

# Impact of NPIs for COVID-19 on Other Infectious Diseases and Mental Illnesses in South Korea

Hyun Seo Noh<sup>1</sup> and Mi Sung Kim<sup>#</sup>

<sup>1</sup>The Frederick Gunn School, Washington, CT, USA

<sup>#</sup>Advisor

## ABSTRACT

Due to COVID-19, high-intensity nonpharmaceutical interventions (NPIs) are implemented and these regulations may trigger changes in the incidence of other infectious diseases. The goal is to determine the impact of NPIs on other infectious diseases and mental illnesses in South Korea. Data were collected from an open-source dataset concerning NPIs covering the period of January 2018 to July 2020. The data comprised average daily mask production volume and number of companies newly authorized to offer disinfection and sterilization services, and numbers of patients with sentinel surveillance infectious disease and mental illness. This study compared changes in NPIs and incidence of infectious diseases and mental illnesses before and after the COVID-19 outbreak in South Korea. In 2020, the average daily mask production volume and the number of companies newly authorized to offer disinfection and sterilization services markedly increased following the virus outbreak (380% and > 94.8–99.5%, respectively). Meanwhile, the incidence of respiratory and intestinal infectious diseases declined, including those of influenza (49–55%), acute respiratory infection (78–79%), hand-foot-and-mouth disease (84–94%), enterovirus (94–97%), and intestinal infectious disease (36–40%). The weekly incidence of sexually transmitted diseases in 2020 remained constant regardless of the COVID-19 outbreak. Meanwhile, the number of outpatients increased by 7–16% for depressive episodes, 5–12% for other anxiety disorders, and 10–28% for sleep disorders. NPIs significantly reduced the incidence of respiratory and intestinal infectious diseases and negatively affected mental health. Therefore, while NPIs should be continued to prevent the spread of infections, systematic policies must be enacted to support mental health.

## Introduction

COVID-19, a new disease that has impacted the entire globe, is a contagious disease caused by severe acute respiratory syndrome coronavirus 2 (SARS-CoV-2). According to the World Health Organization, SARS-CoV-2 can be transmitted by direct contact with infected people (contact transmission), respiratory droplets exhaled by an infectious person (droplet transmission), or inhalation of infected particles suspended in the air (airborne transmission). In response to these various modes of transmission, countries around the world, including South Korea, have enacted new guidelines and restrictions to limit the spread of the virus.

To interrupt the various modes of transmission, the Korean Ministry of Health and Welfare has strongly recommended frequent handwashing and use of sanitizer and has enforced strict mask guidelines requiring face masks in all public spaces. Additionally, the government has encouraged citizens to keep a distance of two arm-lengths from one another. Moreover, all incoming travelers are placed into a 14-day quarantine to reduce the risk of disease spread. However, these regulations to control personal infections might produce considerable changes in the incidence of other infectious diseases as well as in the lives of South Koreans.

During COVID-19 pandemic, there have been studies on the impacts of nonpharmaceutical interventions (NPIs) on COVID-19 control. There have also been reports on the impact of NPIs on acute respiratory illness which has a similar transmission pattern to the COVID-19, and mental health which was mainly based on surveys. In order

to expand the scope of NPIs impact based on national data, this study focused on the impact of NPIs on the prevalence of sentinel surveillance infectious diseases and mental illnesses based on the data derived from South Korea.

## Literature Review

Nonpharmaceutical interventions (NPIs) are actions that people and communities can take to help slow the spread of illness like pandemic virus (Centers for Disease Control and Prevention, 2020). Because the pandemic virus is new, the human population has little or no immunity to it. NPIs allows the virus to spread rapidly from person to person worldwide. NPIs include frequent hand washing, wearing a face mask or shield, keeping a distance from sick people, and social distancing measures such as closing schools, stay-at-home, and avoiding crowding. NPIs are one of the best ways to control the pandemic virus when there is no vaccine or antiviral medications.

In previous studies (Markel et al., 2007 and Leung et al., 2020), the effective use of NPIs can lead to dramatic declines in the number of cases of influenza, mortality from it, and medical burden on the healthcare. Markel et al. study (Markel et al., 2007) assessing the effect of NPIs implemented in 43 cities in the United States during the 1918-1919 influenza pandemic reported that the cities that implemented NPIs earlier showed greater delays in reaching mortality, lower peak mortality rates, and lower total mortality. Similarly, during the COVID-19 pandemic, many studies have demonstrated that NPIs are effective in reducing the spread of SARS-CoV-2 and other respiratory infections (Cowling et al., 2020). On the other hand, negative outcomes for mental health have been reported due to economic and social hardships and inadequate public compliance when implementing NPIs (Strong and Welburn, 2020, Witteveen and Velthorst, 2020, and Liu et al., 2021).

## Materials and Methods

### Data Collection

To determine the current status of NPIs, average daily mask production volume data for the period between 2019 and March 2020 in South Korea were obtained from the Korean Ministry of Food and Drug Safety. Additionally, the numerical data of companies newly authorized between January 2018 and July 2020 to provide disinfection and sterilization services were collected from the Gyeonggi Database, a government database.

Statistical data for incidence of sentinel surveillance infectious diseases were collected from the open-source dataset released on the Infectious Disease Portal from January 2018 to July 2020. Sentinel surveillance infectious diseases are defined as infectious diseases that are difficult to report or that have relatively low severity and high incidence in South Korea; as such, they require continuous and regular governmental monitoring for analysis. Sentinel surveillance infectious diseases include influenza, acute respiratory infection, parasitic infection, hand-foot-and-mouth disease, enterovirus, sexually transmitted infection, imported parasitic infection, intestinal infectious disease, and health-care-associated infection. Among these diseases, those presenting the following scenarios were excluded: 1) those with an annual incidence less than 100 people, imported/non-imported parasitic infections, and 2) those acquired from hospitals, health-care-associated infection.

To assess the influence of NPIs for COVID-19 on mental health, statistical data of the number of patients who received outpatient treatment for depressive episodes (F32), other anxiety disorders (F41), or sleep disorders (G47) during the first quarter of the year from 2018 to 2020 were obtained from the Healthcare Big Data Hub. Codes of F32, F41, and G47 were based on the seventh Korean Standard Classification of Diseases (KCD7). These disorders, which are related to mental health, were ranked among the top 100 most frequent diseases and disorders in outpatients in South Korea.

## Analysis

The changes in NPIs since the COVID-19 outbreak in South Korea were compared. To reveal the impact of NPIs on sentinel surveillance infectious diseases, the incidence data of these diseases from week 4 to week 28 of three consecutive years (2018, 2019, and 2020) were compared. In other words, disease cases from week 1 to week 3 were excluded because the first case of COVID-19 in South Korea was reported in week 4 of 2020.

Microsoft Excel (Microsoft Corporation, Redmond, WA, USA) and Google Sheets (Google, LLC, Mountain View, CA, USA) were used to create graphs that visualize the collected data.

## Results

Table 1 summarizes the average daily mask production volume, number of companies newly authorized to offer disinfection and sterilization services, and incidence of sentinel surveillance infectious diseases and mental illnesses.

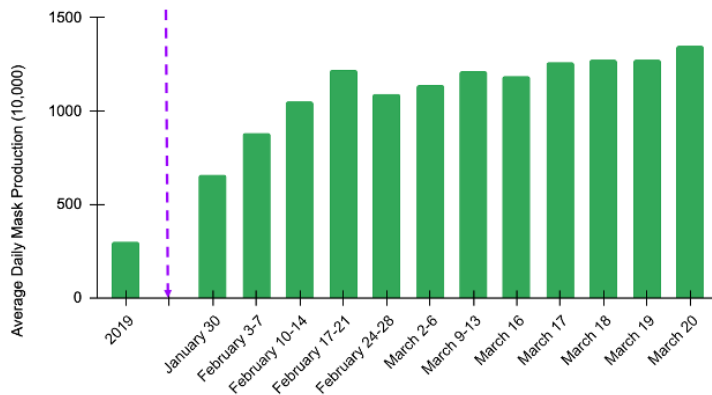
**Table 1.** Number of NPIs and incidence of sentinel surveillance infectious diseases and mental illnesses.

		2018	2019	2020
NPIs	Average daily mask production volume	NA	3,000,000	11,350,000
	Companies newly authorized to offer disinfection and sterilization services*	208	213	415
Sentinel surveillance infectious diseases	Influenza	7,356	6,523	3,297
	Acute respiratory infection	51,178	49,298	10,515
	Hand-foot-and-mouth disease†	5.1	14.3	0.8
	Enterovirus	743	1481	46
	Sexually transmitted disease	13,290	14,908	18,938
	Intestinal infectious disease	10,093	10,644	6,445
Mental illnesses	Depressive episodes	351,141	382,008	406,960
	Other anxiety disorders	301,515	322,427	337,653
	Sleep disorders	226,600	263,805	289,990

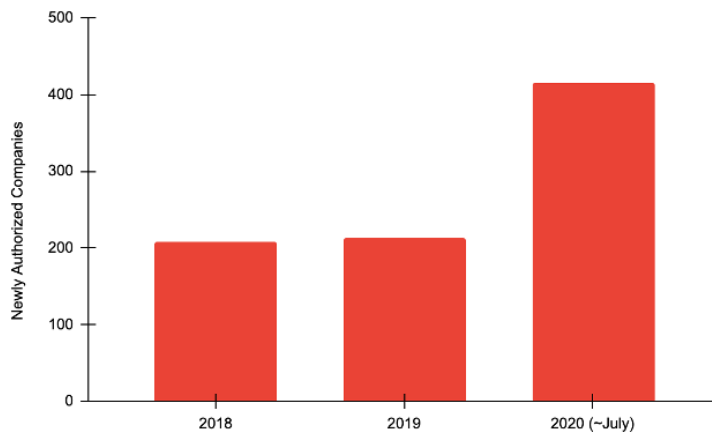
\*Numerical data were collected for 12 months in both 2018 and 2019 but for only seven months in 2020. †Hand-foot-and-mouth disease is reported via an annual disease rate indicating cases per 1,000 outpatient visits. Other variables are numbers of patients. NA = not available, NPIs = nonpharmaceutical interventions

### Nonpharmaceutical Interventions

The average daily mask production volume increased by about 380% from three million units in 2019 to 11.4 million units during the period between January and March 2020 (Figure 1). The number of companies newly authorized between January and July 2020 to offer disinfection and sterilization services increased by about 94.8% to 99.5% relative to the annual totals reported in 2018 and 2019 (Figure 2).



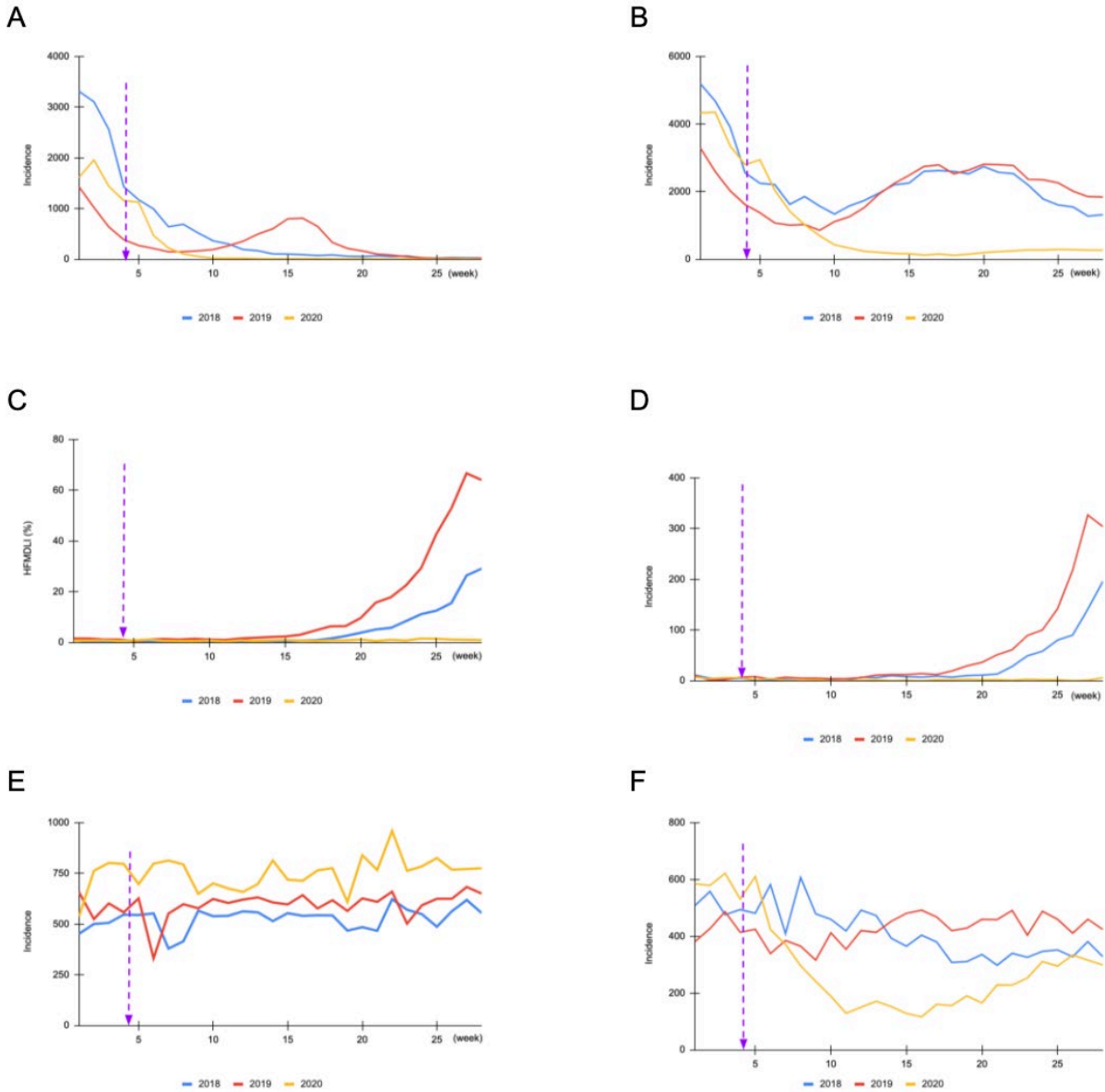
**Figure 1.** Average daily mask production volume. The dotted line represents the first reported case of COVID-19 in South Korea.



**Figure 2.** The number of companies newly authorized to offer disinfection and sterilization services. The numerical data in 2018 and 2019 were collected for 12 months, while data in 2020 were collected for only seven months.

### Sentinel Surveillance Infectious Diseases and Mental Illnesses

Influenza, acute respiratory infection, hand-foot-and-mouth disease, enterovirus, and intestinal infectious disease showed a significant decrease in incidence in 2020 compared to both 2018 and 2019. Meanwhile, the overall incidence of sexually transmitted disease slightly increased in 2020 (Table 1).



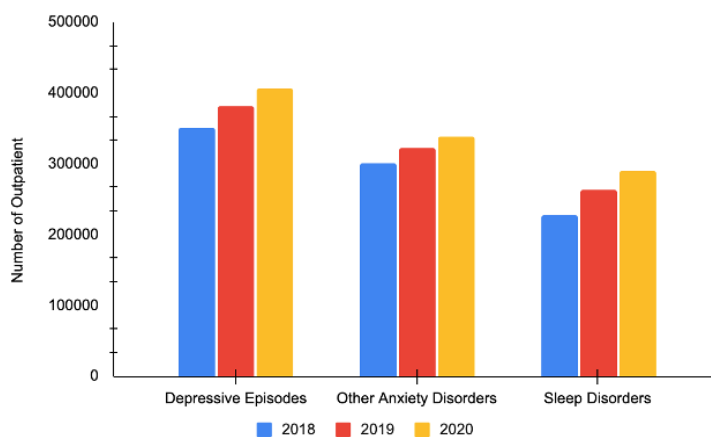
The peak incidence numbers of influenza and acute respiratory infection cases in week 2 of 2020 ( $n = 1,958$  and  $4,352$ , respectively) were higher than those in 2019 ( $n = 1,021$  and  $2,594$ ). While the incidence rates of both

diseases showed a progressive decrease until week 8, after which point, the incidences increased and reached a second peak in 2018 and/or 2019, cases in 2020 gradually decreased and maintained a plateau at their lowest point (Figures 3A and 3B). Ultimately, the incidence rates of influenza and acute respiratory infection in 2020 decreased by 49% to 55% and 78% to 79%, respectively, compared to those during 2018 and 2019.

The average number of weekly hand-foot-and-mouth disease cases per 1,000 outpatient visits in 2020 decreased by 84% to 94% in contrast with those during 2018 and 2019. Similarly, the incidence of enterovirus was reduced by 94% to 97% in 2020 compared with those during 2018 and 2019. Both diseases plateaued near their lowest incidence in 2020, whereas the diseases continuously increased in frequency in 2018 and 2019 (Figures 3C and 3D). Compared to 2018 and 2019, sexually transmitted diseases in 2020 increased by 27% to 42%. The weekly incidence of sexually transmitted diseases in 2020 remained constant regardless of the COVID-19 outbreak (Figure 3e). The occurrence pattern across the three consecutive years (2018–2020) was similar despite the annual increase in the number of cases.

Overall, the incidence of intestinal infectious disease in 2020 was reduced by 36% to 40% in comparison with those during 2018 and 2019; in particular, from week 5 to week 11 of 2020, the occurrence dramatically declined (Figure 3f).

Considering mental illnesses, the numbers of outpatients in 2020 increased by 7% to 16% for those with depressive episodes, 5% to 12% for those with other anxiety disorders, and 10% to 28% for those with sleep disorders, compared with outpatient numbers in 2018 and 2019 (Figure 4).



**Figure 4.** Incidence rates of depressive episodes, other anxiety disorders, and sleep disorders.

## Discussion

The exponential increase in NPIs due to the ongoing COVID-19 pandemic has had a significant effect on the rates of both sentinel surveillance infectious diseases and mental illnesses. NPIs have led to a reduction in occurrence of influenza, acute respiratory infection, hand-foot-and-mouth disease, enterovirus, and intestinal infectious disease; however, the onset of mental illnesses such as depressive episodes, other anxiety disorders, and sleep disorders has been negatively influenced by these interventions.

As an initial response to the outbreak of the virus, the Korean government extensively promoted the importance of handwashing, sanitizing, and wearing facemasks to prevent the spread of COVID-19. For example, the Korean Centers for Disease Control emphasized that handwashing is a “do-it-yourself” vaccine; hand sanitizers have been placed everywhere; and social distancing measures, including restrictions on attendance at in-person gatherings and schools, traveling, and sports, have been introduced (Korea Disease Control and Prevention Agency, 2020). These modes of prevention could reduce the possibility for contact and droplet transmission and cluster infections. The present study showed that various infectious diseases that rely on these transmission pathways, i.e., influenza, acute

respiratory infection, hand-foot-and-mouth disease, enterovirus, and intestinal infectious disease, were markedly declined after the introduction of NPIs for COVID-19. In particular, the incidence of respiratory and enteric infectious diseases, excluding influenza, decreased by more than 78%, while that of influenza was relatively low (49%–55%), although the data did not include the flu season, where the number of influenza cases typically peaks. The results of this study are similar to those of previous investigations that claimed handwashing can prevent 30% of enteric infections (Ejemot et al, 2008) and 20% of respiratory infections (Rabie and Curtis, 2006), while use of hand sanitizer can reduce the risk of respiratory and enteric infections by 47% to 98% (Tamimi et al., 2015). Liang et al. reported that use of masks by healthcare and non-health-care workers can reduce the risk of respiratory virus infection by 80% and 47%, respectively (Tamimi et al., 2015). Additionally, introduction of new workplace social distancing measures triggered a 23% reduction in the cumulative influenza attack rate and delayed and reduced the peak influenza attack rate (Ahmed, Zviedrite, and Uzicanin, 2018). Cowling et al. showed that influenza transmission has been significantly reduced following the implementation of NPIs, with a 44% reduction in the community transmission and a 33% reduction in pediatric hospitalization in Hong Kong (Cowling et al., 2020). Therefore, continuing discussion, education, and implementation of these hygiene rules could lead to improvements in public health, thereby reducing the cost of national health care.

In this present study, sexually transmitted diseases increased from 27% to 42% in incidence. Unlike respiratory and enteric infectious diseases that showed a dramatic reduction from the start of the COVID-19 outbreak, the frequency of sexually transmitted disease cases in 2020 maintained a similar trend throughout the study period. Moreover, the pattern of sexually transmitted diseases in 2020 was similar to those in 2018 and 2019. This indicates that NPIs for COVID-19 did not significantly affect the transmission of sexually transmitted diseases. Thus, the annual increase in sexually transmitted diseases may not be correlated with NPIs but instead is the result of South Korean society's open mindset about sexual activity.

The outbreak of COVID-19 and subsequent NPIs showed a negative impact on mental health in South Korea in this study. The findings of this study are similar to those of a previous meta-analysis that revealed high rates of mental illnesses in the general population during the COVID-19 pandemic in many countries (Xiong et al., 2020), including anxiety (6%–51%), depression (15%–48%), posttraumatic stress disorder (7%–54%), psychological distress (34%–38%), and stress (8%–82%). Mental illnesses can be influenced by several factors. For instance, social distancing, quarantine, and mass lockdowns can lead to loneliness, instability at work, and economic downturn. Witteveen's study showed a positive relationship between economic hardships and emotional expression of depression and anxiety during the COVID-19 lockdown (Witteveen and Velthorst, 2020). Therefore, more attention and systematic policies are needed to assist with people's mental health, particularly in challenging situations such as a public health crisis.

## Conclusion

NPIs introduced for the COVID-19 outbreak significantly reduced the incidence of respiratory and enteric infectious diseases and negatively affected mental health in South Korea. Therefore, while NPIs, i.e., handwashing, sanitizing, and wearing facemasks, should be continued in daily life to prevent the spread of common respiratory and enteric infections, systematic policies must be enacted to support mental health.

## Limitations

There are some limitations in this study. First, the 2020 data collected in this study cover only six months after the outbreak of the virus. Thus, this study does not reflect the long-term effects of prolonged disease prevention on infectious diseases and mental health. Second, it was difficult to collect diverse data related to NPIs because of limitations on the availability of open-source datasets. Nevertheless, the collected information was sufficient to indicate the extreme changes in NPIs in response to the COVID-19 pandemic. Finally, this study included only sentinel surveillance



infectious diseases, which have relatively low severity and commonality, and did not cover all infectious diseases with a transmission mode similar to that of SARS-CoV-2. Additionally, the mental illnesses assessed in this study were limited to those ranked among the top 100 most frequent diseases and disorders in outpatients in South Korea. Therefore, the results of this study might be under- or overestimated.

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