Health Systems & Reform

ISSN: (Print) (Online) Journal homepage: https://www.tandfonline.com/loi/khsr20

National Response to COVID-19 in the Republic of Korea and Lessons Learned for Other Countries

Juhwan Oh , Jong-Koo Lee , Dan Schwarz , Hannah L. Ratcliffe , Jeffrey F. Markuns & Lisa R. Hirschhorn

To cite this article: Juhwan Oh , Jong-Koo Lee , Dan Schwarz , Hannah L. Ratcliffe , Jeffrey F. Markuns & Lisa R. Hirschhorn (2020) National Response to COVID-19 in the Republic of Korea and Lessons Learned for Other Countries, Health Systems & Reform, 6:1, e1753464, DOI: 10.1080/23288604.2020.1753464

To link to this article: https://doi.org/10.1080/23288604.2020.1753464

Published online: 29 Apr 2020.

HEALTH SYSTEMS & REFORM
2020, VOL. 6, NO. 1, e1753464 (10 pages)
https://doi.org/10.1080/23288604.2020.1753464

Taylor & Francis
Taylor & Francis Group

National Response to COVID-19 in the Republic of Korea and Lessons Learned for Other Countries

Juhwan Oh [a,b†], Jong-Koo Lee [c†], Dan Schwarz [d,e], Hannah L. Ratcliffe [d], Jeffrey F. Markuns [f], and Lisa R. Hirschhorn [d,g]

[a]Department of Medicine, Seoul National University College of Medicine, Seoul, South Korea; [b]Department of Social and Behavioral Health, Harvard T.H. Chan School of Public Health, Boston, MA, USA; [c]Department of Family Medicine, Seoul National University College of Medicine, Seoul, South Korea; [d]Ariadne Labs, Brigham & Women's Hospital and Harvard T.H. Chan School of Public Health, Boston, Massachusetts, USA; [e]Division of Global Health Equity, Brigham & Women's Hospital, Boston, MA, USA; [f]Global Health Collaborative, Department of Family Medicine, Boston University, Boston, MA, USA; [g]Northwestern University Feinberg School of Medicine, Chicago, IL, USA

ABSTRACT

In the first two months of the COVID-19 pandemic, the Republic of Korea (South Korea) had the second highest number of cases globally yet was able to dramatically lower the incidence of new cases and sustain a low mortality rate, making it a promising example of strong national response. We describe the main strategies undertaken and selected facilitators and challenges in order to identify transferable lessons for other countries working to control the spread and impact of COVID-19. Identified strategies included early recognition of the threat and rapid activation of national response protocols led by national leadership; rapid establishment of diagnostic capacity; scale-up of measures for preventing community transmission; and redesigning the triage and treatment systems, mobilizing the necessary resources for clinical care. Facilitators included existing hospital capacity, the epidemiology of the COVID-19 outbreak, and strong national leadership despite political changes and population sensitization due to the 2015 Middle East respiratory syndrome–related coronavirus (MERS-CoV) epidemic. Challenges included sustaining adequate human resources and supplies in high-caseload areas. Key recommendations include (1) recognize the problem, (2) establish diagnostic capacity, (3) implement aggressive measures to prevent community transmission, (4) redesign and reallocate clinical resources for the new environment, and (5) work to limit economic impact through and while prioritizing controlling the spread and impact of COVID-19. South Korea's strategies to prevent, detect, and respond to the pandemic represent applicable knowledge that can be adopted by other countries and the global community facing the enormous COVID-19 challenges ahead.

ARTICLE HISTORY
Received 30 March 2020;
Revised 6 April 2020;
Accepted 6 April 2020.

KEYWORDS
COVID-19 pandemic; health system reform; national response; South Korea; triage and quarantine

In the first two months of the COVID-19 pandemic, the Republic of Korea (South Korea) had the second highest number of cases of any country, following only China. Despite this initially high burden of disease, South Korea was able to dramatically lower the incidence of new cases and sustain a low mortality rate, making it a promising example of a strong national response. After February 18, 2020, when the 31st case in the country was confirmed, massive population clusters arose in the city of Daegu and the surrounding areas. By the last day of February, the incidence of new cases peaked at 909 confirmed cases per day, with the rate of new cases slowing to approximately 100 new cases per day by mid-March 2020. During this time, the country achieved a low case mortality rate (111 deaths/8,961 confirmed cases, as of March 23, 2020; crude fatality rate [CFR] = 1.24%). By comparison, China had a much higher mortality rate (3,276/81,601; CFR = 4.01%; Figure 1). At the same time, the pandemic was surging around the world, with many countries also reporting higher mortality rates, such as Italy (5,476/59,138; CFR = 9.26%), Spain (1,720/18,572; CFR = 9.26%), Iran (1,685/21,638; CFR = 7.79%), France (674/15,821; CFR = 4.26%), and the United States (402/31,573; CFR = 1.27%).[1] Importantly, South Korea achieved this control and mortality rate with a relatively blunted economic impact given the extent of the outbreak when compared with other Asia Pacific countries with lower early COVID-19 burden.[2]

As the pandemic continues to spread, understanding the lessons learned from South Korea's national COVID-19 response strategy is critical for countries who are already affected by COVID-19 and those still planning their response to the pandemic.[3] We aim to describe key elements of South Korea's national response, focusing on measures that may have contributed to reducing the surge in incidence ("flattening the curve") and minimizing

CONTACT Juhwan Oh oh328@snu.ac.kr; joh@hsph.harvard.edu
[†]These authors contributed equally to this work
This article has been corrected with minor changes. These changes do not impact the academic content of the article.

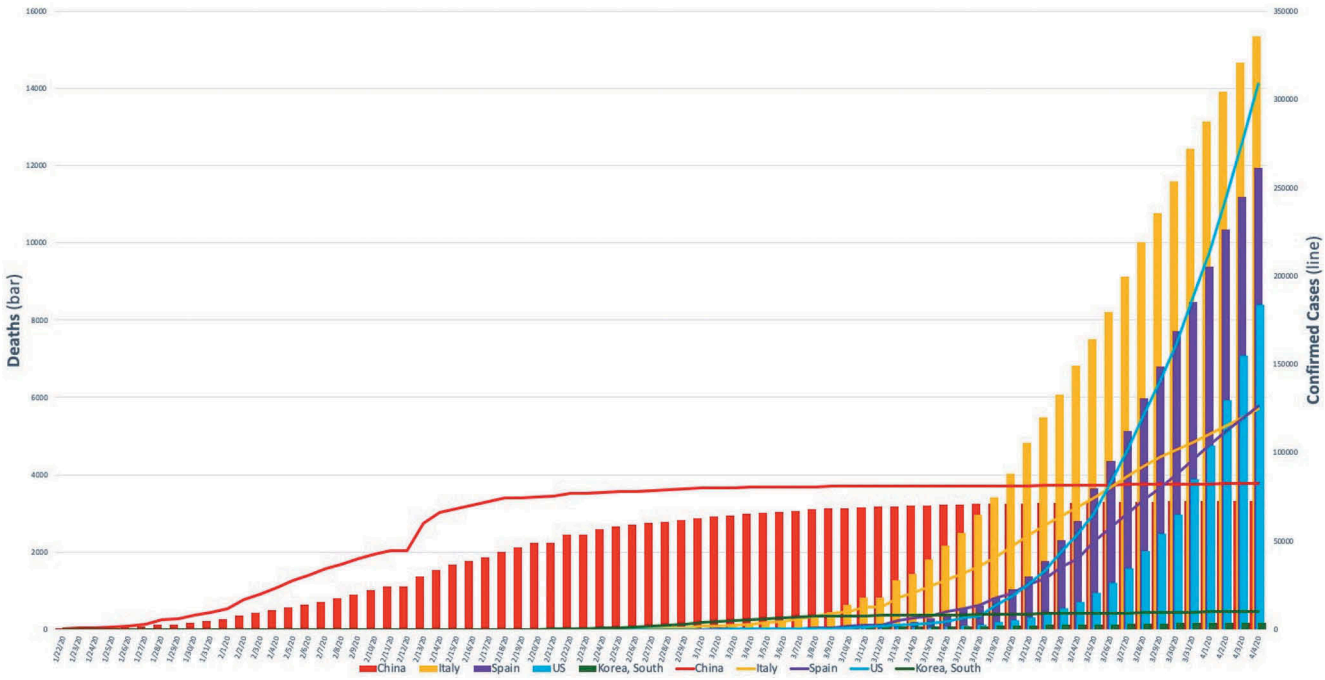

Figure 1. Cumulative Number of Deaths and Confirmed Cases in China, South Korea, Italy, Spain, and the United States
CSSE COVID-19 Dataset: Daily Reports. https://github.com/CSSEGISandData/COVID-19/tree/master/csse_covid_19_data. Accessed April 6, 2020.

economic collapse. Key features of the response to date included specific strategies and strong national leadership and work to ensure effective coordinated and intersectoral response. The strategies included the following (Table 1):

- Early recognition of the threat and rapid activation of national response protocols led by national leadership;
- Rapid establishment of widespread diagnostic capacity;
- Scale-up of measures for preventing community transmission, including contact tracing, quarantine, and isolation; and
- Redesigning the triage and treatment systems and mobilizing the necessary resources for case management.

Below we discuss each of these features, including how they were influenced by the nature of the epidemic, followed by a discussion of challenges to date and lessons learned thus far.

South Korea's COVID-19 Response

Early Recognition of the Threat and Rapid Activation of National Response Protocol

From the time of first case onset on January 20, 2020, until February 18, 2020, there were only 31 new cases, but the incidence rose rapidly to a maximum daily count of 909 identified new cases on February 29.[4] During that week the government of South Korea activated high-level national response protocols to ensure a cross-society and pan-governmental approach to containing the pandemic. The response was informed by epidemiological evidence that the majority of South Korea's initial pandemic was linked to the 31st confirmed patient. Confirmation that the 31st patient was the locus of the epidemic was enabled because of meticulous contact tracing and effective surveillance with rapid feedback of results. These dual processes allowed for rapid detection of the 31st case (diagnosed February 18) as the source with detection of a case surge from one to two per day to 15 on February 19 and increasing daily to 210 on February 23. This surveillance combined with careful contact tracing and case investigation also identified that a high proportion of the newly confirmed patients were from the same megachurch membership. On February 23, the Korean Centers for Disease Control & Prevention (KCDC) announced that 309 (55.6%) of the total 556 cumulative cases to date were members of the megachurch in Daegu city. Further data that emerged as a result of the ongoing contact tracing suggested that 5,051 new infections, or approximately 56.8% of the total confirmed cases as of March 22, 2020, were linked to this 31st patient.[4] The detection of this novel cluster of patients from the megachurch led to a significant effort to increase national preparedness, in anticipation of a large rise in new cases (Table 1).

Table 1. Timeline of National Policy and Strategy Implementation to Tackle COVID-19 Epidemic–Pandemic in South Korea

Phase	Time Period	Dates	Days from First South Korean Case	Implemented Policies and Strategies
0	No cases: From the official declaration of new viral disease by China before the first case in Korea	January7–January 19	−13 to −1	Prioritization of response recognizing potential threat Developing process for diagnostic tool and rapid approval Establishment of public–private partnerships for the rapid development of novel diagnostic tests using RT-PCR technology. Expedited approval by the Korean Food and Drug Administration for the use of these tests for suspected cases
1	Beginning: From the first case to the 30th case	January 20–February 18	1–30	Recognition of threat based on detection of initial few cases and activation of national response protocol National level declaration of the second level (Yellow) of epidemic crisis on January 20 National level declaration of the third level (Orange) on January 28 Scale-up of diagnostic tool production capacity Rapid deployment of these tests throughout the country in partnership with local governments at provincial governmental diagnostic institutes Official announcement of national-level daily diagnostic capacity on February 5 (23rd case): 1,250 per day Viral specimen sharing with domestic research institute for discovery and development of vaccine and medicine on February 17
2	Surge in cases and first death	February 19–February 29	31–41	Scale-up of geographic coverage of diagnostic capacity Establishing national center for disaster relief led by Prime Minister with declaration of the highest (fourth) level (Red) of epidemic crisis on February 23 Initiation of measures to prevent community transmission, including local contact tracing, evaluation through local screening centers, quarantine and isolation, and limited physical distancing Redesigning the triage and treatment systems and resource mobilization Increased emphasis on use of proper personal protective equipment (PPE) use by health personnel
3	Declining numbers of new cases (from 909 to 107/day)	March 1–March 14	42–55	Sustaining capacity and systems to continue response National Human Rights Commission makes recommendation for patients' privacy protection during the patients' contact information release
4	Plateau of new cases (between 70 and 90/day)	March 15–April 5, 2020	56–77	Prime Ministerial declaration: governmental recommendation on active social distancing for two weeks: effective from March 22 to April 5 Mandatory diagnostic test for all incoming travelers from Europe from March 22 Active quarantine of incoming travelers from the United States from March 27 Mandatory period of self-isolation for two weeks, connected by telephone quarantine software application, for all incoming travelers, including long-term foreign visitors, since April 1 after surge in cases in the United States and Europe Mandatory designated accommodation isolation for two weeks applied for every short-term foreign visitor from April 1

This early recognition of the threat to come—given the incubation period between infection and disease onset—gave the government one to two weeks' lead time for preparedness and planning before the inevitable rise in cases.[5] In their response, the Ministry of Health and Welfare and the President's Office developed a two-track approach focused on (1) the public health response in order to prevent and detect further infections, including increasing diagnostic capacity and the scale up of prevention measures,[6] and (2) the clinical response to manage infections.

Rapidly Establishing Widespread Diagnostic Capacity

A key component of the government's response was to rapidly establish widespread diagnostic capacity across the country. This involved three primary interventions:

(1) Establishment by the leadership of the KCDC of public–private partnerships for the rapid development of novel diagnostic tests using real-time polymerase chain reaction (PCR) technology;
(2) Expedited approval by the Korean Food and Drug Administration for the use of these tests for suspected cases; and
(3) Rapid deployment of these tests throughout the country in partnership with local governments.[3]

South Korea's early and rapid expansion of testing relied on the rapid engagement of the private sector and approval of tests by the Korean Food and Drug Administration. This rapid availability of tests as well as the aggressive use of contact tracing is shown in Figure 2, reflecting an increase from 1,581 test results per day on the day after the 100th case was reported to 11,290 per day on April 1. We used a starting date of the 100th case rather than calendar dates to allow for comparisons between South Korea and the United States from the respective starting times of the epidemic based on data availability from the United States. The strategy of rapid testing scale-up and the use of meticulous contact tracing (below) facilitated earlier and more effective containment of viral spread compared with other countries such as the United States, where scale-up of diagnostic capacity after the 100th case occurred later and with much more limited use of contact tracing. Reflecting these differences, South Korea had much lower cumulative positivity rate (ratio of positive to negative tests) compared with the United States (2.9% versus 17.4%, respectively, 19 days after the 100th case), as well as daily positivity rates at that time (2.9% versus 25.7%, respectively). In South Korea, positivity rates have continued to decline (101 of 11,290 [0.9%] of tests on April 1, 2020), reflecting the sustained strategy of aggressive testing.

Scale-Up of Measures to Prevent Community Transmission, Including Local Contact Tracing, Evaluation Through Local Screening Centers, Quarantine and Isolation, and Limited Physical Distancing

Building on this scaling of diagnostic capacity, several other key prevention measures were identified and rapidly scaled. Extensive contact tracing, including of the superspreader 31st patient, promptly led to the

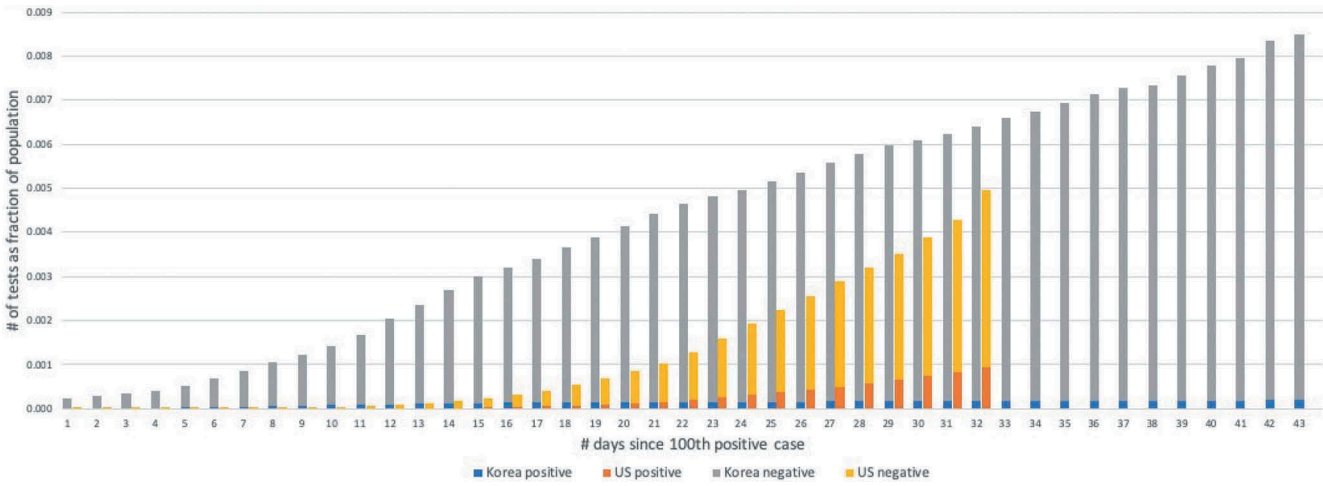

Figure 2. Cumulative Positive and Negative Tests as a Fraction of the Population Since the 100th Case Reported in South Korea and the United States

Sources: Population, total | Data. World Bank Data. https://data.worldbank.org/indicator/sp.pop.totl. Accessed April 5, 2020. Korea CDC Bulletin. https://www.cdc.go.kr/board/board.es?mid=a20501000000% Accessed April 5, 2020. US Historical Data | The COVID Tracking Project. https://covidtracking.com/data/us-daily. Accessed April 5, 2020.

Table 2. Confirmed COVID-19 Case Distribution in the Republic of Korea (as of April 5, 2020)

	Number of Cases	%
Number of cumulative tests	461,032	
Cumulative negative test results	431,425	
Cumulative confirmed cases	10,237	100
Nonclustered cases (infected by individual close contact)	1,783	17.4
Imported cased (detected by national border quarantine	*741*	*7.2*
Other	*1,042*	*10.2*
Clustered cases	8,454	82.5
Known member of megachurch	*5,208*	*50.9*
Other clusters groups or other exposures[a]	*1,878*	*18.3*
Contact from confirmed cases	*1,253*	*12.2*
Imported cases related group	*115*	*1.1*

[a]This includes some health care workers without known contact through the megachurch, but specific data on potential nosocomial transmission were not available.

Source: Constructed using data from the Korean Centers for Disease Control & Prevention.[7]

detection of several clustered cases (Table 2) during the last week of February. This contact tracing was accomplished by a rapidly established temporary workforce of Epidemiological Intelligence Service (EIS) officers.[6,7] These low- to middle-level employees were repurposed from governmental health center officers across approximately 250 districts (each of which includes a population of 50,000–500,000) and, though not fully qualified EIS officers, either had the competency or were quickly trained in standardized protocols for contact tracing.[7]

This multilevel response was particularly effective, with the central, provincial, and metropolitan governments' officers responsible for contact tracing in large clusters and public health centers and county officials handling contact tracing and quarantining in smaller clusters such as family units. The addition of this rapidly deployed workforce enabled South Korea's policy of "never give up" contact tracing. Such meticulous tracing led to earlier case detection than would have otherwise been possible. Continuous use of this strategy also seems to have kept the rate of new infections at a lower pace than that in most other countries impacted by the pandemic.

Although no specific clinical therapeutic intervention was provided to patients identified through early detection, lower crude fatality rates may have resulted from an ability to reduce the rate of infection among high-risk populations as a result of the early detection and isolation of cases, as well as through a flattening the curve approach that prevented hospitals from ultimately becoming totally overwhelmed and thus better able to manage the most severe cases with the resources available.

To prevent disease spread, individuals who were identified as having contact with either confirmed or suspected cases, as well as any individuals who had recently traveled to China or two affected local areas in South Korea with early epidemics, were quarantined at home or in designated support centers for two weeks or until they were confirmed to be clear of infection. Two-week quarantine in these public support centers was provided to individuals free of charge. Drawing from their experience with the Middle East respiratory syndrome–related coronavirus (MERS-CoV) epidemic in 2015, the Ministry of Health and Welfare, working with provincial/metropolitan governments, also activated one triage center per district for any individuals with a fever or respiratory symptoms (see below). The government discouraged all nonessential gatherings to achieve social distancing for the broader population, though this was not strictly mandated during the response period described.

Finally, South Korea implemented national isolation protocols that adhered strictly to the International Health Regulations, which did not entail closing national borders to travelers from affected countries.[8] (South Korea did block inflow from Wuhan, China—the epicenter of the outbreak—but only after China also applied a lockdown to the same region.) Rather than close its borders, South Korea instituted a strict program of self-quarantine and contact tracing for all incoming travelers, including through a mandatory telephone software application. Additionally, as of the last week of March, South Korea has instituted a mandatory two-week quarantine for travelers from some European countries. The number of cases detected in quarantine increased from three between January 19 and January 25 to 321 in the last week in March, with the highest proportions coming from Europe and the United States. These cases represented six cases per 10,000 incoming travelers in January, increasing to 22 per 10,000 in February (the number of travelers for March was not available at the time of submission).[9] The open border policy has been unpopular with some groups who have sought to blame imported cases as the cause of the domestic epidemic,[10] but the government has sustained a policy of "no blaming of the victimized population," in part to prevent a global and domestic economic downturn.

Redesigning the Triage and Treatment Systems and Resource Mobilization

In response to the outbreak, South Korea redesigned health service provision at the national level. These changes initially focused on the subnational epicenter to create two systems (COVID-19 health system versus non-COVID-19 health system) to both manage the outbreak and to work to ensure continuity of non-COVID related needs. The COVID-19 system included public quarantine, primary

health care triage and admission for observation at the primary care level accommodation support centers staffed by health care workers, and transfer to secondary hospitals and tertiary hospitals based on severity of illness. This strategy included a national-level coordination center that managed the flow of COVID-19 patients to hospitals or, if needed, to other provinces. The restructuring also included diverting the flow of patients with non-COVID-19 conditions through triage centers at the district or hospital level (designated as "system safety guaranteed hospitals" by the government). To establish this proper treatment capacity for the expected surge of COVID-19 cases, six measures were undertaken, including:

(1) Designated triage centers were established at the district level to assess any individuals with a fever or respiratory symptoms. These were often in district health centers or hospitals, and all clinical staff in these units were equipped with personal protective equipment (PPE) Level D, which consisted of mandatory coveralls, gloves, steel toe and shank chemical-resistant boots, disposable boot covers, safety glasses, N95 masks, and face shields, with some variation based on different tasks.[11]
(2) A group of university hospitals and university-affiliated hospitals, equipped with negative pressure intensive care units (including admission areas as well as patient rooms) specially constructed after the SARS outbreak of 2003, novel influenza outbreak of 2009, and MERS-CoV epidemic of 2015, ventilators, and extracorporeal membrane oxygenation availability, as well as medical experts in respiratory and infectious disease, were designated by the Ministry of Health and Welfare as critical care hospitals for critically ill COVID-19 patients.
(3) A number of general hospitals with negative pressure units as well as respiratory medicine and infectious disease subspecialists were designated for severe but not critically ill patients with COVID-19.
(4) For mild to moderate cases, non-hospital beds of diverse dormitories previously used for other purposes such as vocational refresher training were transformed into new clinical facilities(16 total) by three provincial governments, including Daegu and Gyungbuk. This measure established 3,818 more beds for mild to moderate cases as temporary isolation units staffed by health professionals and referred to as "accommodation support centers for affected people" in these two neighboring areas during the last week of February 2020 (the accumulated number of confirmed cases in these two local areas was 6,241 in Daegu and 1,190 in Gyungbuk as of March 19, 2020).[12] This transformation from nonclinical facility to clinical facility was done partly because South Korea wished to maintain ongoing capacity for other non-COVID cases in some other hospitals. Additionally, the lack of a legal framework for the national response to mandate changes in hospitals—which are mostly private in South Korea—made this measure necessary. Despite not being equipped with any negative pressure units, these facilities have to date not experienced any identified patient-to-patient or patient-to-staff transmission.
(5) Governance and coordination at the national level to drive these strategies was critical. This included supply chain decisions as well as delivery design such as a referral system that was also established through the National Medical Center to coordinate referrals from lower level facilities to higher level facilities, even in the absence of a clear legal framework for accomplishing effective coordination. This referral system included moving beyond boundaries of metropolitan city or provincial territories through national-level coordination.
(6) Prioritizing resources for treatment focused on beds, oxygen, RT-PCR testing, computed tomography scans, as well as PPE for medical personnel and other human resources such as physicians and nurses. Through the focus on PPE, South Korea has maintained sufficient human resources for health by preventing local medical personnel from acquiring avoidable COVID-19 infection while providing care. The response also allowed for early innovation to meet needs; for example, drive-through sampling for diagnosis was motivated in part to preserve PPE and limit health worker exposure during the sampling procedure, complementing the media focus on widespread rapid diagnosis.

Complementing this resource planning to prepare for the anticipated surge, South Korea applied China's severity mix profile as a reference for resource allocation ahead of the surge.[13] The pattern of disease progression for COVID-19 in China per the severity mix reference was as follows: (1) Critically severe, 6%; (2) severe, 14% (15%–20% of this group progressed to the critically severe stage); and (3) mild to moderate, 80% (10%–15% of this group progressed to the severe stage). The Ministry of Health and Welfare prepared estimates

of the number of referral cases due to severity progression based on this reference rate that could be anticipated at the designated centers. Despite this planning, in the early phase, there were shortages in key elements, including PPE, negative pressure rooms, and health care workers at the center of the outbreak. These shortages were being addressed through national-level changes to patient flow and management of COVID-19 patients that started at the end of February.

Favorable Conditions Compared with Other Countries

The more favorable outcomes associated with the South Korea outbreak compared with other affected countries, such as the lower crude fatality rate and decreased rate of new infections, may also be influenced by several other contextual factors. The government structure and close relationship between the Ministry of Health and Welfare, with authority over the KCDC, ensured a science-based authority working at the highest level. This evidence and data-driven decision making was also facilitated by the presence of a health systems researcher as Chief Secretary for the President, overseeing the governance of all sectors including the health sector. As a result, the coordination between the Prime Minister's office, Ministry of Health and Welfare, and KCDC was very effective and facilitated a rapid and data-driven response including reallocation of resources in a relatively short time.

Some of the success of South Korea's response may have been related to the experience of MERS-CoV in South Korea, where high numbers of fatalities due to MERS-CoV occurred in 2015: 38 deaths from 186 confirmed cases and an additional 16,752 suspected cases.[14,15] During the six months of the outbreak, the South Korean people were living in fear under a threatened environment. The South Korean government experienced huge economic losses, including an estimated 2.6 billion USD lost in tourism revenue,[16] 12 million USD on costs for MERS diagnosis and treatment during the outbreak, and 860 million USD from the central government's budget associated with MERS response activities. Key officials of KCDC who were responsible for this response, including the current KCDC director, were heavily criticized and seriously punished, although the level of punishment was subsequently reduced. This painful memory of the South Korean people and government officials might have triggered early, aggressive responses to the COVID-19 epidemic to prevent similar results and increased the willingness of the population to listen to and adhere to the advice of the government and public health officials. South Koreans may also have had a deep understanding of how important this collective action was to prevent the tragedy of mass contagion and preserve their safety. For example, a recent 2020 poll showed higher levels of individual adherence to the public prevention protocols recommended by KCDC and the central government compared to similar adherence during the period of MERS-CoV in 2015.

There are other enabling factors as well. For instance, the affected patients were more likely to be younger compared with those in China or Italy; lower fatality rates have been reported across many countries for those in younger age groups. However, age-specific case fatality rates were also a bit less severe in South Korea compared with other countries, with no deaths among individuals under the age of 30 recorded as of March 25, 2020.[9]

In addition, the number of hospital beds per population before the pandemic was much higher in South Korea than in many other high-income countries (about three times that of Italy and two to three times the Organization of Economic Cooperation and Development average).[17] Although this situation has been criticized in the past and is associated with a predominance of private-sector hospitals, the higher number of beds required less flattening of the curve to remain below the hospital system capacity threshold. These extra beds and the rearrangement of beds dedicated to COVID-19 and non-COVID-19 cases between hospitals resulted in more room within the system to flexibly respond to this new epidemic without sacrificing care for non-COVID-19 patients while simultaneously avoiding long waiting lists for COVID-19 patients requiring admission.

As noted, the government had discouraged all nonessential gatherings to achieve social distancing and, despite not being strictly mandated, most people voluntarily followed this recommendation until slowing of the incidence rate was achieved in the middle of March. The population was already aware of the risk from the MERS experience, which may have contributed to better adherence without the need for closure of businesses. South Korea also did not need to implement school closures because this period was during the typical winter break; however, the new academic year has been recently postponed from the usual start date of March 1.

Finally, most cases in South Korea were clustered in more specific confined areas than was the case in China or other countries . South Korean cases were related to a smaller number of larger, more socially structured clusters of transmission, including the megachurch member clusters as the largest one, other religious groups, a hobby sports group, and workers in a densely

populated environment in the tele-communication center of a bank. As a result, it may have been more efficient to carry out the meticulous contact tracing through EIS officer team action than designing it would have been had cases been dominated by multiple smaller size clusters and community transmission as seen in other countries such as China, Italy, and Spain.

Challenges to Date

This success has not come without challenges. For example, in response to an urgent call from the Daegu Medical Association, many physicians and nurses volunteered to provide care in facilities with a high density of patients per medical personnel (in part due to the loss of some medical personnel resulting from COVID-19 infection). However, this influx of workers was not enough to meet workforce needs and was complicated by the exhaustive workloads with extended use of PPE and need to stay in nearby hotels instead of their homes for several weeks. Some of the challenges arose in part because neither the government nor the Korea Medical Association—despite being inclusive of most physicians in South Korea—have direct authority over the largely public-sector health workforce. In response, the government is considering establishing a legal framework for reallocating human resources for health during an epidemic. Additionally, despite forecasting, insufficient PPE supplies such as masks and gloves often became a problem at an institutional level. Finally, though South Korea has managed to slow the epidemic, experts still do not know how many sporadic cases are about to appear in communities and what newly imported cases may be arriving from other countries. The future of the pandemic in South Korea will continue to evolve, and time will show whether the government and society of South Korea will continue to contain the COVID-19 epidemic through existing or new strategies.

Lessons Learned

During this time when many countries around the world are just seeing the beginning of community spread as well as the potential of health care–related transmission of COVID-19, South Korea offers several important lessons, many of which can be implemented now. Most fundamental, South Korea recognized the problem posed by COVID-19 early and responded accordingly. All countries should now acknowledge the challenge and move quickly to implement the following lessons.

Establish Diagnostic Capacity

As quickly as possible and on the largest scale feasible, countries should work to build testing capacity and prepare mechanisms for deploying this testing outside of the usual health care system. This includes recruiting private-sector capacity as part of the national response.

Implement Aggressive Measures to Prevent Community Transmission, Including Meticulous Contact Tracing, Quarantine, and Isolation Supplemented as Needed by Physical Distancing Interventions

The meticulous contact tracing by the expanded number of local EIS officers was likely a critical factor in the successful results to date. This EIS-based workforce development may be a possible strategy to replicate in other affected countries. Other countries could begin now by training and utilizing out-of-work or underemployed workers, especially those within the health professions who may be experiencing reduced typical caseloads due to COVID-19, to lead and implement such a strategy in their countries. But this must be done with training and adequate PPE to protect this new workforce and ensure that they do not themselves become sources of spread. Even identifying contacts and simply informing them of their risk and the need for and how to implement strict isolation at home is important to mitigate spread.

In addition, identifying facilities to house patients who are in need of strict isolation and/or quarantine but are unable to do so at home may be helpful, while ensuring that appropriate care is available without undue additional expense to individuals.

Redesign and Reallocate Clinical Resources for New Environments

Governments should be looking at all available outpatient and inpatient health care facilities and identifying which are best suited for managing which types of COVID-19 cases and determining which facilities or sections should be preserved for primarily non-COVID-19 related primary health care. Governments should partner with private-sector facilities to make these determinations and provide necessary incentives to promote collaboration and compliance. Though South Korea was able to implement district-level triage (using local government health centers), redesigned primary health care triage is also critical for flattening the surge of incidence and mortality and effectively protecting health professionals. Though non-COVID-19 primary health care services were reduced, virtual consultations and prescribing were

approved during the epidemic. If such measures are not implemented, a negative impact on treatment capacity for both COVID-19 and management of non-COVID-19 chronic diseases will appear quickly in affected countries.

Prioritizing the Control of Spread and Impact of COVID-19 Can Limit the Economic Impact

Just as important to note are the strategies South Korea did *not* have to take, in part reflecting the success of strategies to prevent, detect, and respond. For instance, South Korea did not close its borders but instead focused on broad application of meticulous contract tracing and employed this strategy with travelers as well. In addition, through a greater focus on contact tracing and selective quarantine and isolation, they did not implement a large-scale population lockdown and closure of businesses now in place in many other countries. By adhering to the International Health Regulations, not only did South Korea show solidarity with the international community in addressing the pandemic but it likely reduced the economic shock—and potential resulting additional health impacts—that would typically occur.

Conclusions

A two-track approach to harmonizing strategies through both clinical services (health system redesign through reallocation and prioritization of treatment resources to align with increased demand) and public prevention measures (quarantine, contact tracing, and isolation) were critical and should be quickly considered for application in other affected countries. This approach was facilitated by both decisive central leadership and a strong decentralized system open to the repurposing and flexible reallocation of resources and depended on political leadership and a commitment and willingness to try innovative responses. Many of these responses reflect important activities that included but went far beyond changes to care delivery, such as governance, surveillance, community engagement, supply chain management, and rapid use of data for developing and adapting strategies.[18] Our hope is that by explicating the strategies to prevent, detect, and respond from South Korea, transferable and applicable knowledge can be adopted by other countries and the global community facing the COVID-19 challenge.

Acknowledgments

The authors gratefully acknowledge the work of the field clinicians and health officials who are working tirelessly to care for the health and safety of populations all over the world, as well as all those working to ensure the availability of data for research and learning in this pandemic era.

Disclosure of Potential Conflicts of Interest

No potential conflict of interest was reported by the authors.

ORCID

Juhwan Oh http://orcid.org/0000-0003-0983-4872
Jong-Koo Lee http://orcid.org/0000-0003-4833-1178
Dan Schwarz http://orcid.org/0000-0002-6975-4519
Hannah L. Ratcliffe http://orcid.org/0000-0003-4134-5112
Jeffrey F. Markuns http://orcid.org/0000-0002-8044-2575
Lisa R. Hirschhorn http://orcid.org/0000-0002-4355-7437

References

1. Coronavirus disease 2019 (COVID-19) situation report – 63. World Health Organization; 2020.
2. APAC: COVID-19 impact on economic growth by country or region 2020. *Statista*; [accessed 2020 Mar 26]. https://www.statista.com/statistics/1103215/apac-covid-19-impact-on-economic-growth-by-country/.
3. Fisher M. How South Korea flattened the Coronavirus curve. *The New York Times*; 2020 Mar 23.
4. 2019 coronavirus: the Korean clusters; 2020 Mar 20 [accessed 2020 Mar 26]. https://graphics.reuters.com/CHINA-HEALTH-SOUTHKOREA-CLUSTERS/0100B5G33SB/index.html.
5. Backer JA, Klinkenberg D, Wallinga J. Incubation period of 2019 novel coronavirus (2019-nCoV) infections among travellers from Wuhan, China, 20-28 January 2020. Euro Surveill. 2020;25(5). doi:10.2807/1560-7917.ES.2020.25.5.2000062.
6. COVID-19 National Emergency Response Center, Epidemiology & Case Management Team, Korea Centers for Disease Control & Prevention. Contact transmission of COVID-19 in South Korea: novel investigation techniques for tracing contacts. Osong Public Health Res Perspect. 2020;11(1):60–63. doi:10.24171/j.phrp.2020.11.1.09.
7. Korea Centers for Disease Control & Prevention. COVID-19 Korea profile (March25, Regular Briefing). 2020 Mar 22 [accessed 2020 Mar 27]. https://www.cdc.go.kr/board.es?mid=a20501000000&bid=0015&list_no=366619&act=view.
8. Kwon G-Y, Moon S, Kwak W, Gwack J, Chu C, Youn S-K. Epidemic intelligence service officers and field epidemiology training program in Korea. Osong Public Health Res Perspect. 2013;4(4):215–21. doi:10.1016/j.phrp.2013.07.001.
9. Gebrekidan S. The world has a plan to fight Coronavirus. Most countries are not using it. *The New York Times*; 2020 Mar 12.
10. Kim S. How South Korea lost control of its Coronavirus outbreak. *The New Yorker*; 2020 March.
11. COVID-19 Triage Working Protocol. National disaster response headquarter; 2020 Feb 21 [accessed 2020 Mar 27]. http://ncov.mohw.go.kr/upload/viewer/skin/doc.

html?fn=1582276119365_20200221180840.hwp&rs=/upload/viewer/result/202003/.
12. Oh J. Gunbo industrial complex launches 'Life treatment center management support group' … Support for medical treatment and salary. *MediSobiza*; 2020 March 18.
13. Report of the WHO-China Joint Mission on Coronavirus Disease 2019 (COVID-19). World Health Organization; 2020.
14. Kim KH, Tandi TE, Choi JW, Moon JM, Kim MS. Middle East respiratory syndrome coronavirus (MERS-CoV) outbreak in South Korea, 2015: epidemiology, characteristics and public health implications. J Hosp Infect. 2017;95(2):207–13. doi:10.1016/j.jhin.2016.10.008.
15. Oh M-D, Park WB, Park S-W, Choe PG, Bang JH, Song K-H, Kim ES, Kim HB, Kim NJ. Middle East respiratory syndrome: what we learned from the 2015 outbreak in the Republic of Korea. Korean J Intern Med. 2018;33(2):233–46. doi:10.3904/kjim.2018.031.
16. Joo H, Maskery BA, Berro AD, Rotz LD, Lee Y-K, Brown CM. Economic impact of the 2015 MERS outbreak on the Republic of Korea's tourism-related industries. Health Secur. 2019;17(2):100–08. doi:10.1089/hs.2018.0115.
17. Health care resources: Hospital beds. OECD.Stat; [accessed 2020 Mar 27]. https://stats.oecd.org/index.aspx?queryid=30183.
18. Veillard J, Cowling K, Bitton A, Ratcliffe H, Kimball M, Barkley S, Mercereau L, Wong E, Taylor C, Hirschhorn LR, et al. Better measurement for performance improvement in low- and middle-income countries: the Primary Health Care Performance Initiative (PHCPI) experience of conceptual framework development and indicator selection. Milbank Q. 2017;95(4):836–83. doi:10.1111/1468-0009.12301.