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Effect of the social distancing measures on the spread of COVID-19 in 10 highly infected countries

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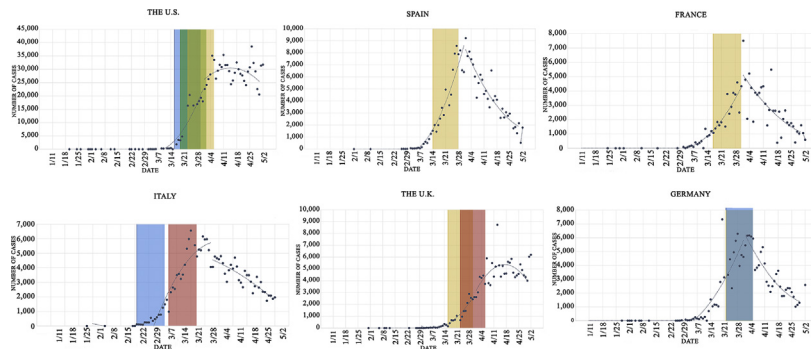
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HIGHLIGHTS

- The statistics of the COVID-19 confirmed-cases and deaths in 10 highly infected countries was collected
- The effectiveness of the social distancing measures on the spread of COVID-19 was analyzed
- It takes 1-4 weeks since the promulgation of highest level of measures until the number of cases starts to decrease.
- The effectiveness of the social distancing measures on the spread of COVID-19 was different between the 10 focused countries.

GRAPHICAL ABSTRACT



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ABSTRACT

From the end of 2019, an unprecedented novel coronavirus, which was named COVID-19 by the World Health Organization (WHO) emerged from Wuhan city, China. Despite rigorous global containment and quarantine efforts, the incidence of COVID-19 has continued to rise, with over 4 million confirmed-cases and over 300,000 deaths worldwide until mid-May. This study aims to present the effect of the promulgation of social distancing measures on the spread of COVID-19 in the cases of 10 highly infected countries. The authors focus on the statistics of the COVID-19 confirmed-cases and deaths in 10 highly infected countries, including The U.S., Spain, Italy, The U.K., France, Germany, Russia, Turkey, Iran and China, and the response to the pandemic of these countries in the period from January 11 to May 2, 2020. The relationships between the social distancing measures and the statistics of COVID-19 confirmed-cases and deaths were analyzed in order to elucidate the effectiveness of the social distancing measures on the spread of COVID-19 in 10 highly infected countries. The results showed it took 1-4 weeks since the highest level of social distancing measures promulgation until the daily confirmed-cases and deaths showed signs of decreasing. The effectiveness of the social distancing measures on the spread of COVID-19 was different between the 10 focused countries. This variation is due to the difference in the levels of promulgated social distancing measures, as well as the difference in the COVID-19 spread situation at the time of promulgation between the countries.

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1. Introduction

From the end of 2019, an unprecedented novel coronavirus, which was named COVID-19 by the World Health Organization (WHO)

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emerged from Wuhan city, China (Yu et al., 2020). The daily spread of the novel coronavirus has become one of the most common public concerns all over the world. On January 30, 2020, WHO declared a global public health emergency (PHEIC) for COVID-19, warning that the epidemic was truly a serious health emergency (Middleton et al., 2020). While medical researchers are urgently getting underway to develop the treatment drugs and vaccines to prevent the coronavirus (Le et al., 2020), reasonable social measures may significantly limit the spread of COVID-19 within the community (West et al., 2020; Sen-Crowe et al., 2020).

The social distancing measures, which can be called “lockdown” have been considered and promulgated in order to limit human interaction at close distances in certain regions as well as in a national scale. To evaluate the effectiveness of the social distancing measures on the spread of COVID-19, Tobias or Saez et al. have analyzed the trends of confirmed-cases and deaths in Spain and Italy before and after their respective national lockdowns using the statistics on a time-series (Tobías, 2020; Saez et al., 2020). The results showed incidence trends were considerably reduced in both countries after the social distancing measures. Danny Ibarra-Vega has developed a mathematical model with the systems dynamics methodology to evaluate the effectiveness of the quarantines or lockdowns on the reduction in community contacts for a population scale of 100,000 (Ibarra-Vega, 2020). Katz et al. have sought to identify the key features of preparedness and the primary concerns of local public health officials in deciding to implement social distancing measures for the case of The U.S. (Katz et al., 2019). Jarvis et al. have evaluated the effectiveness of the physical distancing measures on the transmission of COVID-19 in The U.K. (Jarvis et al., 2020). Lin et al. have developed a conceptual model for COVID-19 outbreak in Wuhan, China with individual reaction and governmental action (Lin et al., 2020). Atangana has used a mathematical model to demonstrate the effect of social distancing measures on the spread of COVID-19 in Italy. The study also took into account the possibility of transmission from dead bodies to humans (Atangana, 2020).

Various numbers of studies have been implemented on the effectiveness of the social distancing measures in specific regions. However, the conditions regarding economic scale, political institutions or medical system etc. of each country greatly differs. Moreover, the period and the scale of COVID-19 spread in countries are also different. Therefore, the levels and the timing of the social distancing measures taken as well as the effectiveness of these measures are not the same between countries. Consequently, the effectiveness of the social distancing measures on the spread of COVID-19 should be objectively evaluated based on a data of a broader scale. The analyses focused on the relationships between the timing, the levels of the social measures and the growth or decline rate of the COVID-19 confirmed-cases in different countries are a useful reference for subsequent social measures as long as coronaviruses still exist in the community.

In this article, the daily statistics of COVID-19 confirmed- and death-cases of 10 countries including The U.S., Spain, Italy, The U.K., France, Germany, Turkey, Iran and China, for almost 4 months, were collected from the database of WHO (World Health Organization coronavirus disease (COVID-2019) Situation Reports, 2020). Moreover, the social measures to prevent the spread of COVID-19 of these countries were collected from the national or regional official websites, and news sites, which daily update information about the pandemic. The relationships between the timing, levels of the social measures and the growth or decline rate of the COVID-19 daily confirmed-cases were analyzed by combining the collected information with a time-series.

2. Materials and method

2.1. Data collection

Since the day the world confirmed the first cases by COVID-19, the confirmed-cases have escalated to millions. The outbreak initially

began in China, and weeks later the disease started to break out in other parts of the world including Europe and the Americas (World Health Organization WHO Timeline-COVID-19, 2020). The infection is spreading day by day and has lasted more than 4 months since the end of December 2019. The current numbers of confirmed-cases and deaths in The U.S. and European countries have strikingly exceeded that of China. This article focused on 10 countries that had high levels of infection and still continue to persist based on WHO's statistics (WHO Coronavirus Disease (COVID-19) Dashboard, 2020). There are many reasons why these countries became the world leading countries in the number of confirmed-cases. One of them may stem from the large number of people coming into their territories, which greatly attract tourism or immigration from other countries. Moreover, many of these severely infected countries are developed countries whose economy will suffer from undoubtedly dramatic downturn when the social distancing measures are promulgated.

In previous studies, the characteristics of population or climate were confirmed to have an important effect on the spread of COVID-19 (Eslami and Jalili, 2020; Ferreira et al., 2020; Wu et al., 2020). The number of COVID-19 tests performed daily also varies from country to country (Our World in Data, Coronavirus Testing, 2020). Therefore, the analyses in this article were performed assuming that these variables within a country were a constant during the focused period. In addition, the analyses primarily focused on assessing the increase or decrease of infection instead of the absolute value of confirmed-death-cases in each country.

In this article, the daily data of COVID-19 confirmed and death-cases in the period from January 11, 2020 to May 2, 2020 was collected from the statistical reports that record the number of worldwide infections daily by the World Health Organization (World Health Organization coronavirus disease (COVID-2019) Situation Reports, 2020). The information related to the social measures of the focused countries was collected from government announcements on national or regional official websites, or on many news sites, which daily update information about the pandemic (the details of references are shown in Table 1 below).

2.2. Investigation of the social measures of 10 highly infected countries and definition of the levels of the social distancing measures

Depending on situation of each country, the prohibitions enacted are different but the national measures are generally classified into three main categories: travel restrictions, facilities shutdown and social distancing. Governments issued travel restriction measures including travel bans from other countries to limit the spread of the virus from outside of their borders, and domestic travel restrictions to limit the spread of the virus among their citizens. The facilities shutdown measures are aimed to further limit the domestic outbreak, by reducing crowds in non-essential places such as bars, restaurants, festivals and prioritizing the safety of children by closing schools. The social distancing measures can be considered the highest level, where people in regions or the whole country are required to stay at home. While the social distancing measures are evidently beneficial in limiting the spread of infection, they also greatly affect people's lives and the whole nation's economy in negative ways. Therefore, many countries took their time to consider the best response before declaring restriction measures.

Specific measures of 10 highly infected countries, their promulgated date and the references are shown in Table 1. In this table, the travel restrictions include: (1) ban entry from highly infected countries (China, Iran, etc.); (2) close national borders and suspend foreign travel; (3) domestic transportation restrictions. The facilities shutdown includes: (1) close schools; (2) close non-essential services and public events; (3) work-from-home order. The social distancing includes: (1) restriction against going outside; (2) stay at home order. There are 2 levels for each order of facilities shutdown and social distancing: (R) by region and (N) nationwide.

Table 1
Classification of social measures in 10 focused countries.

Country	Date	Content of social measures										References			
		Travel restrictions			Facilities shutdown				Social distancing						
		(1)	(2)	(3)	(1)	(2)	(3)	(1)	(2)	(1)	(2)				
		(R)	(N)	(R)	(N)	(R)	(N)	(R)	(Level-1)	(N)	(Level-2)		(R)	(Level-3)	(N)
The U.S.	1/31	√													The White House, 2020
	2/29	√	√												
	3/13	√													
	3/13				√										
	3/15	√			√										
	3/16											√			
	3/19								√						
	3/23					√					√				
	3/25					√									
	Spain	3/14				√		√		√		√			
3/22			√												
Italy	2/23				√		√					√		The Guardian, Italy, 2020	
	3/8				√		√					√			
	3/10					√			√				√		
The U.K.	3/16										√			The U.K. Government, 2020	
	3/20					√		√							
	3/23			√					√				√		
France	3/17		√				√				√			France 24, 2020	
Germany	2/28				√									The Federal Government, 2020	
	3/13				√										
	3/17		√												
Russia	3/22									√		√		The Moscow Times, 2020	
	4/1	√													
	2/2	√													
	2/23	√													
	3/1	√													
	3/8		√												
	3/18		√												
Turkey	3/9					√			√		√			The Ahval, 2020	
	3/26						√								
	3/30			√								√			
	2/1	√													
	2/23	√													
	2/29	√													
	3/12					√									
Iran	3/19						√				√			The Global News, 2020	
	3/28	√		√											
	4/10											√			
	2/20					√									
China	3/18					√								The China Daily, 2020	
	3/25			√			√						√		
	1/23		√	√	√		√				√				
	1/24		√	√											
	3/27		√												

In many cases, COVID-19 infected people do not show any symptom in the early stage, hence they are not aware of their condition and continue to interact with other people. Among measures in Table 1, travel restrictions and facilities shutdown can prevent them to some extent from contacting others and spread the coronavirus, but not completely. Therefore, the social distancing measures were promulgated after or at the same time as the travel restrictions and facilities shutdown measures in most focused countries. The social distancing measures request everyone to stay indoors. Therefore, social distancing measures are considered the strongest measure against contagion within the community. Based on the analyses results described below, the decrease in the daily COVID-19 confirmed-cases appeared after social distancing measures were promulgated. Therefore, in this study, social distancing measures have been more focused than the other measures in Table 1. The social distancing measures are divided into 4 detailed levels as follows.

Level 1: Warnings against going out by region, which is the lightest level, only promulgated on specific areas affected by the spread of virus.

Level 2: Warnings against going out on a nationwide scale.

Level 3: Stay-at-home measures by region. This measure prevents people in highly affected regions from going outside with very few exceptions, including shopping for basic necessities or seeking medical help.

Level 4: Stay-at-home measures on a nationwide scale. Everyone in the country is required to stay home unless it is absolutely vital for them to go out. This measure is similar to level 3, but on a bigger scale in response to the national state of emergency.

3. Results and discussions

3.1. Relationship between the social distancing measures and the statistics of COVID-19 confirmed-cases

Fig. 1 shows the time-series of the daily confirmed-cases from January 11 to May 2, 2020 of 10 highly infected countries. Based on information from coronaviruses such as MERS and SARS, the incubation period of Covid-19 can be up to 14 days according to the World Health

Organization ([World Health Organization coronavirus disease \(COVID-2019\) Situation Report – 73, 2020](#)). Hence, people who are suspected to be infected or exposed to the virus might not show any symptom, therefore unable to be classified as a confirmed-case, until one or two weeks later. Therefore, it takes a certain period of time until the effectiveness of measures can be observed on the data of confirmed-cases. Here, the 14 days from the promulgation of social distancing measures are shown by colored bands in [Fig. 1](#). The beginning of each band marks the date the measures were put into effect. In addition, the data on the figure was analyzed using the trendlines, each of which represents the estimated trend of daily case transition of the month, starting from January to the beginning of May. The trendlines are quadratic polynomials, which better illustrate the fluctuating trends than linear polynomials. Moreover, it is also important to note that the value scale of the vertical axis in these figures is different from each other.

[Fig. 1](#) shows that it took approximately 1–4 weeks since the promulgation of highest level of social distancing measures in each country until the numbers of daily confirmed-cases showed positive results. Within a month since strictest social distancing measures were placed, the number of daily confirmed-cases in most countries reached their peaks and began to decrease. It took Iran and Turkey only one week since the highest level of the social distancing measures were promulgated until the number of daily confirmed-cases started to decrease. The number of weeks before observable recovery in Germany, France, Spain, China and Italy were 1.5, 2, 2.5, 2.5 and 3.5 respectively.

Meanwhile, it took The U.K. and The U.S. about 4 weeks since the highest level of the social distancing measures were promulgated until the number of daily confirmed-cases started to stop rising. However, the trends of the decline in the daily confirmed-cases in these countries were not as clear as those in other countries. In addition, Russia has showed no sign of flattening its curve. 3 weeks after the date of promulgation of the first social distancing measures, the state of infection in this country was still extreme, forcing the government to issue a higher level of social distancing measure. Still, up until the beginning of May, the number of confirmed-cases in this country continued to increase.

Results of [Fig. 1](#) show that the effectiveness of the social distancing measures on the spread of COVID-19 is different between 10 countries. This variation may be due to the difference in the content of promulgated social distancing measures, as well as the difference in the daily confirmed-cases at the time of promulgation between the countries. Some countries including Spain, France, Iran and China only promulgated one social distancing measures throughout the focused time-series. Comparison between these countries shows that the stronger the level of social distancing, the faster it took for the number of daily confirmed-cases to decrease. Meanwhile, other countries started with lower levels before continuing to promulgate stricter measures in order to cope with their specific situations. The time gap between promulgated measures was also different between the countries. For instance, in order to cope with its tremendous rise in the number of cases, The U.S. Government promulgated 3 different levels of social distancing measures quite close together. In Germany, 2 levels of social distancing measures were put into effect on the same day, whereas the time gap between promulgated measures in The U.K. and Italy were 1 and 2 weeks respectively. The two social distancing measures promulgated in Russia were the same level as that of Turkey, and the measures in both countries were promulgated at the same interval of 3 weeks. However, the effectiveness of the social distancing measures was evident in the data of Italy, Germany and Turkey, but not clearly in the data of The U.S. and The U.K. One of the reasons for the case of The U.S. is considered to be because the daily confirmed-cases in The U.S. were relatively high at the promulgated date of the highest level of social distancing measures, and the situation was more difficult to control than other countries at the time when the social distancing measures were promulgated. Moreover, Russia has showed no sign of flattening its curve. There have been several explanations for the situation of Russia, one of which is said to be due to “relatively low” compliance

with lockdown, said Christopher Gerry, Director of Russian and East European Studies at the School of Global and Area Studies at Oxford University (<https://time.com/5836890/russia-coronavirus/>). Other reasons for the continued increase in confirmed-cases in Russia are attributed to poor testing early on preventing the authorities from tracking how far the virus had spread, resulting in the fact that social distancing measures were not strong enough and were imposed quite late.

Based on above results, it can be confirmed that the daily confirmed-cases in most countries declined (despite differences in scale) after social distancing measures were promulgated. Therefore, it can be said that although social distancing is not the radical measure against the pandemic, but while vaccination and medicine are under research and development, the social distancing measures have appeared to have tremendously positive effect on limiting the COVID-19 spread.

3.2. Relationship between the social distancing measures and the statistics of COVID-19 deaths

Similar to [Fig. 1](#), [Fig. 2](#) shows the time-series of daily death-cases of the above countries and the date of promulgation of social distancing measures. [Meo et al.](#) pointed out that the number of COVID-19 confirmed-cases had been proportional to the number of deaths ([Meo et al., 2020](#)). The analyses in this study also showed the similar trends between the confirmed-cases and death-cases in the focused countries. It took roughly the same amount of time for the daily death-cases and the daily confirmed-cases to start declining in Spain, Turkey and Iran. Meanwhile, the period of time it took for the daily death-cases to decline in Germany, France, Italy and China was 2 weeks slower than the time needed for the daily confirmed-cases in these countries to start declining.

In contrast, it took The U.S. 4 weeks since the promulgation of highest level of social distancing measures to control the increase of the daily death-cases, but the daily deaths did not seem to slow down, although after 4.5 weeks, it has stopped rising sharply like the last few weeks. Despite various measures being issued quite close together, fatality rate due to the coronavirus in The U.S. has still been severe. In The U.K., it seems social distancing measures have not made significant difference in the daily death-cases, and the daily deaths fluctuated throughout April. In Russia, although two levels of social distancing measures have been placed in March, up until the end of April, the daily confirmed-cases and deaths continued to rise significantly. The trends in the numbers of deaths in these countries are also similar to the trends of the daily confirmed-cases analyzed in [Section 3.1](#).

Although the trends of the daily deaths and the daily confirmed-cases are similar in most of the focused countries, the ratio of the daily deaths to confirmed-cases is not necessarily the same between countries. It is considered to be the result of many reasons, including difference in the daily testing numbers, the counting method of deaths and the medical systems, etc. between countries ([Johns Hopkins University and Medicine, Coronavirus Resource Center, 2020](#)). While this is a very important issue, it is difficult to evaluate based on only the collected data in this study. Therefore, the authors did not analyze this issue in depth within the scope of this study.

3.3. The growth rate of daily confirmed-cases at the time of promulgating the highest levels of social distancing measures

[Atalan](#) collected data from 49 countries to prove the effectiveness of the social distancing measures on the suppression of COVID-19. Analysis was made using the length of lockdown period as a main parameter ([Atalan, 2020](#)). In this study, the authors have focused on other parameters including levels, timing of promulgation of the social distancing measures as described above. The timing of social

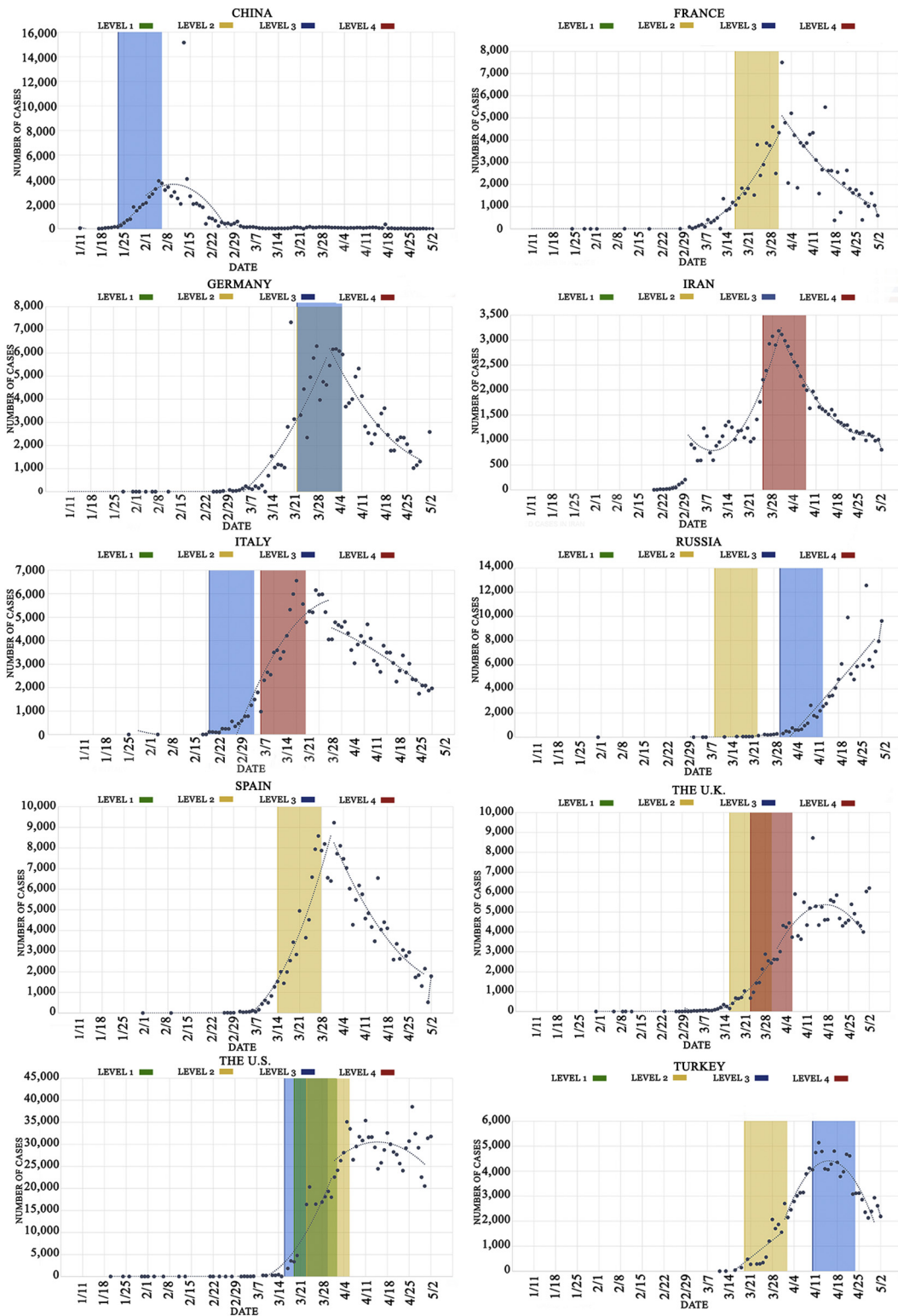


Fig. 1. Time-series of daily confirmed-cases in 10 countries.

distancing measures promulgation plays an important role in the limitation of infected cases. The social distancing measures that are promulgated when the growth rate of daily confirmed-cases is out of control evidently result in severe conditions. Here, Eq. (1) is defined as follows to evaluate the growth rate of daily confirmed-cases at the promulgated time of highest-level social distancing measures since 2 weeks prior (hereinafter referred to as growth rate of daily confirmed-cases).

$$G_R = \frac{(C - C_0) \times 100\%}{C} \tag{1}$$

where,

- G_R : Growth rate of daily confirmed-cases (unit: percent (%))
- C : The daily confirmed-cases at the promulgated date of the highest level of social distancing measures (unit: cases)

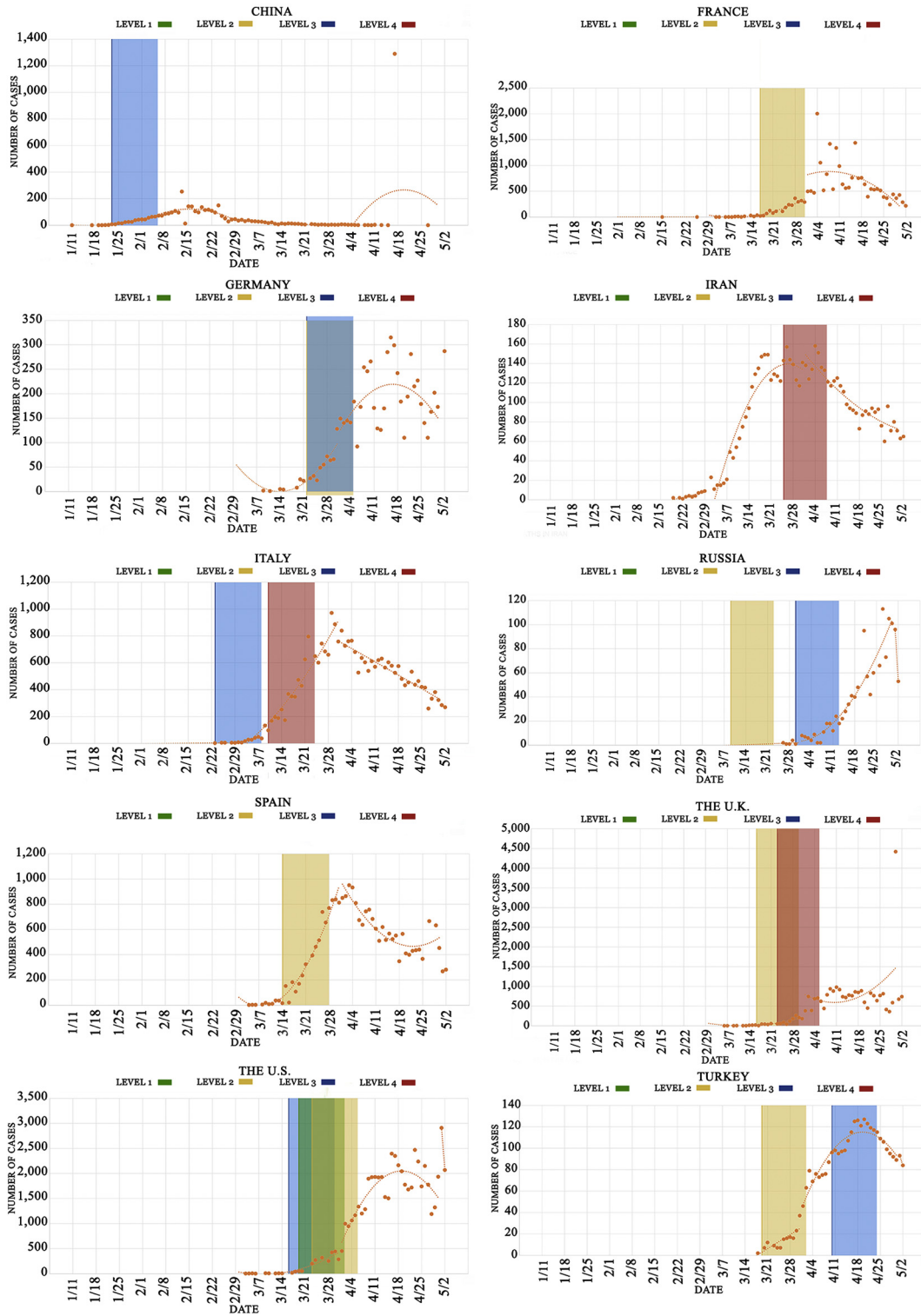


Fig. 2. Time-series of daily death-cases in 10 countries.

C_0 : The daily confirmed-cases at the time of 2 weeks prior to the promulgated date of the highest level of social distancing measures (unit: cases).

Note that, the daily confirmed-cases (C and C_0) in Eq. (1) were determined by the intersection of the trendline and the focused date in Fig. 1. In addition, for example, a growth rate of 100% means that 2 weeks before the social distancing measures was promulgated, there was almost no confirmed-cases. The growth rates of daily confirmed-cases of the 10

focused countries, that were calculated based on Eq. (1), are shown in Table 2. The growth rates of daily confirmed-cases at the date when the social distancing measures were put into effect, are fairly comparable between EU member countries (except Germany), The U.K. and The U.S. The U.S. and The U.K. promulgated their ultimate social distancing measures when the growth rates of daily confirmed-cases in both countries reached 99.9%, which was closely followed by Spain, France and Italy at 99.2%, 96.2% and 95.4% respectively. Meanwhile, the growth rates of Germany, Russia, Turkey and Iran are 85.0%, 72.2%, 70.7% and

Table 2
Growth rate of confirmed-cases in 10 focused countries.

Country	Growth rate (%)
The U.S.	99.9
The U.K.	99.9
Spain	99.2
France	96.2
Italy	95.4
Germany	85.0
Russia	72.2
Turkey	70.7
Iran	62.8
China	-

62.8%, respectively, being lower than those of EU member countries (except Germany), The U.K. and The U.S.

China has started to promulgate their highest level of social distancing order on January 23, 2020, a short period of time after the announcement of the virus spread (BBC News, 2020). As the daily confirmed-cases at the time of 2 weeks prior (January 9, 2020) was outside the time period focused in this study, the growth rate of daily confirmed-cases of China cannot be calculated by Eq. (1). It was undoubtedly expected that China would be the first country to impose the social distancing measures as the virus first emerged in its cities, it is said that the social distancing measures in China was one of the strictest to prevent the virus spread (The Guardian, 2020).

The calculation results in Table 2 do not represent the delay or timeliness of the timing of promulgating the social distancing measures of the countries. However, these results show that the growth rates of EU member countries (except Germany), The U.K. and The U.S. at the time of promulgating the highest social distancing measures were higher than those of other countries. This means that the spread situation of COVID-19 was difficult to control at the time of promulgating the social distancing measures in these countries. This partly affects the effectiveness of the social distancing measures on the spread of COVID-19. Excluding the case of Russia, the social distancing measures were effective in a faster period of time in countries with low growth rates of daily confirmed-cases such as Iran, Turkey or Germany as described in Section 3.1. This also affects the decline rate of daily confirmed-cases after the peak as described in Section 3.4 below.

3.4. The decline rate of daily confirmed-cases after the spread reached its peak

The situation of COVID-19 spread of countries at the time of promulgating the social distancing measures were different, hence the effectiveness of these measures was apparently different between countries. The effect of the social distancing measures can be evaluated by the time it took for the spread to start decreasing and the decline rate of this decrease. In this article, the following Eq. (2) is defined to evaluate the decline rate of daily confirmed-cases from the date of the cases

Table 3
Decline rate of confirmed cases in 10 focused countries.

Country	Decline rate (%)
China	71.0
Iran	51.8
Turkey	50.8
France	48.0
Spain	47.7
Germany	39.2
Italy	35.8
The U.K.	25.9
The U.S.	14.8
Russia	-

of each country reached its peak to 2 weeks later (hereinafter referred to as decline rate of confirmed-cases).

$$D_R = \frac{(D_{\text{peak}} - D_1) \times 100\%}{D_{\text{peak}}} \quad (2)$$

where,

D_R : Decline rate of daily confirmed-cases (unit: percent (%))

D_{peak} : The highest number of daily confirmed-cases in the focused period since January 11 to May 2 (unit: cases)

D_1 : The daily confirmed-cases 2 weeks after the peak (unit: cases).

Similar to Eq. (1), the daily confirmed-cases (D_{peak} and D_1) in Eq. (2) were determined by the intersection of the trendline and the focused date in Fig. 2. In addition, for example, a decline rate of 100% means that 2 weeks after the peak there was almost no daily confirmed-cases.

The decline rates of daily confirmed-cases of the 10 focused countries, that were calculated based on Eq. (2), are shown in Table 3. Since the number of daily confirmed-cases in Russia reached its peak in May 2, the number of 2 weeks later is out of the time-series in this study. Therefore, the decline rate of daily confirmed-cases of Russia cannot be calculated. The decline rates of daily confirmed-cases in Table 3 are lower than their growth rates of daily confirmed-cases in Table 2. Unlike the similarity in the growth rates, the decline rates of these countries vary noticeably. However, the reversal trend between growth and decline rates of daily confirmed-cases, can be observed by comparing Tables 2 and 3, where the higher growth rates leads to the lower decline rates. In other word, the containment of COVID-19 spread may take more time for countries that have high growth rates of daily confirmed-cases at the time of promulgating the social distancing measures. Namely, The U.S. and The U.K. are two countries with the highest growth rates of daily confirmed-cases resulting in their significantly low decline rate (14.8% and 25.9% respectively). On the other hand, the fact that China, Iran and Turkey have the highest decline rates may be partly because they are also the three countries that started to promulgate highest level of social distancing measures when growth rates were lowest.

Based on above analysis, it can be confirmed that the trends of growth and decline of daily confirmed-cases differs between countries. Consequently, nations must evaluate their specific conditions to come up with the reasonable level and timing for social distancing measures. Since the social distancing measures may bring social isolation and negative psychological consequences on human, evaluating the change in post-lockdown social distancing is also an important topic in the future (Block et al., 2020).

4. Conclusion

In this study, the daily statistics of COVID-19 confirmed and death-cases of 10 countries including The U.S., Spain, Italy, The U.K., France, Germany, Turkey, Iran and China, for almost 4 months, and the social measures for the prevention of the spread of COVID-19 in these countries were collected. The relationships between the timing, levels of the social measures and the growth or decline rates of daily confirmed-cases were analyzed by combining the collected information with a time-series. Findings from this research are summarized as follows.

1. In most of the 10 countries, it took 1–4 weeks since the point of highest level of social distancing measures promulgation until the numbers of daily confirmed-cases and daily deaths showed signs of decreasing.
2. The effectiveness of the social distancing measures on the spread of COVID-19 was different between the 10 focused countries. This variation is considered to be due to the difference in the level of promulgated social distancing measures, as well as the difference in the

COVID-19 spread situation at the time of promulgations between the countries.

- The transition of daily confirmed-cases and daily death-cases in each country has similar trends.
- The growth rates of daily confirmed-cases of EU member countries (except Germany), The U.K. and The U.S. at the time of promulgating the highest social distancing measures were higher than that of other focused countries. This means that the spread situation of COVID-19 was difficult to control at the time of promulgating the social distancing measures in these countries.
- The growth rate of daily confirmed-cases at the time of promulgating the social distancing measures partly influences the decline rates of daily confirmed-cases after the spread reached its peak.

However, this study also has several limitations. The influence of public gatherings that have been happening in the US and European countries, was not considered in the evaluation of the effectiveness of social distancing measures in this study. This is because the timings, magnitudes and processes of these gatherings are too complicated for a quantitative evaluation. In addition, apart from main social distancing measures widely publicized by the governments of the 10 countries, there have also been small and regional measures in localities in each country. Since these measures were not widely publicized or difficult to collect correctly, they were not taken into account in this study. Moreover, the COVID-19 pandemic is still going on at the time of this research, some countries are still in quarantine, while others have put terminations to their social distancing measures. The termination process of different countries is also different, as many countries eased measures gradually. The evaluation of the social distancing measures on the spread of COVID-19 should continue in the future work based on a larger scale of data.

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CRedit authorship contribution statement

Tran Phuoc Bao Thu: Conceptualization, Data curation, Formal analysis, Writing - original draft. **Pham Nguyen Hong Ngoc:** Conceptualization, Data curation, Formal analysis, Writing - original draft. **Nguyen Minh Hai:** Conceptualization, Supervision, Writing - review & editing. **Le Anh Tuan:** Conceptualization, Supervision, Writing - review & editing.

Declaration of competing interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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