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A comparative study of public health and social measures of COVID-19 advocated in different countries [☆]

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ARTICLE INFO

Article history:

Received 29 September 2020

Revised 24 May 2021

Accepted 25 May 2021

Editor: Prof. R. Busse

Keywords:

Public health and social measures

Public health policy

National policy

Comparative study

COVID-19

The WHO

ABSTRACT

Coronavirus 2019 (COVID-19) has had a significant impact on the world. Different countries introduced various public health and social measures (PHSMs) against the coronavirus. This paper aims to (a) examine how national policies on PHSMs were framed and which PHSMs were adopted; (b) compare the similarities and differences of PHSMs advocated by different countries; and (c) examine whether these measures have changed with time.

We performed a content analysis of 160 COVID-19 policy documents on the websites of the WHO and ten countries' government websites on COVID-19 between December 1, 2019 and May 31, 2020. Results showed that although the initial responses to COVID-19 in different countries varied, there was a homogenization of PHSMs over time: by May 31, 2020, almost all the countries we studied implemented the major PHSMs that the WHO recommended, except Sweden, which applied only part of the major PHSMs recommended by the WHO. The differences among countries were in the speediness, strictness and resourcefulness of the PHSMs implementation. We suggest that a timely and effective utilization of the integrated package of health measures with the support of adequate resources may help the efficient implementation of PHSMs.

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1. Introduction

Coronavirus 2019 (COVID-19) attacked human societies since 2019, putting tremendous pressure on governments' health officials and medical systems all over the world [1,2]. In response to this surmounting pressure, most countries developed different policies of non-pharmaceutical interventions (NPIs), which refer to those actions used against the virus, apart from vaccines and medicines [3,4]; these NPIs were used to prevent the spread of the virus because vaccines were not available at the early stage of the outbreak. To guide governments all over the world, on May 18, 2020, the World Health Organization (WHO) released a toolkit as a general guideline of NPIs against COVID-19, which they named 'public health and social measures' (PHSMs) that included 'measures or actions by individuals, institutions, communities, local and national governments and international bodies to slow or stop the spread of an infectious disease, such as COVID-19' [5–7]. The tools suggested movement measures, physical and social distancing mea-

asures, personal measures and special protection measures for special populations and vulnerable groups to slow down the spread of the virus and to prevent associated illness and death (For details, see Table 1). Note that physical distancing appeared both in physical and social distancing measures and personal measures in the WHO's PHSMs. The former referred to measures to ensure safe physical distancing from the society level while the latter referred to such measures from an individual level.

We argue that the official toolkit of PHSMs, issued by the WHO, provided researchers with a systematic framework to analyze the complicated health policies that countries implemented against COVID-19. Before the WHO released its guidance on PHSMs on May 18 as we mentioned above, each country had developed its own policies on PHSMs and researchers have observed that the differences in such policies across nations could possibly be due to cultural, political and epidemiological factors [2,8]. Besides, the PHSMs that each government implemented also varied across time based on changes in the spread of the virus, thus increasing complexity when examining those policies. With the PHSMs framework at hand, we can systematically compare and contrast the empirical data of health policies against COVID-19 across nations, analyzing the differences and similarities in those policies. In return, examining the differences and similarities in PHSMs among

[☆] Open Access for this article is made possible by a collaboration between Health Policy and The European Observatory on Health Systems and Policies.

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Table 1
Selected public health and social measures for consideration in the context of COVID-19 by the WHO.

	Movement measures	Physical and social distancing measures	Personal measures	Special protection measures
Aim	To prevent the virus from spreading from infected areas to non-infected areas by limiting movement	To ensure a safe physical distance between people to reduce the spread of the virus	To limit transmission of the virus from person-to-person, protect people and their close contacts, and reduce contamination of frequently touched surfaces	To reduce vulnerable groups' risks of exposure to the virus.
Examples	Local and national movement restrictions, offering travel guidance, etc.	Working from home, staying at home, physical distancing, cancelation of mass gatherings, and avoiding crowded spaces, etc.	Hand hygiene, physical distancing, wearing facemasks, respiratory etiquette, disinfection and environmental cleaning.	Vulnerable groups include: 1) People who are at risk for more serious illnesses from COVID-19 contamination, such as older people; 2) People with social vulnerabilities, such as migrants, refugees, displaced or homeless; 3) Those in closed settings, such as seniors' residences, long-term living facilities, and prisons; 4) People with higher occupational risks of exposure to the virus, such as healthcare workers.

different countries, as well as the changes in those measures over time, could help us enrich the PHSMs that the WHO provided as a comprehensive framework in public health. Moreover, it could help the governments, the public and world organizations to promote strategies against COVID-19 and future pandemics. Thus, we aim to launch a comparative study targeting PHSMs against COVID-19 across both nations and time periods.

2. Materials and methods

We conducted a content analysis of COVID-19 policy documents on the websites of the WHO and ten countries' government websites between December 1, 2019, the symptom onset date of the first reported case [9], and May 31, 2020, when we conducted the research. During this time, we experienced the first wave of the global pandemic in which the disease moved from Western Pacific region to Europe and then to the North American continent and other regions. We took a selection of countries from each region as a sample to see how their policies varied over time. Ten countries were selected according to the rank of confirmed cases in each region by May 31, 2020 [10] and Gross Domestic Product (GDP) rank in 2019 [11], to control the impact of economy on policies. Combining the rank of confirmed number and GDP in each region, we sampled China, Japan, South Korea and Singapore in the Western Pacific; the UK, Italy, and Germany in Europe; the United States (U.S.) in the American continent; and South Africa in the Africa continent. In addition, Sweden was chosen because researchers pointed out that it had a relatively different approach in terms of PHSMs [12,13]. For details of the sample, see Table 2. We acknowledge that our sample did not cover every country during the first wave of the pandemic, but by combining the order of the breakout, the severity of the pandemic, and GDP, our sample could reflect the PHSMs of countries with the earliest outbreak of COVID-19 during the first wave of the pandemic.

From the WHO's website and ten countries' government websites on COVID-19, we downloaded all the policy, public advices, and guideline documents in the COVID-19 section. A total of 160 documents were identified in our search (See Table 3). For details of the sample, see Supplemental data file. All the files were

downloaded in English except those from China, Germany and Italy which were downloaded in their native languages due to the lack of a comprehensive English version. They were translated into English by professional translators for analysis.

The full text and images of each file was examined for coding. Following the WHO's framework, we content analysed the ten countries' PHSMs from the four aspects and identified one more aspect: strategies on public health resources and added many unlisted sub-measures of the five aspects based on pilot coding. The unit of analysis is country. Each policy was coded as '✓' when the country advocates a policy on its website, and '×' when the country advocates against a policy on its website. When the policy was not mentioned, it was coded as '-' and double checked with news websites to make sure that the country did not have such a policy. Dates were noted for each policy's implementation, or a reporting date where an implementation date was not available. Two graduate students who are fluent in English coded all the files. We calculated inter-coder reliability of the two coders by double-coding a random subsample ($n = 32$ or 20%) of the data. Krippendorff's alpha ranged from 0.92 to 1.0 for the 31 policy items.

3. Results

3.1. Laws and regulations on epidemic control in the 10 countries

Before we analyze the PHSMs policies of the ten countries under study, we first reviewed the laws and regulations on epidemic control in the 10 countries under study (Table 4). Four countries (China, Japan, the U.S. and South Africa) used existing laws and regulations to cope with the COVID-19 outbreak. Six countries (South Korea, Singapore, Italy, the UK, Germany and Sweden) passed COVID-19 related laws and regulations or rapidly amended current laws and regulations to cope with the pandemic.

In the four countries that used existing laws, China and South Africa's central governments had stronger power than their local governments, while, in the U.S., local governments had stronger power than the central government, and, in Japan, neither the central government nor local governments could enforce compulsory lockdown or social distancing measures. China's response to

Table 2
Sample selection.

Region	Country	Confirmed number as of May 31, 2020	Confirmed case rank in the region	GPD in 2019 (billion US dollars)	GDP rank in the region
Western Pacific	China	84,570	1st	14,340.60	1st
	Singapore	34,366	2nd	372.07	6th
	Japan	16,851	4th	5148.781	2nd
	South Korea	11,468	5th	1646.739	3rd
Europe	UK	272,830	2nd	2833.301	2nd
	Italy	232,664	4th	2005.135	4th
	Germany	181,482	5th	3861.55	1st
	Sweden	37,113	11th	531.28	10th
Americas	U.S.	1715,078	1st	21,433.225	1st
Africa	South Africa	30,967	1st	351.35	2nd

Table 3
Sample description.

Country	The number of documents	The source of documents
China	30	National Health Commission of the People's Republic of China and Chinese government website
South Korea	9	The South Korea Ministry of Health and Welfare website
Japan	14	The Japanese Ministry of Health, Labor and Welfare website
Singapore	18	The Singapore Ministry of Health website
Italy	22	The Italy Ministry of Health website and Italy government website
The UK	19	The UK Department of Health and Social Care website and UK government website
Germany	9	The German Federal Ministry of Health website
Sweden	12	The Sweden government website
The U.S.	9	The U.S. Centers for Disease Control and Prevention (CDC) website and the U.S. government website
South Africa	5	The South African government website and the South Africa Department of Health website
The WHO	13	The WHO website

Table 4
COVID-19 related laws and regulations in the 10 countries as of May 31, 2020.

Country	Existing epidemic laws and regulations	New decrees/laws/regulations/law amendment for coping COVID-19
China	Regulations on Contingent Public Health Emergencies (2003/5/9); The PRC Law on the Prevention and Treatment of Infectious Diseases (enacted in 1989; revised in 2004); the Constitution of the People's Republic of China (2004/3/14); PRC Law on Emergency Response (2007).	None
South Korea	Infectious Disease Control and Prevention Act (2016)	Amended three separate acts (2020/3/4): Infectious Disease Control and Prevention Act; Quarantine Act; Medical Service Act
Japan	Law Concerning the Prevention of Infections and Medical Care for Patients of Infections (1998); Quarantine Act (1951)	None before 2020/5/31
Singapore	Infectious Diseases Act (1977)	COVID-19 (Temporary Measures) Act 2020 (CTMA) (2020/4/7)
Italy	The Consolidated Health Laws	Decree-Law No. 6 (2020/2/23); Decree-Law No.18 (2020/03/17); Decree-Law No. 33 (2020/05/16), etc.
UK	Public Health Act 1875 (1875)	Coronavirus Act 2020 (2020/3/25)
Germany	Infection Protection Act (2000)	Protection of the population in an epidemic situation of national scope and the COVID-19 Hospital Relief Act (2020/3/27); The Second Law for the Protection of the Population in the Event of an Epidemic Situation of National Significance (2020/5/15).
Sweden	Communicable Diseases Act (2004)	Law amendment for the Swedish Infectious Disease Control Act and Sweden's Emergency Legislation (passed on 2020/4/16; Effective from 2020/4/18–2020/7/1).
U.S.	Public Health Service Act (1944; amended in 2006, 2013 and 2019); Robert T. Stafford Disaster Relief and Emergency Assistance Act (1988); National Emergencies Act (1976).	None
South Africa	Disaster Management Act 2002, amended by Disaster Management Amendment Act 16 of 2015; Surveillance and Control of Notifiable Medical Conditions gazetted in June 2017 under the National Health Act 2003	None

COVID-19 was mainly based on the Regulations on Public Health Emergencies, which was issued during the SARS (Severe Acute Respiratory Syndrome) outbreak in 2003 [14]. It stipulated that when an emergency occurs, local governments' emergency response headquarters are placed under the direct control of the central government's emergency response headquarters. The authorities, then, have the power to evacuate or isolate people, blockade areas in which there are infectious disease epidemics, and impose the compulsory quarantine and treatment of suspected disease carriers and the people in close contact with them. South Africa's COVID-19 regulations were issued under the Disaster Man-

agement Act, 2002 [15]. The regulations granted the authorities the right to prohibit social gatherings, close schools, and penalize those who behaved in ways contrary to the regulations. The U.S. response to COVID-19 was mainly based on the Public Health Service Act (1944; amended in 2006, 2013 and 2019) [16], which granted federal officials limited authority to initiate epidemiologic investigations. Thus, many U.S. CDC guidelines have been suggestive rather than compulsory. In conducting epidemiological investigations, state officials usually had broader powers than federal officials. During our study period, Japan did not have a legal framework for imposing lockdown [17]. It could only request that busi-

nesses and citizens voluntarily comply with the suggested COVID-19 measures, and it could impose no penalties for non-compliance. We noted that Japan and the U.S. both amended their laws in 2021, which is beyond our study period.

Of the six countries that passed new laws or regulations, South Korea and Singapore had already strengthened their laws after previous epidemic outbreaks, while the four European countries under study strengthened their governments' power during the COVID-19 outbreak. After the 2015 outbreak of MERS (Middle East Respiratory Syndrome) in South Korea, the country amended the Infectious Disease Control and Prevention Act [18], which empowered its authorities to obtain the private data of confirmed and potential patients, including their credit card information, the GPS (Global Positioning System) information from their mobile phones, and the ETC (Electronic Toll Collection System) data from their cars. The authorities could also shut down contaminated locations and restrict or prohibit large social gatherings during the state of emergency. To cope with COVID-19, South Korea amended three acts on March 4, 2020, to give its authorities more power over imposing penalties for non-compliance [19]. Similarly, Singapore also strengthened its Infectious Diseases Act during the SARS outbreak and passed the COVID-19 (Temporary Measures) Act in April 2020, which granted the authorities greater powers to enforce controls [20].

The four European countries sampled in this research all enacted new laws or amended their laws to strengthen their governments' powers after the COVID-19 outbreak. In March 2020, Italy enacted a series of legislations, which empowered the authorities to enforce measures such as quarantining all infected individuals, closing all commercial activities, and suspending work activities [21]. The UK passed a new act, the Coronavirus Act 2020, on March 25, 2020, which granted the government more power to enforce measures such as limiting or suspending public gatherings and detaining individuals suspected to be infected with COVID-19 virus [22]. In March 2020, Germany amended its Infection Protection Act to allow the federal government more power over the states. It allowed the authorities to give stay-at-home orders and regulate visits to public places, prohibit border crossings, and track the contacts of infected persons [23]. Sweden amended its Infectious Disease Control Act in April 2020 to grant the government power to temporarily limit public gatherings and temporarily close public facilities, such as shopping malls, social and cultural meeting places, and transportation facilities [24].

After reviewing the ten countries' laws and regulations on COVID-19, we content analyzed COVID-19 policy documents on their government websites and the WHO's website. Results of our content analysis of PHSMs policies are shown in Table 5. In terms of infectious disease alerts, while seven countries (China, Japan, South Korea, Italy, Germany, the U.S. and South Africa) set the highest-level infectious disease alert or announced a national emergency, three countries did not as of May 31, 2020: the UK set their COVID-19 alert to level to 4 out of 5 at its peak in March; Singapore set its alert level to 3 out of 4 at its peak in February, and Sweden never set any infectious disease alert. The time between the date when the first case in each country was confirmed to the date when the highest-level infectious disease alert was announced was shortest for Italy (0 days), followed by Singapore (15 days), South Africa (21 days), South Korea (35 days), Germany (50 days), the U.S. (51 days), the UK (54 days) and Japan (102 days). We could not calculate China on this time as the date of the first confirmed cases in China was not reported in either the Chinese CDC or the WHO. As policies have changed with the changes in the severity of the pandemic, we drew 10 timelines of major PHSMs adopted by each country and the number of confirmed cases in each country. For details, see Figs. 1–10.

3.2. Movement measures

3.2.1. International movement control

To prevent the virus moving from one area to another, countries across the globe enforced strict border control policies. At first, border control policies only applied to visitors from Hubei, China. Later, the list of banned or restricted areas included more countries and regions. As of May 31, 2020, most countries either banned entry of all foreign nationals at the peak of the pandemic, such as Singapore (March 23) and China (March 28) or enforced a mandatory 14-day quarantines on all passengers arriving from all parts of the world, such as Japan (March 9), Italy (March 18), Singapore (March 20), South Africa (March 26), South Korea (April 1), Germany (April 8), and the U.S. (May 27).

Among the ten countries under study, two countries (Singapore and Italy) enforced movement-related policies since January 2020. Three countries (the U.S., South Korea, and the UK) enforced movement restriction policies since February 2020. Most other countries enforced movement-restriction policies since March 2020. After the peak of the pandemic, all ten countries gradually lifted international travel restrictions and allowed their citizens to return from abroad. For details, see Fig. 11.

3.2.2. Domestic movement control

For domestic movement control, several countries enforced strict travel restrictions between cities or provinces/states to lock down cities with severe pandemics. On January 23, 2020, the city of Wuhan, where the pandemic first broke out, was locked down to stop the spread of the virus. Inter-city transportation in Wuhan such as airports and railway stations were shut down, and intra-city transportation such as city bus, subway, ferry and long-distance transportation operations were also suspended. Other countries such as Italy (March 1) and South Africa (March 26) also locked down severely affected cities.

By May 31, three of the ten countries examined had lifted their initial movement restrictions. For example, Japan declared a state of emergency on February 28 and lifted the state of emergency on May 25. Italy locked down 'red zone' cities on March 1, and then relaxed their lockdown policies on May 4. The city of Wuhan in China was locked down on January 23 and was unlocked on April 8. We noted that some countries that were able to lift the restrictions in the spring of 2020, when the study was conducted, had to reintroduce these measures in the autumn and winter when the case numbers rose again.

3.3. Physical and social distancing measures

We reviewed physical and social distancing measures of the WHO and the ten countries on three kinds of people: confirmed cases and their close contacts, suspected cases and the general public.

3.3.1. Confirmed cases and close contacts

For confirmed cases and their close contacts, the WHO asked all nations to identify, isolate, test, and provide clinical care for all cases, and trace and quarantine all contacts. Consistent with the WHO's guideline, all ten countries asked confirmed cases and their close contacts to isolate, though specific directions varied across countries. As of May 31, China (January 22), Singapore (February 3), Japan (February 28), South Korea (March 5), Italy (March 9), and South Africa (March 18) made it mandatory for confirmed cases and their close contacts to be isolated while Sweden (March 12), the UK (February 10) and the U.S. (January 26) asked confirmed cases to self-isolate at home. As of May 2020, most countries under study announced tracking COVID-19 patients and their close contacts except Sweden.

Table 5
Public health and social measures policies on COVID-19 recommended by the WHO and issued by 10 countries.

Country	China	South Korea	Japan	Singapore	Italy	UK	Germany	Sweden	U.S.	South Africa	WHO
Date of the first confirmed case reported by WHO	12/1/2019	1/20	1/15	1/24	1/31	2/1	1/28	2/1	1/23	3/6	-
Date of the first confirmed case reported by each country	-	1/20	1/15	1/23	-	1/30	1/28	2/1	1/21	3/5	-
Date of highest infectious disease alert level (the second highest for the UK and Singapore)	1/30: ✓	2/23: ✓	4/7: ✓	2/7: ✓	1/31: ✓	3/23: ✓	3/17: ✓	X	3/13: ✓	3/26: ✓	-
The time between the date when the first case in each country was confirmed to the date when the highest-level infectious disease alert (days)	-	35	102	15	0	54	50	-	51	21	-
Confirmed number (as of 5/31)	84,570	11,468	16,851	34,366	232,664	272,830	181,482	37,113	1716,078	30,967	-
Confirmed cases per capita (per million)	58.45	223.68	133.23	5874.19	3848.11	3747.31	2166.07	3674.82	5348.55	522.13	-
The number of cited articles (2019.12.1–2020.5.31)	22	8	14	15	21	18	10	12	13	2	13
1. Movement restriction											
1.1 Banning entry of all foreign nationals who had been to China's Hubei province in the past two weeks	-	2/2: ✓	3/27: ✓	1/29: ✓	-	-	-	-	2/1: ✓	-	-
1.2 Banning entry of foreign nationals from other high-risk areas besides Hubei, China	-	2/2–3/16: ✓	3/27: ✓	2/1;3/4; 3/16: ✓	-	3/26: ✓	3/16;3/17: ✓	3/19: ✓	3/13;5/28: ✓	-	-
1.3 Banning entry of all foreign nationals	3/28: ✓	-	-	3/23: ✓	-	-	-	-	-	-	-
1.4 Mandatory 14-day quarantine on all passengers arriving from Hubei, China	-	2/2: ✓	3/9: ✓	1/28: ✓	-	-	-	-	2/2: ✓	-	-
1.5 Mandatory 14-day quarantine on all passengers arriving from all parts of the world	3/3–3/23: ✓	4/1: ✓	3/9: ✓	3/20: ✓	3/18: ✓	-	4/8: ✓	-	5/27: ✓	3/26: ✓	5/18: ✓
1.6 Domestic travel restrictions between cities or provinces	2019/12/23: ✓	-	-	-	3/1: ✓	-	-	-	-	3/26: ✓	5/18: ✓
2. Physical and social distancing measures											
2.1 Confirmed cases and close contacts											
2.1.1 Mandatory isolation of confirmed cases and their close contacts	1/22: ✓	3/5: ✓	2/28: ✓	2/3: ✓	3/9: ✓	-	5/11: ✓	-	-	3/18: ✓	1/5: ✓
2.1.2 Tracking COVID-patients and their close contacts	1/22: ✓	3/9: ✓	2/25: ✓	1/23: ✓	4/23: ✓	3/17: ✓	4/23: ✓	-	5/26: ✓	-	5/10: ✓
2.1.3 Develop mobile applications to track COVID-19 patients and close contacts	2/11: ✓	3/9: ✓	-	4/23: ✓	-	5/5: ✓	4/7: ✓	-	-	-	5/13: ✓
2.1.4 Patients with different degrees of symptoms treated in different locations	1/22: ✓	3/1: ✓	5/1: ✓	4/4: ✓	-	-	-	-	-	3/24: ✓	5/18: ✓
2.2 Suspected cases											
2.2.1 Self-isolation of those from high-risk areas	1/25: ✓	3/9: ✓	3/9: ✓	1/2: ✓	2/21: ✓	3/3: ✓	3/9: ✓	-	5/6: ✓	2/10: ✓	2/16: ✓
2.2.2 Self-isolation for symptomatic people or for those living with symptomatic people	1/22: ✓	-	2/28: ✓	1/23: ✓	2/21 ✓	3/13: ✓	-	5/29: ✓	3/6: ✓	-	4/17: ✓
2.2.3 Temperature check in public spaces	1/26: ✓	3/19: ✓	-	1/3: ✓	2/4: ✓	-	X	-	-	3/26: ✓	2/16: ✓
2.2.4 Virus testing	1/27: ✓	2/2: ✓	3/15: ✓	3/4: ✓	4/15: ✓	2/7: ✓	4/17: ✓	3/29: ✓	3/4: ✓	3/15: ✓	3/20: ✓
2.3 The general public											
2.3.1 National stay at home orders	2/11: ✓	-	-	4/7: ✓	3/9: ✓	3/26: ✓	3/20: ✓	-	-	3/26: ✓	-
2.3.2 School closure or delayed start of school semesters	2019/12/26: ✓	3/17: ✓	3/2: ✓	4/7: ✓	2/23: ✓	3/18: ✓	3/16: ✓	-	3/18: ✓	3/18: ✓	5/18: ✓
2.3.3 Working from home	2/9: ✓	3/12: ✓	2/25: ✓	3/20: ✓	3/9: ✓	3/20: ✓	3/15	3/16: ✓	3/16: ✓	-	5/18: ✓
2.3.4 Non-essential shops and services closed	1/24: ✓	3/16: ✓	-	3/26: ✓	2/23: ✓	3/21: ✓	3/23: ✓	-	-	3/18: ✓	5/18: ✓
2.3.5 Curfew	-	-	-	-	-	-	3/20; 3/21: ✓	-	-	3/26: ✓	-
2.3.6 Cancellation of public events	1/24: ✓	3/22: ✓	3/19: ✓	3/11: ✓	2/23: ✓	3/23: ✓	3/3: ✓	3/12: ✓	3/8: ✓	3/18: ✓	5/18: ✓
3. Personal measures											
3.1 Hand washing	1/24: ✓	2/25: ✓	2/25: ✓	1/2: ✓	2/24: ✓	3/3: ✓	3/11: ✓	5/14: ✓	3/6: ✓	3/26: ✓	5/18: ✓
3.2 Ventilation	1/24: ✓	3/9: ✓	3/1: ✓	3/13: ✓	5/14: ✓	-	5/26: ✓	-	-	-	1/29: ✓
3.3 Social distancing	2019/12/24: ✓	2/29: ✓	2/25: ✓	3/13: ✓	4/27: ✓	3/3: ✓	3/14: ✓	3/12: ✓	4/3: ✓	3/26: ✓	5/18: ✓
3.4 Wear a face mask in public for healthy people	2019/12/24: ✓	2/25: ✓	2/25: ✓	4/14: ✓	4/18: ✓	-	4/3: ✓	5/14: X	4/3: ✓	3/26: ✓	2/27: X; 4/6: X
4. Special protection measures for special populations and vulnerable groups	1/25;1/28: ✓	3/8: ✓	3/28: ✓	3/10: ✓	3/25: ✓	4/10: ✓	3/25: ✓	4/1: ✓	4/7: ✓	3/28: ✓	5/18: ✓
5. Public health resources strategies											
5.1 Supply medical goods and materials	1/26: ✓	5/3: ✓	3/28: ✓	2/1: ✓	-	4/10: ✓	-	-	-	-	2/12: ✓
5.2 Provide healthcare staff protective gears	1/26: ✓	3/9: ✓	4/1: ✓	1/31: ✓	4/18: ✓	3/3: ✓	3/16: ✓	3/19: ✓	3/14: ✓	4/1: ✓	3/19: ✓
5.3 Increase hospital beds for treating COVID-19 patients	1/24: ✓	3/9: ✓	4/7: ✓	3/24: ✓	-	3/17: ✓	-	4/6: ✓	-	-	5/21: ✓
5.4 Dispatch medical teams from other parts of the country to epidemic areas	1/26: ✓	3/9: ✓	-	-	-	-	-	-	-	-	2/16–24: ✓
5.5 Military support	1/26: ✓	1/27: ✓	-	1/31: ✓	3/18: ✓	3/19: ✓	-	4/6: ✓	3/18: ✓	3/26: ✓	-

Note: For simplicity, the year 2020 is omitted for all the dates and the year of 2019 is retained.

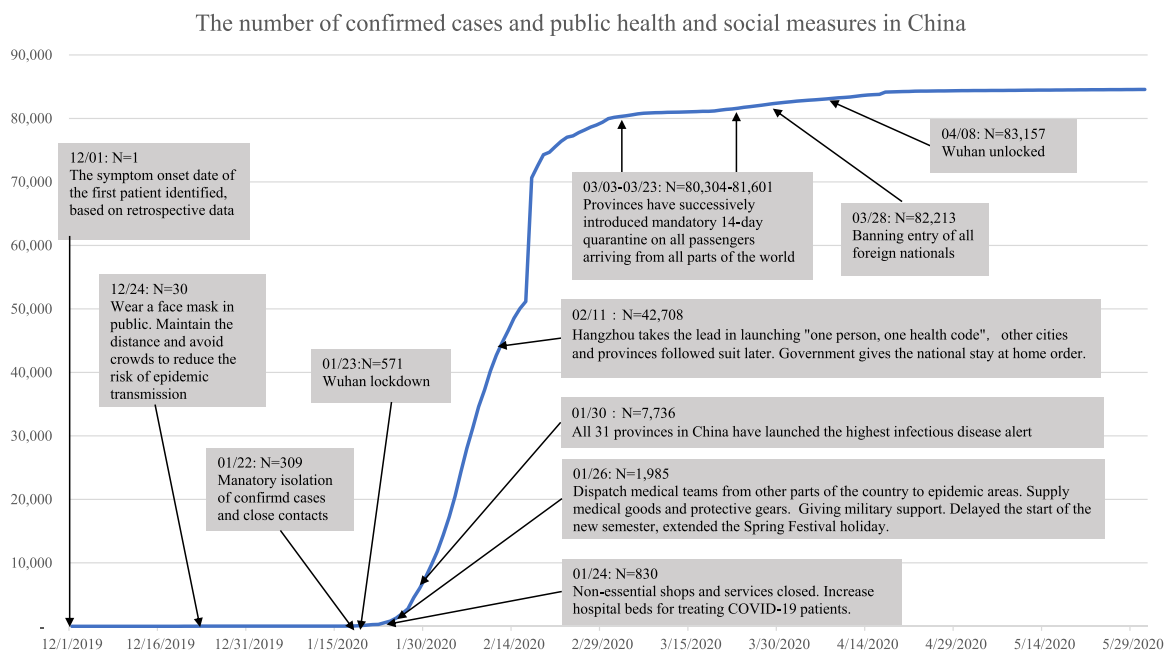


Fig. 1. The number of confirmed cases and public health and social measures in China. Note: WHO did not provide the number confirmed cases in China before January 21, 2020, and therefore the number before January 21, 2020 was from National Health Commission of the People’s Republic of China.

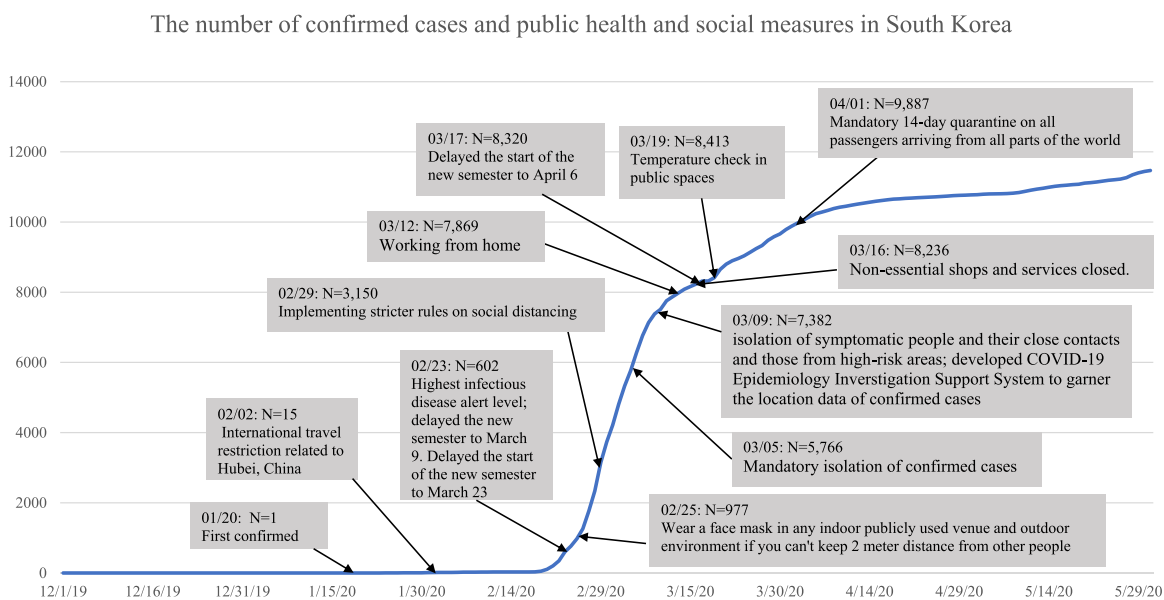


Fig. 2. The number of confirmed cases and public health and social measures in South Korea.

China (January 22), South Korea (March 1), Singapore (April 4) and Japan (since May 2020) treated both severe cases and mild cases in hospitals or temporary hospitals while the other six countries could only receive severe cases. To avoid overwhelming hospitals, the four countries mentioned above treated people with different degrees of symptoms in various locations. For example, China treated and isolated people who tested positive but with mild symptoms in Fangcang shelter hospitals—large, temporary hospitals built by renovating existing indoor venues into health-care facilities [25]. South Korea treated people tested positive but with mild symptoms at residential care centers, reserving hospitals for severe cases. Singapore treated COVID-19 patients with mild symptoms at the Community Care Facility. In February, Japan asked those who tested positive but with mild flu-like symptoms to stay at home, and later, in May, provided lodging facilities for

those with mild symptoms. On March 24, South Africa government announced that it will establish a system for ‘centralized patient management’ for severe COVID-19 cases and ‘decentralized primary care’ for mild cases.

To find out who these people were, some countries combined extensive testing and digital technology. To speed up testing for the virus, South Korea built drive-through and walk-through screening stations (February 26). In February 2020, cities in China developed an application called Health Code, an e-permit that can prove the health of the holder and show to the sites where the Health Code is required [26]. Since March 2020, South Korea developed and ran the COVID-19 Epidemiology Investigation Support System in cooperation with the Korean CDC, mobile carriers and credit card companies to garner the location data of a person confirmed with the virus. On 23 April 2020, Singapore developed a

The number of confirmed cases and public health and social measures in Japan

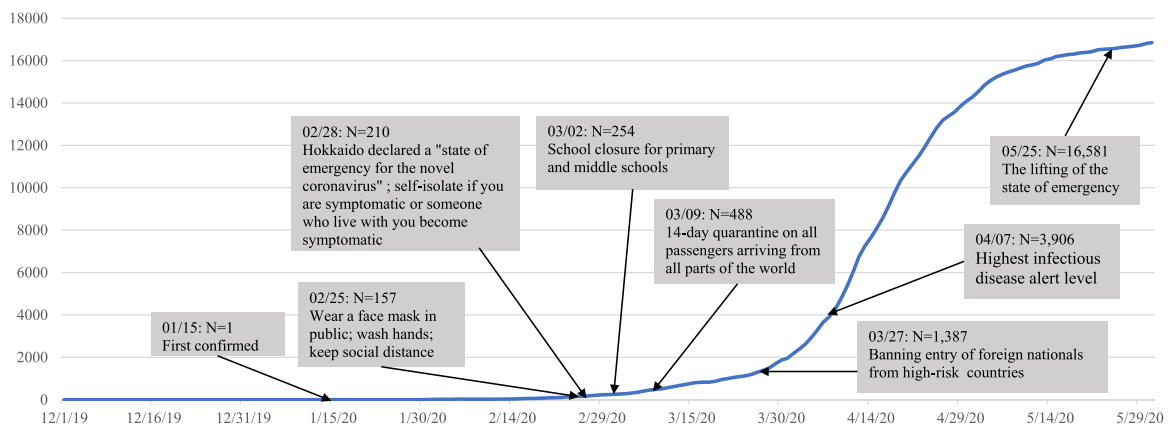


Fig. 3. The number of confirmed cases and public health and social measures in Japan.

The number of confirmed cases and public health and social measures in Singapore

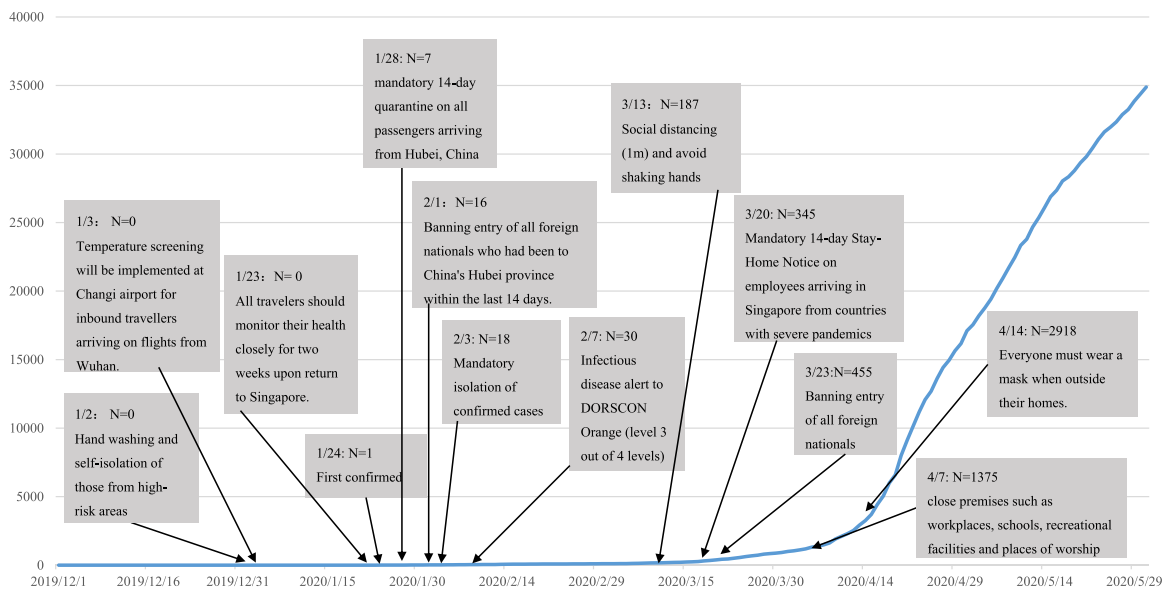


Fig. 4. The number of confirmed cases and public health and social measures in Singapore.

The number of confirmed cases and public health and social measures in Italy

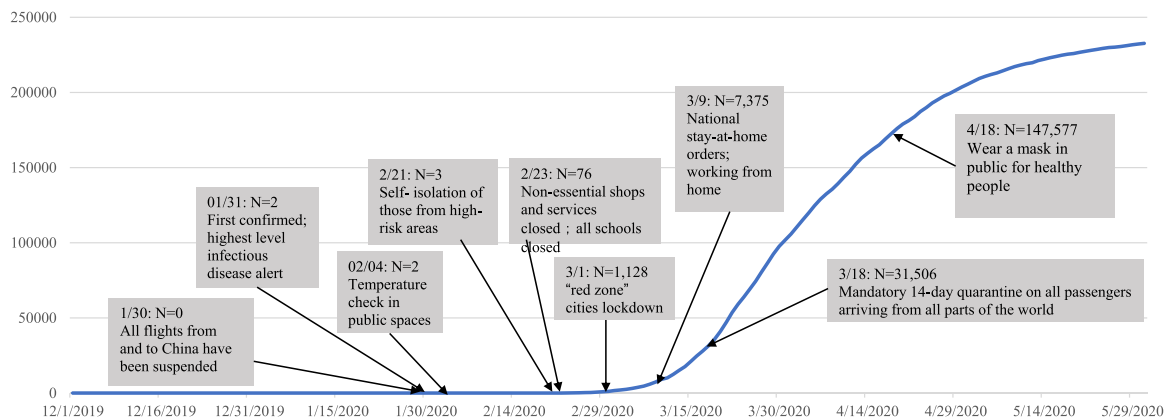


Fig. 5. The number of confirmed cases and public health and social measures in Italy.

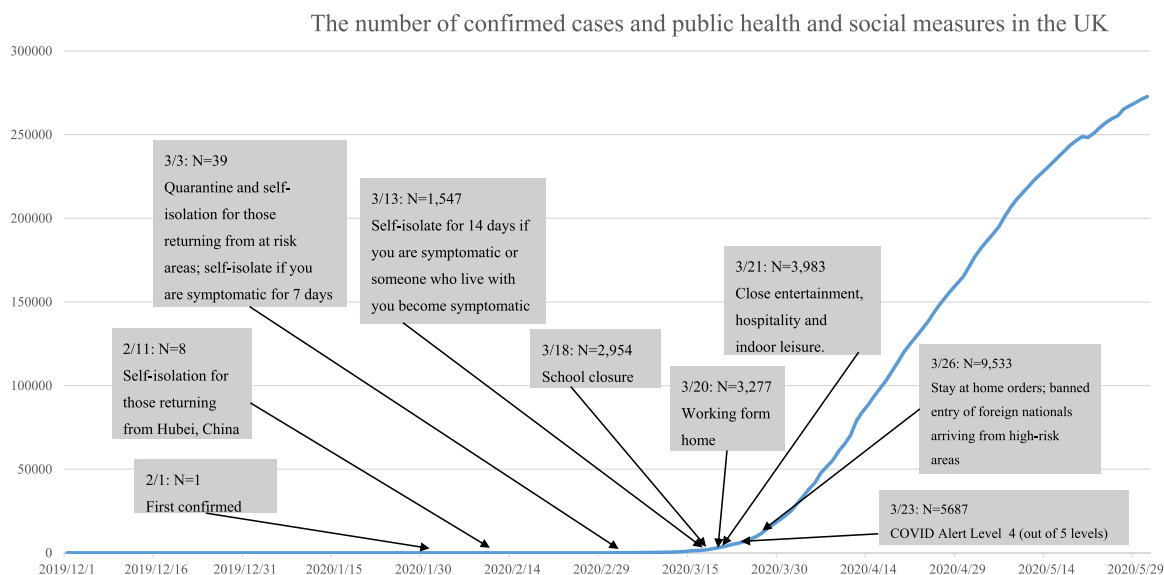


Fig. 6. The number of confirmed cases and public health and social measures in the UK.

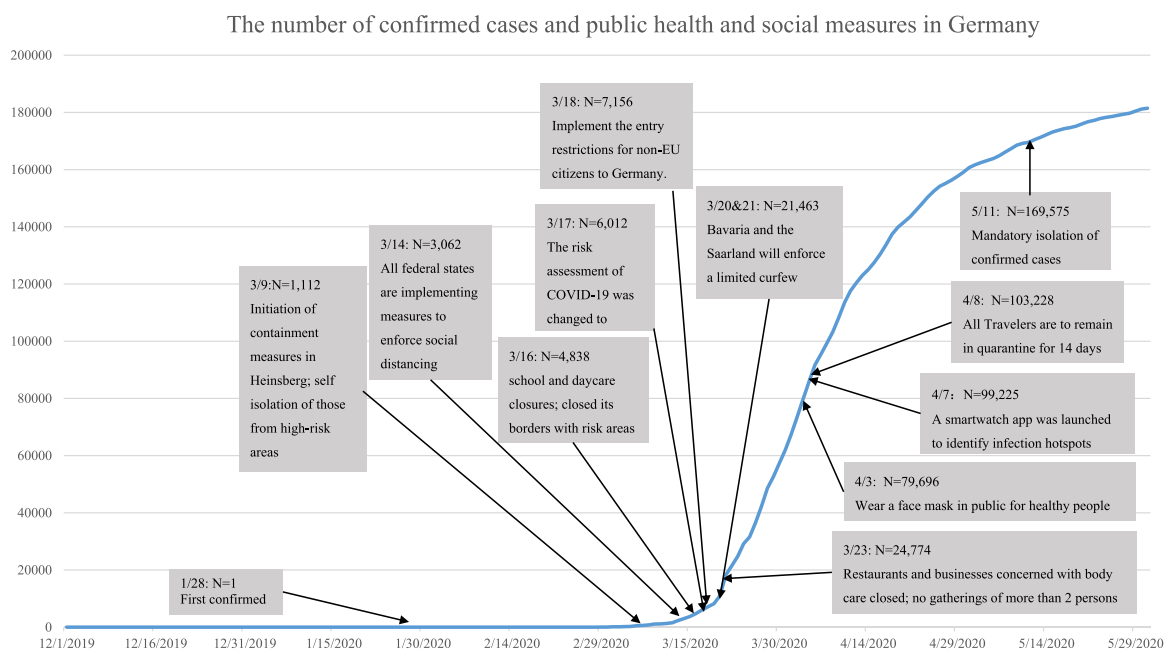


Fig. 7. The number of confirmed cases and public health and social measures in Germany.

national digital check-in system called SafeEntry that logs individuals' entry into a venue to find close contacts of infected cases quickly. On April 7, the German Robert Koch (RKI) launched a mobile application, 'Corona Datenspende' ('corona data donation'), for recording COVID-19 symptoms. The application was not intended to track contact persons individually, but to help identify infection hotspots. The UK launched Coronavirus Status Checker for recording COVID-19 symptoms in April. Also in April, an Italian company launched an application called StopCovid19, which uploads the users' location into a database, so only the health department could determine the contacts of a person who has tested positive for COVID-9 at a certain time and place. In May, the UK launched the NHS Test and Trace application to trace COVID-19 patients and their close contacts, but the application was suspended due to technical problems during our study period. More applications have been developed after our study period.

3.3.2. Suspected cases

For those who came back from high-risk areas, all the countries asked them to self-isolate except Sweden. For a person who had COVID-19 symptoms or living with a person who became symptomatic, Singapore (January 23), Italy (February 21), Japan (February 28), Germany (February 28), the U.S. (March 6), South Korea (March 9), the UK (March 13), and Sweden (May 29) asked the person to self-isolate. China's policy on symptomatic people was 'early detection, early isolation and early treatment', and it asked those with symptoms to go to designated COVID-19 hospitals for inspection (January 22). When self-isolating, South Korea (March 9), Japan (February 28), Singapore (January 23) and Italy (February 21) advised people with COVID-19 symptoms to stay at home, refrain from going out and restrict all contact with other people. On March 6, the U.S. CDC said people with symptoms of COVID-19 can go out while self-isolating but advised that when leaving home, they should keep 6 feet or about 2 meters from others and

The number of confirmed cases and public health and social measures in Sweden

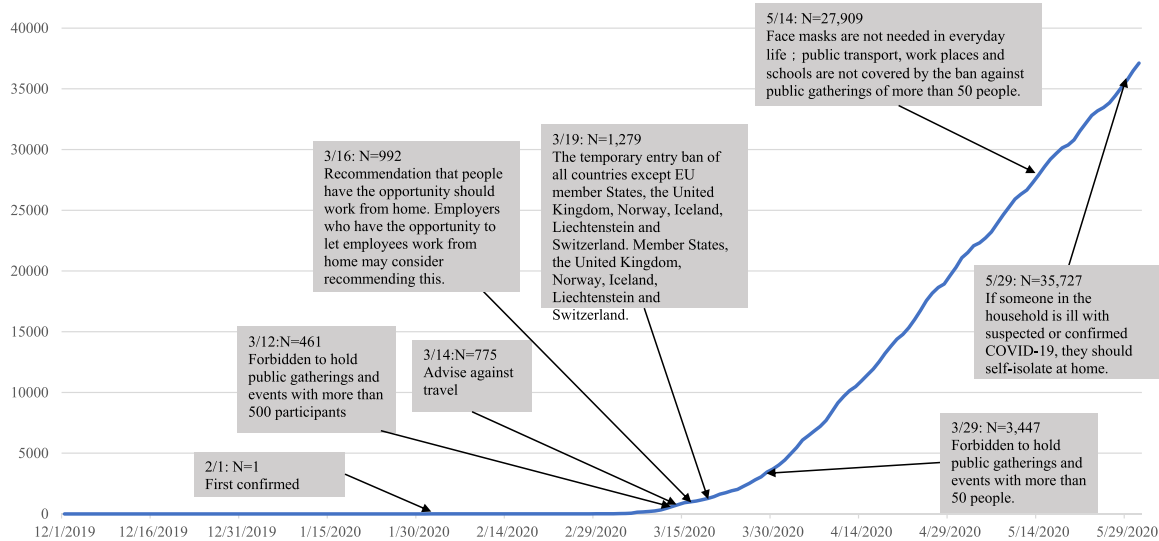


Fig. 8. The number of confirmed cases and public health and social measures in Sweden.

The number of confirmed cases and public health and social measures in the US

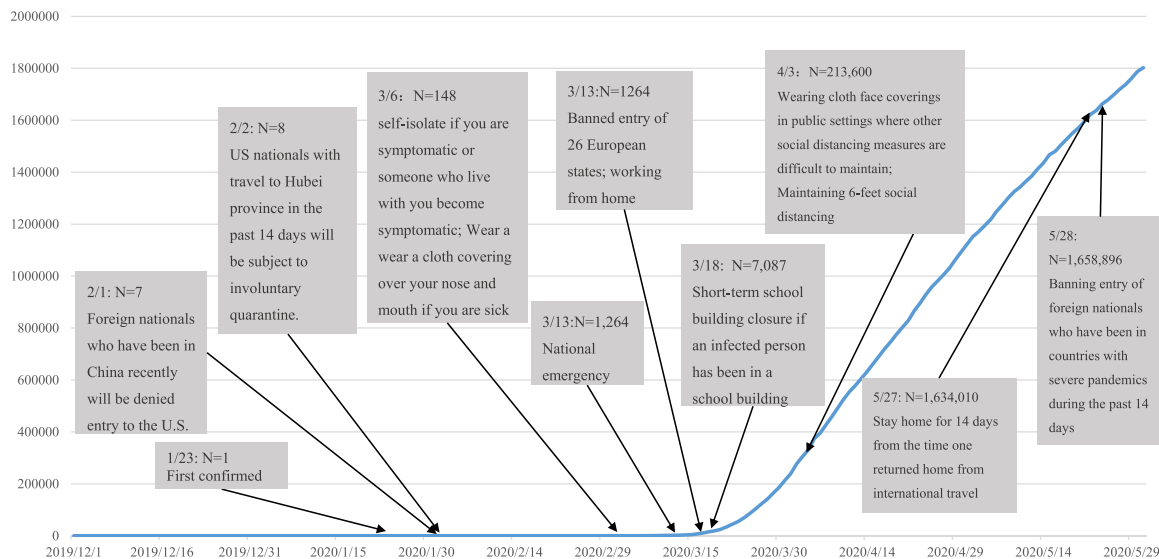


Fig. 9. The number of confirmed cases and public health and social measures in the US.

wear a cloth face covering when around other people. On May 29, Sweden asked the person with symptoms to self-isolate at home, but allowed family members with no symptoms to go to school or work as normal. For the time requirement of self-isolation, most countries asked people who had symptoms to self-isolate for 14 days while the UK asked them to self-isolate at home for at least 7 days on March 12. To ascertain who had COVID-19 symptoms, Singapore (January 3), China (January 26), Italy (February 4), South Korea (March 19), and South Africa (March 26) required temperature checks in public spaces, while other countries had no such requirements as of May 31. All ten countries conducted virus testing for those who have COVID-19 symptoms.

3.3.3. The general public

Table 6 showed the physical and social distancing measures for the general public of the ten countries. For the general public, the WHO recommended a minimum distance of at least 1 m between people to limit the risk of interpersonal transmission. Four coun-

tries have enforced this recommendation and even increased the minimum distance. The minimum distance of at least 1 m was required in Singapore (March 13) and Italy (in high-risk regions, on March 8; nationally, on March 20), 1.5 m in Germany (March 14), 6 feet or about 2 m in the U.S. (April 3), 2 m in the UK (March 3). Sweden, China, South Korea and Japan did not given such guidelines as of May 2020.

In order to ensure that people keep their physical distance, countries enforced stay-at-home orders to varying degrees. The strictest stay-at-home order was implemented in the city of Wuhan in China. After January 23, people in communities with confirmed cases or suspicious cases could not go out: food and necessities were delivered to their doors. After the stay-at-home order in the city of Wuhan, China issued a national stay-at-home order on February 11.

Another group of countries did not enforce the strictest stay-at-home orders, people were allowed to go out under certain circumstances, such as the UK (March 26), South Africa (March 26), Ger-

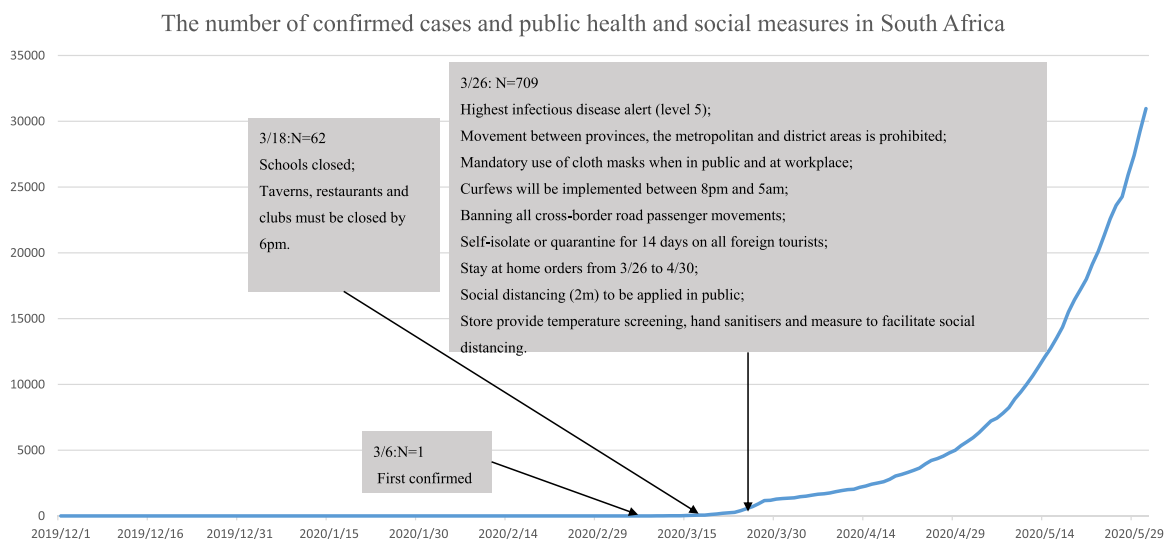


Fig. 10. The number of confirmed cases and public health and social measures in South Africa.

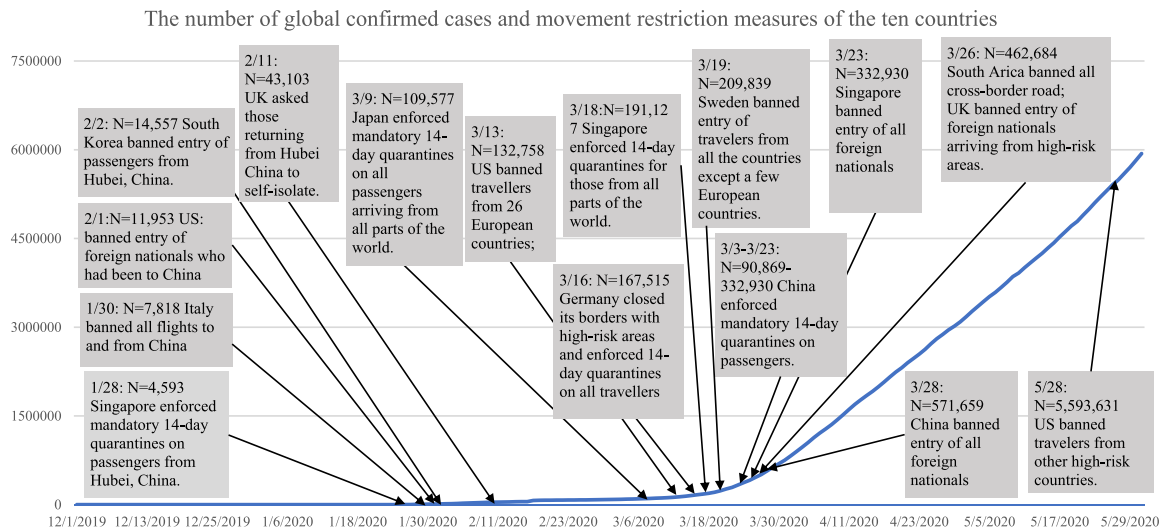


Fig. 11. The number of global confirmed cases and movement restriction measures of the ten countries. Note: N stands for the number of global confirmed cases on that day.

many (March 22), and Italy (May 4). When citizens broke the rules of stay-at-home orders, Germany (March 22), South Africa (March 25), Singapore (March 26), the UK (March 26) and Italy (March 27) gave penalties to the offenders. Germany did not call this policy as ‘stay-at home orders’, instead, they call it ‘limited free movement outside of people’s homes’ (March 22).

South Korea and Japan did not give a national stay-at-home order and only suggested people to stay at home, avoid cross provincial mobility. Sweden did not give a stay-at-home order and allowed free movement of people. Though allowing people to move freely, Sweden banned public gatherings and events with more than 500 people on March 12, and the number further reduced to 50 people on March 29. People who breached the ban could be fined or imprisoned for up to six months. The U.S. did not have a national regulation on stay-at-home orders, with laws placed based on each state’s decision. All ten countries we examined had restrictions on mass gatherings. The maximum number of people in a social gathering (apart from people one lives with) is 2 for the UK (March 26) and Germany (March 22), 10 for Singapore (March

26) and the US (March 30), and less than 100 for South Africa (March 16). Italy only allowed gatherings of 15 people for religious ceremonies and funerals on May 4. China (January 24) and South Korea (March 22) banned all mass gatherings regardless of the number of people. Meanwhile, instead of banning gatherings, the Japanese government only strongly requested people not to hold events where clusters could emerge (February 25).

To further ensure safe distances between people, all the countries under study—except Sweden—closed their schools or delayed the start of school semesters as of May 31, 2020. Although Sweden did not officially close its schools, on March 17, it recommended secondary schools, universities and colleges to switch to distance learning. In addition, all ten countries recommended working from home. China (January 24), Italy (February 23), South Korea (March 16), Germany (March 16), South Africa (March 18), the UK (March 21), and Singapore (March 26) closed non-essential shops and services. Germany (March 20 and 21) and South Africa (March 26) also enforced curfews at the peak of the pandemic in the spring. All ten countries canceled public events.

Table 6
Physical and social distancing measures for the general public.

Country	Distance	The maximum number of a social gathering	Reasons for leaving home	Punishments for breaking social distancing rules
China	–	1/24: ban all mass gatherings	–	–
South Korea	–	3/22: ban all mass gatherings.	–	–
Japan	–	–	–	–
Singapore	3/13: 1 m	3/26: 10 people	–	3/26: A fine of up to \$10,000 or imprisonment of up to six months or both.
Italy	3/8; 3/20: 1 m	5/4: 15 people for religious ceremonies and funerals.	5/4: To buy food, to work, to travel by a parent to pick up under-age children living with the other parent, or a guardian.	3/27: A penalty of € 400 to € 3000.
UK	3/3: 2 m	3/26: 2 people	3/26: 13 reasons such as to obtain necessities, to take exercise either alone or with other members of their household, to seek medical assistance, to provide care or assistance, to donate blood, to work, to attend a funeral, to fulfill a legal obligation, etc.	3/26: Fixed penalty notice and arrest.
Germany	3/14: 1.5 m	3/22: 2 people	3/22: To commute to work, participation in meetings, grocery shopping, emergency care appointments, medical appointments, necessary appointments and exams, to provide support to others, to exercise, to move around in fresh air, to do any other necessary activities.	3/22: A fine.
Sweden	–	3/12: 500 people; 3/29: 50 people.	–	3/29: Fines or imprisonment for up to six months.
U.S.	4/3: 6-feet	3/16: 10 people.	–	No national order, with laws placed based on each state's decision.
South Africa	2 m	3/16: less than 100 people.	3/26: To buy food, medicine and other supplies, seek medical care, collect a social grant, and attend a funeral.	3/25: A fine or imprisonment of up to six months or both.

3.4. Personal measures

Consistent with the WHO's guideline, most countries conducted public information campaigns to educate people about personal measures to limit person-to-person spread, protect individuals and their contacts, and reduce contamination from frequently touched surfaces. All ten countries advocated hand hygiene and social distancing; China (January 24), Japan (March 1), South Korea (March 9), Singapore (March 13), Italy (May 14) and Germany (May 26) advocated ventilation.

In terms of wearing a face mask in public for the asymptomatic people, the WHO did not recommend them to wear a mask of any type in February. In April, the WHO advocated people with COVID-19 symptoms to wear a medical mask, but for healthy people, the WHO stated that there is no evidence that 'wearing a medical mask by healthy individuals in the households or among contacts of a sick patient, or among attendees of mass gathers may be beneficial as a preventive measure' and stressed that 'it is critical that medical masks and respirators be prioritized for health care workers' [27]. We noted that at the time of this recommendation, there were global shortages of PPE (personal protective equipment), including medical masks for health care workers.

Although the WHO only advocated people with COVID-19 symptoms to wear a medical mask and did not recommend healthy people to wear masks [28], most countries advocated or made it compulsory that healthy people should wear face masks in public. Asian countries such as China (December 24, 2019), South Korea (February 25), and Japan (February 25) were the first to ad-

vocate such a policy, while South Africa (March 26) advocated it in March and the U.S. (April 3), Singapore (April 14), Italy (April 18) and Germany (April 3) advocated it in April. As of May 31, the UK has not mentioned such a measure. Sweden's public health agency stated that face masks were not needed in everyday life on May 14.

In terms of the type of masks, most countries advocated for the general healthy public to wear non-medical face masks rather than medical face masks. The strictness of face mask requirements was different from country to country. While most countries recommended wearing face masks in indoor venues, South Africa required the use of cloth masks when in public and at the workplace (March 26). Singapore (April 14) and Japan (February 25) also required the use of masks, including to all venues outside the home. The strictness of face mask requirements also changed as time went by. For example, Singapore's requirement changed from January when those with respiratory symptoms such as a cough or runny nose needed to wear masks, to April, when everyone needed to wear a mask when outside their homes.

3.5. Special protection measures for special populations and vulnerable groups

Consistent with the WHO's advice, many countries, including China (January 25), Japan (March 28), Sweden (April 1) and Italy (May 4) banned visits to care homes for older people. China, Italy and South Korea published guidelines for vulnerable groups. South Korea (March 8), Japan (March 28) and the UK government (April

10) provided aid for the purchase of medical goods and materials for childcare centers, senior citizen centers, and etc. Due to supply problems, most countries prioritized the use of protective gear such as medical face masks for healthcare workers.

3.6. Strategies on public health resources

Besides the four PHSMs advocated by the WHO, we also identified the fifth set of PHSMs: public health resource strategies. This kind of PHSM includes supplying medical goods and materials, providing protective gears to healthcare staff, increasing hospital beds, dispatching medical teams from other parts of the country to the epidemic areas, and providing military support. These measures play the role of a support system for the other PHSMs, ensuring that general health strategies can run smoothly.

For the supply of medical goods and materials, Asian governments took a leading role in the procurement, production and distribution of public health resources while other governments left it to the market. For example, the South Korean government effected public procurement for the entire production of masks, expanded production capacity, and utilised digital technologies in the allocation and distribution process (May 3). The Chinese government coordinated and arranged the emergency transfer of medical materials such as protective clothing, masks, gloves, goggles, etc. from the Central Medical Reserve to Wuhan (January 26).

To increase the number of hospital beds for the treatment of COVID-19 patients, some countries, such as China (January 24), the UK (March 31) and Germany (May, 11), built new hospitals, while others, such as South Korea (March 9) and Sweden (April 6), remodeled existing hospitals to treat COVID-19 patients. Singapore (March 24) expanded its beds in community care centers by remodeling its exhibition centers and migrant worker dormitories. The Japanese government used large tents and prefabricated buildings to provide drive-through and walk-through medical care (April 7). The UK increased hospital beds for the treatment of COVID-19 by discharging other patients who were well enough to go home or could be cared for in the community (March 17).

To help areas with a severe pandemic, China (January 26) and South Korea (March 9) dispatched medical teams from other parts of the country to epidemic areas. Many countries also asked their military to provide services and public health resources.

4. Discussion

By comparing the health policies across nations, we identified 5 sets of PHSMs (movement measures, personal measures, physical and social distancing measures, special protection measures for special populations and vulnerable groups, and public health resource strategies) and 31 sub-items. Apart from identifying the fifth set of PHSMs (public health resource strategies), we also enriched the four existing sets of PHSMs by adding unlisted sub-measures (e.g., using mobile applications to track COVID-19 patients and their close contacts) into the PHSM package.

The major limitation of this study was in the sampling. We only sampled and analyzed the data from developed countries or relatively well-off developing countries. The PHSMs implemented in developing countries remain a large missing piece in this study. In addition, the policies we analyzed were only from the government websites in each country. There are other ways for governments to communicate with the public (e.g. traditional media and social media) and they were not explored in this study. In addition, we only sampled the PHSMs of ten nations prior to 31 May 2020. Changes in public health policies after our study period were not examined in our study. Finally, as a comparative study, we could only compare national policies across countries; thus, we may have overlooked the local policies of each country.

Despite the above limitations, the strengths of this study still enriched our understanding of ten countries' public health policies on COVID-19. First, our study demonstrated that the developed and relatively well-off developing countries were not protected from COVID-19. To understand why those countries with economic advantages still faced tremendous challenges, we looked more closely at the similarities and differences in PHSMs that those countries had implemented. We found that with the global spread of COVID-19 over time, the PHSMs of the ten nations had become homogenized, regardless of the countries' political and cultural differences. Interestingly, such a homogenization process happened before, not after, the WHO released its toolkit of PHSMs. It seemed that different countries were somehow learning from each other throughout the pandemic, forming a global synchronization of health policies. The differences between these countries were reflected in how they applied PHSMs. To be more specific, the differences lay in nations' speed, strictness and richness of resources when applying the measures and sub-measures of PHSMs. These differences may explain the difficulties faced by the developed countries and the relatively rich developing countries in fighting against COVID-19.

4.1. Homogenization of the PHSM framework over time

Although initial responses to the COVID-19 pandemic varied, as time passed, the general framework of PHSMs that the ten countries implemented turned from non-uniformed to uniformed, segregated to integrated. Movement restriction was one of the most likely responses to COVID-19 from the ten countries. However, when they found this singular policy was not able to stop the virus from spreading, they started to implement multiple measures against COVID-19. As of May 31, 2020, nine out of the ten countries required or recommended multiple PHSMs to their public, which are generally consistent with the PHSM framework of the WHO. One special case is Sweden, which did not recommend some of the physical and social distancing measures to their citizens.

4.2. Differences in PHSMs across nations

4.2.1. Speediness in actions

Speediness refers to how fast a government launched PHSMs against COVID-19. Scholars found that non-pharmaceutical interventions, which lie in the core of PHSMs, will successfully cut off virus transmission when they are applied in a swift way [28]. Clearly, time matters with regard to the effectiveness of PHSMs. In the case of COVID-19, Demircuc-Kunt, Lokshin, and Torre have proven that "the sooner" NPIs can be applied against the virus "the better" for health outcomes. Other scholars have also found a positive correlation between timely NPI implementation and a reduction in the epidemic's peak [29]. Based on the above studies, we believe that time matters with regards to the effectiveness of PHSMs.

We argue that the difference in speediness in actions could be due to the lack of effective laws or regulations against pandemics. Human societies have been constantly attacked by global outbreaks like SARS, Ebola, MERS and H1N1. Countries, such as China and South Korea, which have experienced serious epidemic outbreaks, have already implemented epidemic preparedness plans and legislations. Thus, they could react more quickly to the COVID-19 pandemic. In contrast, countries, such as Japan and the U.S., which neither had strong power to enforce strict measures in their current law system nor passed COVID-19-related laws to strengthen such power during our study period, responded to COVID-19 less quickly.

Cultural differences could be another reason for the varied speediness in actions of different countries. Most Asian countries, including China, South Korea and Japan, required or recommended

that their citizens wear a face mask in public within weeks of the first confirmed local case. By contrast, countries like the UK, the U.S. and Germany spent months debating on whether it was necessary to do so. Flakerud pointed out that cultural differences matter with regard to the policy of wearing masks; specifically, while Asian cultures regard masks as a means of self-protection, Western people associated masks with sickness [32]. It is important to acknowledge that mask-wearing policies were influenced by more than just cultural differences, as international experts in the Western societies sent mixed messages concerning the effectiveness of masks during the study period [32,33]. However, in the Asian countries, there was already a consensus about the effectiveness of wearing masks [34]. In addition, the speediness to launch travel restrictions could also be influenced by political concerns. For instance, Hane observed that the delay in travel restriction policies in Japan might be due to the political needs for hosting the Olympic Games [30].

4.2.2. Strictness in policies

We have found that some countries applied PHSMs swiftly, but even that reaction did not stop the quick transmission of the epidemic. Italy, for instance, implemented movement restriction measures even before the first local case was confirmed, yet it still suffered greatly from COVID-19. Researchers point out that loose policies against the virus were why Italy failed to control its outbreak, and they suggest strict quarantine measures for reducing the peak of COVID-19 [35]. This suggestion is echoed in the second difference among the ten countries sampled in this study: policy strictness. For example, though most nations we examined implemented a mandatory 14-day quarantine on all passengers arriving from abroad, South Korea and Singapore arranged for special staff to make phone calls and visit homes to ensure the quarantine was effective while other countries did not have such strict supervision. In the case of China, which applied very strict policies of quarantine, passengers coming from abroad were asked to quarantine at the hotels the local governments arranged for them, and only elderly passengers, passengers with young kids, and passengers with long-term sickness could ask for staying at home during quarantine. A similar case happened with regard to the stay-at-home order. While Italy and China both launched a stay-at-home order, Italy allowed its citizens to go out with conditions, whereas China asked its citizens to strictly follow the stay-at-home rule and coordinated food deliveries for the communities. In Singapore and South Africa, if citizens broke the stay-at-home orders, they would face fines and even prison time, but in other countries, the penalties are not that serious. While most Western countries gave specific directions on the minimum distance between people, most Asian countries did not. This may be because Asian countries already required people to wear face masks in public.

The level of strictness in PHSM policies, we argue, is closely related to the political system in each nation. In general, nations with strong authorities (e.g., China, Singapore) released stricter PHSMs than did liberal countries, while governments of the latter needed to consider more the reactions of the public and their political opponents than governments of the former. In the case of the U.S., a survey illustrated that with regard to the measure of social distancing, Democrats were 30% less likely to attend large gatherings than Republicans [36]. The controversies between Republicans and Democrats may result in disagreements amongst federal and state governments with regard to PHSMs.

Besides the difference in political systems, we also found that culture matters in the strictness of the PHSM policies. Most of the Asian governments we observed, whether liberal or authoritarian, easily applied stricter policies than did their Western counterparts and easily won the support from local communities. The South Korean CDC believed that local citizens would adhere voluntarily to

the rules and attributed such collectivist reaction to their 'community spirit' [37], a cultural virtue in Asia.

Another possible reason that may grant some Asian governments more room to facilitate strict PHSMs policies could be trust in government. The scholars found that people in China and South Korea were willing to follow the governments' policies during COVID-19, trusting that the government would take care of their health [38]. Interestingly, scholars also found that in the case of South Korea, the government's strict and swift policies in return bounced up the public trust in the government [39], while the similar policies triggered protests in some Western societies [40].

4.2.3. Resource richness

The third aspect that matters in the application of PHSMs is called resource richness, which can be categorized into resource richness in the medical system and resource richness in digital technologies. According to our data (See Table 5, 2.1.4), only five out of the ten nations (China, South Korea, Japan, Singapore and South Africa) can receive patients with different degrees of symptoms in medical centers or other health-care facilities. Other nations (South Korea, Italy, the UK, Sweden and the U.S.) asked patients with mild symptoms to just stay home in order to avoid overwhelming the local medical systems. Moreover, though most nations launched virus testing, the daily testing capacity varied greatly from country to country. With regards to digital technology resources, as of May 31, six (South Korea, China, Singapore, Italy, Germany, and the UK) of the sampled nations developed COVID-19-related smartphone applications, but only China and South Korea's applications were able to track patients and their close contacts at a national level. Mathematical models have proven that tracking applications could partially reduce the average number of secondary infections from a random infected individual. In other words, tracking applications could positively impact health outcomes across nations [41].

The United Nations have warned that the least developed countries are under the devastating threats of COVID-19 because they lack the resources to cope with the disease [42]. All the countries we sampled in this study are either developed countries or relatively well-off developing countries. However, we found that the countries with better economic development are also struggling with inadequate resources, which hurt the efficiency of PHSM application. As previous studies have shown, inadequate resources could harm the efficiency of the fight against COVID-19, even causing social panic and disorder [31,43].

5. Conclusions and implications for policy

Drawing from the WHO's guide and the policy data from ten countries' government websites on COVID-19, we identified 5 sets of PHSMs and 31 sub-items. Apart from identifying the fifth set of PHSMs, we also enriched the four existing sets of PHSMs by adding unlisted sub-measures into the PHSM package. We found that with the global spread of COVID-19 over time, the PHSMs of the ten nations have become homogenized. This could be due to the severity of the pandemic urged policy makers to do something, although they might be uncertain about the effect of some PHSMs at the beginning of the pandemic. The differences in PHSMs of these countries lie in their speediness in actions, strictness in policies, and resource richness in using those measures and the sub-measures.

We suggest that a timely and effective utilization of the integrated package of health measures with the support of adequate resources may help the efficient implementation of PHSMs. However, is it 'the stricter/faster, the better' with regard to PHSMs? People should not ignore the complicated social, cultural, and political atmosphere that may affect PHSMs in different nations. It

is crucial to find a balance between human rights, economic well-being, and the application of PHSMs.

On the basis of this study's findings, we present four suggestions to improve the application of PHSMs. 1) Governments need to develop coherent laws or regulations on PHSMs at the national and global levels against future outbreaks of infectious diseases. 2) Considering cultural, social and economic differences, each government must arrange political discussions and public hearings and form a social consensus (even a flexible one) with regard to controversial PHSMs like social distancing and wearing face masks. 3) Governments need to prepare strategic reserves of PHSMs against infectious disease on a routine basis and ensure the sufficiency of resources. 4) Governments can cooperate with enterprises to develop digital technologies related to PHSMs against future infectious diseases with consideration for privacy and legalization issues.

We call for more complete comparative studies in the future and for testing the effectiveness of PHSMs in different nations. Future studies can also explore the reasons behind the differences in PHSMs of different countries, such as culture, political system, legal system, economic situation, international relations, and etc. Another interesting issue is whether virus fighting experience is an important factor in influencing the adoption of PHSMs in various countries. Future studies can compare PHSMs used in countries with and without virus outbreaks in recent years, and test whether this factor plays a role.

Funding

This work was supported by the Higher Education Fund of the Macao S.A.R. Government [grant number: HSS-MUST-2020-05] to [Di Wang]; Ministry of Education of the People's Republic of China [grant number: 20C10590040] to [Zhifei Mao].

Ethics approval

None.

Acknowledgements

None.

Supplementary materials

Supplementary material associated with this article can be found, in the online version, at [doi:10.1016/j.healthpol.2021.05.016](https://doi.org/10.1016/j.healthpol.2021.05.016).

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