

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Abstract: The COVID-19 pandemic significantly impacted the Republic of Korea's Health Emergency and Disaster Risk Management (Health-EDRM). This study aims to examine the Republic of Korea's response to the COVID-19 pandemic, focusing on Health-EDRM, especially human resources, health services, and logistics. Challenges in the Republic of Korea, including lack of medical workforce, confused risk communication, shortage of hospital beds, and inefficient distribution of medical resources, have been highlighted in this paper in terms of human resources, health service delivery, and logistics, which are components of Health-EDRM. It is essential to address the cooperation between the government and private sectors, the protection of occupational health and safety of medical staff during the pandemic, and strategies and technologies to scale up the health facilities, to respond to a future crisis like the COVID-19 pandemic.

Keywords: COVID-19; health emergency and disaster risk management; human resources; health service delivery; logistics



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1. Introduction

Since the first case of COVID-19 in the Republic of Korea, there have been more than 25 million cumulative confirmed cases until November 2022, and more than 25,000 people have died from COVID-19. There have been several waves of COVID-19 epidemics due to the lack of medical response, cluster outbreaks in group facilities such as correctional facilities, hospitals, nursing facilities, and religious facilities, easing of social distancing, and the continuous emergence of mutated viruses (Figure 1) [1]. The first period covers 205 days from 20 January to 11 August 2020, as the cluster outbreak that had begun in Daegu and Gyeongsangbuk-do spread across the country. The second period covers 93 days from 12 August to 12 November 2020, with cluster outbreaks induced by religious rallies and large-scale downtown gatherings in Seoul on 15 August 2020. The third period covers 236 days from 13 November 2020 to 6 July 2021, and arose by nationwide cluster outbreaks in correctional facilities, healthcare facilities, and nursing homes in Chungcheongbuk-do, and religious organizations around the capital area. The fourth period covers 197 days from 7 July 2021 to 19 January 2022, which marked a decrease in vaccine effectiveness, the dominance of the Delta variant, and the emergence and spread of the Omicron variant. The fifth wave period, from January 2022 to May 2022, and the sixth wave period, from July 2022 to September, are now occurring due to the spread of Omicron and its sub-variants.



Figure 1. Daily confirmed COVID-19 cases in the Republic of Korea between January 2020 and January 2022. Source: Johns Hopkins University CSSE COVID-19 Data.

Recently, but before the COVID-19 pandemic, Health Emergency Disaster Risk Management (Health-EDRM) emerged as “the latest knowledge, research, and policy paradigm shift from response to preparedness and health risk management in non-emergency times” [2]. Health-EDRM is a continuum of measures in which the emphasis is on managing the risks of the potential emergency or disaster, not solely responding to the event or crisis, and on building the resilience of communities and countries. To reduce the probability of events or problems and minimize health consequences, the program is established with the broad engagement of the health system and multiple sectors and a strong community focus from a natural, biological, technological, and sociological perspective [3]. Health-EDRM functions are organized with ten components, including (i) policies, strategies, and legislation; (ii) planning and coordination; (iii) human resources; (iv) financial resources; (v) information and knowledge management; (vi) risk communication; (vii) logistics; (viii) health and related services; (ix) community capacities for Health-EDRM; and (x) monitoring and evaluation. The World Health Organization (WHO) also encourages this framework to prepare for emergencies [4].

Many analyses have been reported that considered the policy-oriented, managerial, or non-pharmaceutical responses to COVID-19 at the national level [3,5–10]. Two of the above studies are on the Republic of Korea’s response [6,9]. Kim et al. investigated the different kinds of risks associated with COVID-19 infection in the Republic of Korea and how those risks have been changed by the countermeasures taken by the Republic of Korea’s authorities and citizens [6]. It mainly focused on managing government sectors during several waves of COVID-19 in the Republic of Korea; however, it did not show specific responses to the various factors that make up Health-EDRM. Turi et al., compared the public health policies and pandemic management between the Republic of Korea and the V4 countries (Czech Republic, Hungary, Poland, and Slovakia) [9]. The study used ten Essential Public Health Operations (EPHO), which set out the operations for protecting and improving the population’s health and preventing disease. EPHO seems relevant to Health-EDRM; however, it only describes how they dealt with each area, not what problems they encountered and how they solved them. Therefore, it is necessary to examine the Republic

of Korea's response to the COVID-19 pandemic focusing on Health-EDRM, especially human resources, health services, and logistics.

This study hypothesizes that the Republic of Korea's responses to the COVID-19 pandemic have partially met the Health-EDRM framework. The study is a part of the WHO Kobe Center funded project "The COVID-19 pandemic response and its impact on post-Corona health emergency and disaster risk management", which involves Japan, the Republic of Korea, Mongolia, Iran, Italy, Thailand, and the United States [11–14].

We aimed to answer key questions from the project regarding components of Health-EDRM framework [12]. The project consisted of four key questions: (1) What difficulties and challenges has the Republic of Korea experienced during COVID-19 in terms of human resources, health service delivery, and logistics? (2) How did the Republic of Korea respond to and deal with these challenges? (3) What did the Republic of Korea's society learn from the current COVID-19 pandemic to prepare for the future response in terms of human resources, health service delivery, and logistics? (4) What influence have these challenges and responses had on the present and post-corona Health-EDRM system? By systematically answering the questions, this article presents challenges to, responses to, lessons learned from, and influences on the post-coronavirus Health-EDRM system.

2. Materials and Methods

2.1. Methods Setting

According to the key questions, literature in the Republic of Korea was hand-searched with terms such as "COVID-19", "human resources", "health service delivery", and "logistic systems", using the Google search engine during the research team's meetings. Using the Health-EDRM framework, six authors (JP, JM, J-HS, MYP, HY, and OK) collected and extracted key components of each domain of Health-EDRM.

Various documents, such as guidelines and academic articles written by the government of the Republic of Korea and related societies from December 2019 to March 2022, were investigated by document analysis and reviewed. The research team, consisting of all but two of the authors, extracted information through discussion. The other two authors (JL and J-PM) combined the reports from the researchers and made refined descriptions. If there was any disagreement in extraction and combination of collected resources, government documents, documents from public institutions and academic societies, and news articles were prioritized, in that order. All the steps were progressed with weekly meetings of the authors and using 'notion.so', an online collaboration platform.

2.2. Literature Resources

Because in Republic of Korea, responses to COVID-19 were mainly dependent on central government policy, we focused on government materials. The latest official government documents from the Republic of Korea until March 2022 were included for document analysis. Because the frequently changing situations of the COVID-19 pandemic made for time gaps too compressed for academic articles, most documents on COVID-19 responses have remained in the forms of primary official government documents published in the fields of labor, healthcare, public administration, and security. They consist of documents titled 'All About Republic of Korea's Response to COVID-19', 'Guidelines for Preparation of Business Continuity Plan (BCP) for Infected Diseases', 'Guidelines for Operation of Respiratory Clinic', and 'Guideline on Standards and Specifications for Filtering Respirators'. The authors also reviewed these documents, as well as the official Republic of Korea government website press releases. The governmental sources have been published by the Ministry of Foreign Affairs, Ministry of Employment and Labor, Ministry of Health and Welfare, Ministry of Food and Drug Safety, and Ministry of Land, Infrastructure, and Transport. We included literature that had been reported to the public. We excluded the literature which was reported only in private newspapers or web pages without authorized government documents.

Documents from public institutions and academic societies were also reviewed. Major publishing institutions related to healthcare policy in the Republic of Korea include the Republic of Korea International Cooperation Agency (KOICA), the Republic of Korea Human Resource Development Institute for Health and Welfare (KOHI), the Research Institute for Healthcare Policy (RIHP) of the Republic of Korea Medical Association (KMA), the Republic of Korea Medical Journal, as well as the Medical Journal of Health, etc. In addition, other sources were referred to, such as the “Guidelines on the management of COVID-19”, “Infection prevention and control (IPC) measures for the safety of healthcare workers (HCW)”, and “Emergency Medical Center Closure and Quarantine of Medical Staff” [15–17]. Various news or internet articles published in the Republic of Korea prior to March 2022 were hand-searched with search terms (human resources, health service delivery, and logistic systems with COVID-19) via websites to review the private sector’s response to the COVID-19 pandemic.

3. Results

3.1. Human Resources

3.1.1. Challenges Experienced during COVID-19 and Responses

Shortage of Medical Staff

Since the first outbreak of COVID-19, a shortage of medical staff to cope with infectious diseases has been a primary problem. In particular, medical resources were insufficient during the second pandemic, when the outbreak occurred in Daegu, Gyeongsangbuk-do [18]. Some medical staff even quit their jobs due to the high workload of the positions [19,20].

The Republic of Korea’s government dispatched public health doctors to epicenters of the COVID-19 pandemic, screening centers, airport quarantines, and hospitals [21]. The cumulative number of dispatched medical personnel was 6577 by December 2020 [22]. Because of the lack of medical staff, the government had also mobilized and recruited additional healthcare workers and volunteers to overcome the pandemic crisis. Both the central government of the Republic of Korea and local governments recruited medical staffs such as physicians, nurses, nurse assistants and medical technologists [23]. In April 2022, total accumulated dispatched medical manpower was 24,189, which was four times as many as in December 2020 [22]. A total of 58.1% of the total dispatched medical manpower were nurses (11,905, 49.2%) and nurse assistants (2143, 8.9%). Of the total dispatched medical personnel, 25.5% were doctors (6157, 25.5%). The Republic of Korea was able to deploy public health doctors and army surgeons (1059, 4.4%) working in rural administrative areas for their obligatory military service under the law of the Republic of Korea. Among the dispatched doctors, the majority were public health doctors (4528, 18.7%) [22]. The central government supported the dispatched personnel with financial aid, such as work allowances, risk allowances, overtime allowances, travel expenses and monitoring allowances [23]. In the period of the Delta variants’ dominance, more than two thousand healthcare workers, including nurses and medical technicians, were involved in the fight against COVID-19 by providing about 20 billion Republic of Korea won (equivalent to 16 million U.S. dollars) [24]. Volunteers assisted healthcare workers with non-medical or basic medical tasks, such as cleaning, disinfection, and fever checks.

Unskilled workforces and short turnover of workforces caused inefficiency. More medical personnel were needed to be temporarily deployed than there were medical staff who continued to deal with infectious respiratory diseases, so on-the-job training was needed frequently. To compromise these problems, the Republic of Korea’s government developed and implemented an efficient administrative process, including diagnostic testing schemes, computer systems, and mobile apps, to make the current health workforce work efficiently. For example, the Republic of Korea’s Health Promotion Institute conducted on-the-job training for public health doctors before placement in the COVID-19 field, and other organizations offered training programs for healthcare workers [25].

Complicated Guideline

The COVID-19 response in the Republic of Korea was mainly led by the central government. The graded social distancing policy was the main policy of the central government [26]. Unlike the newly updated social distancing policy and guidelines, there were no clinical guidelines for diagnosing or treating COVID-19 patients because it was a new infectious disease. Those clinical guidelines were not frequently changed even when up-to-date guidelines were published. At last, professional associations made available guidelines on the management of COVID-19 for clinicians. For example, the Republic of Korea Society of Infectious Diseases, the Republic of Korea Society of Critical Care Medicine, the Republic of Korea Society of Internal Medicine, and the National Academy of Medicine of Republic of Korea all published medical guidelines [17].

3.1.2. High Vulnerability

Healthcare workers were at risk of infections. To ensure the safety of healthcare workers, infection prevention and control (IPC) measures, including sufficient PPE, more negative-pressure isolation rooms, and telemonitoring, were provided [16]. Additional government-level budget and allowances were paid to COVID-19 medical staff.

Healthcare workers were also a high-risk group vulnerable to mental health problems during the pandemic [27–29]. Given the lack of a sufficient medical workforce, their workload accumulated [19,20]. According to a domestic qualitative survey of healthcare workers who participated in the COVID-19 clinical practice, role ambiguity and lack of well-trained staff were raised as primary work-related struggles [30]. When conducting COVID-19-related stress assessments in public health doctors, they had a high level of occupational stress due to the lack of national clinical guidelines for COVID-19 testing, treatment, and post-discharge management [27].

The governmental program also contained mental health support for healthcare workers. For example, the ‘Mind-relieving bus’ for medical staff against COVID-19 was one of the mental support programs which provided stress measurement, stabilization programs, psychological education, and counseling by visiting the site in person.

3.1.3. Lessons Learned from the Current COVID-19 Pandemic to Prepare for the Future Response

It was essential to have up-to-date data on health workforce availability and their managing skill profiles given the shortage of healthcare workers in the global pandemic emergency era. In addition, it was necessary to train the unskilled or update skilled healthcare workers rapidly in a crisis. Providing adequate and timely (re)training is essential, and the training should reflect the health worker’s needs. When responding to infectious diseases, support for not only patients but also responding personnel, including medical staff, is also essential, and only when they are supported will they be able to cope with the infectious disease crisis in the long term. Psychological support is also important, but it is also essential to solve problems such as frequent changes in guidelines or procedures for new infectious diseases, insufficient education, poor compensation, and anxiety about the risk of infection.

3.1.4. Impact of Challenges and Responses on the Present and Post-Corona Health-EDRM System

An official system is under development at the national level to manage healthcare resources, including healthcare workers, by integrating systems in public organizations [29]. The government could dispatch public health doctors to epicenters of the COVID-19 pandemic, screening centers, airport quarantines, and hospitals under the government’s plan. However, more healthcare workforces might be necessary for future health emergencies.

Evidence-based medicine is critical in the process of diagnosing and treating diseases. Due to the suddenness of the COVID-19 pandemic, each academic medical society voluntarily provided and distributed guidelines. After that, it was necessary to introduce a

system that could present appropriate policies on time, centering on the Republic of Korea Medical Association. All the descriptions above regarding human resources are listed in Table 1.

Table 1. Challenges, responses, and lessons regarding human resources from the COVID-19 pandemic in the Republic of Korea.

Challenges Experienced during COVID-19 and Responses	Responses during COVID-19	Lesson Learned from the Current COVID-19 Pandemic to Prepare for the Future Response	Impact of Challenges and Responses on the Present and Post-Corona Health-EDRM System
• A shortage of medical doctors, nurses, laboratory technicians and paramedics • Lack of diagnostic and treatment experience in COVID-19 clinical management and lack of guidelines • Safety and security of health care workers and physical and mental health problems of health workers • Manpower vacancy due to mass cluster infection in the workplaces	• Training for public health doctors before placement in the COVID-19 field • Producing official guidelines on the management of COVID-19 for clinicians • Utilizing public health doctors, volunteers, and temporary healthcare workers • Additional budget and allowances paid to COVID-19 medical staff	• Importance of up-to-date data on health workforce availability • Providing adequate and timely (re)training • Psychological support	• Development of an official system to manage healthcare resources • Establishing appropriate guidelines on time centering on Republic of Korean Medical Association • Psychological support program and infrastructure to provide protection

3.2. Health Service Delivery

3.2.1. Challenges Experienced during COVID-19 and Responses Risk Communication

Several challenges in the Republic of Korea during the COVID-19 pandemic were administrative difficulties, including the control towers of the disease management institutes. It was challenging to respond to the COVID-19 pandemic because the institution's authority was insufficient, and the scale was small. The introduction of vaccines had also been delayed due to the lack of delegated authority. Due to the lack of guidelines for diagnosing and treating COVID-19, authorized treatment was complex and unverified information was spreading, resulting in confusion among healthcare workers and in general populations.

Shortage of Hospitalization for COVID-19 Patients

The shortage of hospital beds was a big challenge in the public health sector. The Republic of Korea has a very large number of acute treatment beds among OECD countries, with 7.1 beds per thousand people [23]. However, in the case of COVID-19 patients, it was difficult to secure hospital beds because a specialized bed, such as a negative pressure room, was required [23]. For the treatment of severe COVID-19 patients, an ICU bed was necessary. Not only globally, but also in the Republic of Korea, insufficient numbers of ICUs created a bottleneck for health service delivery [31].

The problem of insufficient beds was resolved by a centralized bed supervising, bed allocating, and triage screening system. In December 2021, the government allocated a hospital dedicated to COVID-19 [32]. The primary role of bed allocation is performed by the public health center in charge of the actual residence so that the confirmed patient can be linked to the list of empty beds over the country. Almost all public hospitals dedicated to COVID-19 were designated as such to secure stable preliminary beds by force. Patients with mild symptoms were assigned to residential treatment centers (RTC), and self-quarantine and medical staff were monitored twice daily [1]. In April 2022, 2823 intensive care units, 5334 semi-intensive care units, 24,977 acute treatment beds, and 19,395 residential treatment centers (RTC) for COVID-19 were possessed. And 67.8% of the total intensive care units were operated for COVID-19 [33].

Operation of the Emergency Medical Center

Emergency Medical Center closures and the quarantining of medical staff were also issues in the Republic of Korea [15]. More medical staff were needed due to the rapidly increasing number of COVID-19 patients; however, some medical staff could not be protected from COVID-19, emergency medical centers were closed, and medical staff panicked during the early period of the pandemic.

According to government guidelines for the operation of emergency rooms in the infectious disease epidemic, some emergency centers revised the triage screening system to solve the emergency room staffs' infection problems from January 2021 [34,35]. If the chest imaging showed abnormal findings or the patient had respiratory symptoms or risk factors, the patients were moved to a negative-pressure isolation room [15]. However, in the actual field, it did not work as in the guidelines, because information could not be shared in real time. Allocating of ICU or emergency rooms was difficult. So transferring time and first response time were delayed [36].

Vulnerable Groups in Healthcare

As medical resources were concentrated on treating COVID-19 patients, and quarantine was strengthened, it became difficult to use medical institutions, and there are those patients who are vulnerable and require medical treatment.

The Central Disaster Management Headquarters in the Republic of Korea promoted the expansion of hospitals and wards in aid of vulnerable patients such as children, women in labor, and patients with hemodialysis among the COVID-19 confirmed patients. COVID-19 delivery hospitals and wards were established, and outpatient hemodialysis institutions for COVID-19-confirmed patients were also expanded. The number of children's wards was also raised; children with severe diseases were treated at children's medical institutions focusing on severe conditions, and a children's outpatient treatment infrastructure was established. In April 2022, a total of 1442 children's ward and 26 hospitals in Republic of Korea were assigned as children's specialized COVID-19 hospitals [37]. The Ministry of Health and Welfare announced that it would improve the accessibility of medical care to the homeless. In the case of a group of infections in a long-term care hospital, those infected were transferred to other hospitals with available beds as much as possible. If not, the hospitals were isolated entirely [38].

Introduction of Vaccination, Oral Antiviral Drugs

The physical and financial burden of vaccination in the Republic of Korea was reduced to increase the vaccination rate [39]. After the vaccines' introduction, the residual vaccination and abnormal reactions were transparently managed with the assistance of IT technology. The governmental server showed the capacity information in real time. IT service providers could receive the data and show information on residual vaccination capacity in their map services (Figure 2).

There was an increased demand for oral antiviral drugs due to the rapid spread of Omicron variants. In January 2022, oral antiviral drugs Paxlovid and Lagevrio were first introduced in the Republic of Korea. The government conducted a pre-purchase contract for 1.00 million people. However, in the fifth wave, February to April 2022, COVID-19 newly confirmed patients were more than 30,000 in one day. Because of the massive size of the pandemic, the oral antiviral drug was needed in clinics [40].



Figure 2. An example of IT service for COVID-19 residual vaccination information. The English translation is colored in red.

3.2.2. Lessons Learned from the Current COVID-19 Pandemic to Prepare for the Future Response

It is necessary to strengthen the preemptive crisis response system for new infectious diseases and develop new illnesses' crisis response capabilities. For this purpose, appropriate administrative power and budget support are essential. Risk communication between the public and professional groups is also important to prevent public confusion. In preparation for the emerging new infectious diseases, there was a need to prepare enough beds exclusively for infectious diseases. It is also important to properly implement triage and ER surveillance protocols concerning the characteristics of infectious diseases.

On the other hand, if the capabilities of the existing medical system are focused only on responding to infectious diseases, there is a situation in which other necessary medical treatments cannot be received. Infectious diseases have a more critical effect on the socially vulnerable population who need preventive support. In terms of institutions & policies in Republic of Korea, reforming infection control payment, supporting home care, and checking vulnerable facilities the local government is required. In addition, the installation of infection control and prevention (IPC)-related facilities are required [38].

3.2.3. Impact of Challenges and Responses on the Present and Post-Corona Health-EDRM System

In order to strengthen preemptive response, the needs (1) to establish a hospital specializing in infectious diseases, (2) to strengthen epidemiological investigation capabilities, and (3) to create a research base emerged. Social movements have begun to build hospitals dedicated to infectious diseases and (4) to be based on legislation. In the current situation where COVID-19 is spreading, screening tests using chief complaints or patients' vital signs were ineffective in distinguishing asymptomatic patients. Therefore, the triage classification system based on chest imaging should be spread further [15]. The importance of expert groups is also emphasized for providing appropriate information.

The Republic of Korea has a flawed medical system in charge of emergencies, children, and women in labor, and there is a large gap in access to medical services between regions. In the event of an infectious disease epidemic, access to medical care will be further

limited for the medically vulnerable sector, so the overall medical system also needs to be revised. Since most hospitals in the Republic of Korea are private hospitals, public medical centers have mainly played the important roles in responding to COVID-19 in the Republic of Korea. Most public medical centers also covered the medical services for the economically vulnerable population in the Republic of Korea. During the COVID-19 pandemic periods, those public hospitals were working mainly for infectious diseases, while the other medical services, for CVDs, Orthopedics, Dermatologic diseases, etc. had limited resources provided for them.

Cohort isolation is the most controversial part of the COVID-19 response measures in group facilities and long-term care hospitals. Cohort isolation was implemented as a temporary measure without any legal basis. At present, many controversies, such as the violation of the fundamental rights of cohort-quarantined patients, lack of operating facilities, and the shortage of workforce, are being raised, so it seems that the legal basis and supplementation of the operating facilities are necessary.

All the descriptions above regarding health service delivery were listed in Table 2.

Table 2. Challenges, responses, and lessons regarding health service delivery from the COVID-19 pandemic in the Republic of Korea.

Challenges Experienced during COVID-19 and Responses	Responses during COVID-19	Lesson Learned from the Current COVID-19 Pandemic to Prepare for the Future Response	Impact of Challenges and Responses on the Present and Post-Corona Health-EDRM System
- Administrative Difficulties of Infectious Disease Control Organization - Lack of communication with the public about new infectious diseases and confusion of information - Vacancies in medical treatment for non-COVID-19 patients and specialized patients such as children, women in labor, and dialysis patients among COVID-19 patients - Increased demand for oral antiviral drugs due to the rapid spread of Omicron variants - Overload of public health centers/tertiary hospitals due to lack of treatment for COVID-19 in primary health care centers	- Transparently managing residual vaccination and abnormal reactions with assistance of IT technology - Expansion of hospitals and wards in charge of vulnerable patients - Transferring to other hospitals with available beds as much as possible	- Appropriate administrative power and budget support - Risk communication between the public and professional groups - Necessity of resources accounting for more critical effect on the socially vulnerable population - Reforming infection control payment, supporting home care, and checking vulnerable facilities - Installation of infection control and prevention-related facilities	- Establishing a hospital specializing in infectious diseases - Strengthening epidemiological investigation capabilities - Creating a research base - Legal basis and supplementation of the operating facilities

3.3. Logistics

3.3.1. Challenges Experienced during COVID-19 and Responses

Shortage of Personal Protective Equipment

With the rapidly growing disease outbreak of COVID-19, there was a shortage of PPE, including facial masks, sanitizers, and diagnostic kits. There was massive cornering and hoarding in the market, causing a shortage of supplies and a price surge in facial masks. The need for rapid development of diagnostic methods and urgent commercialization emerged. The disease's spread had primarily affected the Republic of Korea's economy. As for the global logistic crisis, the shut-down of exporting systems resulted in domestic exporters' financial crisis, which influenced the Republic of Korea's economy [41]. Meanwhile, there was a great demand for couriers and non-face-to-face transportation to secure daily necessities due to difficulties in face-to-face activities.

The Republic of Korea's government controlled the total volume of masks in the market by restricting the export of facial masks and enforcing mandatory mask shipments. A new category (KF-AD, Republic of Korea Filter–Anti Droplet) was given to facial masks, which allowed manufacturers to control mask quantity and stabilize their price [42]. In March 2020, the government mandated 80% (the timeline changed the ratio) of the daily production of medical masks to be sold as “public masks” at the designated places for a fixed price [43]. After the stabilization of the mask market, the government withdrew mandatory mask production in July 2020 [23].

With the diagnostic tools, a new test method in Republic of Korea, Real-Time Polymerase Chain Reaction, was developed, which can diagnose faster than the existing pan-Corona test method. The Ministry of Food and Drug Safety allowed ‘emergency use authorization’ so that private medical institutions could use the new test method. The test method was disclosed to domestic reagent manufacturers to facilitate the production and supply of reagents [44].

Increasing of Non-Face-to-Face Consumption

The economy was greatly affected by the spread of COVID-19 in the Republic of Korea. Small and medium-sized businesses faced more significant challenges due to the “rising air logistics costs” in the global logistic crisis regarding the COVID-19 pandemic. The government announced support of transportation costs to export small and medium-sized businesses by implementing the “Air Freight Fee Conservation Project” due to COVID-19, with the cooperation of the Republic of Korea International Trade Association, logistics companies, and large companies [45,46].

Meanwhile, as a follow-up execution to the surge in non-face-to-face consumption and e-commerce, there was the need for the Ministry of Land, Infrastructure, and Transport to implement the “Consumer Logistics Service Industry Development Act” to guarantee employment contracts for courier companies, switch registration systems, and limit working hours to improve treatment for courier workers [47]. Recommendations for protective measures for courier workers include such measures as sufficient recruitment of courier vehicles and courier drivers, the establishment of an appropriate workload system, and a guarantee of break time through sequential delivery by holding a meeting of the Ministry of Land, Infrastructure, and Transport [48].

3.3.2. Lessons Learned from the Current COVID-19 Pandemic to Prepare for the Future Response

The shortage of supply for masks suggests the importance of reducing dependence on imports and securing goods through self-production. In addition, the problem of stagnant distribution of masks in the market due to cornering and hoarding or price surges can be appropriately managed through government interventions such as the notice of prohibition and direct redistribution of goods.

In the case of diagnostic tools, preemptive support for the reagent manufacturing research field can lead to the rapid development of new assays in emergencies. At the time of the MERS epidemic in the Republic of Korea in 2015, ‘emergency use authorizations’ were prepared to temporarily approve the use of developed reagents that were evaluated above a certain level when urgent use of diagnostic reagents was required, but there were no domestic supported reagents. In this COVID-19 situation, we responded based on the approval system prepared during the last infectious disease epidemic.

During the disease's spread, with a shortage of ships, the Republic of Korean government and others such as logistic companies tried to increase the stability of the shipping industry and facilitate investment. It is urgently necessary to improve the system, including investor tax benefits and deregulation of entering the shipping industry for owners who have large goods. After COVID-19, the number of courier service users increased, and the width of items used expanded; however, the long hours of intensive labor of courier industry workers still continued. Therefore, in the event of a logistics crisis caused by infec-

tious diseases, government support for the courier transportation industry, improvement of workers' treatment, and health management measures are essential.

3.3.3. Impact of Challenges and Responses on the Present and Post-Corona Health-EDRM System

Medical masks are usually sold directly by private companies. Still, in some emergencies, we needed a governmental system so that the essential goods would be managed by the government and shipped only through designated public vendors. The system can be used to facilitate the supply of medical products in future health-related emergencies.

The test method developed through research was established by the Republic of Korea Centers for Disease Control and Prevention Agency and verified by the Republic of Korea's Society of Diagnostic Laboratory Medicine. Public and private cooperation was established, and the test method was disclosed to reagent manufacturers through emergency use approval, enabling rapid development and supply. This experience can be used as a good precedent for establishing urgent development and supply in the event of a new infectious disease that might spread in the future.

All the descriptions above regarding logistics were listed in Table 3.

Table 3. Challenges, responses, and lessons regarding logistics from the COVID-19 pandemic in Republic of Korea.

Challenges Experienced during COVID-19 and Responses	Responses during COVID-19	Lesson Learned from the Current COVID-19 Pandemic to Prepare for the Future Response	Impact of Challenges and Responses on the Present and Post-Corona Health-EDRM System
- Market cornering and hoarding, shortage of supplies, and price surges for masks. - Due to the sharp increase in the number of confirmed cases, the need for rapid development of diagnostic methods and urgent commercialization emerged - Damage to domestic exporters caused by the global logistics crisis. - Surge in courier and non-face-to-face transportation to secure daily necessities due to difficulties in face-to-face activities.	- Government's support transportation costs to export small and medium-sized businesses - Implementing a new Act to guarantee employment contracts for courier companies - Recommendation of guidelines for protective measures for logistics workers	- Importance of reducing dependence on imports and securing goods through self-production - Government's intervention such as the notice of prohibition and direct redistribution of goods - Preemptive support for the reagent manufacturing research field - Improving administrative system including investor tax benefits and deregulation of entering the shipping industry - Support for the courier transportation industry	- Necessity of a governmental system to manage essential goods in case of emergency - Supporting research to implement appropriate diagnostic test methods

4. Discussion

During the COVID-19 pandemic, the Republic of Korea had to face challenges in various fields due to the pandemic's huge impacts on health, economy, culture, and transportation. The anticipated risk of the infection was beyond the prediction of the conventional Health-EDRM [6]. The challenges were significant, particularly in the area of human resources and health service delivery and logistics. We reviewed documents on the Republic of Korea's responses in these areas and found possible impacts on the future health-EDRM system.

4.1. Human Resources

Healthcare workers in the Republic of Korea have been vulnerable to overwork and its health consequences, including overwork death. To remedy this, and many other issues, including establishing new schools of medicine for public health, the Republic of Korea's National Health Insurance System enacted policies to reduce inequalities in the healthcare system, and ensured that training more professional healthcare workers was reviewed

and debated. In addition, several discussions within the healthcare system had taken place aiming to provide personal protective equipment for protecting medical personnel, infection control education, the establishment of infrastructures such as telemedicine and negative-pressure isolation rooms, and financial support as well as psychological support for medical staff who have mental problems such as burnout and PTSD.

For the part of human resources, we could make the existing healthcare workers work more efficiently and safely by supporting the Epidemiological Investigation Support System, a self-check mobile app, a self-quarantine safety protection app, and remote monitoring [49]. Public health doctors dispatched by the government undertook essential roles in the midst of the outbreaks [21]. Also, many healthcare workers in the private sector volunteered and played major roles [24]. This highlights the importance of communication and cooperation between government and non-governmental sectors [4]. But, many healthcare workers are burnt out by overwork, so more support, including psychological support, might be needed for overloaded healthcare workers in the future [27]. To manage human resources effectively, an official system is under development at the national level [29].

4.2. Health Service Delivery

At the beginning of the COVID-19 pandemic, risk communication and health service delivery were challenged. The lack of hospitalization resources for COVID-19 patients was diminished by the central government's allocating systems. We reorganized the Republic of Korea's CDC to have more power and control over medical resources. We could supply and allocate medical equipment and devices to places in need under strong administrative control. However, in the field, many medical personnel complained that the allocation system was delayed and inefficient because of a lack of control given the untrained workforces.

As medical resources are concentrated on COVID-19 prevention and medical management, support for the social welfare system has been reduced for the elderly, the disabled, and individuals with limited physical and mental functions. For these vulnerable groups, the government has proposed several alternatives, but long-term plans are insufficient. For future health service delivery, it is necessary to expand the subject of infectious disease rights and obligations to prevent the occurrence of medically vulnerable groups. In addition, the number of beds and manpower in public medical institutions should be increased to cope with infectious diseases [50].

4.3. Logistics

Many businesses have experienced disruptions in their supply chains due to factory closures, reduced capacity, and increased demand for certain products, such as PPE, facial masks, and diagnostic kits. In pandemics, more resilient and flexible adaptation would be favorable. For this issue, communication, and collaboration are the key for preparation.

4.4. Limitations of Materials and Methods

This study's literature review was based on a hand search, not on strict criteria as many systematical reviews set. This study included official documents from national and local governments. However, to promptly review responses to COVID-19 in non-governmental sectors, it was necessary to hand-search and include literature from various sources. To remedy this limitation, the authors had several meetings to extract reliable and relevant information. Also, directly interviewing medical staff, public health doctors, and volunteers who worked in the pandemic epicenters was beyond our resources; future studies will address these limitations to improve Health-EDRM.

5. Conclusions

In spite of its limitations, the study certainly adds to our understanding of the Health-EDRM, highlighting the importance of cooperation between government and private sectors, protection of occupational health and safety of medical staff during the pandemic,

and strategies and technologies to scale up the health facilities to respond future crisis like COVID-19 pandemic. Sharing lessons from the crisis with other countries will strengthen future Health-EDRM.

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References

1. Yang, S.; Jang, J.; Park, S.Y.; Ahn, S.H.; Kim, S.S.; Ryu, B. COVID-19 outbreak report from January 20, 2020 to January 19, 2022 in the Republic of Korea. *Public Health Wkly. Rep.* **2022**, *15*, 796–805.
2. Chan, E.Y.Y.; Lam, H.C.Y. *Health-Related Emergency Disaster Risk Management (Health-EDRM)*; MDPI-Multidisciplinary Digital Publishing Institute: Basel, Switzerland, 2020.
3. Ho, G.W. Where Everyone Plays a Part: Singapore's Health EDRM Responses in Face of the COVID-19 Crisis. In *COVID-19 Pandemic, Crisis Responses and the Changing World*; Springer: Berlin/Heidelberg, Germany, 2021; pp. 149–157.
4. World Health Organization. *Health Emergency and Disaster Risk Management Framework*; World Health Organization: Geneva, Switzerland, 2019.
5. Hung, K.K.C.; Mashino, S.; Chan, E.Y.Y.; MacDermot, M.K.; Balsari, S.; Ciottone, G.R.; Della Corte, F.; Dell'Aringa, M.F.; Egawa, S.; Evio, B.D. Health workforce development in health emergency and disaster risk management: The need for evidence-based recommendations. *Int. J. Environ. Res. Public Health* **2021**, *18*, 3382. [[PubMed](#)]
6. Kim, Y.-K.; Poncelet, J.-L.; Min, G.; Lee, J.; Yang, Y. COVID-19: Systemic risk and response management in the Republic of Korea. *Prog. Disaster Sci.* **2021**, *12*, 100200. [[PubMed](#)]
7. Sanfelici, M. The Italian response to the COVID-19 crisis: Lessons learned and future direction in social development. *Int. J. Community Soc. Dev.* **2020**, *2*, 191–210.
8. Tashiro, A.; Shaw, R. COVID-19 pandemic response in Japan: What is behind the initial flattening of the curve? *Sustainability* **2020**, *12*, 5250.
9. Túri, G.; Virág, A. Experiences and lessons learned from COVID-19 pandemic management in South Korea and the V4 Countries. *Trop. Med. Infect. Dis.* **2021**, *6*, 201.
10. Chan, E.Y.Y.; Shahzada, T.S.; Sham, T.S.T.; Dubois, C.; Huang, Z.; Liu, S.; Ho, J.Y.-e.; Hung, K.K.C.; Kwok, K.O.; Shaw, R. Narrative review of non-pharmaceutical behavioural measures for the prevention of COVID-19 (SARS-CoV-2) based on the Health-EDRM framework. *Br. Med. Bull.* **2020**, *136*, 46. [[CrossRef](#)]
11. Lamberti-Castronuovo, A.; Parotto, E.; Della Corte, F.; Hubloue, I.; Ragazzoni, L.; Valente, M. The COVID-19 pandemic response and its impact on post-corona health emergency and disaster risk management in Italy. *Front. Public Health* **2022**, *10*, 1034196.
12. Chen, A.P.; Hansoti, B.; Hsu, E.B. The COVID-19 Pandemic Response and Its Impact on Post-Pandemic Health Emergency and Disaster Risk Management in the United States. *Sustainability* **2022**, *14*, 16301. [[CrossRef](#)]
13. Ishimaru, T.; Shimizu, S.; Teshima, A.; Ibayashi, K.; Arikado, M.; Tsurugi, Y.; Tateishi, S.; Okawara, M. The Impact of COVID-19 Outbreak on Health Emergency and Disaster in Japan. *Sustainability* **2022**, *14*, 15686. [[CrossRef](#)]
14. Ghotbi, N. The COVID-19 Pandemic Response and Its Impact on Post-Corona Health Emergency and Disaster Risk Management in Iran. *Sustainability* **2022**, *14*, 14858. [[CrossRef](#)]
15. Chung, H.S.; Lee, D.E.; Kim, J.K.; Yeo, I.H.; Kim, C.; Park, J.; Seo, K.S.; Park, S.-Y.; Kim, J.H.; Kim, G. Revised triage and surveillance protocols for temporary emergency department closures in tertiary hospitals as a response to COVID-19 crisis in Daegu Metropolitan City. *J. Korean Med. Sci.* **2020**, *35*, e189. [[PubMed](#)]
16. Jeon, Y.; Kim, Y. COVID-19: Protecting Health-Care Workers in South Korea. *Disaster Med. Public Health Prep.* **2021**, *16*, 2355–2357.
17. Shin, H.-S.; Park, H.; Kwon, J.S.; Namgoong, H.; Kim, S.-J.; Kim, J.M.; Peck, K.R.; Lee, K.; Lee, J.-k.; Lee, J. National Academy of Medicine of Korea (NAMOK) key statements on COVID-19. *J. Korean Med. Sci.* **2021**, *36*, e287. [[CrossRef](#)]
18. Kim, J.-H.; An, J.A.-R.; Min, P.-k.; Bitton, A.; Gawande, A.A. How South Korea responded to the COVID-19 outbreak in Daegu. *NEJM Catal. Innov. Care Deliv.* **2020**, *1*. [[CrossRef](#)]
19. Cheong, H.S.; Kwon, K.T.; Hwang, S.; Kim, S.-W.; Chang, H.-H.; Park, S.Y.; Kim, B.; Lee, S.; Park, J.; Heo, S.T. Workload of healthcare workers during the COVID-19 outbreak in Korea: A nationwide survey. *J. Korean Med. Sci.* **2022**, *37*. [[CrossRef](#)] [[PubMed](#)]
20. Kang, Y.; Shin, K.R. COVID-19: Korean nurses' experiences and ongoing tasks for the pandemic's second wave. *Int. Nurs. Rev.* **2020**, *67*, 445–449. [[PubMed](#)]

21. Choi, S. A hidden key to COVID-19 management in Korea: Public health doctors. *J. Prev. Med. Public Health* **2020**, *53*, 175.
22. Extending the Period of Intensive Operation of Cremation Facilities Nationwide (~4.30). Available online: https://ncov.kdca.go.kr/tcmBoardView.do?brdId=&brdGubun=&dataGubun=&ncvContSeq=371038&contSeq=371038&board_id=140&gubun=BDJ (accessed on 30 April 2022). (In Korean)
23. Shin, J.; Cheon, M.K. Expansion of Health Care Resources to Respond to COVID-19: Three Axis. *Health Welf. Issue Focus* **2021**, *408*, 1–11.
24. Mistry of Health and Welfare. The Public Health Center Supports 2064 Temporary Workers in Response to COVID-19. Available online: <https://www.korea.kr/news/pressReleaseView.do?newsId=156487566>. (accessed on 23 January 2023). (In Korean)
25. Korea Health Promotion Institution. Korea Health Promotion Development Institute Conducts Job Training in Preparation for the Deployment of COVID-19 Korea Health Webzine. Available online: https://www.khealth.or.kr/webzine/vol_03/cnt_1_2.jsp (accessed on 15 September 2022). (In Korean)
26. Sung-geun, K. Estimating the Effects of Social Distancing for COVID-19: Applying Spatially Explicit SEPIR Model. *J. Korea Assoc. Policy Stud.* **2021**, *30*, 237–270.
27. Choi, K. *Survey on Mental Health Status of Korean Public Health Doctors Who Dealt with COVID-19 Pandemic*; 2021–18; KMA Research Institute for Healthcare Policy: Seoul, Republic of Korea, 2022.
28. Han, S.; Choi, S.; Cho, S.H.; Lee, J.; Yun, J.-Y. Associations between the working experiences at frontline of COVID-19 pandemic and mental health of Korean public health doctors. *BMC Psychiatry* **2021**, *21*, 1–18. [CrossRef] [PubMed]
29. Hea, Y. *A Consignment Study for the Integrated Management of Health and Medical Resources*; G000BD2-2021-97; Ajou University Industry-Academic Cooperation Foundation: Suwon, Republic of Korea, 2021.
30. Lee, J.-Y.; Lee, J.-y.; Lee, S.H.; Kim, J.; Park, H.Y.; Kim, Y.; Kwon, K.T. The experiences of health care workers during the COVID-19 pandemic in Korea: A qualitative study. *J. Korean Med. Sci.* **2021**, *36*, e170. [CrossRef] [PubMed]
31. Development. *Beyond Containment: Health Systems Responses to COVID-19 in the OECD*; OECD Publishing: Paris, France, 2020.
32. Minister Kwon Deok-Cheol Visited the Site of Pyeongtaek Park Ae Hospital on the 1st Anniversary of the Designation of a Hospital Dedicated to the COVID-19 Base. Available online: http://www.mohw.go.kr/react/al/sal0301vw.jsp?PAR_MENU_ID=04&MENU_ID=0403&page=1&CONT_SEQ=368862# (accessed on 23 January 2023). (In Korean)
33. Ministry of Health and Welfare. Implementation of Additional Measures to Expand Cremation Capacity and Burial Space in Cremation Facilities Nationwide. Available online: http://www.mohw.go.kr/react/al/sal0301vw.jsp?PAR_MENU_ID=04&MENU_ID=0403&page=57&CONT_SEQ=370703 (accessed on 23 January 2023). (In Korean)
34. Ministry of Health and Welfare. Emergency Room Operation Recommendations in the Event of an Infectious Disease Epidemic. 2021. Available online: https://www.ydp.go.kr/health/downloadBbsFileStr.do?bbsNo=321&atchmfnlStr=A5J6ULE42SVOC5MBLVRFXSKYFB2AVW3LMFWUHOLR6JTZYUDNVQ_AILO (accessed on 12 December 2022).
35. Centers for Disease Control and Prevention. *Standard Operating Procedure (SOP) for Triage of Suspected COVID-19 Patients in Non-US Healthcare Settings: Early Identification and Prevention of Transmission during Triage*; Centers for Disease Control and Prevention: Atlanta, GA, USA, 2020.
36. Han, J.H.; Lee, S.M.; Lee, D.H.; Heo, T. The analysis of the status of emergency department-based screening clinic according to the spread of coronavirus disease 2019: A retrospective single-center study. *J. Korean Soc. Emerg. Med.* **2022**, *33*, 19–27.
37. Mistry of Health and Welfare. *Expansion of Infrastructure for Face-to-Face and Inpatient Treatment of COVID-19 Confirmed Patients in Children*; Mistry of Health and Welfare: Sejong, Republic of Korea, 2022.
38. Kim, T. Improving preparedness for and response to coronavirus disease 19 (COVID-19) in long-term care hospitals in Korea. *Infect. Chemother.* **2020**, *52*, 133.
39. Kwon, S.L.; Oh, J. COVID-19 vaccination program in South Korea: A long journey toward a new normal. *Health Policy Technol.* **2022**, *11*, 100601.
40. Ministry of Health and Welfare. The COVID-19 Oral Antiviral Drug Will Be Introduced Tomorrow (1.13.) for 210,000 People, and Will Be Available as Early as January 14. Available online: http://www.mohw.go.kr/react/al/sal0301vw.jsp?PAR_MENU_ID=04&MENU_ID=0403&page=32&CONT_SEQ=369685&SEARCHKEY=CONTENT&SEARCHVALUE (accessed on 20 January 2023). (In Korean)
41. Yoo, J.-H.; Park, S.-K.; Cheong, I.-K. The Impact of COVID-19 and Korea's New Southern Policy on Its Global Value Chain. *J. Korea Trade* **2020**, *24*, 19–38.
42. Ministry of Food and Drug Safety. Guidelines for Preparing Anti-Droplet Mask Standards and Test Methods. Available online: https://www.mfds.go.kr/brd/m_578/view.do?seq=41854&srchFr=&srchTo=&srchWord=&srchTp=&itm_seq_1=0&itm_seq_2=0&multi_itm_seq=0&company_cd=&company_nm=&page=1 (accessed on 20 January 2023). (In Korean)
43. Min-kyung, J. South Korean Government Takes Full Control of Face Mask Supply, Bans Exports. Available online: <https://www.koreaherald.com/view.php?ud=20200305000730> (accessed on 20 January 2023). (In Korean)
44. Ministry of Food and Drug Safety. Public-Private Partnerships Accelerate the Diagnosis of the Novel Coronavirus. Available online: https://udiportal.mfds.go.kr/brd/view/P01_01?ntceSn=42 (accessed on 20 January 2023). (In Korean)
45. Ministry of SMEs and Startups, and the Korea SMEs and Startups Agency Are Recruiting Additional Companies Participating in the Aviation Maritime Freight Conservation Project. 2021. Available online: <https://www.etnews.com/20210830000114> (accessed on 20 January 2023).

46. The Korea SMEs and Startups Agency and the Ministry of SMEs and Startups Have Provided Support for Soaring Aviation Logistics Costs Due to COVID-19. 2021. Available online: <https://www.mss.go.kr/site/smba/ex/bbs/View.do?cbIdx=86&bcIdx=1028879> (accessed on 20 January 2023).
47. Choi, D. The Protection of Workers in the Consumer Logistics Service Industry Development Act, Which Supports the Delivery Ecosystem Suffering from COVID-19, Will Be Implemented Tomorrow Hankookilbo. 2021. Available online: <https://www.hankookilbo.com/News/Read/A2021072610040002337> (accessed on 20 January 2023).
48. Ministry of Labor. *Recommend Improvement of Safety Treatment for Courier Workers in Response to COVID-19*; Ministry of Labor: New Taipei, Taiwan, 2020.
49. Ministry of the Interior and Safety. All About Korea's Response to COVID-19. Available online: https://www.mois.go.kr/eng/bbs/type002/commonSelectBoardArticle.do?bbsId=BBSMSTR_000000000022&nttId=80581 (accessed on 23 January 2023). (In Korean)
50. Hyeji, C.; Younghee, W. *Remaining Season. The Status of Human Rights Security for the Vulnerable in the COVID-19*; National Human Rights Commission: Seoul, Republic of Korea, 2021.

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