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REPUBLIC OF KOREA'S COVID-19 PREPAREDNESS AND RESPONSE

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Post-MERS (Middle East respiratory syndrome) legislative and regulatory reforms enhanced the public health preparedness and response system in the Republic of Korea. Investment in strengthening the Korea Centers for Disease Control and Prevention (KCDC) in policy, research and training as well as proper and flexible financing of public health measures proved to be crucial. Massive testing, isolation of cases, and extensive contact tracing as well as public participation in social distancing all enabled Korea to control COVID-19 without a painful lockdown. With close public-private partnership and an available approval process already in place, rapid decision making and swift action for the development of testing kits and guaranteeing their availability in both public and private laboratory facilities may have been the crucial part of Korea's COVID-19 response.

Universal health coverage, thanks to a National Health Insurance (NHI) system, which provides coverage to the entire population and encompasses all health care providers through a single pool, ensures access to testing and treatment without financial barriers. The high degree of trust in and effective communication by the government contributed to compliance with government policy and adherence to social distancing. Maintaining flexibility and making adjustments was crucial as the epidemic worsened, and data were fed in for analysis and decision making. A new type of treatment facility, living treatment centers, was introduced to care for patients with milder symptoms. Drive-through test centers were introduced to rapidly increase testing and avoid further potential infections.

Korea's experience shows that sustained investment in preparedness and response pays off handsomely, and is a lesson for all countries, low, middle and high income. Decisive and data-driven leadership, strategic clarity (a focus on testing and contact tracing), and willingness to be innovative are also crucial. Results show that the Korean economy will be one of the least affected in terms of loss of productivity, unemployment, and growth.

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Executive Summary

Many countries, especially those that have been caught unprepared, responded to the pandemic with severe lockdowns and other very restrictive measures, with the consequent devastating effects on the economy and society, especially the poor and the vulnerable. The first case of COVID-19, a traveler from Wuhan, China, was confirmed on January 20 in the Republic of Korea (Korea). For two weeks in late February, Korea had the highest number of confirmed COVID-19 cases outside China. The government raised the alert level to the highest one to significantly strengthen the country's response system. Without resorting to lockdowns or other highly restrictive measures, the number of confirmed cases has been very stable after March. While COVID-19 continues to affect Korean society, Korea has achieved important milestones, such as flattening the curve in the most heavily impacted areas, undertaking rapid testing, holding a parliamentary election, and nuancing social distancing to ensure that life and economic activities are least disrupted. Results show that the Korean economy will be one of the least affected in terms of loss of productivity, unemployment, and growth.

As for the commitment to enhancing national capacity, post-MERS (Middle East respiratory syndrome) legislative and regulatory reforms enhanced Korea's public health preparedness and response system. Investment in strengthening the Korea Centers for Disease Control and Prevention (KCDC) in policy, research, and training as well as proper and flexible financing of public health measures proved to be crucial. Massive testing, isolation of cases, and extensive contact tracing as well as public adherence to social distancing all enabled Korea to control COVID-19 without a painful lockdown. With close public-private partnership and an available approval process already in place, swift decision making and action for the development of testing kits and guaranteeing their availability in both

public and private laboratory facilities may have been the crucial part of Korea's COVID-19 response.

The government has led the preparedness and response, and it has worked with the private sector toward the common good, from the manufacturing of personal protective equipment (PPE), to scaling up testing, and sharing responsibilities in patient care with private entities—both private hospitals and living treatment centers. While one is often tempted to underestimate the potential for public-private mix under normal circumstances, let alone in the case of a pandemic, having a sound and effective system of governance, in tandem with a single purchaser could significantly and effectively leverage what the private sector has on offer for the common good. Universal health coverage (UHC) through the National Health Insurance (NHI) system, which covers the entire population and encompasses all health care providers through a single pool, ensures access to testing and treatment without financial barriers.

Whole-of-government governance in extensive use of digital platforms and technologies to deliver a swift, expansive, and effective response, with minimal risk for privacy, confidentiality, and citizens' rights, demonstrated the government's leadership, decisiveness, and ability to inform the citizenry of the pros and cons of accessing private information and to persuade them of the need to do so at minimal risk, given the circumstances and the imperative of swift action for testing, tracking, self-health, check-in, and quarantine. The high degree of trust and effective communication contributed to compliance with government policy and social distancing. Most people voluntarily followed government recommendations on social distancing, wearing masks and hand washing, canceling in-person meetings, and working from home even in the absence of major restrictive measures.

Through the course of the outbreak, Korea has had to amend a few laws, reconfigure roles and responsibilities of some agencies such as KCDC, and establish a high-level response headquarters under the leadership of the prime minister. Maintaining flexibility and making adjustments was crucial as the epidemic has progressed, and data are incorporated for analysis and decision making. Initially all those who tested positive for COVID-19 were hospitalized. However, hospitalization of all patients overloaded the health system due to a shortage of beds for severe COVID-19 patients, especially in the Daegu-Gyeongbuk region, where the large Shincheonji Church outbreak occurred. After some patients died at home waiting for hospitalization, the government quickly changed the policy, and patients were prioritized based on severity of infection and allocated across provinces. A new type of treatment facility, living treatment centers, was introduced to take care of patients with milder symptoms. Drive-through test centers were introduced to rapidly increase testing and avoid further potential infections. Telemedicine was temporarily permitted, to protect patients with existing conditions, improve access, and minimize the potential infection of health providers.

Two areas can be highlighted for future improvement in Korea, and by proxy for other countries. One is the importance of having a highly effective primary health care platform for first contact. Health care in Korea has traditionally been largely hospital-centric and predominantly private. The health workforce, while well-trained and competent is also highly specialized, leaving little room for people-centered integrated primary care at the community level. A robust and high-performing health care system with community outreach could have averted some of the initial less-than-optimal response, and reduced the need for extraordinary measures in surveillance, testing, and case detection and follow-up. Second, the provision of more targeted socioeconomic support to the elderly, especially those in extended care facilities, and the poor and vulnerable through a range of policy interventions, from cash transfers to income guarantees, for the duration of the epidemic would have improved the effectiveness of policy response.

In conclusion, Korea has responded remarkably well to the COVID-19 pandemic, mainly by being well prepared, and by reacting swiftly with a whole of government and public-private partnership both

at the central and local levels at negligible cost to the economy, proving once again that sustained investment in preparedness and response pays off handsomely—a lesson for all countries, low, middle, and high income. Decisive and data-driven leadership, strategic clarity (a focus on testing and contact tracing), and willingness to innovate are also crucial.

Introduction

The COVID-19 pandemic has impacted the health and well-being of citizens of almost all the countries in the world. The impact of the pandemic goes well beyond the health and health systems, undermining the economy and the prevailing social contract of societies. Many countries, regardless of their level of socioeconomic development, especially those that have been caught unprepared, responded to the pandemic with severe lockdowns and other highly restrictive measures, producing devastating effects on the economy and society, especially the poor and vulnerable in those countries.

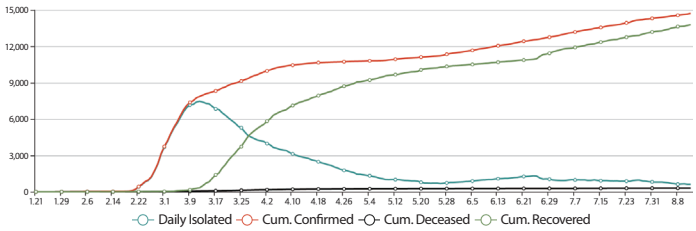
This report documents the Republic of Korea's preparedness for and response to the pandemic; assesses the factors that have contributed to its, by now well-acknowledged, success in effective response to COVID-19; and discusses the lessons learned for the benefit of other countries that may wish to emulate and customize key policy and operational interventions proven to be most critical in Korea. Effective preparedness and early response based on massive testing, extensive contact tracing and isolation of cases, use of innovative information tools, and treatment without financial burden on patients all contributed to successfully flattening the epidemiological curve in Korea, and reducing the surge in demand for health care services while minimizing the impact of the pandemic on the economy. Such a swift, timely, and effective whole-of-government response, the high level of trust of the citizenry to authority, and consequent voluntary adherence to the fundamentals of social distancing and wearing masks mitigated the need for whole-scale lockdowns and other coercive social distancing measures, with the sole exception of a delay in the beginning of the spring semester of primary, middle, and high schools. [1] [2]

On January 3, 2020, the Korea Centers for Disease Control (KCDC) announced the formation of a special taskforce responding to a series of cases of pneumonia of unknown cause reported in Wuhan, China. The first case of COVID-19, a traveler from Wuhan, was confirmed on January 20. For two weeks in late February, Korea had the highest number of confirmed COVID-19 cases outside China (Figure 1). The surge of patients in late February was associated with a large number of infections in Shincheonji Church in Daegu-Gyeongbuk region. On February 23, the government raised the alert to the highest or "serious" (red) level to strengthen the country's response system and embarked on an aggressive public campaign. Even without lockdowns or other highly restrictive measures, the number of confirmed cases has been very stable after March. Since then, the number of daily new confirmed cases (and the total number of confirmed cases) has been much lower in Korea than in other countries, for instance Germany, Italy, and the United Kingdom (Figure 2). While COVID-19 continues to affect Korean society, the last five months have seen important milestones such as flattening of the curve in the most heavily impacted areas, undertaking rapid testing, holding a parliamentary election, and making decisions to return to everyday social distancing and resume schools.

1 See, for example, government response stringency index in Our World in Data (2020), https://ourworldindata.org/coronavirus-country-comparisons.

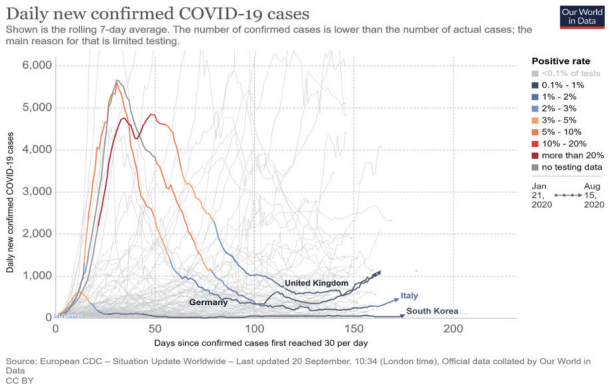
2 Yoo et al., 2020.

Figure 1: Trends in Confirmed Cases, Isolated, Released from Isolation, and Deceased



Source: https://coronaboard.kr/, accessed September 20, 2020.

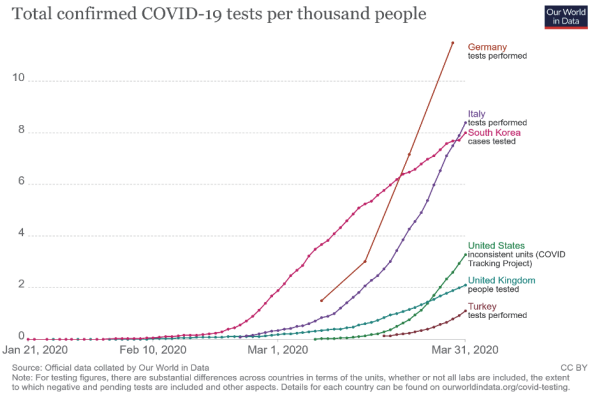
Figure 2: Trend of the Number of Daily New Confirmed cases of COVID-19



Source: https://ourworldindata.org/, accessed September 20, 2020.

There is little difference in the dates of first confirmed cases in the United States, the United Kingdom, Germany, Italy and Korea. In the five countries, the first case was confirmed at the end of January, but the number of tests administered since then has been very different in each (Figure 3). Korea began to perform tests for COVID-19 at a very early stage of outbreaks, while other countries speeded up their testing only in March. The government of Korea approved test kits as early as February, and the drive-through test station was introduced in late February. More recently, Korea has also adopted a policy of anonymous testing to encourage people to get tested without fear of having to disclose personal information.

Figure 3: Number of Laboratory Tests for COVID-19 per 1,000 People



Source: https://ourworldindata.org/, accessed May 13, 2020.

Overall the fatality rate of COVID-19 in Korea has been lower than in many other countries. This is explained in part by a higher percentage of young patients as a result of mass testing, instead of targeted testing for older and vulnerable populations. For example, there was a large number of young patients form Shincheonji Church in Daegu-Gyeongbuk region, as mentioned earlier. Case fatality rates vary across age groups, with higher rates in older patients (Table 1). The highest number of mortalities of elderly people were reported from Daegu City and North Gyeongsang Province, where the region's health system was overwhelmed with the rapidly increasing number of COVID-19 patients in February and early March 2020.

Table 1: Age and Gender Distribution of Confirmed Cases and Mortality (August 15, 2020)

		Confirmed Cases (%)	Deaths (%)	Fatality Rate (%)
Total		15,039 (100)	302 (100)	2.03
Sex	Male	6,875 (45.71)	162 (53.11)	2.36
	Female	8,164 (54.29)	143 (46.89)	1.75
Age	80 +	612 (4.07)	152 (49.84)	24.84
	70–79	983 (6.54)	90 (29.51)	9.16
	60–69	1,977 (13.15)	41 (13.44)	2.07
	50–59	2.660 (17.69)	16 (5.25)	0.60
	40–49	2,035 (13.53)	4 (1.31)	0.20
	30–39	1,922 (12.78)	2 (0.66)	0.10
	20–29	3,742 (24.88)	0 (0.00)	0
	10–19	836 (5.56)	0 (0.00)	0
	0–9	272 (1.81)	0 (0.00)	0

Source: https://coronaboard.kr/, accessed September 20, 2020.

This report is organized as follows: Chapter 2 describes governance, policies, and institutions that played a critical role in enhancing the effectiveness of emergency response and allowed policy and operational innovations during the COVID-19 outbreak. More specifically, this chapter focuses on the types of recent systematic, legal, and institutional changes that have been particularly helpful to strengthen the government's ability to respond to COVID-19. Chapter 3 documents the types of efforts the country has made to further strengthen emergency preparedness and response. In addition, it looks at key areas where the government responded to COVID-19 with detailed plans. Chapter 4 examines the lessons learned and policy implications for other countries, especially low- and middle-income countries (LMICs).

GOVERNANCE, POLICIES, AND INSTITUTIONS: WHAT EXISTED AND WHAT HAS CHANGED

Organization and Policy for Disease Surveillance and Response

Central and Local Governments

At the central level, the Ministry of Health and Welfare (MoHW) plays a central role in system stewardship, policy formulation, health planning, and implementation at the national level. It directly manages several national hospitals (e.g., national cancer center, psychiatric hospitals) and implements various public health policies through collaboration with (or by providing subsidies and grants to) local governments. The role of MoHW and KCDC (Korea Centers for Disease Control and Prevention) in infectious disease management is crucial in regulation, financial support, technical assistance, and training. In a health emergency, it is important that the central government leads the effort by coordinated planning, unified technical guidelines, and allocation of resources across provinces and localities. In addition, MoHW formulates major policies for the National Health Insurance (NHI), which accounts for the lion's share of total funding for the health sector in Korea.

In collaboration with the MoHW, regional governments are in charge of the management of regional medical centers (usually secondary hospitals) based on their own health planning. Municipalities are responsible for public health, vaccination, and antenatal care, mainly through public health centers (primary care). Although the country's public health system is decentralized, the role of the central government is very important in terms of funding and technical support. In a health emergency like COVID-19, coordination among central and local governments can quickly increase government response capacity, compared with a bottom-up approach in a highly decentralized system, as in the United States.[3]

In 2015, the outbreak of the Middle East respiratory syndrome (MERS) in Korea elevated the importance of a robust national quarantine system to effectively cope with emerging infectious disease. The MERS outbreak lasted for almost two months with 186 confirmed cases and 38 deaths; 16,993 individuals were under mandatory self-isolation. At that time, the government was criticized for its failure to respond promptly and transparently. The public was unaware of key information, and a lack of coordination between central and local governments was seen as delaying timely and prompt response.[4]

3 Kim, 2020.
4 Lee and Ki, 2015.

Since the MERS outbreak in 2015, coordination among central and local governments in infectious disease management has been strengthened. Contact tracing is the responsibility of local governments while the KCDC takes responsibility for epidemiological investigation in collaboration with local governments during the outbreak of the most serious infectious diseases, including COVID-19, Ebola, severe acute respiratory syndrome (SARS), and MERS. Although local governments are empowered to implement their own emergency response measures, including the closure of schools, kindergartens, daycares, and public welfare centers, most follow instructions provided by MoHW and KCDC before implementing any emergency measures.

The role of local governments was minimal in the case of MERS. Local governments are now responsible for implementing a range of activities at the local level, including risk communication; public health education, such as personal hygiene and social distancing; surveillance; coordination of testing among public health centers and other local testing facilities; contact tracing with epidemiological interviews by trained district health officers, identifying and confirming close contacts, disinfecting places confirmed patients have visited, and sending regular updates to residents via text messages.

Local governments are also responsible for self-quarantine management, sending self-quarantine notice by the district health authority, providing health education to those under mandatory self-quarantine and their family members, arranging and providing alternative facilities for self-isolation if housing is inadequate, checking symptoms twice a day by phone, and monitoring self-isolation compliance. They are also responsible for local-level resource mobilization and allocation by working with local associations of physicians and nurses and coordination with civil society organizations for better risk communication. In an outbreak of a serious infectious disease, the KCDC allocates personal protective equipment (PPE) such as Level D protective suits, N95 masks, goggles, and facial shields to public health centers, which then allocate them to private providers, although health centers and private providers can also purchase their own.

Legal Framework

The Infectious Disease Control and Prevention Act is the major law dealing with infectious disease and health emergency. After the outbreak of MERS in 2015, the law was revised to respond to health emergencies more rapidly and effectively and gave power to central government (MoHW and KCDC) to make the top-down approach possible during emergencies. The revised law has elevated the KCDC's authority and provided more funding and personnel, for example, hiring more epidemiologists, who are seen as vital to increasing capacity for infectious disease control and pandemic preparedness.

Three rounds of revisions in 2015–2018 permitted MoHW to request and collect information from the Korean National Police Agency and telecommunication companies about locations of patients and potential patients, with the provision that collected information must be destroyed when the relevant tasks for the outbreak are accomplished. This new law enabled extensive contact tracing in the case of COVID-19. The law also mandates the government must disclose information to the public about paths (whereabouts) of confirmed cases to ensure the public's right to know. Thus, the revised law allowed KCDC and MoHW to override certain privacy law provisions at the onset of a serious infectious disease.[5] The revised law mandates employers or governments must compensate employees or the self-employed in treatment or under a mandatory self-quarantine due to outbreaks. Under the revised law, the government is obliged to provide compensation to hospitals that incur loss due to the treatment of infectious disease patients or of those with suspicious symptoms.

Soon after the COVID-19 outbreak, the government saw the need for additional policy measures, and

5 Park, Choi, and Ko. 2020.

the law was promptly revised in March 2020. In the case of the most serious infectious diseases, the revised law introduces a fine for suspected patients who refuse testing and increases the fine for those in noncompliance of the quarantine order. The government is also mandated to provide masks at an affordable price to vulnerable populations in case of a health emergency, and to place temporary restrictive measures such as a ban on exports of critical medicines and medical supplies to ensure adequate stockpiles and prevent shortages. When the government designates hospitals for infectious disease management, the revised law mandates the government must pay for the establishment and operation of necessary facilities. The law also increases the minimum number of epidemiological investigators in the KCDC from 30 to 100.

Contact tracing and information disclosure has been broadly supported; 68 percent of the surveyed support the current level of information disclosure.[6] However, highly detailed information on the restaurants and shops an infected person visited seemed to have a big impact on these business. The recent revision in March 2020 improved the process of information gathering and disclosure, including the appeal process for the patient involved. The law is more specific on public disclosure of information gathered from contact tracing and allows a patient to appeal to correct if disclosed information is inaccurate.

Korea Centers for Disease Control and Prevention

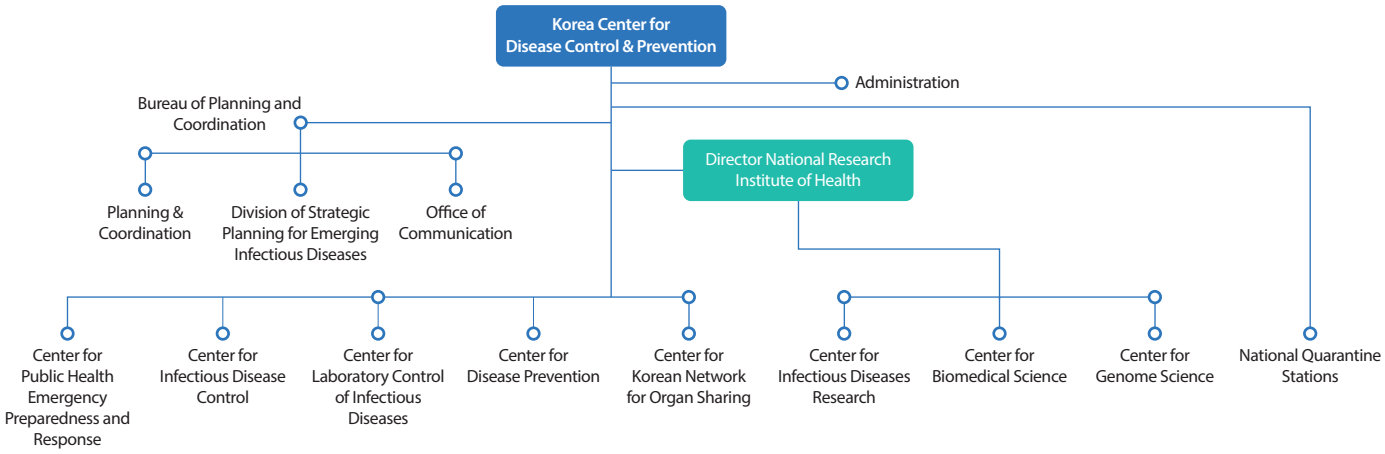
The Korea Centers for Disease Control and Prevention (KCDC) is a specialized agency of the MoHW and provides technical support on the control and prevention of communicable and noncommunicable diseases. It investigates diseases, handles quarantine, and oversees and performs laboratory testing and research to support policy formulation and implementation at the national level. Since 1945, several health-related national agencies have emerged focusing on communicable disease control, such as the Institute of Communicable Disease Control, which later was integrated into the National Institute of Health. KCDC was formally established in 2004 in the aftermath of the global SARS epidemic. In 2004, Korea successfully prevented any occurrence of SARS, and the government decided to establish KCDC as a major agency under the MoHW in charge of national disease control and prevention.

KCDC has been through major expansion and reorganization after the MERS outbreak, and its capacity has been strengthened. The function of emergency operation capacity under the Center for Public Health Emergency Preparedness and Response was expanded with the Emergency Operations Center (EOC). EOC collects and analyzes domestic and international infectious disease information in real-time through a control room that runs 24 hours a day and seven days a week to detect emergency situations at an early phase and effectively controls them by sending an emergency reaction team for early response. In 2018, new departments, such as emergency operations, crisis communication, risk assessment, and international cooperation, were established. Since then, KCDC has expanded its annual budget to US$630 million, and its personnel to 845 as of 2018. KCDC oversees the Korea National Research Institute of Health (KNIH) and the National Quarantine Stations (NQS) (Figure 4). In May 2020, a decision was taken to raise the status of KCDC with expanded capacity in research and policy. The head of KCDC will have the same rank as deputy minister and have autonomy in personnel and budgetary decisions; that is, he/she will no longer need MoHW approval.

Key functions of KCDC include national infectious disease surveillance through the overseeing of the Korea National Notifiable Infectious Disease (KNNID) list with six groups of 80 legally notifiable infectious diseases. Using the KNNID list, KCDC operates a web-based National Infectious Disease Surveillance System (NIDSS). Another of KCDC's

6 You, 2020.

Figure 4: Organogram of KCDC (as of February 1, 2020)



Source: KCDC (2020)

key functions is the operation of an Epidemiologic Investigation Service (EIS) program since 2000 to produce field epidemiologists, or Epidemiologic Investigation Service Officers (EISOs), who have been dispatched to perform rapid response and control of infectious diseases at the central and provincial levels. KCDC has also been operating on the front line of the Field Epidemiology Training Program (FEPT) for public health officers in municipal and provincial government and public health officers in 241 health centers throughout the country to give them management and response capacity to handle infectious diseases outbreaks.[7]

During the COVID-19 outbreak, the KCDC has played a key role in policy decisions on testing, including enhanced testing capacity and rapid approval of medicines and devices. Local governments have followed KCDC's technical lead in the management of the infected, ensuring access to negative pressure wards and stock management for essential equipment. The KCDC centrally coordinates with provincial and municipal governments and specialized hospitals for service delivery and public communication, including providing and updating case definitions, quarantine, and the triage of COVID-19 patients.

Health System

Health Financing and Universal Health Coverage

Funds allocated for public health, mainly through the government budget, accounted for 3.4 percent of national health expenditure.[8] The National Health Insurance (NHI) system is Korea's major funding mechanism, with universal coverage encompassing all types of care, including medical and dental and traditional medical care, medicines, and laboratory testing.[9] [10] The NHI has a single payer system with two agencies: NHIS (National Health Insurance Service) for contribution collection and reimbursement and HIRA (Health Insurance Review and Assessment Service) for claim review and quality assessment. The single pool provides the NHI with high bargaining power relative

7 KCDC, 2019.
8 RoK, MoHW, 2020.
9 Kwon, 2008, 2018.
10 As of 2016, the Health Promotion Fund from tobacco tax contributed about 4 percent of total National Health Insurance expenditures (more than half of tobacco tax is used to subsidize NHI).

to health providers, as well as no regional difference in terms of benefits, contributions, and provider payment. As NHI covers the entire population as well as the participation of all health providers, it collects information on the insured, providers, and health care utilization. Data systems of the KCDC and the NHI are effectively linked to share information on health care utilization and foreign travels of COVID-19 and suspected COVID-19 patients.

The NHI rapidly responded to COVID-19 by listing and pricing COVID-19 diagnostic test reagents and test methods (following rapid approval by the KFDA [Korean Food and Drug Administration]), amending benefit criteria for COVID-19 medicines through a shorter review and rapid approval for listing, and introducing compensation for infection prevention for COVID-19 patients in hospitals. There is no financial burden of treatment for COVID-19 as most costs are covered by the NHI, and copayments for communicable diseases are exempt (i.e., copayments are funded by the government). The cost of testing is ex ante free (paid by the NHI) for those who have traveled abroad, those with symptoms, or those with physician recommendations. It is ex post free if a patient tests positive. As the NHI provides coverage for all patients and encompasses all providers, it has complete information on health care utilization of COVID patients, for example, admission/discharge, severity, medicines, and tests.

As a relief measure, mandatory NHI contribution is discounted for those heavily affected by COVID-19. For three months (March to May 2020), 50 percent of contributions were discounted for those in the bottom 20 income percentile of the insured, and 30 percent discount was applied to the next lowest 20–40 income percentile. For those in the Daegu City and North Gyeongsang Province, 50 percent discount is applied to the lower 50 income percentile of population. The NHIS provides advance payment to health care providers, which is 90 to 100 percent of the reimbursement of the previous year. NHI funding seems stable so far because of sufficient reserve funds, and because health care utilization of non-COVID-19 patients has declined although that of COVID-19 patients has increased. If COVID-19 harshly impacts the economy, the revenue (contribution) of the NHI will decrease in the near future.

Health Service Delivery

Overall, the Korean health care system is predominantly private (e.g., less than 10 percent of hospitals and less than 15 percent of beds are public), yet the majority of COVID-19 patients were treated in public hospitals. Still, all private providers must participate in the NHI, which is mandatory rather than a voluntary contracting between the NHI and providers. All health care providers—both public and private—treat patients with the same contract conditions (benefits package and provider payment), set by NHI law. This strong mandate was introduced with the development of the NHI in the late 1970s. Hospital beds per capita in Korea were the second-highest among Organisation for Economic Co-operation and Development (OECD) countries (12.4 per 1,000 persons as of 2018[11]), causing concerns of overhospitalization and inefficiency (before the COVID-19 pandemic). The number of practicing physicians per 1,000 persons was 2.4 and that of practicing nurses was 7.2 as of 2018 (OECD averages were 3.5 and 8.8, respectively).

Most graduates of medical school become board-certified specialists, many of whom work as office-based physicians or open physician clinics, providing de facto primary care. There are 254 (primary-level) public health centers, which are funded and managed by their respective local governments with technical support by the MoHW. Most public health centers provide preventive and promotive services, including immunization, maternal and child health, screening, health education, and surveillance of communicable diseases. Private clinics and hospitals provide similar services, such as immunization, maternal and child health, and screening, all of which are funded by the NHI.

11 OECD, 2019.

To minimize potential infection by COVID-19 in hospitals as well as to allow hospitals and clinics to continue regular health services for non-COVID-19 patients, the government designated COVID-19 safe hospitals: 343 hospitals (28 tertiary hospitals, 215 general hospitals, 99 hospitals, 2 Korean medicine hospitals), which account for about 20 percent of all hospitals in Korea. These hospitals separate services and patient paths for respiratory and nonrespiratory patients during the treatment process. NHI provides additional reimbursement to those hospitals. At the same time, telemedicine and prescriptions without visit were temporarily allowed to improve access to care and avoid potential infection during outpatient care. Telemedicine has not been introduced in Korea mainly because of the opposition of the Korean Medical Association, which is worried that telemedicine would increase the market share of big hospitals at the expense of physician clinics in the community.

With the COVID-19 outbreak, the government designated 67 hospitals with about 7,500 beds (about 2.5 percent of all hospital beds in Korea), most of which are in the public sector, exclusively for the treatment of COVID-19 patients. Some patients in Daegu City and Gyeongbuk Province, where a huge outbreak in a church occurred, were transferred to hospitals in other provinces. Although all private health care providers are part of the NHI system and played a key role in the response to COVID-19, they were less willing to invest in special facilities for infectious diseases, for example, negative-pressure isolation rooms for control of air flow. Existing patients in public hospitals had to be transferred to private hospitals to make public hospitals available exclusively for treatment of COVID-19 patients. Allocation of COVID-19 patients and coordination among providers nationwide could have been done more effectively if Korea had more public providers.

Effective surveillance is a key element of disease prevention and control. COVID-19 is classified as a new infectious disease under Group 1 of infectious diseases for the Mandatory Surveillance System. Health care providers are mandated to report suspicious cases to public health centers at the district level via a web-based reporting system, and metropolitan and provincial governments are tasked with integrating the information and reporting to the KCDC. More than 600 COVID-19 test centers were established in public health centers and hospitals, both public and private. Almost all public health centers provide tests for COVID-19. Hospitals do not need an approval to do so but must report to the government if they open a test center for COVID-19.

Governance of COVID-19 Crisis

Level of Alerts

Korea has a system of crisis management for prevention and preparedness against infectious disease outbreak and prompt response to disasters and crisis. It has four levels of crisis alert, from lowest to highest: blue (level 1, attention), yellow (level 2, caution), orange (level 3, warning), and red (level 4, serious). Levels 1–2 are determined and controlled by the KCDC, and levels 3–4, by the Central Disaster and Safety Countermeasures Headquarters (CDSCHQ) with recommendation of the KCDC. "Attention" or blue-level crisis type includes outbreaks and epidemics of new infectious diseases abroad and infections of unknown cause or reemergence of infections in Korea. Major response activities include the operation of countermeasures for each infectious disease, monitoring of crisis signs, and improvement in the capacity of response monitoring.

Level 2 or "caution" (yellow) responds to domestic influx of new infectious diseases from abroad and the limited spread of infectious diseases of unknown cause and reemergence in Korea. Major response activities include establishment and operation of the Central Diseases Control Headquarter in KCDC, operation of a cooperation system for related organizations, on-site quarantine measures and operation of quarantine infrastructure, and enhanced monitoring and surveillance.

Level 3, "warning" (orange), responds to limited spread of new infectious diseases introduced into Korea and the domestic spread of infectious diseases of unknown cause or their reappearance in Korea. Major response activities include the continued operation of the Central Diseases Control Headquarters, the establishment and operation of the Central Disaster Management Headquarters in MoHW, the establishment and operation of a government-wide Support Center in the Ministry of the Interior and Safety (MoIS), strengthening the cooperation of related organizations, and, if necessary, a government-wide meeting chaired by the prime minister.

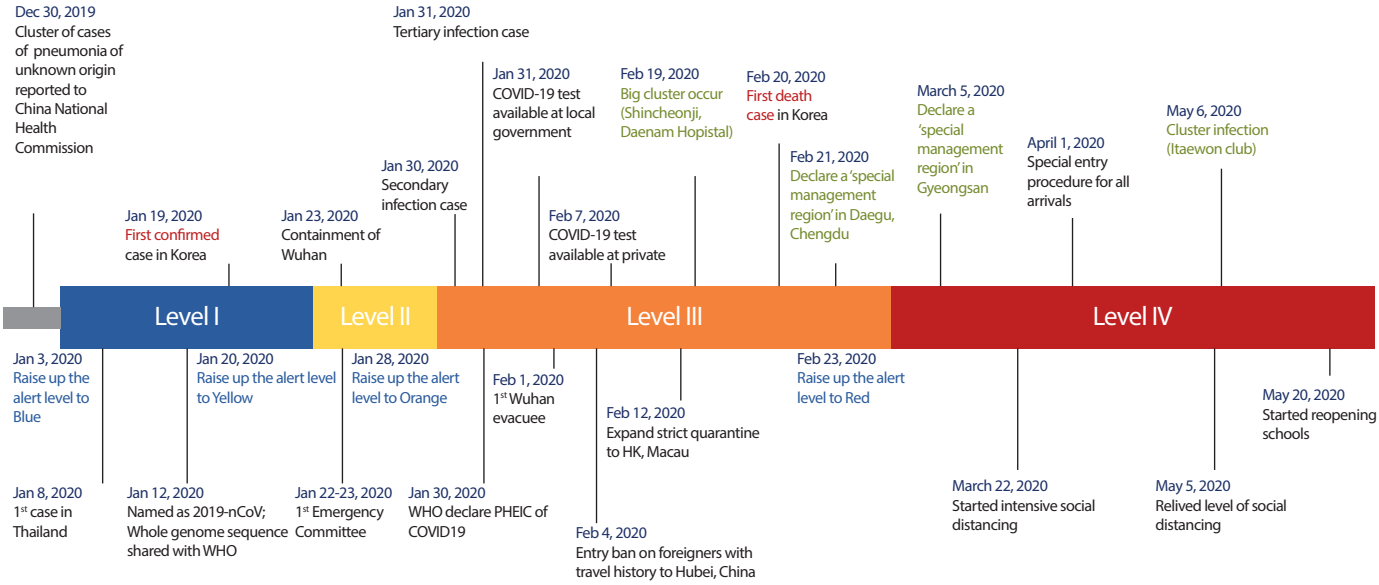
Level 4, "serious" (red) responds to the spread of new overseas infectious diseases to the local community or their spread nationwide, and the nationwide spread of infectious diseases of unknown origin and their reemergence. Major response activities include government-wide total responses and the establishment and operation of the Central Disaster and Safety Countermeasures Headquarters, headed by the prime minister, in addition to centers and headquarters established at lower levels of the alert system.

Control Mechanism

Alert level 1 was issued on January 3 soon after a cluster of cases of pneumonia of unknown origin was reported to China National Health Commission on December 30, 2019 (Figure 5). It was raised to level 2 on January 20, when the first case was confirmed in Korea on January 19. Alert level 3 was issued on January 28. After the outbreak in Shincheonji Church and the first COVID-19–related death was reported, the alert level was raised to level 4 on February 23, allowing the government to take more aggressive policy measures, including restricting certain flights to and from Korea, closing schools, and limiting public transportation. Under Alert 4, lockdowns are a policy option for the government, but these have not yet been activated.

When the level of the national infectious disease crisis was changed to serious (red) on February 23, 2020, the Korean government launched a Central Disaster and Safety Countermeasures Headquarters (CDSCHQ), headed by the prime minister (Figure 6). Considering the technical expertise required to respond to infectious diseases, the KCDC has become the central disease control headquarters and

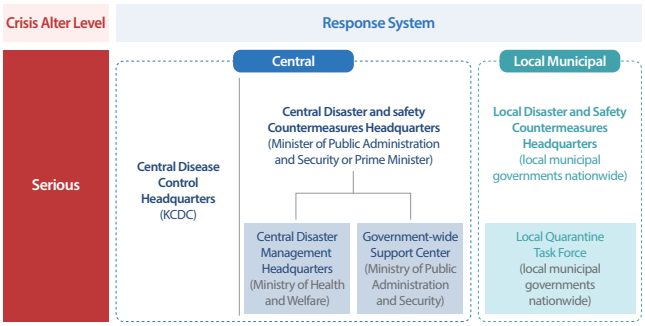
Figure 5: Evolution of Alert Levels



Sources: ROK MoEF et al, 2020, and Authors.
Note: PHEIC = Public Health Emergency of International Concern.

control tower for disease control and it spearheads responses. In other words, final decisions are made in the CDSCHQ led by the prime minister, but KCDC provides key technical information as a vital input to those decisions.

Figure 6: Response Systems of the Korean Government



Source: KCDC (2020)

The minister of health and welfare is the first deputy head for CDSCHQ and the director of the Central Disaster Management Headquarters. The minister of the interior and safety is the second deputy head of CDSCHQ and director of the government-wide Support Center to provide necessary assistance, including coordination between the central and local governments of allocation of patients across public hospitals in different localities. Each local government also establishes its Local Disaster and Safety Countermeasures Headquarters, directed by the head of the local government, which ensures availability of hospitals dedicated to COVID-19 patients. The central government provides support for hospital beds, manpower, and other supplies when local governments face shortages.

Socioeconomic Consequences and the Role of Rapid and Effective Response

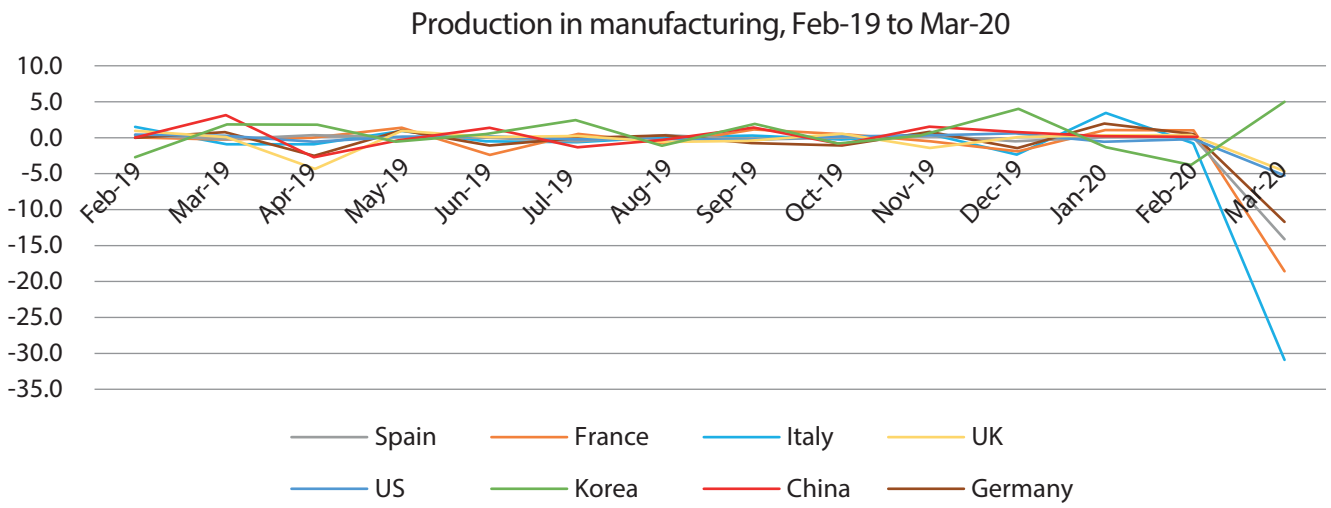
There is a trade-off between disease response and socioeconomic consequences of the outbreak, and strong measures of disease containment can constrain economic activity, at least in the short run. The restrictive measures for outbreak have a bigger impact on the service sector than on manufacturing.[12] The benefits of lockdowns or very restrictive measures are smaller, but their consequences would be more painful for the poor and among low-income countries (LICs) compared with high-income countries (HICs).[13] High informality in the labor market makes LICs more vulnerable to the lockdown.

In Korea, thanks to the early rapid response based on massive testing and contact tracing, there is no shutdown of manufacturing facilities although there were cases of shutdown for a few days to disinfect them when a worker was confirmed positive. Public transportation has not been closed, which helps minimize the negative impact on the economy. Nonetheless, public participation in social distancing has resulted in the decline in economic activity in the service sector, for example, restaurants, shops, and the travel industry, but the demand shock is smaller than in the case of complete lockdown.

Korea experienced a decline in retail sales and manufacturing in January and February (measured in the percentage change on the previous month) but an increase in March 2020 (Figures 7 and 8). Italy, France, and Spain saw a plunge in retail sales and manufacturing in March 2020. The magnitude of change (decline) in Korea is much smaller than in Italy, France, and Spain, which adopted lockdown or very strict restrictions. Thanks to a rapid and effective response to COVID-19, Korea avoided lockdowns, which seems to contribute to the smaller (negative) impact on the economy, compared to in the United States and Europe.

12 Goldman Sachs, 2020.
13 Loayza, 2020.

Figure 7: Monthly Change in Production in Manufacturing Output in February 2019–March 2020[14]

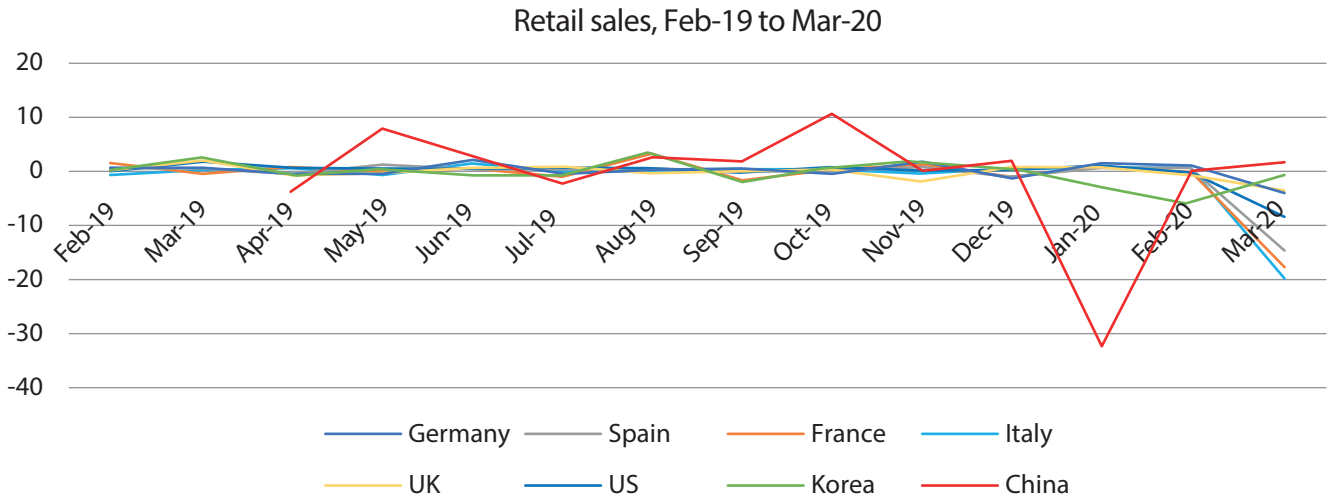


Source: Authors.

Notes:

1. Total production in manufacturing, percentage change on previous period (seasonally adjusted), except for China.
2. For China, total industry production excluding construction (not adjusted) was used because of data availability; figures for March`20 were also unavailable.

Figure 8: Monthly Change in Retail Sales, February 2019–March 2020[15]



Source: Authors.

Note:

1. Monthly retail sales, percentage change on previous period (seasonally adjusted).
2. For European Union countries, retail trade except of motor vehicles and motorcycles was used because of data availability.
3. For China, total retail sales in 100 million yuan were retrieved from the data source, and percentage change was calculated without seasonal adjustment.
4. For China, only aggregated total retail sales for January 20 to February`20 were reported (52,129.8 hundred million yuan), so half of the aggregated total was equally allocated each month.

14 Data for EU countries: https://appsso.eurostat.ec.europa.eu/nui/submitViewTableAction.do.
Data for Korea: https://kosis.kr.
Data for the United States: https://www.census.gov/mtis/index.html.
Data for China: https://fred.stlouisfed.org/tags/series?t=china%3Bmonthly.

15 Data for China: https://fred.stlouisfed.org/tags/series?t=china%3Bmonthly.

PREPAREDNESS AND RESPONSE

This section highlights steps the government has taken to bolster its capacity to more effectively mitigate and respond to infectious disease; examines measures the government has implemented, such as rapid testing, contact tracing, and social distancing campaigns; and discusses key interventions to treat patients and prevent the infection of medical and public health professionals on the front line.

Investing in Preparedness for Public Health Emergency

Law and Funding

The revision of the Infectious Disease Control and Prevention Act allocated additional resources to strengthen the KCDC's infectious disease surveillance and response system. A new article was also introduced to allow the director of KCDC to designate "adjacent areas to contaminated areas" that are at risk of infectious disease outbreak and to strengthen quarantine measures for travelers from those areas. Therefore, it has become mandatory for travelers who have spent time in or traveled via contaminated areas, as well as areas adjacent to contaminated areas to submit a health condition questionnaire. In addition, the manager of a facility, such as an airport or a harbor, must give information to users of the facility about the location of contaminated areas (including adjacent areas) and introduce preventive measures.[16]

The reform has come with increased budget allocation. The Korean government's spending on new infectious disease increased from ₩ 68.8 billion in 2015 to ₩ 194.0 billion in 2020 (182 percent increase in five years; annually increased by 23 percent on average).[17] During the same period, total government spending increased by 36 percent and spending on public health increased by 30 percent. In addition, in 2018, the Government-wide R&D Fund project for Infectious Diseases (GFID) research was established with the participation of seven government ministries with ₩ 40 billion for five years (2018–22). Many research projects financed under GFID, such as mathematical predictive analytics for infectious disease, inform the government's response to COVID-19.

Investing in People for Preparedness

The lack of capacity for epidemiological investigation was identified as a major hurdle to control of MERS; this has led to an amendment that mandates the MoHW must maintain at least 30 epidemic intelligence service officers (EISOs). The amendment requires city and provincial governments to have at least two EISOs. After the outbreak of COVID-19, the act was revised again to increase the number of minimum EISOs under the MoHW to 100.[18] The number of EISOs increased to 130 as of January 2020, of which 77 are working for the KCDC and 53 are hired by cities and municipalities.

While the exact amount of time to complete epidemiological investigation differs in each COVID-19 case, on average, a team of three EISOs has spent two to three days to review one patient. With COVID-19, EISOs review two to three cases on a daily basis. These EISOs are credited with providing key information on movement and contact details of confirmed patients, thus allowing health authorities to test and isolate those exposed to COVID-19. Nonetheless, as it was difficult to recruit the

16 Hwang and Hong 2016.

17 The information in this section comes from an analysis done by a senior research fellow at an independent think tank (Narasalim Research Center) conducting public finance analysis.

18 Infectious Disease Control and Prevention Act (Act No.17067), partially amended on March 4, 2020.

necessary number of EISOs through the public sector, provincial and city governments had to temporarily engage private sector medical professionals to perform the role of EISOs. To be qualified as an EISO, one needs to undertake two years of on-the-job training, including a three-week basic training and six sessions of three-day continuation training. In addition to physicians, other medical professionals and public health specialists can apply for EISO positions advertised by the MoHW and provincial and municipal governments.

The 2015 MERS experience highlighted that wearing PPE during emergency could be stressful to medical professionals,[19] and that there was a strong need for training as part of preparedness measures. During the Korean MERS epidemic, although doctors and nurses used PPE, some were infected with Middle East respiratory syndrome–related coronavirus (MERS-CoV), which some epidemiologic researchers attributed to inadequate use of PPE.[20] Since the MERS outbreak, regular training on the use of PPE has been provided to doctors, nurses, and other medical professionals on the front lines by MoHW/KCDC, local and city governments, and medical professional associations. In addition to PPE, a separate training of senior managers of local governments on public health emergency response has been carried out since 2016. In collaboration with the private sector, various other training courses are also being provided to hospital staff for managing health care–related infections and emerging and reemerging infectious disease.

Establishment of Infectious Disease Surveillance and Reporting System

The Korean government has a National Infectious Disease Surveillance System (NIDSS), which covers both the Mandatory Surveillance System (MSS) and Sentinel Surveillance System (SS). For the Mandatory Surveillance System in particular, the national notifiable infectious diseases are to be reported according to the Infectious Disease Control and Prevention Act, and can be reported through the web-based NIDSS (http://is.cdc.go.kr). NIDSS has been developed and managed by KCDC, and occurrence of diseases are reported by public and private health care facilities.[21]

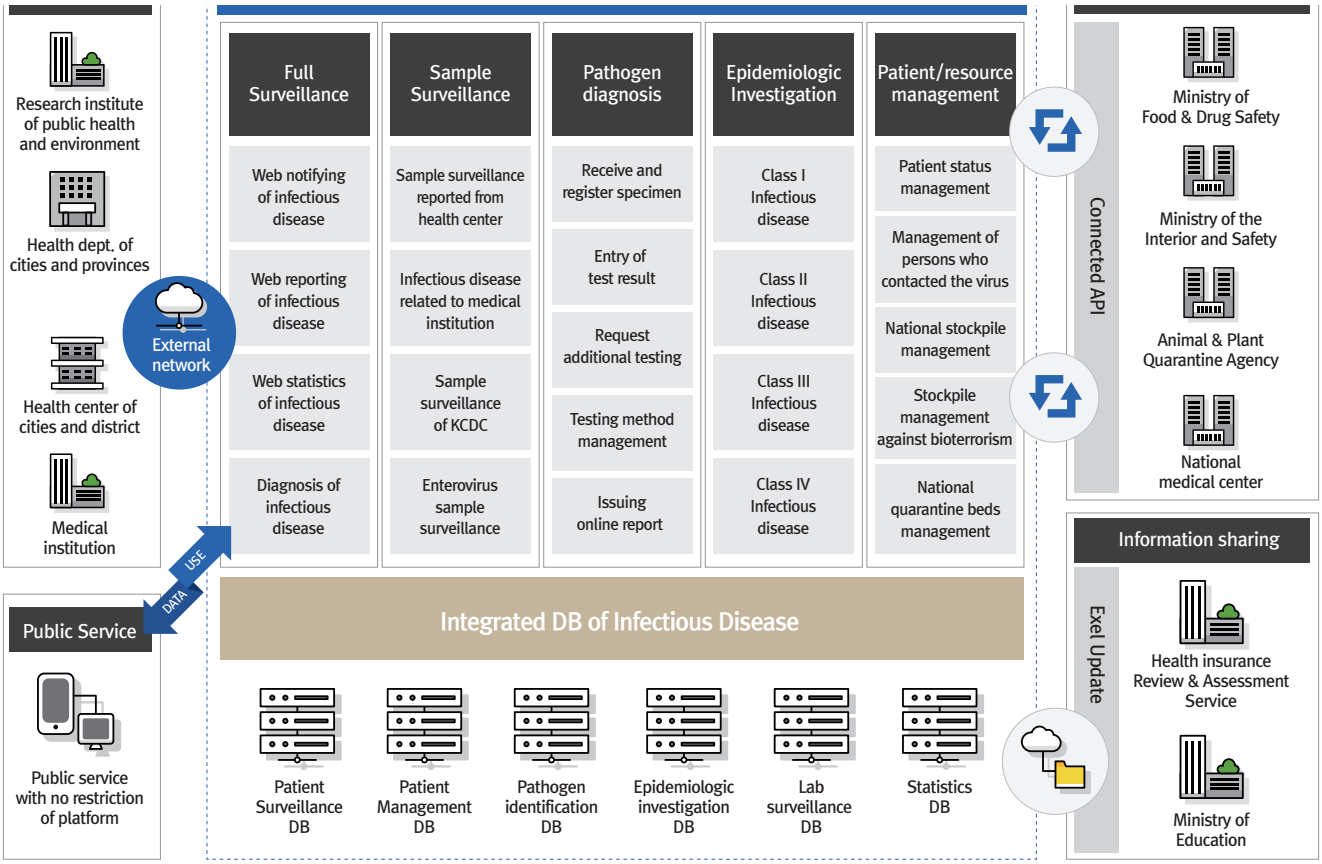
In 2013 KCDC developed the Informatization Plan for the Prevention and Management of Infectious Diseases, and in 2015 the Integrated Information Support System for Monitoring and Control of Infectious Diseases. The system integrates different data reporting activities, such as monitoring of patients, monitoring of pathogen and medium, diagnosis of pathogens, epidemiological investigation, vaccination, management of patients and their contacts, and quarantine management, which are related to national notifiable infectious disease (Figure 9). Status of infectious disease cases can be checked by linking data with other ministries through the Integrated Information Support System for Monitoring and Control of Infectious Disease Management.[22] Currently, the system is integrated with 19,000 medical institutions and health facilities, and when a patient is diagnosed for certain notifiable infectious diseases, the physician at the medical institution can enter the diagnosis result into the Electronic Medical Record (EMR) system at the facility, and the EMR system automatically generates an infectious disease occurrence report, which will be sent to the National Infectious Disease Surveillance System (NIDSS).[23]

SMART Quarantine Information System

A SMART Quarantine Information System was developed in 2017, following the MERS outbreak in 2015. KCDC developed the SMART Quarantine Information System to detect and track any potentially infected patient known to have traveled to

19 Kang et al., 2018.
20 Jeon and Kim, 2016.
21 http://www.cdc.go.kr/contents.es?mid=a20301110100, accessed June 25, 2000.
22 ROK, NIA, 2020.
23 http://www.cdc.go.kr/contents.es?mid=a20301140000, accessed June 25, 2000.

Figure 9: Integrated Information Support System for Monitoring and Control of Infectious Diseases[24]



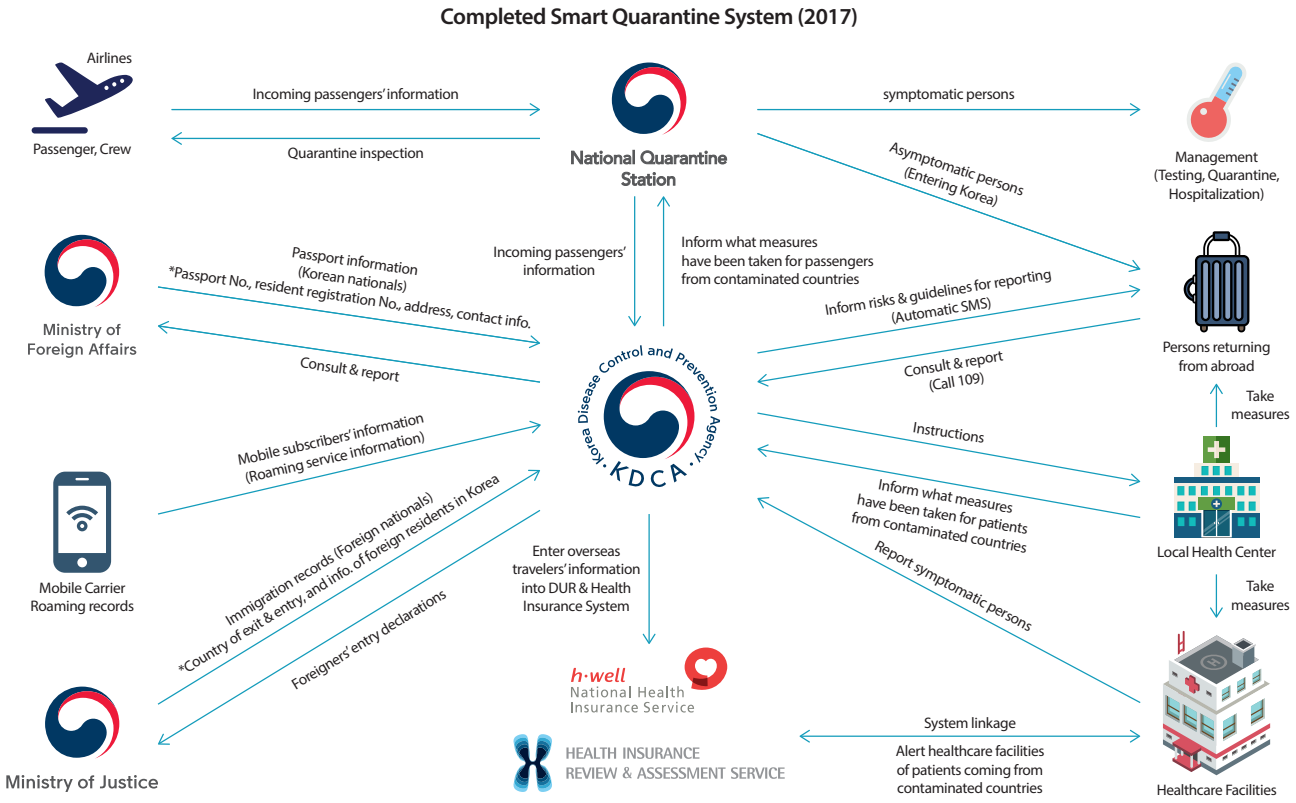
Source: NIA (2020)
Note: DB = Database.

a country with nationwide outbreak of the disease, by utilizing overseas mobile phone roaming information. It was first piloted in partnership with Korea Telecom in 2016, and later the system integrated data from SK Telecom and LG U+ telecom, effectively covering all mobile phone subscribers in Korea.[24] Under this system, information on incoming passengers from the Ministry of Justice, Ministry of Foreign Affairs, airline companies, and telecommunication companies are collected and sent to the quarantine information system of KCDC (Figure 10).

Information on passengers from countries with ongoing infectious disease outbreak is shared with frontline health care facilities during the incubation period of the disease of concern through the Drug Utilization Review and NHI system. Because doctors in local health care facilities can identify overseas travel history during the process of registration, treatment, and prescription, the system helps local doctors quickly identify suspected cases of imported infectious disease, and begin testing, isolation, and treatment of possible COVID-19 cases in a timely manner. Based on roaming data information, Korean citizens and long-term resident foreigners returning from countries with COVID-19 outbreak are notified by telecommunication companies through SMS text messages about the reporting of COVID-19 symptoms. However, there are certain limitations, for instance, if the person does not use the roaming service when taking the mobile phone overseas. Also, if foreign nationals enter Korea without subscribing to one of the three mobile network providers, it will not be possible to detect those travelers.

24 ROK, NIA, 2020, p.12.
25 Yoon et al., 2016.

Figure 10: Smart Quarantine Information System (KCDC)



Source: ROK, MoEF et al. 2020.

Response to Contain the Outbreak

Containing the Spread via Non-Pharmaceutical Interventions

Since the outbreak of the first case, the government has pursued aggressive public health campaigns that mainstream key non-pharmaceutical interventions (NPIs) such as social distancing, personal hygiene including handwashing, coughing etiquette, and mask wearing, and environmental hygiene including ventilation and disinfection. While the KCDC does not have a standing team to constantly monitor and predict the spread of virus by using the epidemic transmission model, it has consulted several GFID-financed research teams doing such work. Established in 2018, several teams in Korea have perform ongoing research on predictive models of infectious disease to understand the scale of infection (reproduction number, *R*).[26] In April, for example, the KCDC explained that keeping R below 1 is an important milestone for COVID-19. The research team, led by one of the coauthors of this case study, calculated R as .5 on average when there were 28 patients in Korea during the first month of the COVID-19 outbreak. The same model assessed the R number of Daegu City and North Gyeongsang Province as 3.5 during the rapid surge based on data provided as of February 28.[27] This figure was almost equivalent to the R of Hubei, China,[28] permitting authorities to elevate the country's alert level for

26 *R* is the disease's ability to spread and indicates the number of people that one patient can pass virus to during the infectious period.
27 Choi and Ki, 2020.
28 Choi and Ki, 2020.

public health emergency and to implement all its associated measures.[29]

Epidemiologists say the R number is determined by the probability of infection (*P*), level of contact with infected persons (*C*), and duration of time a patient is spreading the virus (*D*); for example, *R = P*C*D*. In this public health model, the KCDC and other experts advocate the importance of handwashing and mask wearing to reduce the probability, whereas social distancing campaigns (e.g., flexible work arrangements, closure of high-risk facilities, temporary ban on public protests) have been put forward to reduce the level of contact with infected persons.[30] The government emphasized measures to reduce the duration of infection through aggressive contact tracing, rapid and mass diagnostic testing, and enhanced quarantine to isolate high-risk individuals.

Wearing face masks (reducing the probability of infection)

From the early days of the COVID-19 outbreak, authorities have sent text messages and advised the public to wear masks when symptoms of cough or other respiratory illness are present. As mask wearing was stressed during a significant public health campaign, the country was faced with a serious mask shortage soon after the COVID-19 surge began.

Social distancing (reducing the contact and duration of infection)

The central, provincial, city, and municipal governments have undertaken aggressive public health campaigns, in close collaboration with the private sector and civil society organizations. After designating Daegu City as a special care zone with a strong call for enhanced voluntary social distancing, a nationwide enhanced social distancing measure

29 During the daily briefing on April 6, 2020, the KCDC noted that the aim of preventive measures is to reduce R below 1. As COVID-19 continues to hit the capital region in June, it has been reported that the R of the capital region is 1.8 (reported June 12) which is three times R in other provinces.

30 Cheon, 2020.

Box 1: Management of Mask Inventories via Public Distribution System

The outbreak of COVID-19 in Korea and neighboring countries in East Asia Pacific led to the shortage of face masks in the domestic market and panic buying. To ensure that face masks are available to the public, the Korean government intervened in production and distribution of masks. In February 2020, the government increased the mandatory public supply of face masks, and producers were required to sell 80 percent of their total production through the Public Procurement Service. To increase supply in the domestic market, only 10 percent of the total production was allowed for export; this was revised again, and export was soon banned.

To support producers bearing the cost of extended operations during nights and weekends, the government procured face masks at a higher price—₩ 50 per mask—for quantities produced outside normal operation hours. Also, 8 percent tariff on melt-blown filters was reduced to 0 percent from March 18 until June 30, 2020, to ease the burden of domestic producers. Tariffs on surgical masks was also reduced from 10 percent to 0. In the private sector, large conglomerates played a role in securing components from abroad that were critical to production of mask filters and provided technical assistance to mask producers—most are small and medium enterprises (SMEs)—to increase their outputs through production system management.

People were initially allowed to purchase two masks per week at pharmacies, designated post offices, and agricultural cooperative markets, depending on one's year of birth. The allowance gradually increased to three from April 27 and then to ten from June 18 onward. To prevent multiple purchases, Health Insurance Review and Assessment Service (HIRA) developed a monitoring system, whereby sellers can track buyers' purchase records.

Source: Authors.

was introduced officially on February 29, advising the general public to avoid gathering in groups and to maintain space between people. With the continued upward trend, a stricter social distancing measure was introduced in March for 15 days and then renewed on April 6 for another two weeks, strongly recommending high-risk facilities (e.g., religious sites, indoor sports and entertainment facilities) to suspend operations. After observing consistent downward trends on the daily number of new COVID-19 patients and successful conduct of a nationwide parliamentarian election, measures were partially relaxed on April 20 to allow opening of low-risk facilities that operate outdoors (e.g., sports facilities) or those where user movements may be sufficiently dispersed (e.g., museums).

Prompt and Timely Management of the Source of Infection to Reduce the Duration of Infection

One of the Korean government's most decisive actions has been to prioritize early detection through preemptive and widespread diagnostic tests and rigorous and rapid epidemiological investigation to identify potential patients and isolate them as quickly as possible.

Widespread diagnostic testing capacity

Establishing a widespread diagnostic testing capacity early in the COVID-19 pandemic is credited as one of the most important actions the government has taken to respond to the COVID-19 surge.[31] As of early January, the KCDC set up a special taskforce, which prioritized the development of test kits to effectively and promptly diagnose the COVID-19 virus via reverse transcription polymerase chain reaction (RT-PCR) testing in anticipation of a potential surge. Even before the first confirmed case emerged on January 20 in Korea, the KCDC decided to develop a testing kit for RT-PCR use. The KCDC had developed a pan-corona virus testing methodology by January 11, which involves testing of a sample and comparing it to all existing and known corona viruses, such as SARS. If the result is negative for all other previously known corona virus types, one knows the sample is a case of COVID-19. With this test methodology available, KCDC began the process of developing severe acute respiratory syndrome-coronavirus-2 (SARS-CoV-2)–specific RT-PCR testing kit for COVID-19 on January 13 in cooperation with the Korea Society for Laboratory Medicine, a professional association, and private companies.

By January 26, SARS-CoV-2–specific RT-PCR testing kits were developed and Emergency Use Authorization (EUA) was initiated for expeditious approval. Simultaneously, the KCDC started to assess the viability and performance of potential EUA products from four private laboratory diagnostic manufacturers. The KCDC shared its protocol for RT-PCR test with related academic societies and transferred the RT-PCR laboratory testing technique to 18 public health laboratories in cities and provinces. Less than 10 days later, the first four commercial SARS-CoV-2 RT-PCR products with EUA were released. The process, from protomodel to production for diagnosis, took about 17 days.

By mid-February, the SARS-CoV-2 RT-PCR test was available in public and private laboratory facilities, with about 600 screening sites for patients nationwide, making the COVID-19 test widely and readily available throughout the country. There are a total of 118 institutions administering diagnostic tests: Korea Centers for Disease Control and Prevention (1), National Quarantine Stations (4), Institutes of Health and Environment (18), and private clinical laboratories and hospitals (95). On average, 15,000 tests (maximum 20,000) can be performed per day with a testing turnaround time of 6 to 24 hours, with all laboratories under strict quality assurance supervision. Test centers are distributed across the country, and people have easy access to them (Table 2). Screening sites are designated facilities for collecting specimen samples, not testing, and they are located in public health centers and

31 Oh et al., 2020.

public hospitals as well as in designated private hospitals.

Table 2: Testing Capacity across Regions

Metropolitan City/Province	Total	Where Samples Can Be Collected	Per 1 million persons
Seoul	73	71	7.2
Busan	44	39	11.4
Daegu	19	19	7.8
Incheon	31	31	10.5
Gwangju	12	11	7.6
Daejeon	14	14	9.5
Ulsan	12	12	10.5
Sejong	2	2	5.8
Gyeonggi	111	107	7.8
Gangwon	38	38	24.7
Chungbuk	32	32	20.0
Chungnam	33	33	16.0
Jeonbuk	28	28	15.4
Jeonnam	57	55	29.5
Gyeongbuk	48	48	18.0
Gyeongnam	55	53	15.8
Jeju	13	13	10.4
Total	622	606	11.5

Source: https://www.mohw.go.kr/react/popup_200128_3.html.

Innovations in testing: Reducing contacts and protecting medical/quarantine professionals

Both drive-through and walk-through screening facilities have been utilized to effectively screen without making such sites potential clusters of infection.

- Drive-through screening centers

The drive-through screening procedure was introduced for faster and safe screening practice and is widely shared globally since its pilot introduction in February. With the drive-through process, the person who is to be tested does not exit the vehicle, minimizing the chance for infection transmission. As soon as the concept was suggested and implementation guidelines became available, drive-through screening centers were established in four different locations, and now the practice has spread to many parts of the country and is widely available both within Korea and in many other countries as well. Currently, there are about 50 drive-through screening centers in operation in Korea.[32]

- Walk-through testing

While drive-through sites served well for testing patients with private vehicles, they were not optimal in dense urban environments with fewer drivers and less available space for car queues. To expand low-contact testing to these areas, hospitals created "walk-through" centers, where rows of plastic booths (roughly the size of a phone booth) were fitted with depressurizers, intercoms, and attached gloves for doctors outside the booth to interact with and collect samples from patients. Subsequent variants have inverted the model by placing the health care worker inside the booth, while the patient stands outside to be tested; this speeds up the process, since the booth does not need to be disinfected between patients. These booths have made low-contact testing possible for nondrivers, and their small, mobile footprint allows them to be deployed in dense urban cores nearer to transit and residential areas.

Establishing a System to Conduct Rapid Epidemiological Investigation

The epidemiological investigation is conducted by the epidemic intelligence service officers (EISOs) led by either KCDC and/or the city and provincial health authority to investigate, classify, track, and manage contacts by identifying the patient's route to prevent further transmission. To ensure promptness, primary epidemiological investigations for individual cases are performed by local governments. For outbreaks within health care institutions and group facilities, the Emergency Response Epidemiological Team of KCDC is dispatched to perform epidemiological investigations in collaboration with the epidemiological investigation bureau of the local government. In dealing with COVID-19, KCDC tripled its initial 10 Emergency

32 https://www.mohw.go.kr/react/popup_200128_4.html, accessed June 27, 2000.

Response Epidemiological Teams to 30. Each team comprises 5 to 7 people including one quarantine officer, one or two EISOs (mostly medical doctors or public health experts), and other supporting public health personnel. Local governments appointed their own ad hoc Epidemiological Investigative Teams composed of medical professionals. The central and local teams work in close collaboration.

The process of epidemiological investigation involves four steps: investigation, risk assessment, contact classification, and contact management. In the process of epidemiological investigation, a detailed patient interview is conducted to obtain information to identify the route of movement. If needed, interviews with health care workers and family members may also be conducted. However, omissions and errors in listing, describing, and recalling activities can occur during the interview. To overcome these limitations, additional information to objectively verify the patient's claims (medical facility records, GPS-based mobile phone location information, credit card transaction log, and closed-circuit television footage) are used for COVID-19 contact investigations.

Access to mobile phone usage location data and credit card log makes it possible to identify the detailed movement and location of where the patient has been. Based on the Infectious Disease Control and Prevention Act revised in 2015, KCDC and local governments can request national and local police agencies for location information of patients. Although the KCDC has been granted access to that information, the request for information was done manually for each epidemiologic investigation, taking about 24 hours for the contact tracing effort to be completed. The police, telecommunication company, and credit card agency responded to the request for every case separately as well. Thus, in COVID-19's earlier phase in Korea, there was still much human effort; not everything was undertaken through a fully ICT-based process.

To facilitate investigation and risk assessment processes of epidemiological investigation, the government launched the COVID-19 Epidemiological Investigation Support System (EISS), a centralized data collection and multiagency coordination platform. In accordance with the Infectious Disease Control and Prevention Act, this platform was developed by the Ministry of Land, Infrastructure, and Transport (MoLIT) by utilizing the smart city data hub technology that collects and processes large amounts of data produced in the city. The data hub was researched and developed in Daegu City and Siheung (Gyeonggi Province), to enable real-time analysis of big data, such as transportation, energy, environment, and safety, in various areas of the city.

In this data platform, transmission routes and places visited by the confirmed patient can be identified by real-time analysis of GPS data, mobile phone information, and credit-card transactions for a spatial-temporal analysis. Further, big data analysis can process large amounts of the real-time data, including locations visited and time spent at each location, and enable detection of any incidence of cluster infection and show the source of transmission. This platform is currently managed by the KCDC and operated in close collaboration with the Korean National Police Agency, Credit Finance Association, three telecommunications companies, and 22 credit card companies. This system is not used for all confirmed cases, but when epidemiological investigators determine the information collected through the interview is insufficient, and more objective data are needed for verification. EISS has reduced the time needed for each case analysis from 24 hours to 10 minutes.

Following the epidemiological investigation, information on the whereabouts of confirmed cases is uploaded on websites. However, pertinent information is anonymized and disclosed to the public with due care to protect privacy, but allow those who may have crossed paths with confirmed cases to get themselves tested.

Contact Management

Family members, housemates, and other contacts identified by epidemiological investigation on patient travel and infection routes are subject to self-quarantine for the maximum incubation period (14 days) beginning from the day after the date of contact with a confirmed patient, and must have their symptoms monitored.

The Ministry of the Interior and Safety (MoIS) and local governments manage those under self-quarantine on a one-to-one basis. The contacts identified during the investigation are required to attend health care education, have their symptoms monitored, and remain in self-quarantine. Those in self-quarantine are prohibited from leaving the country for 14 days regardless of their health status. Those who violate self-quarantine guidelines may face up to a ₩ 10 million fine or one year of imprisonment. All contacts are subject to self-isolation for 14 days regardless of test results.

Finding patients through screening for groups at high risk of infection

The government carried out screening for groups at high risk of infection as part of its strategy for early detection, especially in long-term care facilities, such as geriatric hospitals, nursing homes, and mental care institutions. From April 17 to 27, the government carried out sample screening tests for long-term care facilities in the Seoul Metropolitan Area. Given the limited capacity to administer tests for all facilities, screening was conducted for a randomly selected sample of 46 facilities. This represents approximately 10 percent of 438 long-term care facilities in the area. In total, 6,544 employees and patients were tested using a pooling testing method. The tests showed negative results for all people who were tested. The government will continue to strengthen monitoring for high-risk facilities and plans to expand and continue preemptive screening for groups at high risk of infection.

Overseas infection sources—no entry, or inspection and quarantine after entry

The government put measures in place to manage the potential risk of cross-border traffic, not with a blanket entry ban, but with continuous adaptation and fine-tuning of measures designed to control and track inbound travelers. These measures include special entry procedures, self-diagnosis mobile app, mandatory testing, and facilities for quarantine or self-quarantine for two weeks for all inbound travelers.

As a measure to reduce imported cases of infection, Korea only banned foreigners from entering the country via Hubei Province on February 4. During that time, the country transferred about 845 Koreans to the country three times (January 31, February 1, and February 12) from Wuhan (capital of Hubei), which was previously blocked. Considering potential unintended side effects of the entry ban on the economy and foreign relations, the government chose not to impose a significant entry ban. Instead, in January, inbound travelers from China or via China were required to check for fever and confirm contact before departure and install a Corona Management App to be used in Korea. Since the rapid outbreak, those who enter the country from high-risk countries with confirmed widespread local transmissions have been tested for COVID-19 either at the airport or within three days, and actively monitored for 14 days through the Corona Management App if they are negative.

Use of self-health check-in and self-screening

To expedite the screening process, all inbound travelers have been required to install self-health–check mobile apps at the point of entry since April 1. Through the app, inbound travelers fill out a special quarantine form and record their temperatures. (The minimum requirement for this process is ownership of a smartphone. Non-smartphone users with 2Gpitcher phone will still have to go through a manual screening process.) Self-health check and screening must be performed for common symptoms of COVID-19 infection, including the presence of fever and/or any respiratory symptoms. This self-health–check mobile application is being used by all incoming passengers during the initial arrival and screening process; if there is any combination of symptoms, such as fever and sore throat, the person will be examined and tested by public health officials. For Incheon International Airport, which is the largest airport in the country and the main gateway for inbound travelers, the test is performed at the airport. If test results are positive, the infected person will be hospitalized for at least 14 days, at a special quarantine hospital for severe cases, and at a living treatment center for mild cases. Even if there are no symptoms, if the traveler is from a COVID-19–prone country, he/she must be quarantined for 14 days and a quarantine procedure must be strictly followed.

Monitoring of Self-Quarantine Cases

During the process of contact tracing of confirmed COVID-19 cases, if the person in question is a "close contact" case, he/she has to undergo movement restriction and self-quarantine effectively. To enhance monitoring of the self-quarantine, the government developed the Self-Quarantine Safety Application. Self-quarantine is required for all inbound travelers from outside of Korea, and use of the app has also been mandatory for inbound travelers including Korean citizens since April 1. Two different self-quarantine apps have also been developed, the first type for the person in quarantine, and the second for the assigned government officer monitoring the person in quarantine.

During the self-quarantine process, the person in quarantine should stay in the designated location for 14 days and must check and report temperature and symptoms using the Self-Quarantine Safety Application. During the quarantine, if the person does not report his/her symptoms, he/she will be tracked through the self-health–check mobile system. Also, if the person ventures away from the designated quarantine location, notification will be sent to the local authority's monitoring personnel, who will make immediate inquiries about the person's whereabouts. The application has three key functions, namely, self-diagnosis and result submission, GPS-based location tracking for preventing quarantine violation, and provision of information such as self-quarantine guidelines and contact information of the case officer.

Usage of the app among inbound travelers from outside of Korea has been 95.0 percent; for Korean citizens residing in Korea, the usage rate was 87.7 percent; and the cumulative overall usage rate was 93.8 percent (as of June 12, 2020). Among all people who have been in self-quarantine, only 0.16 percent (531 out of 324,160) breached self-quarantine. However, of that 531, 31 percent (162 cases) were reported by neighbors, and only 27 percent (141 cases) were discovered by smartphone application. Although Self-Quarantine Safety Application would help monitor people in self quarantine, it doesn't seem to be a perfect solution, and local government officers' manual monitoring through phone call or visits still seem to be necessary.[33]

33 MoHW Press Release, June 12, 2020, https://www.mois.go.kr/frt/bbs/type010/commonSelectBoardArticle.do?bbsId=BBSMSTR_000000000008&nttId=77840.

Response to Reduce Mortality

Countermeasures to reduce mortality are predominantly medical responses; key to Korea's efforts to manage mortality was redesign of the triage and treatment systems and transfer of patients to appropriate levels of treatment institutions. Patients with mild symptoms were admitted to a living treatment center, whereas patients with severe symptoms were admitted to designated hospitals. Those with critical conditions were admitted to a state-designated isolation room. In Korea, about 85 percent of patients had mild symptoms. Therefore, when there are insufficient medical facilities due to the high incidence of patients, about 10 percent of moderately ill patients were admitted to hospitals with oxygen treatment. About 5 percent of patients with critical conditions received treatment in hospitals with intensive care units equipped with ventilators. About 1 percent was reported to have required an extracorporeal membrane oxygenation (ECMO) treatment.

An innovative approach that has been viewed as critical in the response to COVID-19 has been the use of living treatment centers for mild cases of infection. With a large number of suspected and confirmed cases during the short period of time in February, the medical care system in Daegu City was quickly overwhelmed. Initially, most confirmed patients were hospitalized in isolated beds in various medical facilities. However, the isolated bed capacity was quickly filled, and later even the regular hospital beds were in shortage, with confirmed patients having to stay home waiting to be admitted, and some dying before hospital admission. A number of dormitories or hotel-like facilities were quickly mobilized and transformed into living treatment centers; some were government facilities such as the National Training Institute of Education, Science, and Technology, and some were training and retreatment facilities of private corporations that volunteered their facilities for public use.

At living treatment centers, confirmed patients perform self-monitoring twice a day; operations are supported by a pan-government support team composed of health care and administrative staff and medical supplies such as PPEs and specimen collection kits for on-site screening. While patients are provided appropriate care in isolation, for example, telemedicine, if the clinical condition of patients worsens, it can be quickly identified and the patient transferred to the hospital for requisite and timely care. As for monitoring of patients, temperature and other COVID-19 related symptoms including respiratory symptoms are monitored. Operations at all living treatment centers are supported by nearby private and public hospitals, including many university hospitals. As of June 19, 20 living treatment centers are in operation, and a total of 4,016 confirmed COVID-19 patients have been treated there, of which 3,145 have been discharged.[34]

Depending on the hospital or medical institution managing the living treatment center, patient symptoms are monitored by telephone calls, use of google survey tool or smart phone applications, or telehealth/telemonitoring systems. At the living treatment center supported by Kangwon University Hospital, smartphone applications were used for self-monitoring of symptoms, through a dashboard to view temperature and other symptoms.[35] In Seoul National University's living treatment centers, a smart patient monitoring system for telemonitoring of patients has been utilized for continuous automated monitoring of temperature and other vital signs including electrocardiogram (ECG), blood pressure, oxygen concentration, and respiratory rate.[36]

34 MoHW Press Release, June 19, 2020, http://www.mohw.go.kr/react/al/sal0301vw.jsp?PAR_MENU_ID=04&MENU_ID=0403&page=1&CONT_SEQ=355063.

35 Park et al., 2020.

36 Seoul National University Hospital, March 19, 2020, http://www.snuh.org/m/board/B003/view.do?bbs_no=5104&searchKey=&searchWord=&pageIndex=1.

Prevention of Infection of Medical Staff

To reduce the number of medical staff infections, there has been a switch to non-face-to-face care such as telephone counseling, proxy prescription, and video treatment for regular patients, and COVID-19 tests are conducted for symptomatic patients before entering the hospital, intensive care unit, and emergency room. For early detection of suspected patients, the medical institution provides patient information such as the history of visiting COVID-19 outbreak areas and contact with confirmed patients, by utilizing the NHI information system. Above all, the government ensures that PPE—full-body protective clothing and N95 masks—are supplied to medical staff to meet demand and to stockpile supplies in case the number of patients increases further. Hospitals dedicated to infectious diseases and living treatment centers secure safety zones that distinguish the movements of COVID-19 patients and medical personnel.

Public Sharing of Data and Information

Risk Communication and Messaging

The government sends out emergency messages to the general public on the COVID-19 situation using Cellular Broadcasting Service (CBS). Messages can be sent without having to use general SMS text messaging, with customized warning sounds in the affected area through mobile telecom carriers. Short messages can be sent through this system with emergency alerts or guidelines to citizens. The public warning system is administered by the Ministry of the Interior and Safety in collaboration with related government agencies, local governments, and mobile telecom service providers. After contact tracing has been conducted, detailed information about movement history and locations the patient has passed through are shared with the general public for open and transparent communication.

Data Privacy Issues and Other Challenges

While the government's prompt response has been generally lauded for containing the COVID-19 outbreak in Korea, controversies have arisen on data privacy as have other challenges. First, MoHW and KCDC were granted access to large amounts of personal data, for collecting, profiling, and sharing of seven categories of information for large-scale infectious disease outbreak. Data on locations, credit card transactions, and closed circuit television (CCTV) footage were extensively used for contact tracing. Additionally, sex and age of confirmed cases were shared by some local governments, and information such as names of restaurants, shops, and other businesses were disclosed in some cases.[37] Later, a guideline was issued on the scope and details of information disclosure by municipal and local governments, and a recommendation not to reveal exceedingly detailed information has been issued by the National Human Rights Commission.

Finding the Balance between Data Privacy, Confidentiality, and Transparency

There are difficulties in deciding how much of the data can be accessed and utilized to control outbreak of infectious disease. A citizen's right to privacy is an important consideration, but urgency and transparency of sharing information is also crucial for public health. In the long run, justification of sharing data related to individual citizens will be granted only when scientific and epidemiological rationale for concrete benefits can be clearly demonstrated. However, in the event of a previously

37 Park, Choi, and Ko, 2020.

unknown, widespread outbreak of novel infectious disease, timely response is crucial, and there can be justification through consensus for using some part of the data for contact tracing and making them available to the general public. The so-called Korean model of COVID-19 control is not in its final form but rather a work in progress and continued narrative of effort to respond to the outbreak.

Transitioning to Reduced Restrictions

The Central Disaster and Safety Countermeasures Headquarters announced an end to strict social distancing from May 6 to make disease prevention and control compatible with daily life, such as engaging in economic activities, while managing risks and preparing for possible contingencies. The quarantine authorities and other experts evaluate the COVID-19 situation periodically and comprehensively with the aim to maintain an average of fewer than 50 new cases per day, less than 5 percent of cases of unidentified infection route, and the number and size of the cluster outbreak. Depending on the results of the evaluation and periodic assessment of risk, the level of distancing required will be adjusted among three stages: social distancing, enhanced social distancing, and strict social distancing.

LESSONS LEARNED AND KEY TAKEAWAYS FOR OTHER COUNTRIES

The Korean experience offers many takeaways for responding to the COVID-19 pandemic. First, countries need to take their own global health security ranking, and the criteria behind the ranking, seriously. According to the Global Health Security Index (GHSI), Korea is ranked ninth overall, as one of the most prepared countries, and behind only the United States, the United Kingdom, and Sweden, to name a few; and fifth and sixth, globally out of 195 countries for early detection and rapid response, respectively.[38] High ranking has, at least for Korea, proved to have validity in predicting its overall highly effective response, and as such should be a case study for other countries that would like to emulate Korea's success.

Second, in view of Korea's highly effective response, much better than those countries ranked higher, another lesson is to have a much closer look at gaps between the theory and action in both preparedness and response, and why and how in the case of Korea, these were minimal if not nonexistent. One of the six components of the GHSI refers to having a "sufficient and robust health system to treat the sick and protect the health workers," and another cites "commitment to enhancing national capacity, financing and adherence to norms." Korea ranked 13 and 23, respectively, still high rankings, but classified as "more prepared" rather than "most prepared." And yet, the evidence presented in the report clearly demonstrates that the "robustness" of Korea's health care system was only partly put to the test in responding to a surge in demand, which did not really occur, except in one municipality (Daegu City) early on, because of very effective and widespread testing, tracking, isolation, and quarantine, resulting

38 Global Health Security Index, www.ghsindex.org.

in a low caseload for the health care system. As for commitment to enhancing national capacity, post-MERS legislative and regulatory reforms, and investment in strengthening KCDC and training EISOs as well as proper and flexible financing of public health measures proved to be not only crucial but a clear case of an ounce of prevention being worth a pound of cure.

A third lesson is about the importance of learning lessons from the past. Korea did that effectively after the SARS and MERS outbreaks through a series of legislative, regulatory, institutional, and financing reforms to shore up its public health preparedness and response system. The strengthening of KCDC through a reorganization of the NIH, its policy, applied research, and training capabilities are cases in point. In short Korea, unlike the majority of countries globally, was prepared and ready.

A fourth lesson for LMICs where there is mix of public-private provision in service delivery is the role of government in leading the preparedness and response, and yet working with the private sector for a common good—in manufacturing of PPEs, scaling up of testing, or sharing responsibilities in patient care with private entities, including private hospitals and living treatment centers. While one is often tempted to underestimate the potential for the public-private mix under normal circumstances, let alone during a pandemic, sound and effective system governance, in tandem with a single purchaser, as shown here, could significantly and effectively leverage what the private sector has on offer for the common good. Universal health coverage, thanks to the NHI system, covering the entire population and encompassing all health care providers through a single pool, ensures access to testing and treatment without financial barriers.

A fifth lesson would be the added value of whole-of-government governance to establish extensive use of digital platforms and technologies for a swift, expansive, and effective response, with minimal risk for privacy, confidentiality, and citizens' rights. This would demonstrate government's leadership, decisiveness, and ability to inform citizens of the pros and cons of accessing private information and to persuade them of the need for doing so at a minimal risk, given the circumstances and the imperative of swift action for testing, tracking, self-health, check-in, and quarantine. Granted, Korea is a developed country, and Koreans are digitally very well connected. Still, a high degree of trust was necessary to ensure compliance with fairly intrusive measures such as the requirements for downloading apps to track mobility in case of quarantine and track consumer behavior, or require citizens to regularly enter information about their whereabouts and health, not to mention integrate data across a panoply of public (e.g., Ministry of the Interior and Safety, Ministry of Foreign Affairs) and private entities (telecom companies).

A sixth and final lesson would be about flexibility and making adjustments as the epidemic progresses and data are fed in for analysis and decision making. Through the course of the outbreak, Korea had to amend a few laws, reconfigure roles and responsibilities of some agencies such as KCDC, invoke the establishment of the CDSCHQ under the leadership of the prime minister, come up with the concepts of drive-through testing and living treatment centers for the asymptomatic, create new apps to monitor and track cases and domestic and international mobility, and fine-tune social distancing to ensure that life and economic activities are least disrupted. And the results show that the Korean economy will be one of the least affected in terms of loss of productivity, unemployment, and growth.

Could Korea have done even better than it did? What could have enhanced its effectiveness above and beyond what has been the case? There are two areas for future improvement in Korea, and by proxy for other countries. One is the importance of having a highly effective primary health care platform for first contact. Health care in Korea has traditionally been highly hospital-centric and predominantly private. The health workforce, while highly trained and competent, is also highly specialized, leaving little room for people-centered integrated primary care at the

community level. In so much as the overall response of the health care system has been exemplary in many ways, a robust and high-performing health care system with community outreach could have averted some of the initial less-than-optimal response, and reduced the need for extraordinary measures in surveillance, testing and case detection, and follow-up. Second, is more targeted socioeconomic support to the elderly, especially those in extended care facilities, the poor, and the vulnerable through a range of policy interventions including cash transfers, income guarantees for the duration of the epidemic, and additional measures to support those providing essential services.

Some caveats should be noted on the Korean experience: culturally and legally, the society is more tolerant of personal data-sharing, and its success has been heavily dependent on its ability to rapidly scale up technological solutions. Further, in the early stage, transmission occurred in a small number of events or locations, such as megachurch services, that facilitated contact tracing, in contrast to other settings where cases spread through multiple smaller clusters and community transmission. Conditions in other countries may hinder adapting such strategies.

In conclusion, Korea has responded remarkably well to the COVID-19 pandemic, mainly because it was well prepared for it, and by acting swiftly with a whole-of-government effort and public-private partnerships both at the central and local levels at negligible cost to the economy, proving once again that sustained investment in preparedness and response pays off handsomely many times over, a lesson for all countries, low, middle or high income. Decisive and data-driven leadership, strategic clarity (a focus on testing and contact tracing), and willingness to innovate are also crucial.

References

Acemoglu, D., V. Chernozhukov, I. Werning, and M. D. Whinston. 2020. *A Multi-Risk SIR Model with Optimally Targeted Lockdown*. NBER Working Paper 27102. Cambridge, MA: National Bureau of Economic Research.

Cheon, Byeong-cheol. 2020. "The Reason Why Social Distancing Is the Most Powerful Measure for Preventing the Spread of Infectious Disease." March 30. http://www.korea.kr/news/contributePolicyView.do?newsId=148870965&pageIndex=1.

Choi, S., and M. Ki. 2020. "Estimating the Reproductive Number and the Outbreak Size of COVID-19 in Korea." *Epidemiology and Health* 42. https://www.e-epih.org/journal/view.php?doi=10.4178/epih.e2020011.

Goldman Sachs. 2020. "Global Economics Comment: Effective Lockdown Index." https://www.gspublishing.com/content/research/en/reports/2020/04/27/3a0089c7-c1d1-4243-8dbd-da6141a501be.html, Accessed May 8, 2020.

Hwang, Ji-hye, and Hong Sung-jin. 2016. "Alteration of Quarantine System since MERS Outbreak in Korea." August 11. Seoul: Division of Quarantine Support, Center for Infectious Disease Control, Korea Centers for Disease Control.

Infectious Disease Control and Prevention Act (IDCPA). 2015. Seoul: Republic of Korea. http://www.law.go.kr/lsInfoP.do?lsiSeq=172762&ancYd=20150706&ancNo=13392&efYd=20160107&nwJoYnInfo=N&efGubun=Y&chrClsCd=010202&ancYnChk=0#0000.

_____. 2020. Seoul: Republic of Korea. http://law.go.kr/LSW/lsRvsRsnListP.do?lsId=001792&chrClsCd=010102&lsRvsGubun=all.

Jeon, M. H., and T. H. Kim. 2016. "Institutional Preparedness to Prevent Future Middle East Respiratory Syndrome Coronavirus-Like Outbreaks in Republic of Korea." *Infection and Chemotherapy* 48 (2): 75–80. https://doi.org/10.3947/ic.2016.48.2.75.

Kang, J., E. J. Kim, J. H. Choi, H. K. Hong, S. H. Han, I. S. Choi, J. G. Ryu, et al. 2018. "Difficulties in Using Personal Protective Equipment: Training Experiences with the 2015 Outbreak of Middle East Respiratory Syndrome in Korea." *American Journal of Infection Control* 46 (2): 235–37.

Kim, B. 2020. "Lessons for America: How South Korean Authorities Used Law to Fight the Coronavirus," *Lawfare*. https://www.lawfareblog.com/lessons-america-how-south-korean-authorities-used-law-fight-coronavirus.

KCDC (Korea Centers for Disease Control and Prevention). 2020. "2018 White Paper for Management of Disease Control." Cheongju: KCDC.

Kwon, S. 2008. "Thirty Years of National Health Insurance in South Korea: Lessons for Achieving Universal Health Care Coverage." *Health Policy and Planning* 24 (1): 63–71. doi:10.1093/heapol/czn037.

_____. 2018. "Advancing Universal Health Coverage: What Developing Countries Can Learn from the Korean Experience?" Universal Health Coverage Studies Series no. 33. Washington, DC: World Bank.

_____. 2020. "COVID-19: Lessons from South Korea." *Health Systems Global Blog*. https://www.healthsystemsglobal.org/blog/406/COVID-19-Lessons-from-South-Korea.html.

Lee, C., and M. Ki. 2015. "Strengthening Epidemiologic Investigation of Infectious Diseases in Korea: Lessons from the Middle East Respiratory Syndrome Outbreak." *Epidemiology and Health* 37: e2015040-e2015040. doi:10.4178/epih/e2015040.

Loayza, N. V. 2020. "Costs and Trade-Offs in the Fight against the COVID-19 Pandemic: A Developing Country Perspective." Research and Policy Brief no. 35. Washington, DC: World Bank.

ROK, MoEF, MSIT, MoIS, MoHW, MoLIT, and KIPO (Republic of Korea, Ministry of Economy and Finance, Ministry of Science and ICT, Ministry of the Interior and Safety, Ministry of Health and Welfare, Ministry of Land, Infrastructure, and Transport, and Korean Intellectual Property Office). 2020. "Flattening the Curve on COVID-19. How Korea Responded to a Pandemic Using ICT." Sejong Special Governing City, April 15. https://www.mois.go.kr/eng/bbs/type002/commonSelectBoardArticle.do?bbsId=BBSMSTR_000000000022&nttId=76748 Accessed June 30, 2020.

ROK, MoHW (Republic of Korea, Ministry of Health and Welfare). 2020. *2020 Ministry of Health and Welfare's Budget and Fund Management Plan Overview*. MoHW, Sejong Special Governing City.

RoK, MoHW, CDSCHQ (Republic of Korea, Ministry of Health and Welfare, Central Disaster and Safety Countermeasures Headquarters). 2000. "Coronavirus Infection-19 Current Status in Korea." CDSCHQ, Sejong Special Governing City. http://ncov.mohw.go.kr/tcmBoardView.do?contSeq=359027. Accessed September 20, 2020.

ROK, MoHW, KCDC, and MoEF (Republic of Korea, Ministry of Health and Welfare, Korea Centers for Disease Control and Prevention, and Ministry of Economy and Finance). 2020. "Tackling COVID-19: Health, Quarantine and Economic Measures of South Korea." Sejong Special Governing City, March 31. http://english.moef.go.kr/pc/selectTbPressCenterDtl.do?boardCd=N0001&seq=4868. Accessed June 15, 2020.

ROK, NIA (Republic of Korea, National Information Society Agency). 2020. "Korean ICT Services against COVID-19 Pandemic." NIA, Sejong Special Governing City. https://www.nia.or.kr/site/nia_kor/ex/bbs/View.do?cbIdx=39485&bcIdx=22151&parentSeq=22151, Accessed June 28, 2020.

OECD (Organisation for Economic Co-operation and Development). 2019. *Health at a Glance 2019: OECD Indicators*. Paris: OECD Publishing. https://doi.org/10.1787/4dd50c09-en.

Oh, J., J. K. Lee, D. Schwarz, H. L. Ratcliffe, J. F. Markuns, and L. R. Hirschhorn. 2020. "National Response to COVID-19 in the Republic of Korea and Lessons Learned for Other Countries." *Health Systems and Reform* 6 (1): e-1753464.

Our World in Data. 2020. "COVID-19 Government Response Stringency Index." https://ourworldindata.org/coronavirus-country-comparisons.

Park, P. G., C. H. Kim, Y. Heo, T. S. Kim, C. W. Park, and C. H. Kim. 2020. "Out-of-Hospital Cohort Treatment of Coronavirus Disease 2019 Patients with Mild Symptoms in Korea: An Experience from a Single Community Treatment Center." *Journal of Korean Medical Science* 35 (13).

Park, S., G. J. Choi, and H. Ko. 2020. "Information Technology–Based Tracing Strategy in Response to COVID-19 in South Korea—Privacy Controversies." *Jama* 323 (21).

Parpia, A., M. Ndeffo-Mbah, N. Wenzel, and A. Galvani. 2016. "Effects of Response to 2014–2015 Ebola Outbreak on Deaths from Malaria, HIV/AIDS, and Tuberculosis, West Africa." *Emerging Infectious Diseases* 22 (3): 433–41.

Seoul National University Hospital. 2020. "State of the Art Monitoring System That Was Embedded in Moon Kyung Residential Treatment Center Managed by Seoul National University Hospital." http://www.snuh.org/m/board/B003/view.do?bbs_no=5104&searchKey=&searchWord=&pageIndex=1. Accessed July 27.

Taylor, K., and L. Silver. 2019. "Smartphone Ownership Is Growing Rapidly around the World, but Not Always Equally." Washington, DC: Pew Research Center.

WHO (World Health Organization). 2020. "Public Health Criteria to Adjust Public Health and Social Measures in the Context of COVID-19." https://www.who.int/publications/i/item/public-health-criteria-to-adjust-public-health-and-social-measures-in-the-context-of-covid-19.

Yoo, Katelyn J., Soonman Kwon, Yoonjung Choi, and David Bishai. 2020. "Systematic Assessment of South Korea's Capabilities to Control COVID-19." Under Review.

Yoon, J. H., T. J. Son, E. H. Kim, and S. J. Hong. 2016. "Smart Quarantine System Using ICT." *Public Health Weekly Report* 9 (51): 1040–43.

You, M. 2020. "Risk Perception by Public on COVID-19: 4th Wave." PPT Presentation, School of Public Health, Seoul National University.

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