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## Research Articles

# MERS-CoV infection in South Korea and strategies for possible future outbreak: narrative review

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Although there were some positive viewpoints from international press and academia that the Republic of Korea (hereafter South Korea) successfully controlled the Middle East Respiratory Syndrome (MERS) outbreak in 2015, the domestic point of view towards the MERS response in South Korea was critical. As people in the world's 11<sup>th</sup> largest economy, South Koreans criticized the failure of hospitals' initial response to the MERS index case and the lack of a proper control strategy for secondary and tertiary cases. To contain the MERS outbreak, South Korea implemented mainly three MERS control and intervention strategies: quarantine and isolation system, temporary closure of schools and cancelation of public events, and share of correct knowledge of MERS from trustworthy authorities, such as central and local governments and non-governmental organizations (NGOs). The traveler tracking system, the health care delivery system, and the Infectious Disease Prevention Act should be strengthened or amended. The establishment of bioethics and adherence to the World Health Organization (WHO)'s guidelines are also recommended to prevent possible future outbreak.

Middle East Respiratory Syndrome (MERS), caused by MERS coronavirus (CoV), is a severe acute respiratory illness with symptoms of fever, cough, and shortness of breath.<sup>1</sup> Countries in or near the Arabian Peninsula are the origins of MERS, and the first MERS case was reported in Saudi Arabia in September 2012.<sup>2</sup> In 2015, a total of 17 countries outside of the Arabian Peninsula were infected with MERS through travelers, and among them, the Republic of Korea (hereafter South Korea) was the country where the most severe MERS outbreak occurred.<sup>2</sup>

The objective of this study is to analyze the MERS epidemic in South Korea in a critical view: 1) how MERS initially imported in South Korea; 2) how the index case spread the virus and what the consequences were; 3) what kinds of interventions were implemented to control MERS; 4) what lessons we learned from the MERS outbreak; and 5) what interventions would be recommended to control a future disease outbreak.

### SEARCH STRATEGY

A non-systematic narrative literature review was done through four databases (PubMed, Medline, Scopus, Web of Science). Additionally, relevant information from Korea Centers for Disease Control and Prevention (KCDC), Centers for Disease Control and Prevention (CDC), World Health Organization (WHO), Google Scholar, and online newspapers were manually identified. The searching strategy was as follows:

1. PubMed: "Middle East Respiratory Syndrome Coronavirus"[Mesh] AND "Republic of Korea"[Mesh] AND ("2015/05/01"[PDAT]: "2017/12/31"[PDAT]) (Results: 57 in PubMed)
2. Medline: 1. "Republic of Korea" / or Korea /, 2. Limit 1 to yr= "2015 - Current", 3. Middle East Respiratory Syndrome Coronavirus/, 4. 1 and 2 and 3 (Results: 70)

3. Scopus: (TITLE-ABS-KEY (mers) AND TITLE-ABS-KEY (korea)) AND PUBYEAR > 2014 (Results: 221)
4. Web of Science: TOPIC: (mers) AND TOPIC: (korea) Timespan: 2015-2017. (Results: 184)

### MERS OUTBREAK IN SOUTH KOREA

The diagnostic pathway to MERS-CoV infection requires laboratory diagnosis through a real time reverse transcriptase PCR (rRT-PCT) or serological tests<sup>3-4</sup> at a tertiary general hospital, either with a referral slip from a primary or secondary hospital or through emergency medical services. However, detecting MERS patients in a timely manner is challenging because symptoms of MERS-CoV infection are non-specific and the spectrum of illness caused by MERS-CoV is not firmly defined, which requires clinical judgement from healthcare providers.<sup>5</sup> Thus, it is essential for hospitals to strengthen biosafety and infection prevention/control procedures, such as enhancing early detection and prompt triage and isolating patients through strict safety control policies, to efficiently stop transmission of MERS-CoV.<sup>5-6</sup> The 2015 MERS outbreak in South Korea began with a single 68-year-old patient (the index case) who often traveled to the Middle East for his greenhouse building business.<sup>7</sup> However, none of the first three hospitals diagnosed him with MERS until he visited fourth medical facility for two times, the Samsung Medical Center, to treat his illness.<sup>7</sup> During this 10-day period, he ended up contacting 742 people and transmitting MERS-CoV to 28 individuals.<sup>7</sup>

Failure to detect the index case early caused devastating results. A total of 186 MERS-CoV cases, including 39 deaths, were reported in South Korea<sup>8,9</sup>, and the case fatality rate was 20.97% (39 deaths / 186 cases). The total number of quarantined individuals was 16,752<sup>10</sup>, and the MERS outbreak caused the loss of US\$ 18 billion in gross domestic product (GDP), equivalent to 1.31% of the annual average

GDP.<sup>11</sup> To facilitate laboratory testing for MERS molecular diagnosis during the outbreak, the Korean Society for Laboratory Medicine (KSLM) launched a MERS response task force.<sup>4</sup> Nevertheless, residents of South Korea criticized the government and hospitals harshly, saying that they failed to detect the index case and conduct an initial epidemiologic investigation as expeditiously as possible.

## MERS CONTROL AND INTERVENTION STRATEGIES

To contain the MERS outbreak, three approaches from central and local governments, non-government organizations (NGOs), and schools were mainly implemented as follows:

### 1. QUARANTINE AND ISOLATION SYSTEM

Historically, quarantine has been the cornerstone of a coordinated disease-control strategy to stop spreading infectious diseases, from the Black Death and plague to cholera to influenza.<sup>12</sup> To control the MERS outbreak, the South Korean government decided to put 16,752 people into quarantine and authorize a law with up to two-year sentences in prison or fines of up to US\$ 18,000 for violating quarantine.<sup>10, 13</sup> However, quarantine has always been a controversial strategy because it raises ethical, political, and socioeconomic issues, requiring a careful balance between public concerns and individual civil rights.<sup>12</sup> Quarantined people for MERS in South Korea had persistently high levels of anxiety and anger, even four to six months after the removal of isolation due to the lack of mental health support.<sup>14</sup> Voluntary quarantine at home or in an isolated area was also strongly recommended for those who were exposed to the disease.<sup>15</sup>

### 2. CLOSING SCHOOLS TEMPORARILY AND CANCELING PUBLIC EVENTS

Although there was no exact data to count the total number of closed schools, it is estimated that more than 2,400 schools, including 22 universities canceled classes to protect students from the MERS outbreak.<sup>16, 17</sup> A joint South Korean-WHO mission said that it was unnecessary to put students in their homes because MERS was hospital-associated and schools were not linked to the transmission of the virus.<sup>17</sup> When the school boards of Seoul and Gyeonggi province announced the extension of school closures, the mission recommended reopening schools.<sup>17</sup> Many public events, such as music or film festivals, agricultural events, and international book fairs, were canceled or postponed.<sup>18</sup> Despite the WHO's skepticism, it was obvious that temporary school closure and canceled public events prevented any possibility of the disease spreading outside of hospitals.

### 3. SHARING CORRECT KNOWLEDGE FROM TRUSTWORTHY AUTHORITIES

One online study of the risk perception of university students during the epidemic says that only half (53.5%) of them had the essential knowledge about MERS, and trust in mass media was positively associated with overreaction.<sup>19</sup> Central and local governments and NGOs tried to provide the correct knowledge about the disease outbreak so that people would not overreact due to mass media. NGOs in South Korea have tough competition to receive public money.<sup>20</sup> Since NGOs were greatly involved in disaster management, the government supported NGO's education and training program for staff and volunteers who are frontrunners in the field.<sup>21</sup> Also, establishing NGO networks to disseminate and exchange disaster management information

was important to avoid previous mistakes. Although social media, such as Facebook, Google+, and Twitter, would be a good platform that could enhance the public's response and accelerate the detection of a disease outbreak, it could also disseminate inaccurate information causing exaggerated concerns and social panic.<sup>19, 22</sup> It was not timely, but the provision of appropriate and correct public health information from central and local governments, and NGOs was the key to have people gain the risk perception without unnecessary fear and have compliance with self-quarantine at home.

## LESSONS LEARNED AND RECOMMENDATIONS FOR THE FUTURE OUTBREAK

From the MERS outbreak in South Korea, it is important to learn the lessons to prevent any future outbreak. A total of five recommendations is listed as follows:

### 1. TRAVELER TRACKING SYSTEM VIA INFORMATION AND COMMUNICATIONS TECHNOLOGY (ICT)

There was no system to keep track of travelers' movements outside of the country and to have a close contact line among airports, medical facilities, and KCDC. KCDC should have promoted MERS awareness thoroughly for those who traveled to the Middle East region. South Korea's ICT sector, the highest valued-added among Organization for Economic Cooperation and Development (OECD) nations<sup>23</sup>, could potentially solve this disconnected communication loop. The leading telecom company, KT, introduced the system to keep track of travelers' moving routes through the big data, location data, and roaming data from 7.3 billion mobile phones to prevent the global spread of infectious disease in real time at the United Nations (UN) Global Compact Leaders Summit 2016.<sup>24</sup> Once this system is set up, there is no need to rely on travelers' unclear retrospective memory, and the airports and medical facilities will be able to organically share any of the possible pathogen carriers.

### 2. STRENGTHENING THE HEALTH CARE DELIVERY SYSTEM

Almost all MERS cases (183 out of 186 cases) were from nosocomial infection, both intra-hospital infection and hospital-to-hospital transmission because South Korean medical facilities' patient rooms and emergency rooms were very crowded (7, 25). In addition, hospitals had to compensate the lack of income by having more than half of their rooms include 4+ beds per room and reducing professional health care providers.<sup>25, 26</sup> In consequence, the infection routes turned out to be from the same ward patients (33.3%), visitors (26.7%), hospital workers (16.1%), patients' families (9.9%), and caretakers (1.8%).<sup>14, 25, 27</sup> Also, MERS-CoV RNA was detected in many different places from anterooms, medical devices, and air-ventilating equipment as well as environmental objects, such as bed sheets, bed rails, IV fluid hangers, and X-ray devices in the hospital.<sup>27</sup> A referral management system, from primary/secondary hospitals to tertiary hospitals, needs improvements to ensure prompt, optimal care at the right time by sharing patients' prescription and medication data among hospitals, so that further diagnosis can be effectively made at the higher-level hospital. Furthermore, it is important to review the current referral policy to the tertiary hospital and think about the strategy to disperse patients in the emergency rooms to respond to the real emergency cases.

### 3. AMENDING THE INFECTIOUS DISEASE PREVENTION ACT

Hospitals were not professional enough to deal with infection control. Since there was no obligation to share MERS information to the public, the Samsung Medical Center refused to initially share, which exacerbated the outbreak.<sup>28</sup> The Infectious Disease Prevention Act of 2015 has been amended to regulate quarantine measures more effectively: 1) the government has the legal authority to order medical institutions to follow property quarantine measures immediately, and 2) the medical institution's loss incurred from property quarantine enforcement will be financially compensated by the government.<sup>29</sup> Through these amendments, medical institutions will not be slow to respond to or evade their responsibility to future disease control. To make this Act effective, the risk communication system should be established between the government and medical stakeholders, and the compensation fund should be consolidated as a national subsidy for medical institutions that sacrifice private interest for the execution of property quarantine enforcement.

### 4. ESTABLISHING BIOETHICS

Bioethics is not an established field in South Korea.<sup>30</sup> The quarantine was the primary response to the MERS outbreak, but it restricted the liberty of individuals; in the future, bioethical principles and values – transparency from the government and the protection of privacy for those involved – should be established.<sup>30</sup> For the response to the next outbreak, ethical considerations, such as the advice from the University of Toronto Joint Centre for Bioethics, have to be incorporated into the disease control intervention.<sup>30</sup>

### 5. FOLLOWING WHO'S GUIDELINES

Between 28 August and 1 September 2017, the WHO's Joint External Evaluation (JEE) assessed South Korea's capacity to prevent, detect, and respond rapidly to the public health emergency, aligning with the International Health Regulations (IHR) (2005).<sup>31</sup> South Korea has achieved most of the sustainable capacities to manage health threats required under the IHR, but there are still opportunities for improvement. The important factors that need to be considered are 1) the most pressing public health risks should be priori-

tized, 2) the resources to address them should be mapped, 3) a system for deploying health personnel should be established, and 4) risk communication mechanisms should be established.<sup>31</sup>

### CONCLUSIONS

The MERS outbreak in South Korea began from a single infected traveler who returned from the Arabian Peninsula. South Korea was a defenseless state of spreading MERS, despite the fact that it is one of the most developed countries in the world. Although 39 South Koreans died from MERS, an intensive quarantine and isolation system, school closure, and government and NGO's efforts could stop further MERS transmission. These steps along with lessons learned from MERS are expected to prevent and control a future disease outbreak.

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