



Original Article

KCDC Risk Assessments on the Initial Phase of the COVID-19 Outbreak in Korea

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ABSTRACT

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Objectives: This study aims to evaluate the risk assessments of coronavirus 2019 (COVID-19) in the Korea Centers for Disease Control and Prevention (KCDC), from the point of detection to the provision of basic information to the relevant public health authorities.

Methods: To estimate the overall risk of specific public health events, probability, and impact at the country-level were evaluated using available information. To determine the probability of particular public health events, the risk of importation and risk of transmission were taken into consideration. KCDC used 5 levels ("very low," "low," "moderate," "high," and "very high") for each category and overall risk was eventually decided.

Results: A total of 8 risk assessments were performed on 8 separate occasions between January 8th to February 28th, 2020, depending on the detection and report of COVID-19 cases in other countries. The overall risk of the situation in each assessment increased in severity over this period: "low" (first), "moderate" (second), "high" (third), "high" (fourth), "high" (fifth), "high" (sixth), "high" (seventh), and "very high" (eighth).

Conclusion: The KCDC's 8 risk assessments were utilized to activate national emergency response mechanisms and eventually prepare for the pandemic to ensure the containment and mitigation of COVID-19 with non-pharmaceutical public health measures.

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Introduction

On December 31st 2019, a cluster of pneumonia cases with unknown etiology was reported in Wuhan City, China [1]. On January 11th, 2020, the Chinese authority identified a new type of coronavirus from 41 cases and isolated the nucleic acid of the pathogen [2]. The South China Seafood Market in Wuhan city was thought to be the source of the outbreak, which remains under investigation. Since then, the number of confirmed cases in China has rapidly increased, with the outbreak spreading to other countries. As of 5th March 2020, a

total of 89,253 confirmed cases of coronavirus-19 (COVID-19), including 3,246 deaths, have been reported in 79 countries [3].

The Korea Centers for Disease Control and Prevention (KCDC) of the Republic of Korea (ROK) first detected the outbreak of pneumonia cases with unknown etiology in China through the Event-based Surveillance System and conducted the first risk assessment. After the 2015 MERS-CoV outbreak in Korea, the KCDC revised and improved its Event-Based Surveillance system and the risk assessment tool, and continued to evaluate the risk of public health events based on the impact of diseases and probability of importation. Risk assessment

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in the ROK mainly aims to provide basic information to the relevant public health authorities. During the COVID-19 outbreak, the ROK conducted risk assessment exercises on 8 occasions, followed by implementation of response measures. The ROK has reported a total of 5,766 confirmed cases of COVID-19, including 35 deaths as of March 5th 2020. This study summarized how KCDC conducted its risk assessments based on the available evidence, with details of measures taken as a result of the risk assessments performed.

Materials and Methods

KCDC has officially established a risk assessment system since 2016 due to lessons learned from the 2015 Middle East Respiratory Syndrome coronavirus (MERS-CoV) outbreak in Korea. The initial format of the system was established using the overall structure of the European Centre for Disease Prevention and Control (ECDC) rapid risk assessment procedures, and updated and modified this based on the requirements of the institution. To estimate the overall risk of specific public health events, probability, and impact at the country-level were evaluated using the available information.

For the probability of certain public health events, risk of importation and risk of transmission were taken into consideration. KCDC risk assessment was categorized into 5 levels (“very low,” “low,” “moderate,” “high,” and “very high”), and overall risk was determined [4]. The emergence of COVID-19, which started as clusters of pneumonia with unknown etiology in China at the end of 2019, was unique and thus, a good example for KCDC to conduct a series of risk assessments to evaluate the potential risk of importation, transmission, and the impact at the country-level. The risk of importation and transmission were evaluated separately as COVID-19 was a newly identified pathogen where information about the coronavirus was limited. Predefined criteria triggered the KCDC risk assessment and enabled each risk assessment to be described in detail.

Results

Since the beginning of the current COVID-19 outbreak, 8 risk assessments have been conducted from January 8th to February 19th, 2020 (Figure 1; Table 1). The first risk assessment was conducted on January 8th, which was 8 days after the official

Table 1. KCDC risk assessments for COVID-19.

Assessment no. (date)	Overall risk	Probability*	Importation	Transmission	Impact	Main trigger for risk assessment
1 st (Jan. 8 th)	Low	Low	Very low	Low	Low	Need for risk assessment of the overall situation
2 nd (Jan. 16 th)	Moderate	High	High	Moderate	Low	The official report of imported cases in Thailand (Jan. 13 th) and Japan (Jan. 16 th)
3 rd (Jan. 20 th)	High	High	Very high	Moderate	Moderate	The confirmation of the first imported case in Korea (Jan. 20 th)
4 th (Jan. 26 th)	High	High	Very high	High	High	The rapid increase of the number of confirmed cases in China
5 th (Jan. 27 th)	High	Very high	Very high	Very high	High	Identification of healthcare worker infection in other countries and potential risk of hospital outbreaks
6 th (Jan. 31 st)	High	Very high	Very high	Very high	High	Declaration of Public Health Emergency of International Concern by the WHO (Jan. 31 st)
7 th (Feb. 19 th)	High	Very high	Very high	Very high	High	Identification of confirmed cases with no clear epidemiological link (Feb. 16 th) and cluster cases related to a private religious group in Daegu province in Korea
8 th (Feb. 23 rd)	Very high	Very high	very High	Very high	Very high	The exponentially growing number of confirmed cases in Korea

* Probability is decided in consideration of importation and transmission.

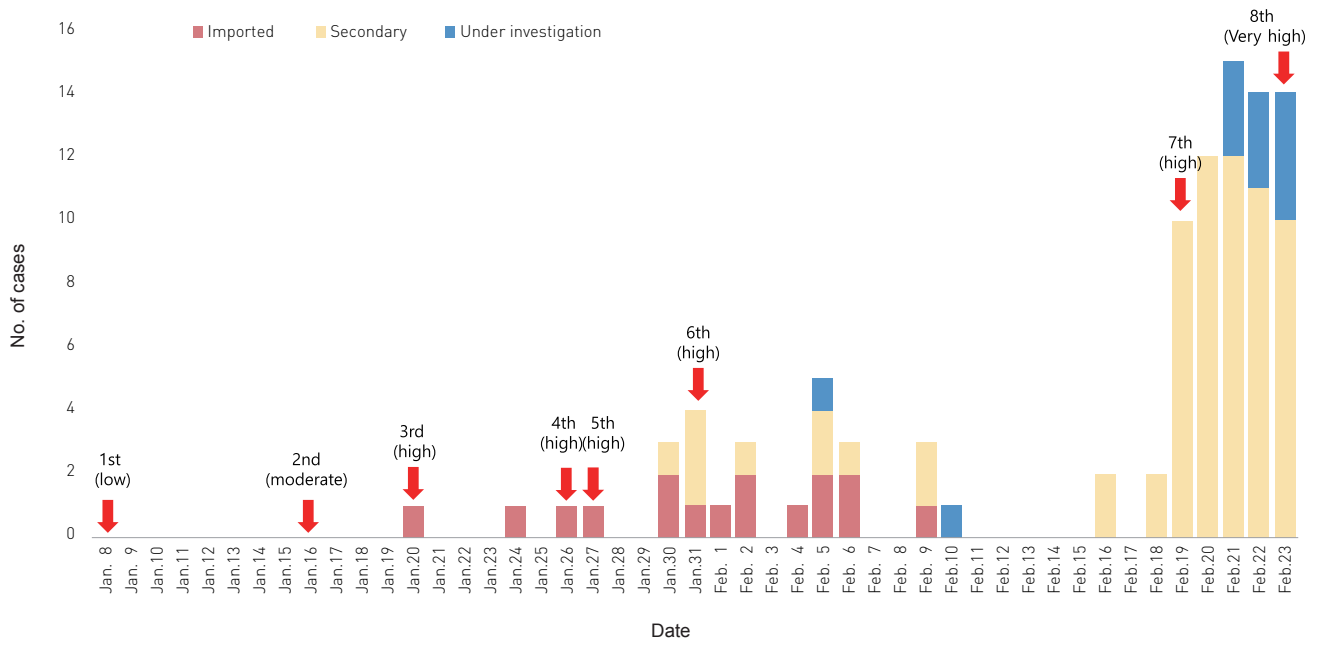


Figure 1. Trend of confirmed cases of COVID-19 in Korea and risk assessment results.

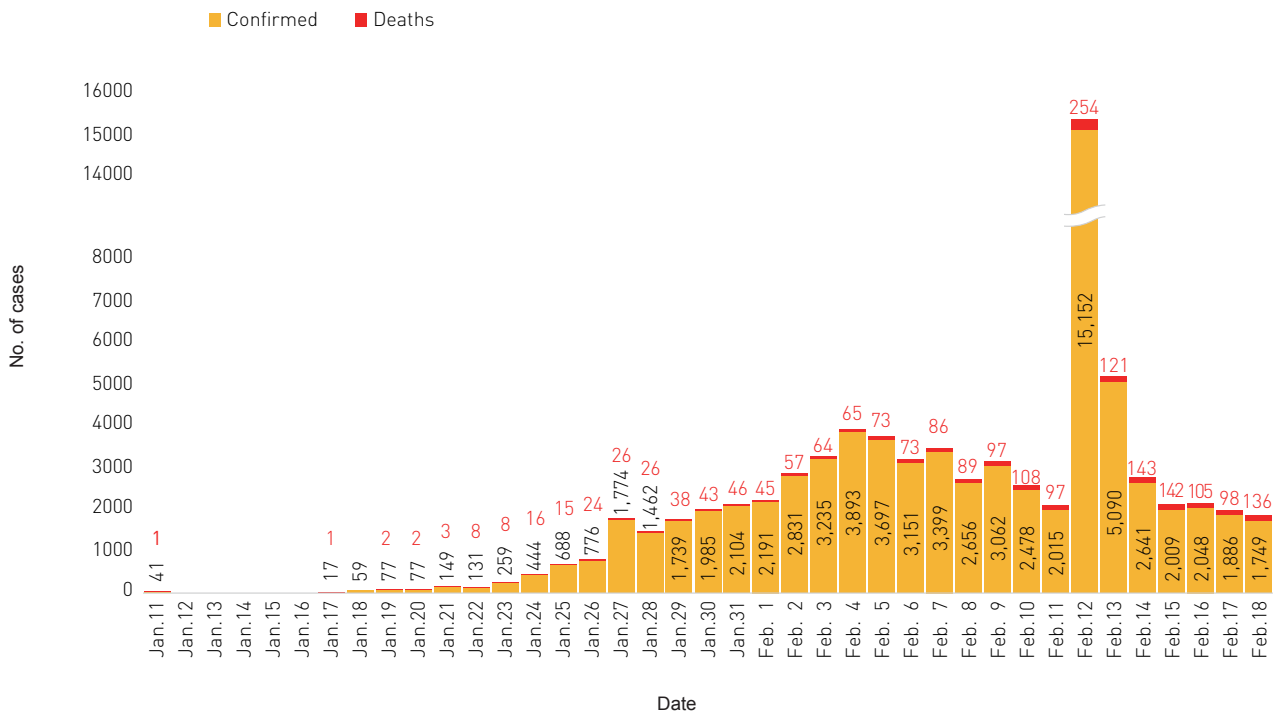


Figure 2. Trend of confirmed cases and deaths of COVID-19 in China.

report of the outbreak in Wuhan city. The overall risk of the situation was considered “low” in the first risk assessment. The risk of importation was estimated “very low” due to the immediate closure of the South China Seafood Market in Wuhan on January 1st. The risk of importation to Korea was “low,” but could not be excluded given the unknown nature of the respiratory pathogens and unknown human to human transmissibility. The impact of the outbreak was “low,” as no fatal cases had been reported in China. The Wuhan pneumonia task force was established on January 3rd, and entry fever screening of flights from Wuhan was initiated. A pan-coronavirus laboratory diagnosis method was established on January 7th.

The second risk assessment was conducted on January 16th, 9 days after the first assessment. The main triggers of this risk assessment were official reports of imported cases in Thailand on January 13th, and in Japan on January 16th. There was no evidence of human to human transmission until this time and no additional case had been officially reported in China since January 3rd. The overall risk was escalated to “moderate” due to the increased risk of importation (“low” to “high”) and transmission (“low” to “moderate”). The risk of importation was estimated as “high” because of the imported cases identified in Thailand and Japan, indicating a possibility of under-reporting of cases due to the unknown nature of the virus. The risk of transmission was also escalated due to the report of 1 potential family cluster in Wuhan, and contact history with an unidentified pneumonia patient from Japan. The impact was “low” as there had been only 1 fatal case who had underlying chronic conditions and the rest of the patients were in stable conditions. Additionally, evidence of recovery of patients in Japan and Thailand also influenced the estimation. On January 11th, the WHO confirmed that the pathogen was a novel coronavirus and a validated primer was distributed and diagnostic probe was made available from January 11th.

The third risk assessment was conducted on January 20th, 4 days after the second risk assessment. The main trigger was the confirmation of the first imported case (Chinese national) in Korea on January 20th. At this time, the overall number of confirmed cases in China was 198, including 3 fatal cases (Figure 2). The risk of importation was evaluated as “very high,” due to increasing concerns over potential human to human transmissibility and large population movement during the Lunar New Year. Moreover, other regions in China including Beijing and Shenzhen also reported confirmed cases. The risk of spread was not changed (“moderate”) as no secondary transmission was officially confirmed. The impact was escalated to “moderate” as there was growing concern over the risk of additional cases, and human to human transmission. Overall, the risk was escalated to “high” accordingly. Meanwhile, updated case definitions were shared with

provincial government and healthcare facilities on January 17th.

The fourth risk assessment was conducted on January 26th because of rapidly increasing numbers of confirmed cases in mainland China. By January 25th, there were 1,975 confirmed cases of COVID-19 (324 severe cases, 56 deaths) in China, leading to Hong Kong declaring a state of emergency. The risk of importation was “very high” as there were rapidly growing numbers of cases in China, with 34 imported cases reported in 13 countries/regions. The risk of spread was “high” because of an early estimate of the basic reproductive number in China (1.4-2.5), and tertiary and quarterly transmissions. The impact was updated to “high” because of the increased number of fatal cases in China (56 total) and the proportion of severe cases which was 16.4%. The overall risk of the event was “high.”

KCDC conducted the fifth risk assessment on January 27th, just 1 day after the previous one. The national crisis management level was upgraded from Level 2 to Level 3 (Level 1 to 4) and the national crisis management center was established on January 28th. The risk of spread was estimated as “very high,” mainly because of the increase in reported cases of healthcare worker infections and the potential risk of hospital outbreaks due to imported cases. Additionally, suspected transmissibility in early stages of infection and potential risk of transmission through asymptomatic infection contributed to this decision. All other categories and overall risk were the same (“high”).

The sixth risk assessment was conducted on January 31st as the WHO declared the Public Health Emergency of International Concern on this day. The case count in China was 7,711 (1,370 severe cases, 170 deaths) and the spread of COVID-19 was also reported in America, Europe, and Oceania, clearly demonstrating that this was now a global issue. There were 20 countries that reported a total of 106 imported cases. There had been 6 confirmed cases in ROK, and secondary transmission was also confirmed in Case #6. Thus, the risk of importation as well as the risk of transmission was evaluated as “very high.” The impact and the overall risk were “high.” The screening of travelers from abroad was expanded to include all travelers from China entering the ROK as of January 28th, and also case definition was updated to cover cases outside of Wuhan. In laboratory-based diagnosis, real time RT-PCR diagnosis was established in 18 provincial public health laboratories, and all test results became available within 6 hours as of January 31st.

The seventh risk assessment was conducted on February 19th, due to cluster cases in Korea. Initially, imported, and secondary cases accounted for the majority of the confirmed cases, but this trend gradually changed and cases without clear epidemiological links were reported since the identification of Case #29 on February 16th. On February 19th, a total of 15 confirmed cases was reported, with 13 of these associated with

a private religious group in Daegu province. Because of this cluster of cases, the risk of infection in this specific province was evaluated and it was estimated as “very high” and also the risk of transmission to other provinces was “high.” All other nationwide risk assessment results remained the same (Risk of importation: “very high,” Risk of spread: “very high,” Impact: “high,” overall risk: “high”).

The last risk assessment was conducted on February 23rd because of an exponential number of confirmed cases. As of February 23rd, 556 confirmed cases were reported. Overall, the progress of the outbreak had significantly changed due to huge clusters in Daegu and Gyeongbuk areas. Out of 556 cases, 315 (56%) were related to the private religious group, and 112 (20%) were linked with the Cheongdo Daenam hospital. Additionally, 4 fatal cases were reported and the mortality rate was 0.7%. This led to an increased impact on the risk estimation, and the overall risk was also increased to “very high” accordingly (Risk of importation: “very high,” Risk of spread: “very high,” Impact: “very high,” overall risk: “very high”). After this risk assessment, the national crisis management level was escalated to the highest level, Level 4.

Discussion

Risk assessment is one of the core functions of a national public health agency, and it has been conducted by many major public health institutions to evaluate the potential risk of public health events for better preparedness and evidence-based responses. The risk assessment in Korea mainly aimed to provide information to enable evidence-based strategic response planning and relevant response measures for KCDC and the Ministry of Health and Welfare. It provided the risk assessment for COVID-19 at given dates, including the details on travel-associated imported cases, clusters outside Korea, risk for healthcare system capacity, options for preparedness and response, risk communication, social distancing, contact tracing and enhanced surveillance. Each risk assessment clearly influenced major decision making as the global situation was evolving, and the result was shared with the relevant ministries for their own planning and preparedness.

COVID-19 is a new emerging pathogen. There is currently no vaccine nor therapeutic medication, and there is no existing immunity in the population. Symptoms of COVID-19 range from no symptoms, to severe pneumonia which can lead to death. COVID-19 can cause mild symptoms in about 80% of cases with most cases making a full recovery, while 14% have severe symptoms, and 6% experiencing critical conditions. The elderly and those with underlying chronic illnesses are most susceptible to severe symptoms of the disease [5]. The risk of COVID-19 ranged from “low” to “very high” in the risk

assessments, based on the likelihood of transmission and the impact on society. Given the available epidemiological and clinical characteristics, the Korean population was deemed to be susceptible, and as more information became available, it was evident that virus transmission was rapid, and had the potential to be a major public health issue in Korea.

The ROK risk assessment covered each phase of the outbreak, with a total of 8 risk assessments conducted. The objective of the risk assessments was to activate national emergency responses and prepare for an epidemic to ensure containment and mitigation of COVID-19 with non-pharmaceutical, public health measures. As for communication of the risks to the general public, knowledge and awareness of the disease must be ensured so that the population accept and engage in community-level and national public health measures. Communication of the risks also helps the preparation of protocols for laboratory-based testing development, diagnosis, surveillance, and treatment. It also helps the public prepare for enhanced surveillance, epidemiological investigation, contact tracing, management of close contacts, case detection, and isolation. Communication of the risks also covers social distancing to deter further spreading by preventing public gatherings, and closure of schools and workplaces. It also covers prevention of nosocomial infection in healthcare facilities.

Risk Assessment 1 and 2 are based on a situation with no reported cases in Korea and reporting of the disease outside Korea. The main public health measures are early detection of possible imported cases and isolation of the case to prevent further transmission in Korea. Communication of infection risks through the media provides information of the disease and upcoming public health measures, enabling public health authorities to lead community engagement for the forthcoming situation. The authorities can use all available formats including social media, homepages, and press-releases. The ECDC evaluated the situation based on the Chinese report, initially indicating a “low” likelihood of importation to Europe [6]. The WHO indicated that the imported case in Thailand did not prove human-to-human transmission as further information was required [7].

Risk Assessments 3, 4 and 5 covered situations where multiple importation cases were observed in Korea. Imported cases have no sustained transmission. That is, only second-generation cases or transmission within a cluster, occurred in Korea. The public health measures focused on blocking transmission, with early detection of imported and locally transmitted cases, so that the health authority contained or delayed the transmission of the disease. Communication of risk at this stage is informative to the global situation, and the result of epidemiological investigations and public health measures. The key messages to the general public include prevention of

infection and transmission, and preparation status of public health authorities. It also addresses multi-sectoral messages to relevant ministries/agencies and healthcare workers. Communication can use all available formats including social media, homepages, and press-releases. ECDC evaluations are escalated when the likelihood of importation to Europe is “low” to “moderate,” and likelihood of importation to neighboring Asian countries is “high,” and human-to-human transmission cannot be excluded [8,9]. The WHO’s risk assessment showed that China’s risk is “very high,” while the risk of the Asia region is “high,” and human-to-human transmission is occurring [10].

Risk Assessment 6 was conducted in a situation where the number of imported cases and local transmission were identified. At this stage, the public health measures aimed to contain, if applicable, or mitigate transmission. This strategy will help to gain time for development and supply of personal protective equipment (PPE) and antivirals. It helps to reduce the burden of national health systems, and to increase the number of laboratory testing kits and increase capacity in the healthcare system. Communication of risk at this stage informs the stakeholders of public health measures, including case isolation, contact tracing, and PPE use. ECDC evaluations of the likelihood of importation to Europe were escalated from “low” to “moderate,” and likelihood of importation to neighboring Asian countries as “high.” Infection contracted in hospital was considered a “low” risk when appropriate infection prevention and control measures were in place [9]. The WHO evaluates risk in China as “very high” and the Asia region’s risk as “high.” The WHO proposed that super-spread events may occur with human-to-human transmission among family members, and healthcare workers [10].

Risk Assessment 7 described a situation with distinct local outbreaks. There was sustained local transmission in Korea. The objective was to mitigate the impact of the outbreak by decreasing general admissions to the hospitals and clinics to protect the general population from contracting the disease. In this situation, communication should be conducted daily. Messages should be balanced and focused on prevention and treatment. It also provides detailed routes of confirmed cases ECDC evaluations are escalated from likelihood of importation to Europe as “moderate” to “high,” and the impact of the disease as “high,” and human-to-human transmission may lead to widespread community transmission [11]. The WHO assesses the situation that several countries show local human-to-human transmission [10].

Risk Assessment 8 dealt with a situation with widespread sustained transmission in a Korean province (Daegu-Gyeongbuk Province) and distinct local outbreaks in other regions of Korea. The healthcare system was overburdened. ICU capacity was strained. The workers suffered from exhaustion, and staff numbers, PPE, and diagnostic testing capacity became

insufficient. The objective was the same as Risk Assessment 7. At this stage, the communication of risk was to ensure close collaboration of the general public with public health authorities, and healthcare providers is essential. Individual, religious, and societal concerns about death need to be considered.

There are several limitations in this study. Firstly, the information in the early phase of the COVID-19 outbreak was preliminary and very limited, mainly since COVID-19 was a new emerging disease, and data from the Chinese government was the main source of information of this novel coronavirus. Thus, we conducted several risk assessments with the ongoing available evidence, in a very short period of time as the situation evolved rapidly. Therefore, the estimation was very likely to be subjective in nature. Secondly, the risk assessment tool was not strictly applied to this novel pathogen as critical information was missing and had to be estimated with limited confirmed evidence. Thus, initial evaluation of this virus pathogenesis was likely to be subjective, and was the one of major factors that needed to be considered when conducting the risk assessment. Once more scientific evidence and knowledge becomes available after the end of this pandemic, overall review procedures and evaluation mechanisms need to be developed to improve and to minimize the limitations of the existing risk assessments by the Korea CDC.

Conflicts of Interest

There was no conflicts of interest to declare.

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