Respond to the COVID-19 pandemic: strategies comparison in six countries

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Research

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Abstract

Objective This study aimed to examine the effectiveness of the containment strategy and mitigation strategy taken by six countries.

Methods We extracted publicly available data from various official websites, summarized the strategies implemented in these six countries, and assessed the effectiveness of the prevention and control measures adopted by these countries.

Results Responding to an unprecedented COVID-19 pandemic, China, South Korea, and Singapore adopted containment strategies, and China and Singapore had a similar epidemic curve and the new daily cases. As of December 31, 2020, the new daily cases of China and Singapore were below less than 100 with the mortality rates per 100,000 population 0.3% and 0.5% respectively. But the new daily cases of South Korea as high as 1029 with the mortality rates per 100,000 1.8%. In contrast, the United States, the United Kingdom, and France responded with mitigation strategies, and had similar epidemic curves and mortality rates per 100,000 population. The United States had up to 234,133 new confirmed cases per day and a mortality rate per 100,000 population was 107%, while the UK had 56,029 new confirmed cases per day and a mortality rate per 100,000 population was 108%, and France had 20,042 new cases per day, with a mortality rate per 100,000 population of 99%.

Conclusions In response to the COVID-19 outbreak that is still spreading globally, countries can consider policy alternatives and novel solutions developed by other countries and adapt them base on their domestic circumstances and resources.

Introduction

The coronavirus disease 2019 (COVID-19) is continuing to spread worldwide. As of Feb 23, 2021, the COVID-19 outbreak has caused 112,222,860 confirmed cases, 2,483,930 death cases. The number of new cases outside China exceeded 290,000, the total of confirmed cases more than 110 million, and the total of death cases more than 2.47 million.¹ However, fortunately, in the past year, at least 186 countries have implemented varying degrees of restrictions on population movement to slow the spread of the severe acute respiratory syndrome coronavirus and prevent health systems from becoming overwhelmed; these restrictions have amounted to lockdowns in 82 countries, resulting in a retreat in both new cases and the mortality rate.^{2,3}

At the beginning of the epidemic, different countries had different attitudes and strategies due to cultural differences, but now many issues reached a consensus. East Asian countries such as China placed more emphasis on non-pharmaceutical interventions in the early stage of the epidemic: containing the epidemic by means including “lockdown city”, universal access to diagnostic techniques, screening for potential infections, and providing a saturation of isolation beds. Because of the low immunity to the COVID-19 and the recurrence of the epidemic, those in East Asia are now placing great emphasis on vaccine development and vaccination and hoping to contain the epidemic with the help of vaccines. In

contrast, the developed countries such as Europe and the United States attached great importance to vaccine and drug development at the beginning of the epidemic, and have made relatively great progress in these areas. Now, Europe and the United States are beginning to focus on non-pharmaceutical control, but the global epidemic is still serious.

Despite the global availability of the COVID-19 vaccine, the importance of non-pharmaceutical interventions to contain the spread of the epidemic cannot be underestimated, given the current global vaccination management chaos, “vaccine shortage” and inequitable distribution. To compare the effects of different types of non-pharmaceutical interventions, this study selected China, South Korea, and Singapore, which were the countries in East Asia with earlier epidemics, and implemented containment strategies. Meanwhile, we also selected the United States, the United Kingdom, and France, which were the countries with more severe epidemics, and implemented mitigation strategies. We hoped that our findings will provide a policy reference for countries experiencing the impact of the COVID-19.

Methods

We extracted publicly available epidemiological data (including national population, total confirmed cases, daily new cases, total deaths, and daily new deaths) from official websites, including data from the National Health Commission of the People’s Republic of China, and Johns Hopkins University & Medicine Coronavirus Resource Center. To collect the available policy information and sort it out in containment and surveillance, healthcare, border control, and community and social. we searched national documents and responses to COVID-19 through various countries’ government web-page, such as media announcements and governmental decrees of these six countries starting from the COVID-19 outbreak. We assessed the effectiveness of the COVID-19 strategies adopted by these countries through combining the strategies of the six countries with the daily new cases and mortality rate per 100,000 population.

Results

National response to the COVID-19 pandemic

China, South Korea and Singapore containment strategies

China was the first country to report the COVID-19 infection. South Korea and Singapore, the next rapidly hit countries after China. At the beginning of the COVID-19 outbreak, with no immediate vaccines and antiviral medication for COVID-19, China being the epicenter of the outbreak swiftly swung into action in managing the epidemic. Typical measures include the use of existing traditional public health epidemic containment strategies of lockdown infectious areas, testing, isolation, quarantine, expanding the number of beds, physical distancing, and community containment.⁴

Similarly, South Korea and Singapore, the next two hit COVID-19 outbreak countries after China, fully utilized their experience from the MERS outbreak in 2015 and the SARS outbreak in 2003 respectively, in responding to COVID-19. South Korea, based on three core principles of openness, transparency, and

creative innovation, was able to effectively implement the strategy of 3Ts of testing, tracing, and treatment.⁵ However, the Singapore government had constructed a three-pronged approach which includes travel, healthcare, and community measures to curb the spread of COVID-19. The major measures taken for COVID-19 in China, South Korea, and Singapore were summarized in Table 1 from containment, healthcare, border, and community and society.

Table 1
The major measures taken for COVID-19 in China, South Korea and Singapore

Measures	China	South Korea	Singapore
Containment and surveillance measures	<p>Implementing strictly the “Four early’s” measures of early detection, early reporting, early isolation, and early treatment.</p> <p>(1) Early detection: performing community screening, setting up temperature testing points in neighborhoods, companies, shopping malls and other public places, and conducting nucleic acid testing screening for people with clinical symptoms, close contacts of confirmed cases, and people returning from epidemic areas.</p> <p>(2) Early reporting: individual initiative reporting, unit uniform reporting, pharmacy discovery reporting, medical institution reporting, joint prevention and control reporting.</p> <p>(3) Early isolation/quarantine: self-quarantine at home, centralized medical isolation, and centralized hospital for observation.</p> <p>(4) Early treatment: clearly diagnose and transfer to a designated hospital as soon as possible.</p>	<p>“Three Ts” measures of fast Testing, meticulous Tracing, and appropriate Treatment.</p> <p>(1) Fast testing, the Korean government granted emergency use authorization for testing kits which helped to build a foundation for large-scale testing. And the introduction of drive-through and walk-through screening stations for sample collection coupled with fast and aggressive testing allowed early detection of confirmed cases in communities.</p> <p>(2) Meticulous Tracing: the time needed for epidemiological investigations was also significantly reduced thanks to the utilization of ICT.</p> <p>(3) Appropriate treatment: confirmed cases are first categorized by severity for access to appropriate treatment.</p>	<p>(1) At healthcare facilities or through contact tracing confirmed cases were based on clinical and epidemiological criteria, and continuously update as change of the COVID-19 situation. Doctors were also allowed to test patients who are suspected for clinical or epidemiological reasons.</p> <p>(2) All suspected and confirmed cases were immediately isolated in hospital. Asymptomatic close contacts were required to quarantine for 14 days. Also, the government launched the “Trace Together” APP to trace close contacts.</p> <p>(3) All public hospital laboratories offer PCR testing for COVID-19 to increase national diagnostic capacity.</p>

Measures	China	South Korea	Singapore
Healthcare measures	<p>(1) Pairing assistance, mobilizing 29 provinces to assist different cities in Hubei province. From January 24 to March 8, 2020, a total 346 medical teams and 42,600 medical personnel were mobilized to support Hubei province.</p> <p>(2) Makeshift hospitals, establishing Huoshenshan hospital, Leishenshan hospital and 16 Fangcang shelter hospitals in Hubei province, these hospitals treated more than 12,000 COVID-19 patients.</p> <p>(3) Classifying management of “four categories of personnel”. All confirmed cases were transferred to the hospitals for centralized treatment, suspected cases, febrile cases who might be carriers, and close contacts were sent to designated venues for isolation and medical observation.</p>	<p>(1) Whether public hospitals or private hospitals were committed to responding to the COVID-19 outbreak.</p> <p>(2) Launching Community Treatment Centers (CTCs), from March 2 to March 26, 2020, a total of 3,292 patients were admitted to 17 CTCs.</p> <p>(3) Case categorization by severity: asymptomatic, mild, severe, and critical. Asymptomatic patients and patients with mild symptoms were isolated at Residential Treatment Centers or self-quarantine, patients with moderate symptoms were hospitalized at Dedicated Infectious Disease Hospitals, patients with severe symptoms or extremely severe symptoms were hospitalized at Government-designated Isolation Hospitals.</p>	<p>(1) Activating the National Center for Infectious Diseases (NCID) for isolation and treatment of confirmed cases.</p> <p>(2) Implementing the “Public Health Preparedness Clinics program” - activated more than 800 fever clinics to treat fever patients and provide subsidies for citizens.</p> <p>(3) The Big Box at Jurong Mall was transformed into a community care facility, accepting mainly mild patients for treatment and isolation.</p> <p>(4) Mild and undifferentiated persons were instructed to self-isolation at home. Those with persistent or worsening symptoms are advised to return to the same doctor for evaluation and referral for testing.</p>

Measures	China	South Korea	Singapore
Border control measures	<p>(1) In the Guidelines on Novel Coronavirus Diagnosis and Treatment emphasized on the elements of the port health quarantine, increased the epidemiological history of travel or residence in countries and regions with serious outbreaks abroad.</p> <p>(2) Nucleic acid testing were required to all travelers or returning residents entering from all ports of entry. They will be released from quarantine if they do not present with symptoms and are tested negative for SARS-CoV-2 after 14 days of quarantine.</p> <p>(3) Implementing the health declaration system for people exit and entry, strictly carrying out entry health quarantine, and suspending the entry of foreigners with valid Chinese visas and residence permits.</p>	<p>(1) Adopted monitoring measures such as special entry procedures and mandatory installation of a Self-Check Mobile App to keep track and monitor the health of inbound travelers after arrival.</p> <p>(2) Introduced mandatory COVID-19 testing and two-week quarantine for all inbound travelers regardless of their port of departure.</p> <p>(3) Visa-free entry and visa-waiver programs were also suspended, with in addition to countries that had not imposed entry bans on Korean travelers.</p> <p>(4) In late June, the Korean government introduced country-specific restrictions, temporarily suspending visa issuance and non-scheduled flights and requiring submission of negative PCR-test results for issuing Korea-bound flight tickets.</p>	<p>Escalating border control measures:</p> <p>(1) Since Jan 3, 2020, temperature and health screening of incoming travelers from Wuhan and extended to all travelers since Jan 29, is in place at all ports of entry.</p> <p>(2) Since Feb 1, Singapore imposed entry restrictions on visitors from China; returning residents and long-term pass holders are subject to a 14-days quarantine.</p> <p>(3) Since March 24, prohibiting short-term visitors and cruise ship stops.</p> <p>(4) Since March 27, everyone who enters Singapore without a Stay Home Notice at a designated facility must wear an electronic tracker.</p>

Measures	China	South Korea	Singapore
Community and social measures	<p>(1) Lockdown infection areas: from Jan 23 to April 7, 2020, lockdown Wuhan city. Also, the different varying degrees of blockade were imposed nationwide.</p> <p>(2) In China, all provinces have activated the highest-level public health emergency response. Subsequently, many tourist attractions were temporarily closed, suspending nationwide tour operations and overseas group travel and free-travel operations.</p> <p>(3) School closures, postponed school opening or online classes, extended Spring Festival holidays or working from home to reduce population moving.</p>	<p>(1) No areas have been locked down.</p> <p>(2) Social Distancing—Isolation/Quarantine, Stay-at-home advisory, Closure of Schools, Postpone School Opening or Online Classes, Restriction on using group facilities, Restriction on group events, and Curfew by district.</p>	<p>(1) No areas have been locked down.</p> <p>(2) Before April 5, 2020, the Singapore government took standing community and social measures: focused on health education, limited recreational restrictions, moratorium on large events, implementation of leave orders and home quarantine orders for different populations, temperature testing.</p> <p>(3) After April 5, 2020, the government introduced strict measures: suspending work, school, and working from home.</p>

United States, United Kingdom and France mitigation strategies

Compared with China, South Korea and Singapore, which the countries occurred COVID-19 infections earlier, United States, United Kingdom and France seemed to be slower to respond to the COVID-19 outbreak and preferred to adopted mitigation strategies. The U.S. federal government's aggressive measures could date back to the declaration of a national emergency on March 13, 2020. Since then, the U.S. has adopted a combination of "containment" and "mitigation" strategies, with multiple channels and means of response and increasing support for prevention and control.

In the UK, the government did not taken more measures to control the COVID-19 epidemic before the mid-March, 2020. The British government began to implement mitigation strategies based on the theory of "herd immunity" until the outbreak in Italy and Spain were nearly out of control. Subsequently, the government further implemented more stringent measures such as city lockdown, school closures, and entertainment closures to stop the virus from spreading more widely.⁶ Likewise, France practiced lax mitigation strategies until mid-March. The French government was alerted only when the COVID-19 epidemic was raging, the number of confirmed cases and deaths increased dramatically. Thereafter, a

strict mandatory stay at home was imposed and a state of national emergency was declared.⁷ The major measures taken for COVID-19 in United States, United Kingdom, and France were summarized in Table 2 from containment, healthcare, border, and community and society.

Table 2
The major measures taken for COVID-19 in United States, United Kingdom and France

Measures	United States	United Kingdom	France
Containment and surveillance measures	<p>The United States had a slow start in widespread SARS-CoV-2 testing.</p> <p>(1) The Trump administration announced a campaign to conduct tests in retail store parking lots across the country, but this was not widely implemented.</p> <p>(2) The NIH launched a new rapid test development program on April 29, 2020, Rapid Acceleration of Diagnostics.</p> <p>(3) As of July 1, 2020, only four states are using contact tracing apps as part of their state-level strategies to control transmission.</p> <p>(4) As of August 2020, the FDA had granted Emergency Use Authorizations to over 200 tests for detecting current or past infection.</p>	<p>(1) The United Kingdom incorporated COVID-19 testing for severe acute respiratory illness (SARI) and ILI surveillances. Starting in early June, mass antibody testing was conducted.</p> <p>(2) Individuals with suspected mild symptoms of COVID-19 (new continuous cough, fever or anosmia) and all members of their households to self-isolate for 7 days and 14 days respectively, and call NHS111 if required. Patients with persistent and severe symptoms were advised to contact their general practitioner (GP) or call emergency services.</p> <p>(3) On May 18, 2020, the NHS Testing and Tracing Service was launched, whereby anyone in the UK with symptoms can request an antigen test via a dedicated website.</p>	<p>(1) French surveillance system: according to the COVID-19 surveillance protocol, physicians suspecting a COVID-19 case have to contact immediately either the emergency hotline (SAMU-Centre 15), if the patient is seeking medical attention from a general practitioner, or a referring infectious diseases specialist at hospital level.</p> <p>(2) Possible cases have to be hospitalized, isolated and cared for in one of the 38 French referral hospitals designated by the Ministry of Health.</p> <p>(3) Setting up case definition and update with the situation of the COVID-19. Contacts are traced from the date of onset of clinical symptoms in a case.</p>

Measures	United States	United Kingdom	France
Healthcare measures	<p>(1) Establishing temporary hospitals: the first temporary hospital in New York was completed on March 28, 2020.</p> <p>(2) Expanding the number of beds: on March 28, 2020, the U.S. medical ship "Mercy" docked in Los Angeles, which can provide 1,000 beds.</p> <p>(3) Appropriate treatment: on August 23, 2020, the FDA approved the use of plasma from recovered individuals to treat patients with severe COVID-19.</p> <p>(4) From early 2020, five or six operating primarily in the U.S. began vaccine research, and COVID-19 vaccine were administered from December 14.</p>	<p>(1) Established temporary critical care hospitals: capacity was upgraded at Belfast City Hospital in Northern Ireland, NHS Louisa Jordan was established in Scotland, temporary critical care NHS Nightingale hospitals were built across England, and the Dragon's Heart Hospital was set up in Cardiff, Wales.</p> <p>(2) Primary care practitioners were advised to avoid face-to-face assessment of suspected cases. Instead, patients should be immediately isolated and referred to the local health authorities via a hotline.</p>	<p>(1) Relying on the military to reinforce medical forces. A field hospital was established in the Milus region of Alsace with a total of 30 intensive care beds on March 25, 2020. Also, France activated a medical high speed train, Air Force A330 and navy helicopters to transport critically ill patients in the east to areas with less severe outbreaks.</p> <p>(2) Launching the White Plan and Blue Plan to coordinate all medical resources, including hospitals, clinics, and social security agencies. Also, retired health care workers and medical students have also been mobilized to join the fight against the epidemic.</p>

Measures	United States	United Kingdom	France
Border control measures	<p>(1) Public health screening at Major Airport on January 22, 2020, and 11 Airports added to Screening Watch List.</p> <p>(2) Suspension of access to the United States: beginning March 21, 2020, U.S. border crossings closed to travel other than "core essential travel".</p> <p>(3) On March 13, 2020, the federal government escalated from a public health to a national emergency, and since March 16 all states had declared a state of emergency or a public health emergency.</p>	<p>(1) In March 2020, the UK went into lockdown. The government banned all non-essential travel.</p> <p>(2) Travelers entering the UK would have to self-isolate for 14 days upon arrival to help slow the spread of COVID-19.</p> <p>(3) From October onwards, varying levels of lockdown were imposed in England.</p>	<p>(1) Emmanuel Macron announced a lockdown period from March 17 to May 11, 2020: ban on all travel except relating to professional activity, buying essential goods, health or family reasons or brief individual exercise.</p> <p>(2) From March 17, France closed its borders for 30 days. The government advised long-term residents who have lived abroad to avoid international travel or return to France for the next 30 days.</p> <p>(3) Macron addressed that France entered a second nationwide lockdown from October 30, 2020.</p>

Measures	United States	United Kingdom	France
Community and social measures	<p>(1) Many additional mitigation policies have been enacted at the state level: school closures, large gathering bans, non-essential business closures, stay-at-home orders, bar/restaurant limits, and primary election postponements.</p> <p>(2) Lockdown infection areas: on December 3, 2020, locked down the city of Los Angeles, USA.</p> <p>(3) Mask mandates have been implemented: as of early August, just over half of states require individuals to wear a mask in public, although in some states without a statewide mandate local authorities have mask wearing ordinances</p>	<p>(1) Implementing a series of TV, radio and social media campaigns and recommendations for behavior change in the general public.</p> <p>(2) The stringency of containment measures escalated: the closure of non-essential services on March 16, follow by a lockdown on March 23. (3) Closures and restrictions: schools closure, non-essential activities were prohibited. Individuals were required to stay at home and work from home where possible, with only an hour of exercise, trips for food shopping and medication allowed per day, and a social distancing measure of 2 m.</p> <p>(4) Mask mandates have been implemented when people take public vehicles.</p>	<p>(1) The first nationwide lockdown: bans on gatherings, closure of most public establishments, and closure of schools and institutes of higher education.</p> <p>(2) Progressive lifting of lockdown restrictions: all gatherings, meetings, activities, travel and usage of public transport were required to respect social distancing rules.</p> <p>(3) Masks made mandatory in an extended range of public places.</p> <p>(4) Curfews and second national lockdown: with similar restrictions to the first national lockdown except that primary- and secondary school children can still attend school.</p>

Epidemiological trends and population mortality rates of COVID-19 in six countries

As shown in Figs. 1, 2 and 3, China, South Korea, and Singapore experienced large COVID-19 outbreaks and initially responded with a containment strategy, and China and Singapore had a similar epidemic curve and the number of new confirmed COVID-19 cases by December 31, 2020. In terms of mortality rate per 100,000 population, China's rate was 0.3%, South Korea's rate was 1.8%, and Singapore's rate was 0.5%. As of December 31, 2020, especially in China and Singapore, which maintained a low mortality rate

per 100,000 population no more than 1%, and new confirmed cases per day only 87 and 30 respectively. However, new confirmed cases per day in Korea were as high as 1029.

Figures 4, 5 and 6 showed that the United States, the United Kingdom, and France, which responded with a mitigation strategy when the COVID-19 pandemics emerged, had similar epidemic curves and mortality rates per 100,000 population by December 31, 2021. Among them, as of December 31, 2020, the United States had up to 234,133 new confirmed cases per day and a mortality rate per 100,000 population was 107%, while the UK had 56,029 new confirmed cases per day and a mortality rate per 100,000 population was 108%, and France had 20,042 new cases per day, with a mortality rate per 100,000 population of 99%.

Whether in the new confirmed cases per day, or the mortality rate per 100,000 population, the difference is significantly remarkable between China, South Korea, and Singapore, which implemented containment strategies, and the United States, United Kingdom, and France, which taken mitigation strategies. Figures 2, 4, 5 and 6 showed that South Korea, the United States, the United Kingdom, and France all had a similar epidemic curve by December 31, 2020. Nevertheless, South Korea had a case fatality rate approximately one-percent of that of countries adopting a mitigation strategy. (South Korea: 1.8% vs. the United States: 107%; United Kingdom: 108%; and France: 99%, by December 31, 2020).

Discussion

In response to the COVID-19 epidemic that is ravaging the world, different countries have employed various strategies for controlling the COVID-19 pandemic based on their national situations. These epidemic control strategies can be classified into two types: one type is a containment strategy, other is a mitigation strategy. A containment strategy focuses on disease prevention and the control of infectious diseases from three aspects: infectious sources, transmission routes, and susceptible populations.⁸ It aimed to break the chain of transmission through a combination of aggressive test-and-isolate policy (identify and isolate all infectious persons, including those with mild illness) and social distancing measures.⁹

Whereas, a mitigation strategy focuses on reducing the rate of transmission, asserting that the spread of COVID-19 cannot be completely interrupted and can only be slowed when the population forms an adequate immune barrier and the intensity of the epidemic decreases to become a seasonal infection such as influenza.⁸ It aimed to reduce death tolls by focusing on the medical care of severe cases while relying on social distancing to flatten the curve of epidemic impact on healthcare systems.⁹

Containment strategy

China, South Korea, and Singapore, the representative countries adopted containment strategies, achieved remarkable results in the fight against the COVID-19 epidemic and all of their case-fatality maintain at a low level. This seems to be inextricably linked to their national cultures and the prevention and control measures they have adopted.

COVID-19 outbreak of China was concentrated in the early stage, in the face of a previously unknown virus and a new public health threat, the great characteristic of China that a leadership system—the Epidemic Prevention and Control Headquarters System (EPCHS)—was set up at all levels, enabling a whole-of-government response and accountability to address the epidemic.¹⁰ Moreover, responding to a dramatic increase in cases and inadequate health resources, a series of strict containment strategies were imposed in China, including lockdown Wuhan city, mobilizing healthcare workers from other provinces to support Hubei (the province where resides Wuhan, the former epicenter), erecting Huoshenshan hospital, Leishenshan hospital, and 16 Fangcang shelter hospitals, classifying management of “four categories of personnel”, and implementing “four early’s” measures (early detection, early diagnosis, early isolation, and early treatment) to the community, even to individuals. After the battle of Wuhan, the subsequent outbreaks of sporadic epidemics and even localized clusters in Harbin of Heilongjiang, Shulan of Jilin, Xinfadi of Beijing, and Qingdao of Shandong all proved to be the most valuable window of time for China’s full-scale nucleic acid testing.

Singapore, one of the first countries affected by COVID-19, adopted a national strategy for the pandemic which emphasized preparedness through a whole-of-nation approach. The most characteristics of containment strategy was that implemented a three-pronged approach of reducing spread from imported cases, detecting and isolating cases early, and emphasizing and supporting social responsibility to control the COVID-19 outbreak.¹¹ In concrete practice, Singapore maximized the detection of suspected patients through public prevention of clinic networks and strictly enforced home isolation orders for patients with mild symptoms.¹²

South Korea, fully utilized its experience from the MERS outbreak in 2015, quickly scaling up testing to detect cases as early as possible in responding to the COVID-19 outbreak.¹³ Hence, the Korean government established more than 600 screening sites that capable of performing SARS-CoV-2 nucleic acid tests including public health-care clinics, drive-through centers, and walk-in screening sites. In South Korea, more than 15,000 screenings can be performed daily. Based on the triage system, patients with mild illnesses, especially those younger than 50 years, were instructed to stay in designated locations or at home rather than in hospitals. Other measures include school closures, locking down areas with severe outbreaks, and banning gatherings.¹⁴ But the objective of Korea’s COVID-19 response strategy was to prevent the spread of the disease, protect public health, and keep the society and economy open so that daily life can continue.¹⁵ The core intervention in China, Singapore, and South Korea has been timely detection and management of suspected and confirmed cases and identification and management of their close contacts.

Mitigation strategy

The United States, the United Kingdom, and France as the typical countries that implementing mitigation strategies, compared with the countries adopting containment strategies, the COVID-19 outbreaks seem to be worse. As we all know, the U.S. is a wealthy country, armed with numerous high technological and biological tools to fight the COVID-19 outbreak.⁴ However, for what it’s worth, the United States had the

highest number of cases and deaths globally, highlighted by a lack of national leadership and a patchwork of state and local government responses but perhaps most detrimental is the division of society along partisan lines.^{16,17} Of course, there is also a primary issue in the U.S. has been the poor coordination of testing efforts and inability to test at-scale to provide comprehensive national (or even state) surveillance.¹⁸ Although the U.S. has begun a series of mitigation measures, such as all states had declared a state of emergency or a public health emergency, school closures, large gathering bans, non-essential business closures, stay-at-home orders, bar/restaurant limits, primary election postponements, and mask-wearing ordinances.

The United Kingdom declared the COVID-19 epidemic as influenza in the early stage, emphasizing that COVID-19 was unlikely to be completely interrupted and focusing mainly on the treatment of severe cases, most of which had mild symptoms. Matters worsened when Vallance initially rejected “eye-catching measures” such as stopping mass gatherings or closing schools. To widespread criticism, he floated an approach to “build up some degree of herd immunity” founded on an erroneous view that the vast majority of cases would be mild, like influenza.¹⁹ With Italy, Spain, and France had taken firm public health action and was in full lockdown, The UK was also starting to work on the prevention of the disease. Policies were to be based on the science, with an initial focus on containment, involving the identification of people infected with SARS-Cov-2, contact tracing, and isolation of people with proven exposure.²⁰ Also a package of intensive interventions put in place including physical distancing, with a particular impact on leisure activities; workers being asked to work from home where possible; shielding of both older individuals (70 years) and people in high-risk groups of all ages; school closures; and self-isolation of symptomatic individuals.²¹

At the beginning of the outbreak, the COVID-19 epidemic did not have a significant impact on France, although with the dramatic increase in new COVID-19 cases, France implemented strict intervention strategies in March 2020, such as implementing strict national lockdown, improving the level of COVID-19 detection, fully protecting the medical workforce, and strengthening research and clinical treatment methods for COVID-19. However, the government’s early dissemination was intended to reassure the population that the probability of the virus spreading in France was low. Moreover, following the rapid spread of the virus in France towards the end of February, the government, totally unprepared for a pandemic.²² This was one of the reasons for the poor control of the epidemic in France, the sharp increase in daily COVID-19 cases and the high mortality rate per 100,000 population (as of December 31, 2020, the mortality rate per 100,000 population was 99%).

Containment versus mitigation strategy

This study found that countries implementing the containment strategy appeared to have better outcomes than those implementing mitigation, whether in terms of trends in daily case growth or curves in mortality rates per 100,000 population. Although each country has implemented a series of non-pharmaceutical interventions at four levels of the epidemic: containment and surveillance, healthcare, border control, and community and society. However, China, South Korea, and Singapore, due to their

experience with previous MERS and SARS epidemics, responding quickly, implementing strict interventions, and control the spread of the epidemic to keep the daily new cases and mortality rate per 100,000 population low. Furthermore, with the inoculation of the COVID-19 in 2021, strict non-pharmaceutical interventions are still being implemented. In contrast, the United States, the United Kingdom, and France, due to their lax approach at the beginning of the epidemic, made the subsequent fight against the epidemic more difficult. Although a series of non-pharmaceutical interventions were implemented, and these countries have initiated vaccination programs for COVID-19, the results seem to be less than satisfactory.

Conclusion

Until the vaccine is globally available and effective, we still need to address the current COVID-19 epidemic with non-pharmacological measures in four aspects: containment and surveillance, healthcare, border control, and community and society to avoid further damage. Countries can consider policy alternatives and novel solutions developed by other countries and adapt them base on their domestic circumstances and resources.

Declarations

Ethics approval and consent to participate

Not applicable.

Consent for publication

Not applicable.

Availability of data and materials

All data generated or analyzed during this study are included in this published article.

Competing interests

The authors have no conflicts of interest to declare.

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Authors' contributions

Haiqian Chen and Gang Sun conceived the paper. Haiqian Chen, Yuyao Zhang, Xiaohan Wang, Manfei Yang, and Jun Jiao collected the data. Haiqian Chen drafted the manuscript. Leiyu Shi, Yuyao Zhang, Xiaohan Wang, Manfei Yang and Jun Jiao revised the manuscript. Gang Sun contributed to the critical

revision of the manuscript for important intellectual content and approved the final version of the manuscript. All authors have read and approved the final manuscript. Haiqian Chen and Gang Sun are the study guarantors.

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Figures

Figure 1

China's COVID-19 epidemic curves and population mortality rate. Note: A Beginning of January 23, 2020, lockdown Wuhan city, all provinces or regions initiated a Class 1 Response Public Health Emergency. B Beginning of April 8, lifting lockdown of Wuhan city, and entering the phase of ongoing epidemic prevention and control. C On April 9, a COVID-19 cluster was detected in Heilongjiang Province. D On June 4, a COVID-19 cluster emerged at Xinfadi Market in Beijing. E On July 26, COVID-19 cases mostly from outbreaks in Xinjiang and Liaoning. F On October 11, a COVID-19 cluster was appeared in Qingdao.

Figure 2

South Korea's COVID-19 epidemic curves and population mortality rate. Note: A Starting on February 19, 2020, cancelling mass gatherings, and various measures were taken to mass testing. B Starting on April 22, lifting restrictions of stores, restaurants, gyms, cram schools, bars, and religious services. C Starting in August, authorities ordered 12 high-risk business categories including nightclubs, karaoke bars, buffet restaurants, and museums to cease operations; banned gatherings; imposed distancing rules; and wear masks continued to be in place. D Starting on November 9, escalating the social distancing level.

Figure 3

Singapore's COVID-19 epidemic curves and population mortality rate. Note: A On March 24, 2020, the Multi-Ministry Task Force announced more stricter measures. B Starting on June 2, relaxing measures and implementing "Safe Reopening". C Starting on June 19, implementing "Safe Transition". D Starting in August, continuously implementing "safe transition", and cautious reopening. E Starting on December 28, implementing "Safe Nation".

Figure 4

U.S. COVID-19 epidemic curves and population mortality rate. Note: A By March 13, 2020, the federal government escalated from a public health to a national emergency, and by March 16 all states had declared a state of emergency or a public health emergency. B Starting in May, reopening of businesses and restaurants, and masks mandate for everyone in public spaces. C Starting in August, second round of closure. D Starting on December 14, the first doses of COVID-19 vaccine were administered.

Figure 5

U.K. COVID-19 epidemic curves and population mortality rate. Note: A Starting in March, 2020, closures and restrictions. Closures and cancellations in March, lockdown continues in April, and lockdown easing begins. B Starting in June, 2020, continued restrictions and local lockdowns. Requiring individuals to self-

isolate for 14 days upon arrival, making face masks compulsory on all public transport, and delaying lockdown restrictions. C Starting in September, restrictions were tightened further. D Starting in November, new lockdowns.

Figure 6

France's COVID-19 epidemic curves and population mortality rate. Note: A Beginning of March 17, 2020, first national lockdown. B Beginning of May 11, progressive lifting of lockdown restrictions. C Beginning of July 20, extension of mask-wearing rules. D Beginning of October 17, curfews and second national lockdown.