Knowledge-based normative safety measure approach: systematic assessment of capabilities to conquer COVID-19

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Abstract In this research article, we have introduced a knowledge-based approach to regional/national security measures. Proposed Knowledge-based Normative Safety Measure algorithm for safety measures helps to take practical actions to conquer COVID-19. We analyzed based on five dimensions: the correlation between detected cases and confirmed cases, social distance, the speed of detected cases, the correlation between imported cases and inbound cases, and the proportion of masks worn. It prompts actions based on the security level of the region. Through the use of our proposed algorithm, the government has accelerated the implementation of social distancing, accelerated test cases, and policies, etc., to prevent people from contracting COVID-19. This idea can be a very effective way to realize the impending danger and take action in advance. Help speed up the process of controlling the COVID-19. In pandemic times, it can be helpful to understand better. Holding the normative safety measure at a high level leads nations to perform excellently on triple T’s (testing, tracking, and treatment) policy and other safety acts. The proposed NSM approach facilitates for improve the governance of cities and communities.

1 Introduction

December 2019, Wuhan, China, registered the first official Corona Virus Disease-2019 (COVID-19) case of a novel RNA virus called the corona virus. Since then, 110 million-plus COVID-19 positive cases have been reported, nearly two and a half million people have died. In the wake of immediate intervention by the respective governments, NGOs, and front-line staff, new health initiatives and the introduction of large testing centers and treatment camps have made it possible to save more than 87 million patients worldwide from Severe Acute Respiratory Syndrome (SARS) respiratory illnesses caused by the novel corona virus. World Health Organization (WHO) announced the situation of COVID-19 as a pandemic, although at the earlier stage of the outbreak [34].

Many developing countries have been hit by the rapid growth of inbound positive civilian cases [31, 32]. Those countries are intended to bring back their populations from other countries made the situation more extreme. Careless screening at the entry stage, short of rapid testing equipment called RT-PCR Reagents, Real-Time PCR Detection Systems, Nucleic Acid Extraction Systems, PCR Work Stations, and insubstantial emergency medicine and treatment equipment such as ventilators, made it very difficult for countries to survive. Furthermore, this has gone even worse among economically developed and developing countries as a result of their infertile healthcare infrastructure and innovations [21]. In order to correct the inadequacy and limit the spread and development of the pandemic COVID-19 positive cases, countries have gone lock-down with strict policies on their own. It has generated risks in the economy, national development, domestic production, and imports, which have contributed to the scarcity of personal protective equipment (PPE), masks, sanitizers, ventilators, etc. between the healthcare services.
The review compares the agility, rapidity, and flexible management of health policy measures in Mediterranean nations when COVID broke out. They did a lot in the epidemic despite having fewer facilities and financial coverage. Taiwan, a close neighbor of China, relies on masks and medical treatment as the essential controlling tools. While the United States and the European Union feel that infected individuals should only wear a mask while they are sick, Taiwan has demanded and encouraged them to wear masks and follow medical advice throughout their lives. Due to thorough screening and these two factors, Taiwan managed the pandemic with very few deaths and affected rates. However, because European nations and the United States have significantly suffered, masking is the most crucial step to prevent COVID spread. Vietnam is yet another nation close to China that is at risk of becoming infected with the COVID-19. In contrast, Vietnam’s primary public health challenges and excellent governance and citizen collaboration, as well as a well-invested health system and a trace and track approach, have helped to combat the COVID-19 epidemic. South Korea is one of the countries that stands uniquely in the highly infectious COVID-19 war with fearless tactics from the Korea Centers for Disease Control and Prevention (KCDC) from day one [25].

In the meantime, certain countries have handled the COVID-19 outbreak successfully, followed strict pandemic guidelines by enforcing a variety of controls, and using technology to keep the situation out of control, which often helps them support other countries in several respects. The fundamental demands for this achievement is people’s self-awareness, coordination with the government by maintaining the social distance. Hence, in some countries the first wave of the pandemic was mitigated with home-stay orders or regional shut-downs by following proper quarantine among confirmed patients and shut down educational institutions. They worked overtime to sustain the economy by advancing the industrialization of modern technologies and meet the needs of medical facilities such as masks, personal protective equipment, and testing equipment [5, 11]. With high-speed internet, robust infrastructure, modernized society, ubiquitous smartphones, new information is immediately exchanged with civilians [18].

The sudden rise of confirmed cases to a height between February and June 2020 brought drive-thru’ testing clinic, made it a success to control the rapid growth rate of COVID-19 with rapid diagnostics and easy-to-access technologies in many countries [22]. Increasing the average daily test count allowing for various viewpoint strategies to concentrate on highly impacted areas. It helps to examine the closest contact of those infected individuals or isolated individuals with symptoms to break the spread chain by shielding them [27]. Disclosure of all COVID-19 related information from the government to public brought people together in one way to prevent the spread of the disease [8]. The response and effective healthcare governance of positive cases, along with digital technologies, has made nations to emulate amid an unfortunate pandemic crisis [12].

2 Related work

A wide variety of research papers have been published to examine and discuss the impact of the novel COVID-19 virus from the first outbreak in the world to the current stage in several fields. While the situation has become a pandemic, there is a reasonable probability for the nations to have an economic effect was published as a case study by [3]. Finucane et al. [13] examined the social confidence among governments and societies, as well as the role of risk management in the creation of a trust, that could transform from low-trust to high-trust. From day one, countries intense confrontation was examined in depth by [16] showing the people’s review of sustainable policies, teamwork in maintaining stable hypo-positive situations. Governments should be release new confirmed cases details in public regularly. Mouratidis [23] studied this information and reported the findings of time-varying reproductive data and doubling time in the most affected regions, which support governments towards control measures. Also, [6] have analyzed information statistically in order to extract the pattern of Spatio-temporal clusters along with the duration of clusters, resulting in the positivity of countries containment policies. In the meantime, [26] estimating the break-point of the pattern on the spread of the novel COVID-19 and setting an uncertain growth rate transmission point, although it is critical to consider. Qi et al. [28] studies suggest that the potential of vast test against COVID-19 is specific to drive-through and walk-through diagnostic methods, and this study also recognizes the value of transport infrastructures, location-based digital monitoring technologies, and the government’s ability to optimize.

A model of the spread of the COVID-19 virus between different communities, modeled by [9] using the Susceptible-Infected-Removed (SIR) model, encourages nations to forecast the future status of the disease situation using current data, which may lead to solid precautionary policies being updated with restrictions. Chu et al. [7] clarified that rapid response, precautionary procedures, day-to-day policy changes, health policies, civilian cooperation with the government, and collaboration of digital technology with newly invented methods for control the spread over high-impact regions and surveillance of each person made a specific model for epidemic situations. Mouratidis and Papagiannakis [24] calculated the delay-adjusted COVID-19 case fatality rate (CFR), and its evolution over the pandemic period highlights the need for caution over time. In addition, [2] predicts isolation of infected patients or symptoms, the release of healed patients, and deceased patients states help the health care team to focus on relevant disciplines and control steps. A comparison analysis by [19] shows the difference in public health interventions, protocols, cluster spread, and public and government coordination between the second wave and the third wave of COVID-19. [14] analyzed herd immunity against COVID-19 multi-fractal formalism on COVID-19 data with power-law growth behavior, [10] developed
a fractal interpolation SIR model to predict the transformation rate in epidemic COVID-19. [17] utilized a fractal-based predictive model for the comparison of COVID-19 dissemination in the first and second waves. [15] utilized the fractal interpolation method to predict the daily positive cases of new variant omicron. [1] developed a mathematical model to measure transmission behavior and control of COVID-19 in Malaysia. [30] developed a radio frequency identification protocol based on the digital Schnorr cryptosystem for the internet of things health in COVID-19. [20] utilized deep learning techniques to predict the COVID-19 infection through CT scan.

2.1 Limitations, motivation and contribution

More important than the extent to which we provide medical facilities to and protect the affected people is the need to improve security measures to prevent them from entering. However, in many countries, COVID-19 can be regarded as the second and third wave. Many countries are working hard to control COVID-19, all countries have implemented social distancing, isolation, and better medical facilities as much as possible, even though many countries are struggling to control the COVID-19. More important than how we do something is how we do it effectively. All countries can reflect the success of controlling COVID-19 in their own countries when they act knowing rather than just looking at actions and how effectively to do all of those actions. We need to analyze the performance and efficiency in the safety management system. To the author’s knowledge, no one research article was published to analyze the range of the efficiency level of the safety management system. From this research gap, we are motivated to propose our method. We analyzed the correlation between the confirmed and tested cases, social distancing level according to the confirmed cases, speed of the testing cases, the correlation between the imported cases and inbound cases, and the percentage of people wearing masks. By analyzing these factors, we can clearly understand the activity level of the safety management system. It helps increase the speed of detecting cases based on confirmed cases and helps implement social distancing programs. Based on these essential factors, we have introduced a new knowledge-based approach for security measures. The introduced normative security measures help measure the security level of a region or country.

A knowledge-based approach is how the knowledge we have learned applies to the problem and helps make decisions more effective by using the knowledge in the situation. In this research article, we proposed a knowledge-based Normative Safety Measure (NSM) algorithm with the COVID-19 data of South Korea [22]. In Sect. 2 we present the related work. In Sect. 3, theory-based work is presented. In Sect. 4, the NSM algorithm is proposed. In Sect. 5, the result and discussion, and conclusion are presented in Sect. 6.

3 Theory basis

3.1 Correlation between tested cases and confirmed cases

In this subsection, we examine the reasons for the success of COVID-19, taking into account the comparative rate of people being tested and those suffering from the disease as an essential factor in it. We need to check all the people who have had contact with them based on the number of people affected by the disease. Thus we can quickly isolate those who will be more vulnerable and bring the situation under control.

Here, we use the Pearson correlation to calculate the correlation between confirmed and tested cases. The Pearson correlation equation is given as follows:

$$C(\Lambda, \Theta) = \frac{\sum(\Lambda_i - \bar{\Lambda})(\Theta_i - \bar{\Theta})}{\sqrt{\sum(\Lambda_i - \bar{\Lambda})^2 \sum(\Theta_i - \bar{\Theta})^2}}$$

where:
- $\Lambda$ – Daily confirmed cases
- $\Theta$ – Daily tested cases
- $i$ – Number of days ($i = \text{Jan 20, 2020 to November 30, 2020}$)
- $\bar{\Lambda}$ – Mean of daily confirmed cases
- $\bar{\Theta}$ – Mean of daily tested cases

If $C(\Lambda, \Theta) = (0, 1]$ then the correlation is positive and $C(\Lambda, \Theta) = 0$ there is no correlation. Suppose $C(\Lambda, \Theta) = [-1, 0]$ then the correlation is negative between confirmed cases and tested cases. The Fig. 1a shows the correlation from February, 2020 to November, 2020. The $C(\Lambda, \Theta) = 0.3760$ which means the overall correlation is positive. The Fig. 1b shows positive correlation coefficient on February and March 2020 with $C(\Lambda, \Theta) = 0.5987$. The Fig. 1c shows the correlation from April, 2020 to May, 2020. The $C(\Lambda, \Theta) = 0.1658$, correlation is positive. The Fig. 1d shows almost there is no correlation on June 2020 with $C(\Lambda, \Theta) = -0.0331$. The Fig. 1e shows the correlation from July, 2020. The $C(\Lambda, \Theta) = -0.1581$, correlation is negative. The Fig. 1f shows positive correlation coefficient on August 2020 with $C(\Lambda, \Theta) = 0.6443$. The safety level value based on the correlation between confirmed cases and tested cases given in Table 1.

As we can see in the Fig. 1, the impact of COVID-19 was significant at that time (March). It can be seen that the comparison rate between tested cases and infected cases is increasing, and the impact of the disease on society is decreasing. Furthermore, the second time in August, when the incidence of COVID-19 was high, the comparison rate between those tested and those affected by the disease was lower than in previous months. Therefore, to reduce the impact of disease on the community level, it is necessary to consider the comparison rate between those tested and those affected by the disease.
Fig. 1 Correlation between confirmed cases and tested cases

![Graphs showing correlation between confirmed cases and tested cases from different months: (a) Overall from February to November, (b) February and March, (c) April and May, (d) June, (e) July, (f) August.](image)

Table 1 Safety level based on the correlation

| Safety measure | Correlation          | Positive  | Negative          |
|----------------|----------------------|-----------|-------------------|
| Less           | 0.1–0.3              | –0.7 to –1.0 |
| Medium         | 0.3–0.7              | –0.3 to –0.7 |
| High           | 0.7–1.0              | –0.1 to –0.3 |

As we all know, the COVID-19 first and second waves have occurred in South Korea in March and August months respectively. As shown in the Fig. 1, the correlation between confirmed cases and tested cases is highly optimistic in the first wave (March 2020) and the second wave (August 2020). They are increasing their actions and process according to the confirmed cases. Maintaining a high degree of positive correlation between the confirmed and tested cases maximized the speed of testing cases, tracing the affected people and isolating the cluster related to the affected people. Hence, a much important action is to keep the correlation positive between the confirmed and tested cases.

3.2 Social distancing

In the absence of effective vaccines and antiviral medications, social distancing is the only way to suppress the spread of the new disease of COVID-19. Social distancing implemented by the government may effectively prevent large clusters but may not be effective in managing small and intermittent clusters. Social distance in life is aimed at maintaining various social and economic activities and the prevention and management of diseases to ready society for a long-term battle against COVID-19. Social isolation raises the potential for an outbreak of a contagious disease, making communicable diseases less likely to break out. Spontaneous social distancing, one form of social distancing accompanied by a person, tends to eliminate a viral infection with asymptomatic infection, which is weak and conditional,
so public social distancing, another type of social distancing will be enforced by the government in public spaces and therefore should be effective enough to suppress infectious agents. Based on the confirmed cases (Table 3), the safety level (Fig. 2) value given in Table 2.

As shown in the Fig. 2, based on the confirmed cases rate, we need to follow the social distancing schemes. Taking the relaxation from that social distancing level causes much in the spread of COVID-19 by increasing the number of testing cases by testing the cluster people, increasing the level of affected people, etc. If the number of confirmed cases per day lies between 0 to 50 in the week, we need to follow the social distancing scheme-level 1. Hence the safety measure level is safe. Following the relaxation from the social distancing scheme-level 1 drops the safety measure level to risk.

If the number of confirmed cases per day lies between 50 and 100 in the week, we need to follow the social distancing scheme level 2. Hence the safety measure level is safe. At this stage, following the social distancing scheme-level 1 takes us to the safety measure level to risk. Following more relaxation from the social distancing scheme-level 1 drops the safety measure level to high risk.

If the number of confirmed cases per day lies between 100 and 200 weekly, we need to follow the social distancing scheme level 3. Hence the safety measure level is safe. At this stage, following the social distancing scheme-level 2 takes us to the safety measure level to risk. Following the social distancing scheme, level 1 drops the safety measure level to high risk.

### 3.3 Speed of testing cases

The number of people tested is one of the most important factors to prevent COVID-19 infection. By speeding up the testing process, we will be able to diagnose and treat infected people quickly. It can also reduce the number of people who die from the disease. Although the percentage of test-takers has increased, we can speed up vigilance and treatment measures. Therefore, we need to calculate whether we are rapidly increasing the percentage of experimenters. The following Fig. 3 shows the flow rate of the number of test cases from January 20, 2020, to November 30, 2020. From the Table 4, we get a clear insight into daily tested cases’ dimensions. The speed of the tested cases (Fig. 4) can be determined by finding the rate of change of the tested cases smoothed. When an infection spreads, it is essential first to know how many of us are affected. By knowing this, it is possible to know at what speed the disease is spreading. It will also help us to realize what kind of action we need to take further. It would be helpful to devise plans to warn people to behave with warning measures. It is also possible to isolate and treat affected individuals and those associated with them. Isolation can be very effective in preventing the spread of disease.

As shown in the Table 4 and figure 4, the test cases at the first wave (March 2020) and the second wave (August 2020) are very high. They are increasing their speed in testing the affected people and clusters related to the affected people. By increasing the rate of testing

### Table 2 Safety level based on the social distancing

| Daily confirmed cases | Level | Safety measure |
|-----------------------|-------|---------------|
| 0–50                  | Level 1 | Safe         |
|                       | Relaxations from Level 1 | Risk         |
| 50–100                | Level 2 | Safe         |
|                       | Relaxations from Level 2 | Risk         |
|                       | level 1   | High risk    |
| 100–200               | Level 3  | Safe         |
|                       | Level 2  | Risk         |
|                       | level 1   | High risk    |

### Table 3 Number of confirmed cases

| Date       | 01.22.2020 | 03.09.2020 | 04.02.2020 | 05.07.2020 | 08.13.2020 | 09.04.2020 | 11.13.2020 |
|------------|------------|------------|------------|------------|------------|------------|------------|
| Number of tests | 851-229 | 242-101 | 94-4 | 12-113 | 103-441 | 198-101 | 205-629 |
| Range      | More than 200 | 200–100 | 100–1 | 1–100 | 100–400 | 100–200 | More than 200 |
3.4 Imported cases ($\text{Im}_i$) vs inbound cases ($\text{Ib}_i$)

When an infection spreads, it is essential to know how many imported cases occurred in the regions. Knowing this makes it possible to know at what speed the disease is spreading through the imported cases. It will also help us to realize what kind of action we need to take further. It would be helpful to devise plans to warn people to behave with warning measures. It is also possible to isolate and treat affected individuals and those associated with them. Reducing the imported cases can be very effective in preventing the spread of disease [19].

The Fig. 5a shows the correlation between imported cases and inbound cases from February, 2020 to November, 2020. The $C(\text{Im}_i, \text{Ib}_i) = 0.1612$ which means the overall correlation is positive. The Fig. 5b shows negative correlation coefficient on February and March 2020 with $C(\text{Im}_i, \text{Ib}_i) = -0.3777$. The Fig. 5c shows the correlation from April, 2020 to May, 2020. The $C(\text{Im}_i, \text{Ib}_i) = -0.3796$, correlation is negative. The Fig. 5e shows negative correlation on June 2020 with $C(\text{Im}_i, \text{Ib}_i) = -0.2961$, correlation is negative. The Fig. 5f shows negative correlation coefficient on August 2020 with $C(\text{Im}_i, \text{Ib}_i) = -0.1912$. The safety level value based on the correlation between imported cases and inbound cases given in Table 5.
Fig. 5 Correlation between imported cases and inbound cases

Table 5 Safety level based on the correlation between (Im₁) and (Ib₁)

| Safety measure | Correlation |
|----------------|-------------|
|                | Positive    | Negative    |
| Less           | 0.1 to 0.3  | – 0.7 to – 1.0 |
| Medium         | 0.3 to 0.7  | – 0.3 to – 0.7 |
| High           | 0.7 to 1.0  | – 0.1 to – 0.3 |

As shown in the Fig. 5a, the overall correlation between the imported cases and inbound cases was highly positive. In February and March 2020, the correlation was negative, as shown in the Fig. 5b. After finding out the COVID-19 cases in Daegu (region of South Korea), the reason behind this is that they restricted the foreigners from certain countries and areas that have more COVID-19 issues. Also, all foreigners are self-quarantined for 14 days, and all foreigners are tested for COVID-19 at the airport. By following these restrictions in the upcoming months (June, July, and August), the correlation between imported and inbound cases was negative, as shown in the Fig. 5e, f. It shows the team management efficiency to control COVID-19.

3.5 Mask

This pandemic teaches us to protect ourselves and to take conscious measures. Wearing a face mask in the community becomes a mandatory habit amongst civilians and governments, and WHO insists on continuously wearing a face mask regularly. Viruses, contagious germs, dust particles containing droplets can almost be prevented from entering the human body. This measure changes the emphasis from self-protection
to altruism, actively includes all people, and is a sign of social unity in the global response to the pandemic [35]. N95 masks, surgical masks, and self-made masks will shield 90 percent of COVID-19 infectious droplets from rebroadcasting. It acts as a key isolation method for individuals, especially Korea and China, to succeed in controlling the spread of the outburst. For fast-paced industrial Korea, face masking is frequently used to prevent pollution, making it convenient for people during the COVID-19 epidemic. Many experts feared that the heavily populated Asian countries might end up in hazardous conditions due to high infectious infections for almost all civilians. Other areas of the world would also find themselves in a critical situation, and everything would collapse. However, fortunately, the widespread knowledge of wearing facial masks makes experts composure [29]. Based on the mask-wearing percentage, the safety level (Fig. 6) value given in Table 6.

4 Proposed method: knowledge-based approach

A knowledge base that allows the thinking process of a decision to be defined and states the reasoning for a decision, meaning that if a problem arises in the final result, the line of thinking can be adequately analyzed. At the start of the project, pertinent information is collected so that the conclusion can be based on context information and experience. They then use accurate, reproducible, and transparent approaches to combine and summarize the information to minimize bias and increase the efficiency and precision of conclusions. It is impossible to move information using information technology [4]. To preventing this, effective information management strategies must be implemented. Knowledge-based decision-making is often used as a predictor and a standard rule in decision-making contexts. The use of knowledge-based applications is shown to be an appropriate methodology (Fig. 7). to supporting decision-making. Capturing and handling the massive amount of data/information that must be analyzed is an inherent aspect that makes applications specialized. Another inherent consideration is the diversity of data sources, which may result in unreliable, unclear, or incomplete information bases as many sources of data are used. As a result, the organization of a knowledge-based system’s knowledge base and the articulation of its customized version are two critical concerns for an excellent knowledge-based system. Decisions in system architecture are intrinsically related to the method, experience, and system principles concerned and would need a more versatile and structured decision process representation that facilitates the mitigation of uncertainties [33].

4.1 Knowledge-based normative safety measure (NSM)

Here, we introduced knowledge-based normative safety measure (NSM) to conquer of COVID-19.

Steps:

1. Determine the correlation (Γ) between $\Lambda_i$—confirmed cases and $\Theta_i$—testing cases.

$$C(\Lambda_i, \Theta_i) = \frac{N \sum \Lambda_i \Theta_i - \sum \Lambda_i \sum \Theta_i}{\sqrt{N \sum \Lambda_i^2 - (\sum \Lambda_i)^2} \sqrt{N \sum \Theta_i^2 - (\sum \Theta_i)^2}}$$

where $N$ is number of pair of values.

2. Calculate the score value of social distancing ($\Psi$) based on the three-level distancing scheme (L1, L2, L3).

$$\Psi = \begin{cases} 1 & \text{if } 0 < \Lambda_i < 50 \text{ and } L = 1 \\ 0 & \text{else} \end{cases}$$

$$\Psi = \begin{cases} 1 & \text{if } 50 < \Lambda_i < 100 \text{ and } L = 2 \\ 0.5 & \text{if } 50 < \Lambda_i < 100 \text{ and } L = 1 \\ 0.25 & \text{else} \end{cases}$$

$$\Psi = \begin{cases} 1 & \text{if } 100 < \Lambda_i < 200 \text{ and } L = 3 \\ 0.5 & \text{if } 100 < \Lambda_i < 200 \text{ and } L = 2 \\ 0.25 & \text{else} \end{cases}$$
3. The speed of the testing cases $S(\Theta)$ can be determined as follows:

$$S(\Theta) = \frac{\Delta \Theta_i}{\Delta d_i}$$

(5)

where, $\Theta_i$ is average daily testing case rate $d_i$ is total number of days $S(\Theta_i)$ is rate of change describes how daily testing case rate changes with respect to changes in the $d_i$.

4. Determine the correlation ($\Phi$) between imported cases ($Im_i$) and inbound cases ($Ib_i$):

$$C(Im_i, Ib_i) = \frac{N \sum Im_i \cdot Ib_i - \sum Im_i \sum Ib_i}{\sqrt{N \sum Im_i^2 - (\sum Im_i)^2} \sqrt{N \sum Ib_i^2 - (\sum Ib_i)^2}}$$

(6)

where $N$ is number of pair of values.

5. Calculate the percentage of the mask-wearing ($\Xi$) level.

6. Calculate the normative safety measure (NSM) by using the following equation:

$$NSM(R) = \frac{1}{2}w_1 \Gamma w_2 \Psi \sin \frac{2\pi}{n}$$

$$+ \frac{1}{2}w_2 \Psi w_3 S(\Theta) \sin \frac{2\pi}{n}$$

$$+ \frac{1}{2}w_3 S(\Theta) w_4 \Phi \sin \frac{2\pi}{n}$$

$$+ \frac{1}{2}w_4 \Phi w_5 \Xi \sin \frac{2\pi}{n}$$

$$+ \frac{1}{2}w_5 \Xi w_1 \Gamma \sin \frac{2\pi}{n}$$

(7)

where, $n$ is the number of factors ($n = 5$). $w$ represents the degree of importance of the factors.

7. Sort NSM(R) values.

4.2 Algorithm-NSM

Algorithm of the proposed NSM approach.

Setting input parameters for the NSM
Let $\Lambda_i$ ← no.of confirmed cases
$\Theta_i$ ← no.of tested cases
$\Delta \Theta_i$ ← average daily confirmed cases
$\Delta d_i$ ← average tested cases
$Im_i$ ← no.of imported cases
$Ib_i$ ← no.of inbound cases
if $C(\Lambda_i, \Theta_i) = 0 : 0.3$ then $\Gamma = 0.1$
elseif $C(\Lambda_i, \Theta_i) = 0 : 0.7$ then $\Gamma = 0.5$
else $C(\Lambda_i, \Theta_i) = 0.3 : 0.7$ then $\Gamma = 0.5$
else $C(\Lambda_i, \Theta_i) = 0.7 : 1.0$ then $\Gamma = 1.0$
for $\Lambda_i = 0 : 50$
if $L = 1$ #level 1 then $\Psi = 1.0$
else $\Psi = 0.25$
for $\Lambda_i = 50 : 100$
if $L = 2$ #level 2 then $\Psi = 1.0$
else $\Psi = 0.25$
for $\Xi = 0.5$
else $L = 1$ #level 1 then $\Psi = 0.5$
Setting input parameters for the NSM

\[ \text{else } \Psi = 0.25 \]
\[ \text{for } \Lambda_i = 100 : 200 \]
\[ \text{if } L = 3 \ #\text{level} \ 3 \]
\[ \text{then } \Psi = 1.0 \]
\[ \text{else if } L = 2 \ #\text{level} \ 2 \]
\[ \text{then } \Psi = 0.5 \]
\[ \text{else } \Psi = 0.25 \]
\[ \text{if } \delta = 0 : 100 \]
\[ \text{then } S(\Theta_i) = 0.2 \]
\[ \text{elseif } \delta = 100 : 200 \]
\[ \text{then } S(\Theta_i) = 0.4 \]
\[ \text{elseif } \delta = 200 : 500 \]
\[ \text{then } S(\Theta_i) = 0.8 \]
\[ \text{elseif } \delta = 500 : 1000 \]
\[ \text{then } S(\Theta_i) = 1.0 \]
\[ \text{if } C(\text{Im}_i, \text{Ib}_i) = 0 : 0.3 \]
\[ \text{then } \Phi = 0.1 \]
\[ \text{elseif } C(\text{Im}_i, \text{Ib}_i) = 0.3 : 0.7 \]
\[ \text{then } \Phi = 0.5 \]
\[ \text{else } C(\text{Im}_i, \text{Ib}_i) = 0.7 : 1.0 \]
\[ \text{then } \Phi = 1.0 \]
\[ \text{if } \varpi = 0 : 30\% \]
\[ \text{then } \Xi = 0.22 \]
\[ \text{elseif } \varpi = 30 : 50\% \]
\[ \text{then } \Xi = 0.4 \]
\[ \text{elseif } \varpi = 50 : 80\% \]
\[ \text{then } \Xi = 0.8 \]
\[ \text{else } \varpi = 80 : 100 \]
\[ \text{then } \Xi = 1.0 \]

Determine the normative safety measure

\[ \Gamma = C(\Lambda_i, \Theta_i) \leftarrow \text{correlation between } \Lambda_i \text{ and } \Theta_i \]

Determine the score of social distance level (Ψ)

Evaluate the speed of testing cases \( S(\Theta_i) \)

Calculate \( \Phi = C(\text{Im}_i, \text{Ib}_i) \leftarrow \text{correlation between } \text{Im}_i \text{ and } \text{Ib}_i \)

Determine \( \Xi \) score of mask wearing level

Calculate NSM(R)

Sort NSM(R) by ascending order

5 Result and discussion

By using the proposed algorithm, the result of the normative safety measure is listed in the Table 7. The normative safety level of each month is given in the Fig. 8a, b. By effectively performing these five factors nations can able to perform safety management policies proficiently.

As shown in the Sect. 3.1, South Korea has not always followed the positive correlation level between confirmed and tested cases. However, as shown in the Fig. 1b and f, they performed well at the peak level of COVID-19 transmission in the first wave (March) and the second wave (August), with a correlation rate of 0.5987 And 0.6443, respectively. The high correlation between the confirmed and tested cases can efficiently perform excellently on their triple T’s (testing, tracing, and treatment) policy. Hence, to execute the triple T’s system effectively, the base system maintains a positive correlation between the confirmed and tested cases. Hence, we can control the spread of COVID-19 by implementing social distancing based on confirmed cases in specific areas. As shown in the Fig. 2, we use three levels of safety, risk, and high risk to measure the safety level of the area based on social distance and the number of confirmed cases. Judging from the results of social distancing safety measures, South Korea scored very high.

As shown in the Fig. 4, the test cases of the first wave (March) and the second wave (August) are very fast, 800 and 382.97, respectively. Having the high speed of testing cases leads to the isolation and tracking of the cluster of persons who are all closely moving with positive case persons, and it helps to execute the triple T’s effectually. By analyzing the correlation between imported and imported cases, the negative correlation is the largest, especially in March and August 2020. Because South Korea follows the restrictions on the incoming persons from China and Europe and on all other high-risk regions, they have implanted a 14-day self-isolation rule for all travelers. By implementing these policies, they have produced a negative correlation between imported cases and inbound cases. When we have a positive correlation between the imported and inbound cases, we need to understand that we are in the emergent situation for implanting the restrictions on the travelers and 14 days’ self-quarantine and tracing the clusters of the travelers who are having the positive test result. As shown in the Fig. 6, we measure the safety level by calculating the percentage of masks worn. We measure the safety level by using four levels as low, medium, high, very high according to the mask-wearing percentage. From the results of the safety measure in the mask-wearing, South Korea keeps a high score.

6 Conclusion

In this research article, we proposed a knowledge based NSM algorithm. We analyzed from five dimensions: the correlation between detected cases and confirmed cases, social distance, the speed of detected cases, the correlation between imported cases and inbound cases, and the proportion of masks worn. Based on these five dimensions, we analyzed the efficiency level of safety management system in conquering COVID-19. The proposed
Table 7  Normative safety measure values

| Month          | February & March | April & May | June | July | August | Overall |
|----------------|------------------|-------------|------|------|--------|---------|
| Normative safety measure | 0.0126           | 0.0152      | 0.0021 | 0.0012 | 0.0122 | 0.0098  |

**Fig. 8** Normative safety measure

The normative safety measures algorithm helps to measure the safety level of the region and helps take measures to prevent and control the vulnerability of COVID-19. What is more, this security measure algorithm will help successfully deal with pandemic situations in the future. The government has hastened the deployment of social distance, accelerated test cases, and regulations, among other things, to prevent people from getting COVID-19. This concept has the potential to recognize upcoming danger and take action ahead of time. Assist in speeding up the control of COVID-19.

Many authors from many vital nations in the COVID-19 pandemic zone have developed a holistic system model, which looks at the problem from multiple perspectives such as the natural habitat, population, healthcare system, and economic structure. The current crisis was treated as a time-delayed feedback control problem with partial controllability and reliability. The overall outcome gives assumptions for controlling activities at each level, assisting the ruling parties in making critical decisions in critical situations.
A comprehensive epidemiological study of the second and third COVID waves shows that the rate of local clusters is relatively low in the third wave, while direct communication transmission and unknown pathways of transmission have grown dramatically. The first and second waves’ experiences make swift and timely social distancing procedures and isolation activities considerably more prosperous and safer third wave.

A matured strategy distinguishes nations extraordinary success even in no total lock-down implementation. It makes easier to restrict the spread of the virus through a series of activities, regulations, and policies. This report presents Korea’s core capability framework, which other nations may use to analyze their pre-existing skills and improve their health systems resilience to future difficulties. Each nation should assess its strengths and weaknesses in terms of its healthcare system’s capacity to react in any instance.

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References

1. A. Abidemi, Z.M. Zainuddin, N.A.B. Aziz, Impact of control interventions on Covid-19 population dynamics in Malaysia: a mathematical study. Eur. Phys. J. Plus 136(237), 1–35 (2021)
2. T. Alafif, R. Alotaibi, A. Albassam, A. Almudhayyani, On the prediction of isolation, release, and decease states for COVID-19 patients: a case study in South Korea. ISA Trans. 2021, 5 (2021)
3. A.I. Alzahrani, H. Al-Samarraie, A. Eldenfria, J.E. Dodoo, N. Alalwan, Users’ intention to continue using mHealth services: a DEMATEL approach during the COVID-19 pandemic. Technol. Soc. 68, 101862 (2022)
4. S. Balaneshinkordan, A. Kotov, Bayesian approach to incorporating different types of biomedical knowledge bases into information retrieval systems for clinical decision support in precision medicine. J. Biomed. Inform. 98, 103238 (2019)
5. Z. Ceylan, Estimation of COVID-19 prevalence in Italy, Spain, and France. Sci. Total Environ. 729, 138817 (2020)
6. A.W.Z. Chew, Y. Wang, L. Zhang, Correlating dynamic climate conditions and socioeconomic-governmental factors to spatiotemporal spread of COVID-19 via semantic segmentation deep learning analysis. Sustain. Cities Soc. 75, 103231 (2021)
7. Z. Chu, M. Cheng, M. Song, What determines urban resilience against COVID-19: city size or governance capacity? Sustain. Cities Soc. 75, 103304 (2021)
8. R. Chundakladan, R. Ravidran, Information flow and COVID-19 recovery. World Dev. 136, 105112 (2020)
9. I. Cooper, A. Mondal, C.G. Antonopoulos, A SIR model assumption for the spread of COVID-19 in different communities. Chaos Soliton Fract. 139, 110057 (2020)
10. D. Easwaramoorthy, A. Gowrisankar, A. Manimaran, S. Nandhini, L. Rondoni, S. Banerjee, An exploration of fractal-based prognostic model and comparative analysis for second wave of COVID-19 diffusion. Nonlinear Dyn. 106(2), 1375–1395 (2021)
11. F.J. Elgar, A. Stefanik, M.J.A. Wohl, The trouble with trust: time-series analysis of social capital, income inequality, and COVID-19 deaths in 84 countries. Soc. Sci. Med. 263, 113365 (2020)
12. M.R. Fatmi, COVID-19 impact on urban mobility. J. Urban Manag. 9(3), 270–275 (2020)
13. M.L. Finucane, R. Beckman, M. Ghosh-Dastidar, T. Dubowitz, R.L. Collins, W. Truexl, Do social isolation and neighborhood walkability influence relationships between COVID-19 experiences and wellbeing in predominantly Black urban areas? Landsc. Urban Plan. 217, 104264 (2022)
14. A. Gowrisankar, T. Priyanka, S. Banerjee, Omicron: a mysterious variant of concern. Eur. Phys. J. Plus 137(1), 1–8 (2022)
15. A. Gowrisankar, L. Rondoni, S. Banerjee, Can india develop herd immunity against covid-19? Eur. Phys. J. Plus 135(526), 1–9 (2020)
16. P. Hubert, S.A. Hadi, A. Mojzisch, J.A. Häusser, The effects of organizational climate on adherence to guidelines for COVID-19 prevention. Soc. Sci. Med. 292, 114622 (2022)
17. C. Kavitha, A. Gowrisankar, S. Banerjee, The second and third waves in india: when will the pandemic be culminated? Eur. Phys. J. Plus 136(596), 1–12 (2021)
18. I. Kim et al., KCDC, early trend of imported COVID-19 cases in South Korea, Korea Centers for disease control and prevention. Osoon Public Health Res. Perspect. 11(13), 140–145 (2020)
19. M. Kim, J. Kang, D. Kim, H. Song, H. Min, Y. Nam, D. Park, J.-G. Lee, Hi-COVIDNet: deep learning approach to predict inbound COVID-19 patients and case study in South Korea. Assoc. Comput. Mach. 2020, 1–8 (2020)
20. R. Kundu, P.K. Singh, M. Ferrara, A. Ahmadian, R. Sarkar, ET-NET: an ensemble of transfer learning models for prediction of COVID-19 infection through chest CT-scan images. Multimedia Tools Appl. 81, 31–50 (2022)
21. X. Li, Z. Zhao, F. Liu, Big data assimilation to improve the predictability of COVID-19. Geogr. Sustain. 1(4), 317–320 (2020)
22. MOEF, All about Korea’s response to COVID-19, in Task Force for Tackling COVID-19, Ministry of Economy and Finance, Republic of Korea (2020), p. 1–239
23. K. Mouratidis, COVID-19 and the compact city: implications for well-being and sustainable urban planning. Sci. Total Environ. 811, 152332 (2022)
24. K. Mouratidis, A. Papagiannakis, COVID-19, internet, and mobility: the rise of telework, telehealth, e-learning, and e-shopping. Sustain. Cities Soc. 74, 103182 (2021)
25. H. Nakamura, S. Managi, Airport risk of importation and exportation of the COVID-19 pandemic. Transp. Policy 96, 40–47 (2020)
26. S. Pang, J. Xiao, Y. Fang, Risk assessment model and application of COVID-19 virus transmission in closed environments at sea. Sustain. Cities Soc. 74, 103245 (2021)
27. T. Papadopoulos, K.N. Baltas, M.E. Balta, The use of digital technologies by small and medium enterprises during Covid-19: implications for theory and practice. Int. J. Inf. Manage. 55, 102192 (2020)

28. Y. Qi, J. Liu, T. Tao, Q. Zhao, Impacts of COVID-19 on public transit ridership. Int. J. Transp. Sci. Technol. (2021). https://doi.org/10.1016/j.ijtst.2021.11.003

29. M.H. Shakil, Z.H. Munim, M. Tasnia, S. Sarowar, COVID-19 and the environment: a critical review and research agenda. Sci. Total Environ. 745, 141022 (2020)

30. M. Shariq, K. Singh, M.Y. Bajuri, A.A. Pantelous, A. Ahmadian, M. Salimi, A secure and reliable RFID authentication protocol using digital Schnorr cryptosystem for IoT-enabled healthcare in COVID-19 scenario. Sustain. Cities Soc. 75, 103354 (2021)

31. D. Slater, A systems analysis of the UK COVID-19 pandemic response: part 2—work as imagined vs work as done. Saf. Sci. 146, 2022 (2022). https://doi.org/10.1016/j.ssci.2021.105526

32. D. Slater, E. Hollnagel, R. MacKinnon, M. Sujan, A. Carson-Stevens, A. Ross, P. Bowie, A systems analysis of the COVID-19 pandemic response in the United Kingdom—Part 1—the overall context. Saf. Sci. 146, 2022 (2022). https://doi.org/10.1016/j.ssci.2021.105525

33. H.-Y. Sung, Y.-L. Chi, A knowledge-based system to find over-the-counter medicines for self-medication. J. Biomed. Inform. 108, 103504 (2020)

34. S. Vandoros, Excess mortality during the Covid-19 pandemic: early evidence from England and Wales. Soc. Sci. Med. 258, 113101 (2020)

35. Z. Zhou, D. Yue, C. Mu, L. Zhang, Letter to the editor: mask is the possible key for self-isolation in COVID-19 pandemic. J. Med. Virol. 92, 1745–1746 (2020)