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Strategies to prevent COVID-19 transmission in the emergency department of a regional base hospital in Korea: From index patient until pandemic declaration

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ABSTRACT

Objective: This study aimed to describe the timely strategies used to prevent the spread of the emerging coronavirus disease 2019 (COVID-19) and present the activities performed in a regional base hospital in South Korea, from the identification of the index patient until the pandemic declaration.

Methods: This is a descriptive study detailing the step-by-step guidelines implemented to manage COVID-19 in a regional tertiary base hospital from January to March 2020. We described our three-phase response to the COVID-19 outbreak as per the national and global quarantine procedures applied during each critical event and highlighted the activities implemented from the perspective of public health crisis preparedness involving emerging infectious diseases.

Results: During the COVID-19 outbreak in Korea, we improved and implemented a rapid and flexible screening system for visiting patients using patient history and radiological testing and created a separate isolation zone for patients under investigation. This active identification-isolation strategy has been effectively applied in the COVID-19 outbreak.

Conclusions: The step-by-step enforced strategies to prevent the spread of COVID-19, though not perfect, adequately reduced the risk of transmission of the highly contagious infectious disease in the hospital while maintaining the emergency medical system.

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1. Introduction

Emerging infectious diseases are a constant threat to global public health and health care systems. In late December 2019, a previously unidentified virus, which is the cause of the current coronavirus disease 2019 (COVID-19) crisis, emerged in Wuhan, China [1]. COVID-19 has rapidly spread worldwide, including South Korea. Korea experienced a large-scale COVID-19 outbreak between January and March 2020 [2].

For many years, South Korea and China have engaged in several cultural and human exchanges due to their close proximity [3]. Ansan City has the highest foreign population ratio in Korea. Most foreigners in Ansan city are Chinese or Korean Chinese [4]. During the COVID-19 crisis, Korea University Ansan Hospital (KUAH), the only tertiary hospital in Ansan, was responsible for controlling and preventing a COVID-19 outbreak in the city and hospital. Since the Emergency Department

(ED) may be the point of origin in case of a contagious event, flexible triage and screening procedures were conducted at KUAH's ED to prevent the spread of COVID-19 in the hospital.

This study aimed to describe the measures taken at a regional tertiary emergency medical center to prevent COVID-19 transmission among the ED patients and extract the concepts of the actions performed from the perspective of public health crisis preparedness in emerging infectious diseases. By presenting these experiences chronologically, we intend to provide a region-specific reference to other medical facilities and emergency care personnel in preventing the spread of an emerging infectious disease.

2. Methods

2.1. Study design and setting

This descriptive study details the strategy adopted by a regional tertiary hospital to deal with COVID-19 for three months from January to March 2020. Our response to the COVID-19 outbreak in Korea is

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described as per the Korea Center for Disease Control and Prevention (KCDC) guidelines applied during each phase of the critical event.

KUAH, located in Ansan City with a population of approximately 800,000, is the only tertiary university hospital with 800 beds [5,6]. Tertiary hospitals, such as KUAH, contain the requisite health care facilities and assume responsibility for the management of critically ill patients in a region. With numerous critically ill patients, KUAH sought to prevent COVID-19 transmission to high-risk patients in the hospitals. KUAH's ED has approximately 50,000 visitors annually, including those with a severe illness.

2.2. Analysis

We presented the events beginning from the identification of the index patient in January 2020 until the pandemic declaration by the World Health Organization (WHO) sequentially. The step-by-step intense strategies for COVID-19 prevention occurred in three major phases. The first phase, starting from January 20 to February 16, focused on epidemiological links. The second phase, from February 16 to February 20, emphasized the possibility of community spread without an epidemiological link. The third phase, from February 20 to March 16, was a response to the COVID-19 outbreak.

We summarized the concepts or ideas implemented by the WHO, KCDC, and KUAH from the perspective of public health preparedness during an emerging infectious disease. For categorization, we referenced a general schematic of selected response stakeholders and the activities occurring before and during the COVID-19 outbreak [7].

3. Results

3.1. Procedures by timeline

Fig. 1 presents a schematic diagram of the chronology of critical events, beginning from the identification of the index patient until the pandemic declaration by the WHO, KCDC, and KUAH.

3.1.1. Phase 0 (before the identification of the index patient in Korea)

After the Middle East respiratory syndrome (MERS) outbreak, the KCDC remodeled the national defense system for better prevention and detection of new infectious diseases [8].

In late December 2019, the previously unidentified SARS-CoV-2 emerged in Wuhan, China, which caused pneumonia in numerous residents of Wuhan and quickly spread throughout the country. On January 4, 2020, the KCDC held a meeting to discuss the unexplained pneumonia in Wuhan and created guidelines and a prevention protocol for COVID-19. Until the causative agent of pneumonia in Wuhan was identified, the KCDC categorized it as a “Highly Infectious Disease, Class 1,” like MERS [9].

3.1.2. Phase 1 (from the initial identification of index patient to implementation of passive screening strategies)

On January 20, the KCDC confirmed the first patient in Korea. The patient was a Chinese national from Wuhan visiting Korea. She was classified as a patient under investigation (PUI) at the airport quarantine and was identified as an index patient after a confirmation test. The KCDC launched a service in the Drug Utilization Review (DUR) to provide travel record information to hospitals if patients had visited China in the past two weeks.

On January 21, the task force team (TFT) was launched at KUAH to respond to COVID-19. KUAH decided to open a site to screen for COVID-19 patients. We developed protocols in the ED to prevent patients with a high risk of COVID-19 infection from entering the ED and opened the COVID-19 screening site. Additionally, we developed a tool to share the current status of the ED in real-time using Google spreadsheets. All medical staff had access to the situation on a real-time basis, even outside the hospital.

On February 7, the designated hospitals nationwide, including KUAH, received government approval to run the COVID-19 real-time PCR test (RT-PCR), PowerChek 2019-nCoV (Kogenebiotech, Seoul, Korea), which is a convenient approach to determine results in a short time (6–8 h) with a single test [10]. Fig. 2 presents the number of PCR tests performed at KUAH's ED and screening clinic according to the increase of confirmed patients in Korea.

3.1.3. Phase 2 (guidelines enforced, including routine portable x-ray testing outside the ED)

A Korean male patient (patient No. 29) aged 82 tested positive for COVID-19 infection at the ED of Anam Hospital, which is another branch of the Korea University Medical Center. The patient had no travel history in recent months or contact with any known confirmed COVID-19 patients. The patient's infection route was unclear even after thorough investigation. This incident raised the possibility of community spread of COVID-19.

The presentation of the 31st patient further supported this possibility. Prior to COVID-19 confirmation, the 31st patient attended a religious worship service at the Shincheonji Church in Daegu province, Korea. After the service, numerous attendants were exposed to and infected with COVID-19. According to KCDC, a total of 5213 infected cases have been linked to Shincheonji Church [11].

KUAH expanded screening protocols to prepare for the possibility of a community outbreak. On arrival of a patient, several steps were implemented to screen highly suspicious patients outside the ED. A nurse took body temperature, checked for any travel history to other countries and provinces (especially hazardous areas), and asked whether the patient had any contact with previously confirmed COVID-19 patients and if the patient had upper respiratory symptoms. After the screening process, highly suspicious patients were transferred directly to the isolation zone (or a negative-pressure isolation room) to obtain a COVID-19 sample. The patient was allowed in the regular treatment area only after the RT-PCR for COVID-19 was negative.

3.1.4. Phase 3 (reforming the ED isolation zone for suspected patients or PUI)

The KCDC released amendments to the sixth and seventh guidelines for COVID-19, which expanded the definition of PUI to include the possible outbreak of COVID-19. As the guidelines for COVID-19 changed, KUAH strengthened its screening protocols and adjusted the ED processes to manage a pandemic outbreak.

The previously used sector for critically ill patients was modified to create an isolation zone in the ED, which altered the department's workflow (Fig. 3). In the isolation zone, all medical personnel wore the recommended personal protective equipment (PPE), which consists of a KF94 (≅N95) respirator, a face shield (or goggles), a disposable surgical gown, a disposable cap, and disposable gloves. Medical personnel entering the negative-pressure isolation rooms wore level D PPE. The three goals of the isolation zone were first, to prevent the influx of PUI into the hospital; second, to minimize unprotected exposure to other patients in the ED; and third, to prevent unexpected infections among the medical personnel in the ED.

All patients who visited the ED, except those who required immediate resuscitation or were critically ill, were allowed to enter only after undergoing a screening chest x-ray for pneumonia. If the chest x-ray showed the possibility of pneumonia, the patient was sent to the designated isolation zone. Patients with normal chest x-ray findings went to the regular zone, where the emergency care personnel performed the usual ED management routine (Figs. 3 and 4). A few patients with normal chest x-rays were diagnosed with pneumonia by an additional CT scan, and these patients were relocated to the isolation zone.

The WHO declared COVID-19 a pandemic on March 11 [12]. After the WHO announcement, KUAH decided to remodel the ED area for

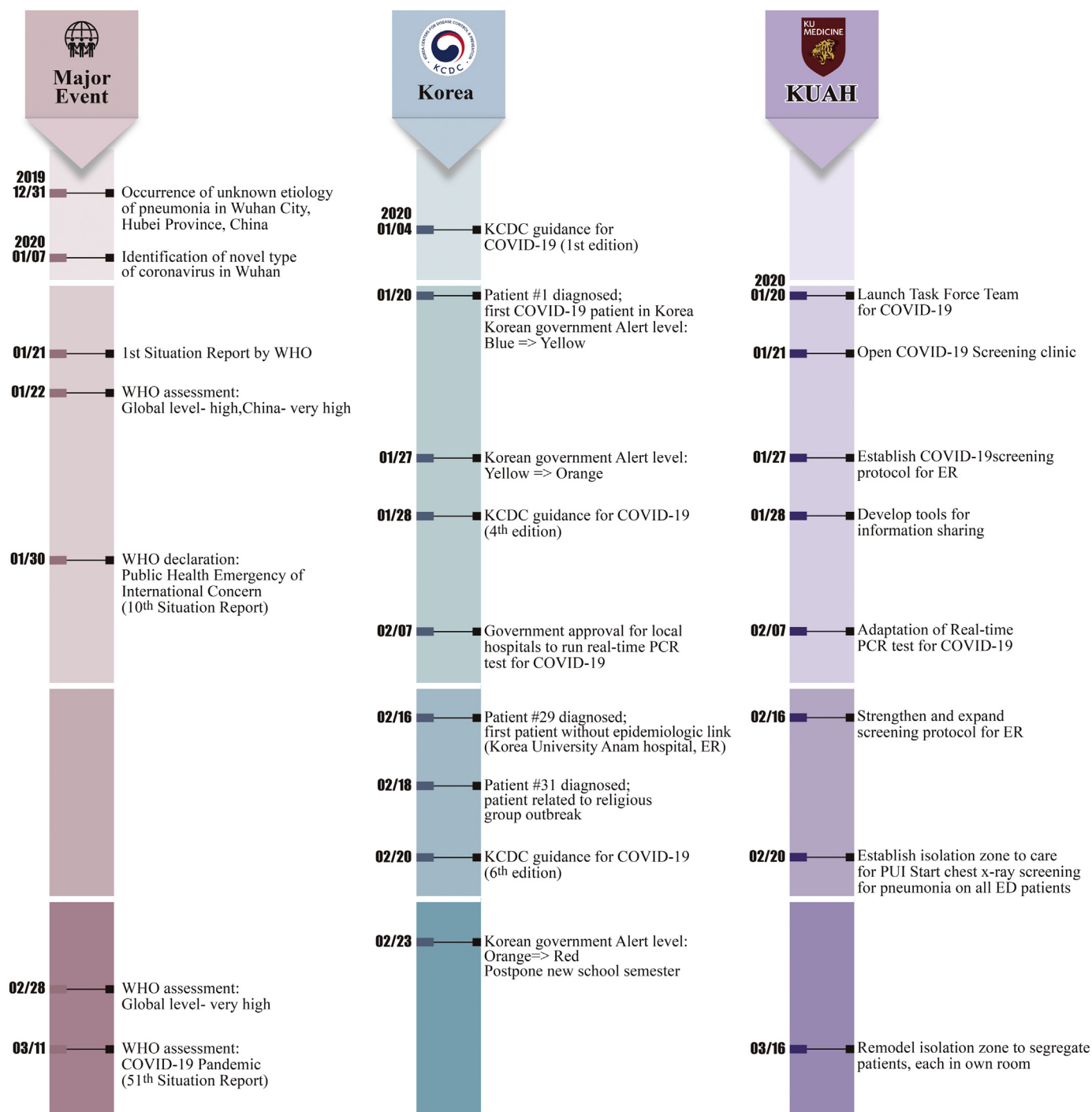


Fig. 1. Schematic diagram of the major chronological events based on organizational actions.

PUI. The purpose of the remodeling was to modify the isolation zone to segregate each patient in a single room. A glass diaphragm with an automatic door between the beds was installed in the isolation zone. The ED assigned a single individual to each bed in an isolated room to maintain adequate distance, thereby establishing a more robust quarantine. The government supported some of the costs for ED remodeling.

3.2. Strategies for emerging infectious diseases

Table 1 shows the important actions performed by the federal government, KCDC, and KUAH. After the traumatic MERS experience in

2015, the federal government legislated amendments to the Contagious Disease Prevention and Control Act and launched nationwide preparedness for emerging infectious diseases. Accordingly, financial support was secured to support necessary facilities, personnel, and equipment to manage emerging infectious diseases.

Immediately after the occurrence of several clusters, the KCDC relentlessly continued to implement information technology-based containment strategies, such as testing, tracing, and treating. As the number of government-designated isolation beds became saturated, the severity of infected patients was classified and various accommodation facilities were changed to “community treatment centers.”

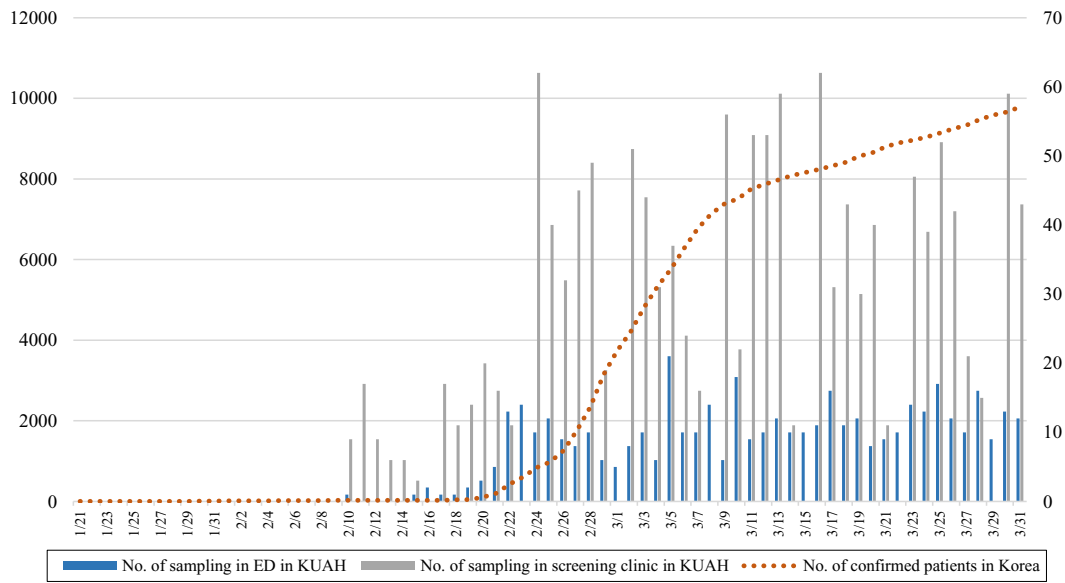


Fig. 2. Number of diagnostic PCR tests according to the increase of confirmed patients. PCR, polymerase chain reaction.

As a base hospital in Ansan city, KUAH ensured an emergency care system in this area by dividing the ED beds into quarantine zones for suspected patients or PUI and those with pneumonia and an area for patients with a general emergency. To manage this workflow and prevent the spread of COVID-19 in the hospital, a screening questionnaire was enforced, and a portable x-ray was utilized to screen all visiting ED patients.

4. Discussion

We described our strategy of developing and implementing the protocols for suspected cases of COVID-19. We implemented step-by-step screening protocols at the regional tertiary medical center and enforced quarantine procedures at ED entry points, considering the large number of foreigners in our community. This strategy

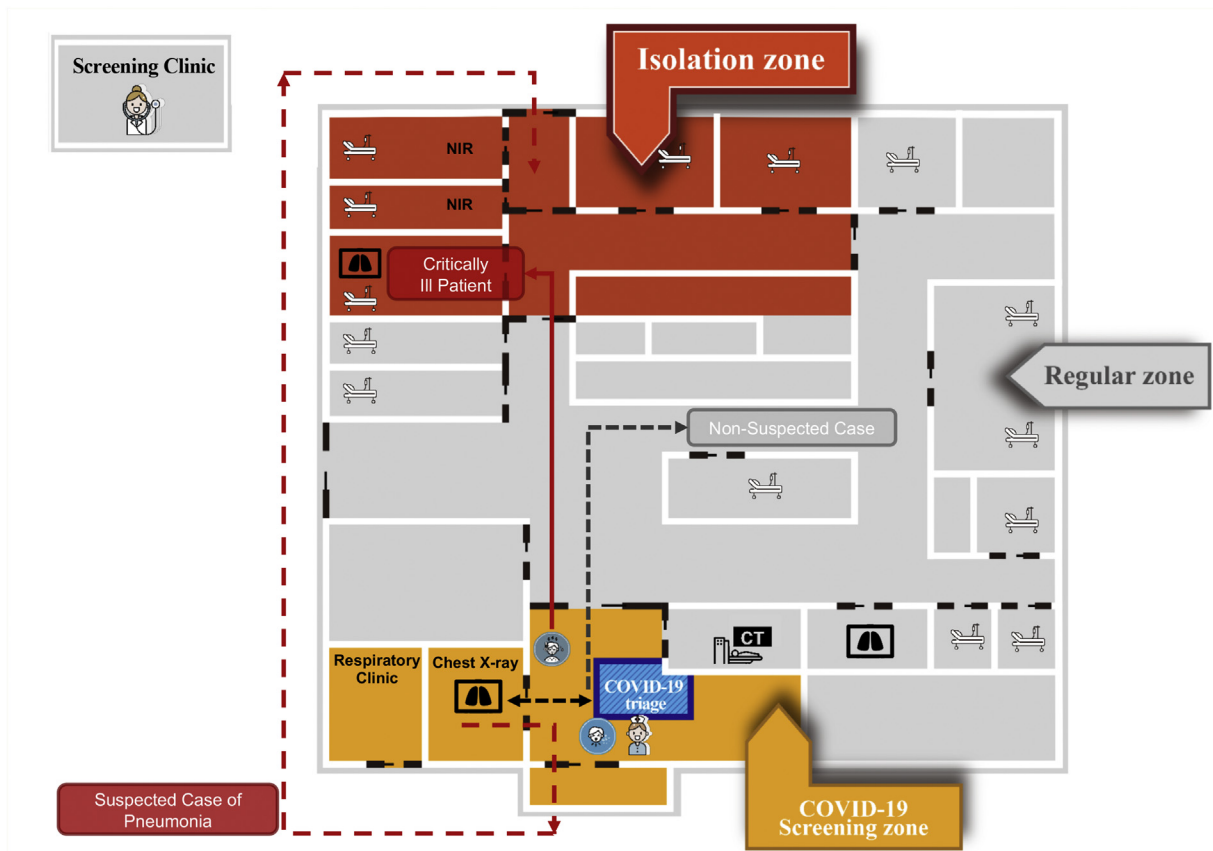


Fig. 3. Flexible remodeling of ED workflow according to the current status of COVID-19. ED, emergency department; COVID-19, coronavirus disease 2019.

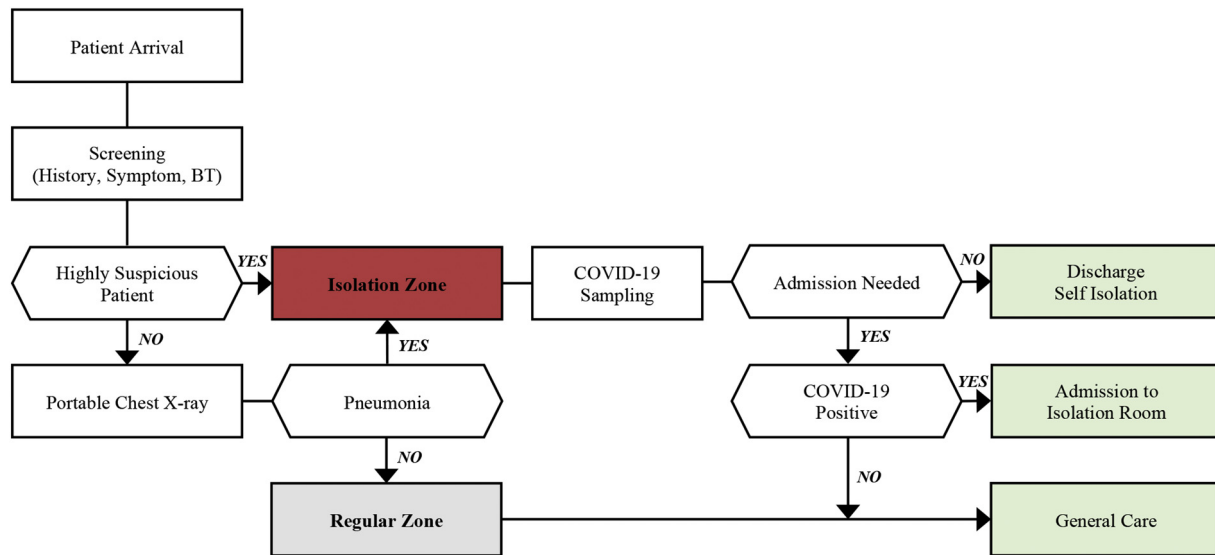


Fig. 4. Diagram of the ED's management of patient workflow. ED, emergency department.

has effectively prevented contamination of the ED from COVID-19 infection thus far. Furthermore, as the only tertiary medical facility in this region, the flexibility in the operation of ED beds, as per the increase in outbreak and status of alertness, effectively contained the spread of this highly contagious infectious disease and prevented the collapse of the emergency care system.

From May to July 2015, Korea had the highest number of MERS cases outside the Arabian Peninsula. MERS is a fatal respiratory disease caused by the new coronavirus (MERS-CoV). It involved 186 laboratory-confirmed cases in Korea, of which 38 died in 2015. Among those 186 cases, 92 were related to Samsung Medical Center, Seoul. At the time, unprotected exposure in the ED led to secondary and tertiary transmission. As a result, 45 patients with MERS were admitted and 9793 were considered to have been exposed to MERS-CoV [13]. After the incidents in 2015, the federal government upgraded and reformed the emerging infectious disease preparedness measures, including the legal framework and the social and medical infrastructure. Particularly, manuals underwent a massive revision and on-demand laboratory diagnostic testing was readily available [14]. The KCDC also established medical facilities to defend against emerging infectious diseases. In addition, ED staff have regularly conducted a tabletop exercise against threats from emerging infectious diseases and training for putting on and removing PPE at least once a year.

As COVID-19 spread through the community, base hospitals needed to implement protocols according to national guidelines. KUAH actively adapted the COVID-19 screening protocols according to the KCDC's revised definition of COVID-19 suspected cases. We shared information in real-time with the regional public health center and municipal officials and actively responded through the KCDC hotline.

Early and comprehensive identification of all suspected patients was necessary to keep the ED free from COVID-19 contamination. Since COVID-19 infections can present non-specific symptoms like fever or myalgia, the case definition to identify a PUI of COVID-19 must be combined with travel history to develop a reasonable and specific screening tool. Also, in the cluster of infection cases, travel history was an important indicator in the chain of transmission. This specific screening was effective at the beginning of the outbreak when all COVID-19 patients had a travel history to China, close contact with those who had travelled or were closely related to a specific religious group.

We obtained portable chest x-rays of all patients who visited the ED as a screening tool after the identification of the 31st patient, who

spread the disease at a religious place of worship. Symptoms and contact history alone were not sufficient to detect COVID-19 infection. The majority of patients who visit the ED have at least a moderate level of illness. Although there have been no reports regarding the sensitivity of x-ray for COVID-19 in moderate to severely ill ED patients, the suspicion of pneumonia by chest x-ray can provide good clinical clues for COVID-19. Although a previous study showed high sensitivity of chest CTs for a diagnosis of COVID-19, using CT as a screening tool for COVID-19 is expensive and time consuming [15]. After considering the advantages and disadvantages, we decided to use a chest x-ray as a screening tool.

To segregate a PUI from other patients, we reorganized the ED into several zones for quarantine, in which the emergency personnel wore PPE. After strengthening ED quarantine protocols, we increased the number of designated single isolation rooms. Patients at risk of transmission of a respiratory infection were mandatorily held in this area until they tested negative for COVID-19. This remodeling of the ED reduced unexpected exposure to other patients and ensured the safety of emergency personnel.

When responding to new infectious diseases, such as COVID-19, it is important to share verified information in real-time [16]. We consider this real-time information sharing as the key to disaster preparedness and management [17,18]. All interested parties in our hospital used a social network service named KakaoTalk (a messenger application) to communicate via group chat and shared spreadsheets. Using these spreadsheets, all medical staff in the hospital monitored the current status of PUI in real-time.

As COVID-19 is spreading worldwide, it is no longer a single country's problem but one that the whole world must consider and solve together. This identification-isolation-information spread strategy has been used effectively in the COVID-19 outbreak. We applied step-by-step strategies in ongoing phases of the COVID-19 outbreak and described them here to serve as a region-specific reference for other medical facilities.

5. Limitations

This study has some limitations. First, the flexible screening protocols and workflow to prevent the spread of COVID-19 may not apply to all hospitals, based on the status of hospital facilities. Second, the strategy devised in this study is based on patient history and radiological screening; therefore, the possibility of hospital transmission exists.

Table 1
Actions implemented according to the events before and after COVID-19 outbreak. COVID-19, coronavirus disease 2019.

Events	KCDC	KUAH
Pre-incident state	<ul style="list-style-type: none"> Government-based online and offline system implementation after MERS 2015 outbreak: Nationwide designated negative pressure isolation beds, designated regional emergency care facilities, rapid approval systems for diagnostic testing Updated users-specific guidelines for provincial governments, healthcare providers, and general public 	<ul style="list-style-type: none"> Mandatory practice for emerging infectious disease every year after MERS outbreak
Biologic incident occurs	<ul style="list-style-type: none"> Information presentation: transparent and clear Innovative information sharing among public and private health care facilities, such as DUR – transferring travel history to hospital registration system Logistic control: Disinfectant products, face masks National health insurance service: nationwide easy and free access to diagnostic test for population including visitors 	<ul style="list-style-type: none"> Hospital TFT for COVID-19 launched including presidents, vice-president, directors related via offline and online social network service Data sharing using information technology system: Online spreadsheets and social network services PCR test preparation: Diagnostic test with a rapid turnaround time
Response plans activation	<ul style="list-style-type: none"> KCDC Quarantine model: 3P (pre-emptive, prompt, and precise) + 3 T (testing, tracing, treating) IT-based epidemiologic containment strategies: Documentation (customized app), modeling (locate potential source of infection), contact tracing Rapid diagnostic tools: Numerous screening sites using diverse ways such as drive-through, walk-through, and diversion 	<ul style="list-style-type: none"> Diversion strategy: Screening site, isolation zone KUAH specified guidelines update: Continuously maintaining the role of base hospital in Ansan city, efficient operation of limited resources and workforces to protect usual care patients and screening of suspected patients Containing the spread of COVID-19 among admitted patients
Post-incident	<ul style="list-style-type: none"> Diversion of infected patients according to severity: designated community treatment centers remodeled after outbreaks previously operated as accommodations and resorts 	<ul style="list-style-type: none"> Enforced quarantine: Visitors limit ED workflow change: Routine portable x-ray screening, limited visitor control, designated pneumonia patient isolation area Nationwide increase in the numbers of designated negative pressure isolation beds and general isolation beds to prevent corruption of emergency care system

KCDC, Korea Center for Disease Prevention and Control; KUAH, Korea University Ansan Hospital; MERS, Middle East Respiratory Syndrome; WHO, World Health Organization; DUR, Drug Utilization Review.

6. Conclusions

During the COVID-19 outbreak in Korea, we modified and applied flexible screening protocols and treatment workflow for ED management based on patient history, radiological screening, rapid laboratory testing, and remodeling. These interventions require close integration with the federal government, KCDC, and provincial authorities for input on case definitions, IT-based screening, and containment strategies. This strategy, although not perfect, can adequately reduce the risk of transmission of a highly contagious infectious disease in a hospital setting while ensuring the smooth operation of the emergency care system.

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Credit author statement

All authors contributed substantially to the revision of the manuscript.

Declaration of Competing Interest

None.

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