RESEARCH ARTICLE

A Safer World after Vaccination against COVID-19, Government Responses and Health Outcomes: A Comparative Study

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ABSTRACT

During the first year of the COVID-19 Pandemic in 2020, world governments were split between the herd immunity strategy and that of strict social distancing. Health outcomes of 14 countries analyzed revealed unexpectedly high levels of deaths due to the disease, particularly among those countries which relaxed control as early as April 2020. Public health experts predicted that the COVID-19 Pandemic, though mutated into Delta, would come to an end in mid-2021 when vaccination became available. Unfortunately, the situation was more complicated and disappointing as the coronavirus mutated further into another generation. Omicron spread faster but was less fatal than the Delta, some early records showed. Some countries therefore have declared that the Pandemic was over while China, sticking to its zero infection policy, was still fighting to contain the Omicron variant. As Hong Kong has lost 3875 lives in the spring of 2022, a similar death rate projected for China would be astronomical. In China, the public health crisis has been prolonged, policies of social distancing remain upheld, and international doors cannot be opened. This study reviewed government responses and health performances of 14 countries in 2020, 2021, and early 2022. The 3 periods were characterized by the impact of COVID-19, Delta, and Omicron. Major indicators analyzed include data from Government Responses and Stringency Index developed by Oxford Tracker and health data provided by the WHO and John Hopkins University. Effects on economies and health care financing, mostly reported by the Economist Intelligence Unit, were also discussed.

Keywords: Social Distancing Stringency, COVID-19 mutations, Government Emergency Responses, Public Health Crisis

Introduction

The National Health Commission of China reported 571 confirmed cases of COVID-19 patients, 19 seriously ill, and 17 deaths in Wuhan on January 22nd, 2020 [1]. The number of confirmed cases exploded between January 20 and February 6 and reached 32,583 cases. The World Health Organization (WHO) named the coronavirus on Feb 11, 2020, as COVID-19 and declared it a Pandemic on March 11, 2020 [2]. Within only one year, the total number of confirmed cases according to John Hopkins University (JHU) had reached 105,745,975, and the total number of deaths was 2,309,000 [3].

The strategy adopted by China was that of "Social Distancing and Isolation". China stopped transportation, education, recreation, production, and outside family social life for the whole country. These actions were an "Unprecedented Response", according to the report of Mcniece, A. in China Daily [4]. It was often referred to as the "Lock Down" or "Shut Down" policy. It is important to note that such stringent measures were accompanied by robust monetary and fiscal policies such as tax reductions and credit support, directed towards small- and medium-sized enterprises (SMEs) that aided economic recovery [5].

A research team of the Huazhong University of Science and Technology analyzed the outbreak from December 8 to March 8 and revealed that in the Wuhan University Central Southern Hospital alone, there were 138 confirmed cases from January 1 to 28. Amongst them, 59% came from the community while 41% (57 cases) contracted the disease in hospitals, including 40 medical staff and 17 hospital patients [6]. The number of daily confirmed cases in Wuhan peaked on February 1. Seemingly, centralized quarantine and treatment, based on universal testing since February 17, was effective in continually leveling the curve of confirmed cases.

An alternative approach adopted by the United Kingdom, Sweden, and later the United States, was the "Herd Immunity Strategy", characterized by mitigation measures that aimed to slow down the spread of the infection without reducing R_0 to 0 [7]. Compared to the Lockdown strategy, this strategy allowed for more economic activities and social freedom.

Wong (2021) studied the preparedness and health outcomes of 14 countries. In this study, each country's preparedness was measured by the Global Health Security Index (GHSI) developed by JHU, and their stringency was measured by the Stringency Index (GRSI) part of the OxCGRT COVID-19 Government Response Tracker developed by Oxford University [8, 9] Health outcomes, including the number of confirmed cases and case fatality, were derived from WHO (2022) reports. Findings of this study suggested that social isolation was more effective in protecting lives and maintaining economic growth in the first year of the pandemic, 2020. Results (See Table 1) specifically noted that:

1) Preparedness measured by GHSI did not predict better health outcomes in terms of attack rate and death rate.

2) The status of national economic development measured by GDP and classified by the World Bank did not predict health outcomes either.

3) Some least developed countries, though poorly prepared to face a public health crisis, did not have high attack rates or death rates. Younger average age and a small percentage of older people were the common characteristics of these countries like Rwanda, Venezuela, and Zambia.

4) Some stringent countries did not get good results. Too early relaxation of stringency and social distancing measures were regarded as the reasons for the resurgence of COVID-19 cases after June 2020.

5) Persistent stringency contributed to better health outcomes, in terms of the lower number

of confirmed cases and deaths in proportion to population. However, there were counter-examples to this rule, like Brazil. Seemingly, stringency is a necessary but not sufficient condition for stopping COVID-19 [10].

Table 1: Preparedness, Response, and COVID-19 Health Outcomes

Country	GHSI	GHSI Rank	GRSI	GRSI Rank	Deaths/ 10,000	Rank by Death rate among 14 countries
BRA	59.7	7	49	11	6.898	14
CHN	48.2	9	66	1	0.033	3
DNK	70.4	4	50	9	1.145	10
DEU	66	6	50	9	1.141	9
IND	46.5	11	55	4	0.758	8
MEX	57.6	8	63	2	6.148	11
PHL	47.6	10	51	8	0.535	7
RWA	34.2	14	41	13	0.022	2
KOR	70.2	5	58	3	0.083	4
THA	73.2	3	55	4	0.008	1
GBR	77.9	2	48	12	6.252	12
USA	83.5	1	52	7	6.308	13
VEN	38.2	13	53	6	0.234	6
ZMB	44.2	12	35	14	0.182	5

At that time there was no vaccine and no medicine to treat the disease. Previous experience with infectious diseases suggested that the spread of the virus would be contained once a certain percentage of the population had been exposed to it, either through infection or vaccination, a concept called herd immunity. With reference to Dr. Anthony Fauci, a CNN report revealed that herd immunity to COVID-19 could be reached once 70% - 75% of the population had been exposed [11]. However, the more the virus spread, the more it mutated. In addition, in order to reach herd immunity without vaccines, lives would have to be lost in great numbers. Many would hope that the early availability of effective vaccines would be able to stop the spread of the coronavirus and decrease the number of deaths. WHO experts, however, were more cautious. The Regional Director for the Western Pacific of WHO, Takeshi Kasai, stressed that vaccines were not the "silver bullet" that would end the nearly year-long pandemic. Instead, he called for greater vigilance amid the roll-out of the coronavirus (COVID-19) vaccine. He also added there was no time for complacency [12]. To follow up on the previous study, the researchers extended the observation period to 2021, in which the spread of COVID-19 entered into the second phase when a number of vaccines were medically approved but a new Delta variant mutation of COVID-19 was confirmed in Japan [13] In short, this paper aimed to examine whether vaccination was effective in enabling better health outcomes during the year 2021, in the same 14 countries selected by Wong (2021) in the study mentioned above.

Phase 1- Year 2020   Phase 2 - Year 2021   Outcomes
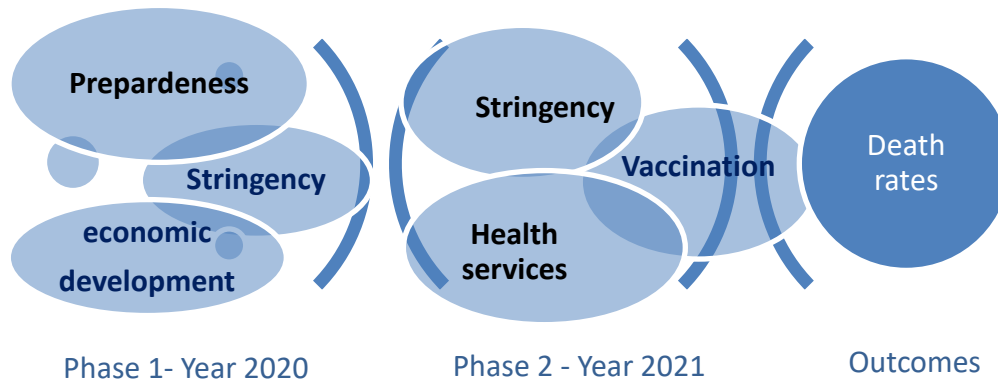
Methodology

Measurements

Data on health outcomes and the rate of full vaccination were derived from the reports of the WHO (COVID-19) Coronavirus Dashboard. [14] Supplementary vaccination charts and tables were extracted from Our World in Data. [15]

Health outcomes included the number of confirmed cases, number of deaths, attack rate, case fatality rate, and death rate measured against population size.

Regarding health outcomes, the confirmed number of cases and deaths in December 2021 were compared with those in December 2020. Differences between these two-time slots, calculated in absolute and relative terms, were presented.

To measure vaccination, a full-vaccination rate was employed, as different vaccines required different numbers of doses and exhibited different degrees of efficacy. By January 2021, one year after the outbreak of COVID-19 in Wuhan, the world was hopeful that the pandemic would end soon, with good reasons. First of all, vaccines had been developed. On December 31, 2020, the WHO approved the first vaccine named the Pfizer/BioNTech COVID-19 vaccine.

Since vaccination was available after early 2021, few countries have launched public vaccination programs in the first half of the year 2021. Some vaccines like Sinopharm were reported to have a lower protection rate and a second dose was required. Based on different vaccine effectiveness, the WHO introduced the concept of "completion of the first protocol", which is regarded as "full vaccination". Consequently, national data on "full vaccination" was not available until July 2021. For this study, the rate of fully vaccinated people was examined at two time periods: one on June 30, 2021, and the other on July 2, 2022. Vaccination data were derived from OurWorldInData.org [16].

To measure Stringency, the Stringency Sub-index of the Government Response and Stringency Indices developed by the Oxford Tracker were used. It followed closely the Country Guidelines of WHO to combat COVID-19, which included 8 indicators: school closure, workplace closure, cancelation of public events, restrictions on gathering sizes, closure of public transport, stay-at-home requirements, restrictions on internal movement, and restrictions on international travel [17].

Selection of countries

A sample of 14 countries was strategically chosen based on economic development as reflected by GDP, population size, and geographic location. On Oct 7, 2020, according to the John

Hopkins University Coronavirus Resource Center, there were 35,832,271 confirmed cases and 1,050,115 deaths globally. By the end of 2020, the countries with the highest death tolls were the United States, India, Brazil, Russia, Colombia, Peru, Spain, Argentina, Mexico, South Africa, France, and the United Kingdom.

The selection of diversified countries could provide a more comprehensive picture of the global COVID-19 situation. The strategical selection was thus based on the following criteria:

1. differences in population sizes;
2. differences in numbers of deaths caused by COVID-19;
3. differences in economic development stages;
4. differences in health care facilities and resources; and
5. differences in regional locations.

As a result, Brazil, China, Denmark, India, Germany, Philippines, Mexico, Rwanda, South Korea, Thailand, the United Kingdom (UK), the United States (US), Venezuela, and Zambia, with different demographic data, were included in this study (Table 2).

Table 2. Selected countries and basic data

Country	Region	Population (Million)	GDP (USD) /capita	% of Age (0-14/60+)	Physicians/ 1000
BRA	S. America	212.559	8,920.7	20.07/14.00	2.2
CHN	Eastern Asia	1,439.324	9,531.9	17.7/17.4	2
DNK	Northern Europe	5.792	61,833.7	16.3/26.1	4
DEU	Western Europe	83.784	47,513.7	14.0/28.6	4.2
IND	Southern Asia	1,380.004	2,054.8	26.2/10.1	0.9
MEX	Central America	128.933	9,694.9	25.8/11.2	2.4
PHL	S-Eastern Asia	109.581	3,102.7	30.0/8.6	0.6
RWA	Eastern Africa	12.952	773	39.5/5.1	0.1
KOR	Eastern Asia	51.269	33,621.9	12.5/23.2	2.4
THA	S-Eastern Asia	69.800	7,273.6	16.6/19.2	0.8
GBR	Northern Europe	67.886	42,526.4	17.7/24.4	2.8
USA	Northern America	331.003	62,917.9	18.4/22.9	2.6
VEN	South America	28.436	7,212.2	27.3/12.1	missing
ZMB	Eastern Africa	18.384	1,572.3	44.0/3.4	1.2

Period of study

According to the number of deaths provided by the WHO, there were several peaks, indicating various major fluctuations, worth closer scrutiny. The historical high and low points of deaths reported were listed in Table 3.

Table 3: Historical high and low points of Weekly Fatality (COVID-19)

Date	High/low	Number of weekly deaths
April 13, 2020	High	50322
May 25, 2020	Low	33008
August 3, 2020	High	45711
September 21, 2020	Low	37381
January 18, 2021	High	102096
March 1, 2021	Low	59943
April 26, 2021	High	95820
June 28, 2021	Low	53716
August 23, 2021	High	71320
December 27, 2021	Low	42803
February 7, 2022	High	77031
June 20, 2022	Low	5727

Source: WHO Coronavirus (COVID-19) Dashboard.

The greatest number of deaths in a week was recorded on January 18, 2021. It took several ups and downs before it finally reached its present level of 5727.

Figure 1: Global Week COVID-19 Related Deaths since the outbreak
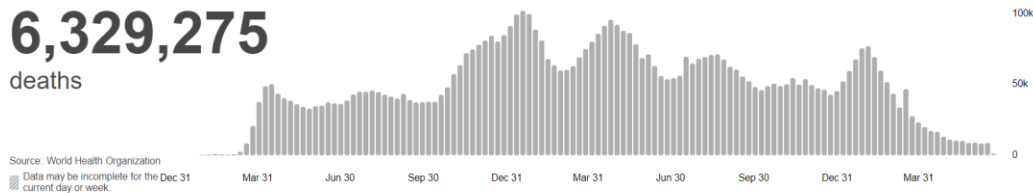
Source: WHO Coronavirus (COVID-19) Dashboard (2022-06-20)

Meanwhile, 77031 deaths still happened on February 7, 2022. In early 2022, there was no sign that the pandemic would end soon. Within two and a half years, the pandemic appeared to have undergone six cycles (see Figure 1).

Based on these fluctuations, this paper examined the period between December 2020 to December 2021, or the whole year of 2021.

Findings

Vaccination

By May 2021, the WHO had already included 5 vaccines for emergency use. The Pfizer/BioNTech was the first vaccine recognized by the WHO for emergency use on 31 December 2020. It was followed by two versions of the AstraZenec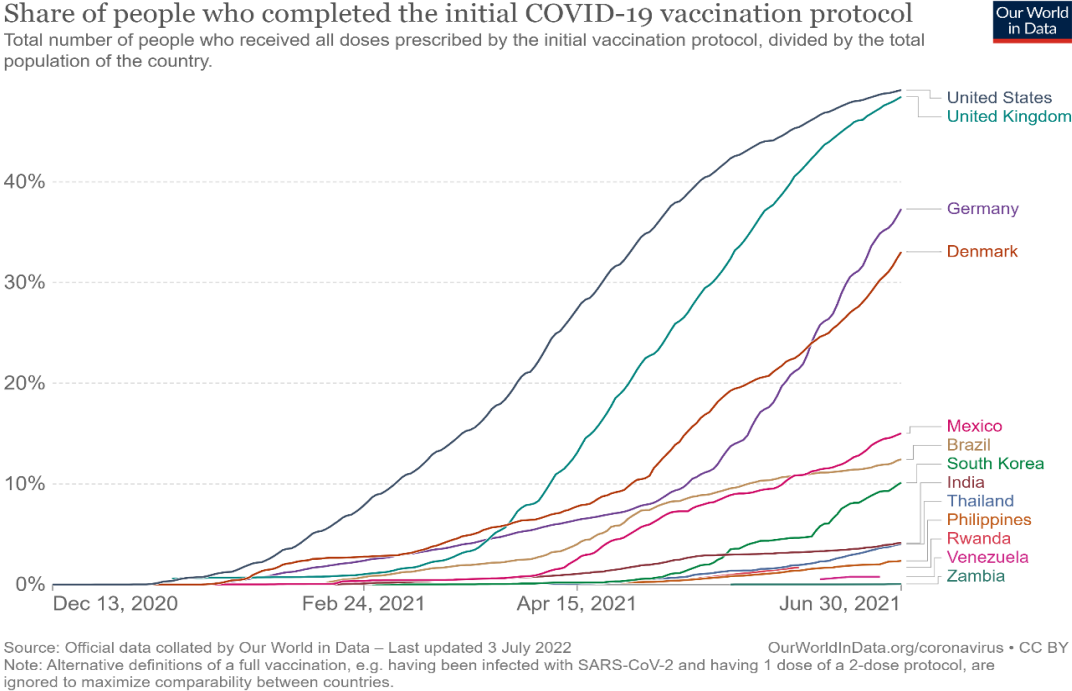a/Oxford COVID-19 vaccine, produced by AstraZeneca-SKBio (Republic of Korea) and the Serum Institute of India, which both got recognized on 15 February 2021. Then the COVID-19 vaccine Ad26.COV2.S developed by Janssen (Johnson & Johnson) was included on 12 March 2021. Lastly, the Sinopharm vaccine produced by Beijing Bio-Institute of Biological Products Co Ltd, a subsidiary

of China National Biotec Group (CNBG), was the fifth vaccine approved on May 8, 2021.

Theoretically speaking, the countries which won the race for producing a vaccine should have reaped the benefits of early protection. It was not surprising to see on June 30 of 2021 that the countries among the 14 research samples having higher vaccination protection were the United States, United Kingdom, Germany, and Denmark (See Figure 2).

Figure 2: Full Vaccination Rate up to Jun 30, 2021.

Share of people who completed the initial COVID-19 vaccination protocol
Total number of people who received all doses prescribed by the initial vaccination protocol, divided by the total population of the country.

Source: Official data collated by Our World in Data – Last updated 3 July 2022   OurWorldInData.org/coronavirus • CC BY
Note: Alternative definitions of a full vaccination, e.g. having been infected with SARS-CoV-2 and having 1 dose of a 2-dose protocol, are ignored to maximize comparability between countries.
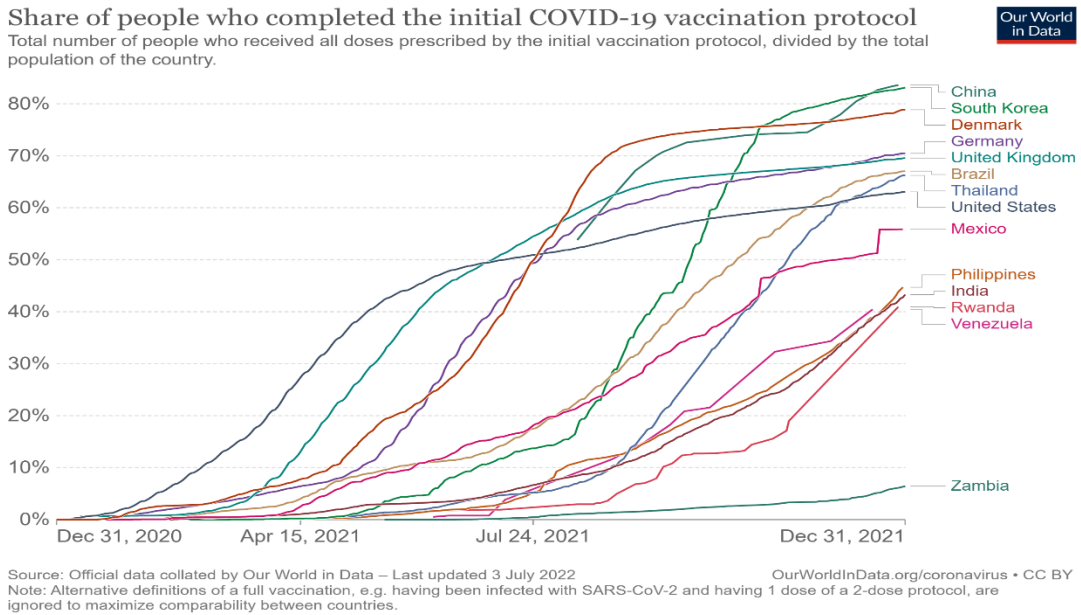
Source: OurWorldInData.org

However, the vaccination scenario changed rapidly after Sinopharm was approved by WHO in May 2021. Though bestowed with a lower capacity for protection and thus the need for double doses, it had the advantage of lower cost and easy transportation. China became the country with the highest full vaccination rate followed by South Korea, Denmark, Brazil, Thailand, and Germany. The United States and the United Kingdom had fallen to the 7th and 8th places respectively among the 14 countries (See Figure 3).

Figure 3: Full vaccination rate up to December 31, 2021.

Share of people who completed the initial COVID-19 vaccination protocol
Total number of people who received all doses prescribed by the initial vaccination protocol, divided by the total population of the country.

Source: Official data collated by Our World in Data – Last updated 3 July 2022
Note: Alternative definitions of a full vaccination, e.g. having been infected with SARS-CoV-2 and having 1 dose of a 2-dose protocol, are ignored to maximize comparability between countries.
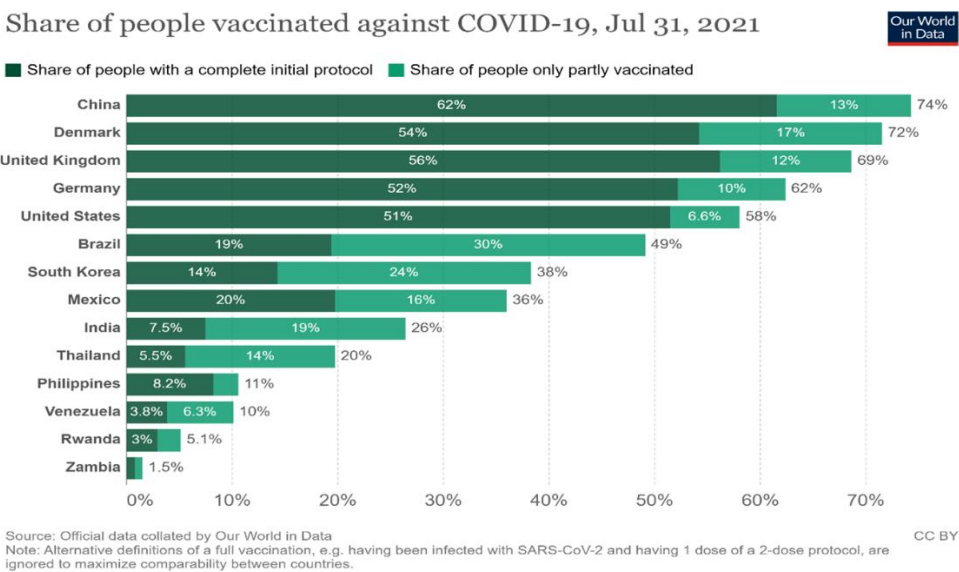
Source: OurWorldInData.org

If time was pushed back to July 31, 2021, the highest vaccinated country was China with a rate of 62%, still below the required level of 70%. In other words, 6 months after vaccines were developed the world was barely protected.

Figure 4: Percentage of Full Vaccination in July 2021.

Share of people vaccinated against COVID-19, Jul 31, 2021

Source: Official data collated by Our World in Data
Note: Alternative definitions of a full vaccination, e.g. having been infected with SARS-CoV-2 and having 1 dose of a 2-dose protocol, are ignored to maximize comparability between countries.

Source: OurWorldInData.org

Stringency

The national trends of stringency (See Table 4) were more difficult to trace and analyze. Some countries adopted stringency as a necessary protective measure. Others chose to balance the policy goals of saving lives and running the economy. In the latter case, stringency would be relaxed as soon as the number of confirmed cases dropped. It would be tightened again if the number of deaths increased. In this way, stringency was "regulated" in an "opportunistic" manner [18].

Table 4: Stringency scores in 2021 by month

Country	Jan-21	Feb-21	Mar-21	Apr-21	May-21	Jun-21	Jul-21	Aug-21	Sep-21	Oct-21	Nov-21	Dec-21
BRA	68.12	71.66	68.92	66.85	60.11	61.76	57.66	51.75	59.72	55.54	50.83	59.78
CHN	78.24	74.07	52.99	74.47	67.82	72.25	75.31	70.83	73.24	74.06	68.06	73.25
DNK	68.13	66.40	63.14	63.89	58.40	53.15	47.04	38.89	25.74	24.07	38.73	47.22
DEU	83.51	82.87	76.70	75.00	74.82	67.90	67.59	59.74	56.48	42.24	54.91	63.89
IND	67.73	61.90	59.30	70.90	79.52	81.94	79.91	72.51	66.58	62.23	56.94	65.14
MEX	71.76	66.67	47.65	45.46	44.44	44.44	48.83	66.77	42.67	38.89	38.64	34.11
PHL	60.47	65.21	72.45	76.27	68.78	71.76	71.76	71.14	74.63	74.09	42.95	61.76
RWA	61.95	71.59	71.66	71.30	65.65	54.63	54.63	54.63	51.94	51.85	51.99	62.11
KOR	64.56	63.89	58.33	58.33	50.81	50.00	44.28	50.63	47.84	47.22	46.48	49.57
THA	59.32	49.31	47.22	51.60	59.26	56.11	59.32	73.22	55.09	57.42	54.78	43.10
GBR	86.89	87.50	79.75	64.51	61.15	52.87	48.28	43.98	42.03	44.97	46.76	46.37
USA	71.76	68.32	63.57	56.94	51.89	55.15	52.26	54.26	54.54	56.02	57.87	50.91
VEN	86.56	86.11	87.12	86.88	87.54	86.54	88.26	83.60	83.15	81.09	38.52	30.13
ZMB	48.89	36.11	36.11	39.69	38.89	44.78	49.73	47.46	42.96	32.14	40.55	37.96

Source: OXCGRT COVID-19 Tracker (https://github.com/oxcgrt/covid-policy-tracker)

Therefore two types of stringency policy were observed, the "Persistent Stringency" and the "Fluctuating Stringency" (See Figure 5a). The former was a result of public health policies that aimed to reduce the spread of COVID-19 to zero, with $R_0 = 0$ or <1. The latter public health policy did not take zero confirmed cases or zero death as goals. Nevertheless, Fluctuating Stringency policymakers acknowledged that stringency was effective in bringing down the number of confirmed cases and deaths. Stringency was used as a panacea but unfortunately, it was not.

Figure 5a: Stringency Trends of countries in 2020 & 2021
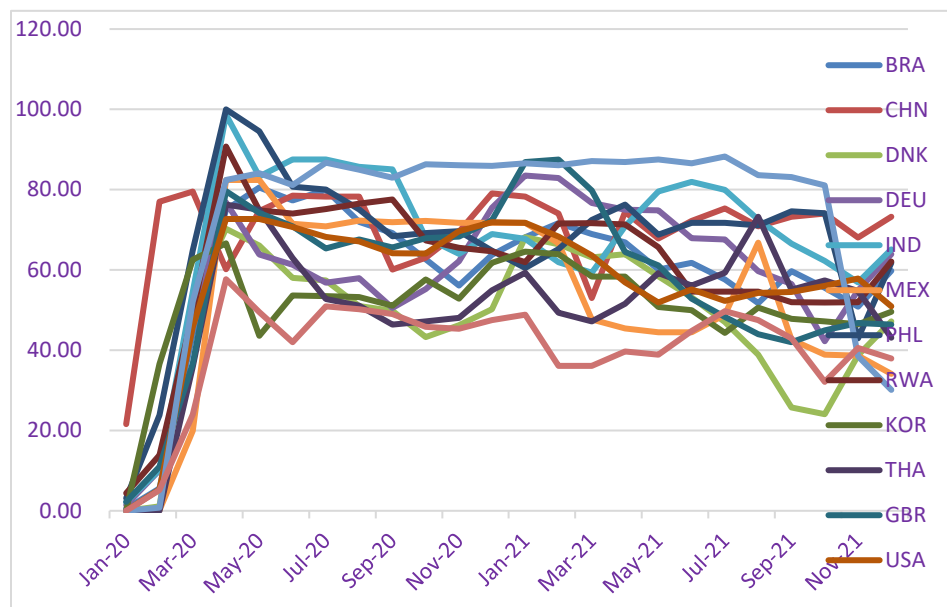
*Source*: OXCGRT COVID-19 Tracker (https://github.com/oxcgrt/covid-policy-tracker)

From the above trends (Fig. 5a) a few observations could be made:

1) For most countries, the highest levels of stringency were imposed around April 2020 but dropped sharply in June 2020.

2) China did not follow the international pattern but regulated stringency at a medium-high level between 60 points and 80 points. After March 2020, it was no longer the country having the highest score in stringency.

3) Venezuela unexpectedly maintained a very high level of stringency and became the strictest country after June 2020. It had a record of above 80 points until Oct 2021 when the country considered it was the appropriate time to relax stringency for good.

A further Hierarchical Cluster Analysis was conducted using Ward's Method with Mean Stringency for the year, 2021 (See Figure 5b).

Figure 5b: Constellation Plot of Stringency
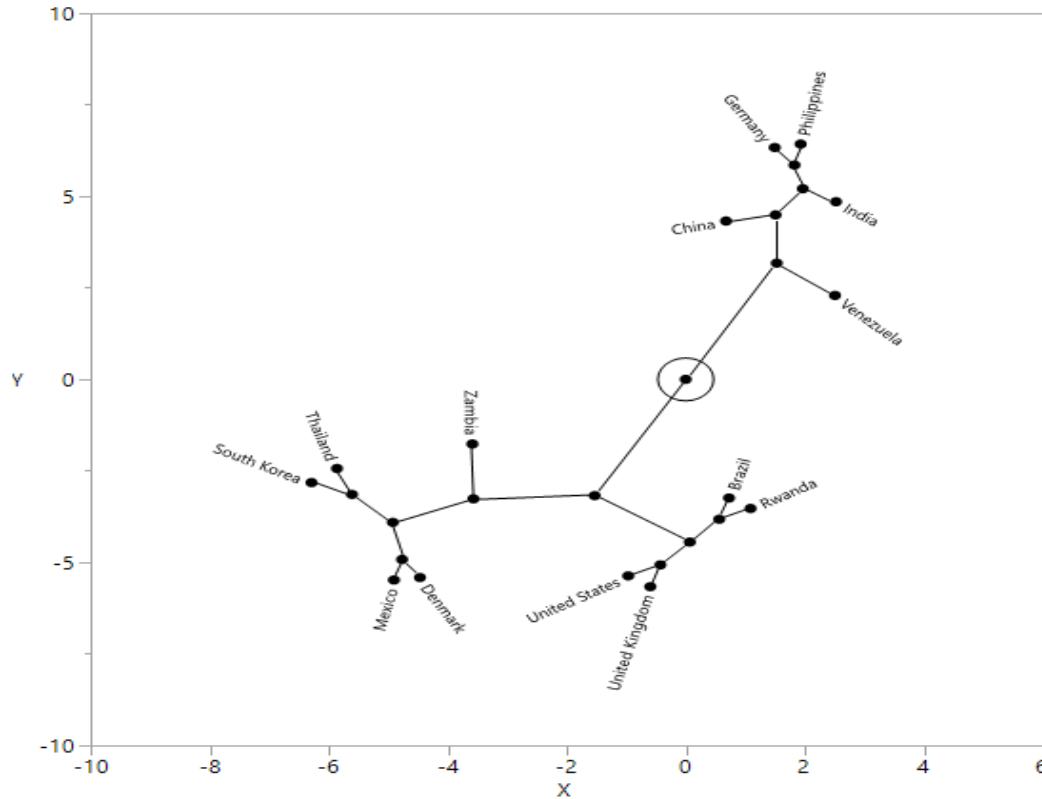
It was evident from the constellation plot that the 14 countries were divided into three clusters. China and Venezuela maintained a rather high stringency all the time while the United States followed pretty closely to the United Kingdom.

Health Outcomes

On the other hand, the number of confirmed cases for the world had decreased after a spike of 4.987 million on January 4, 2021. Unfortunately, the curve bounced back on February 15, 2021. Concerning the number of deaths, it reached the peak of 102.096 on January 18, 2021, and then sharply decreased. However it went on ups and downs four times like a roller coaster in the year of 2021 (See Fig. 1).

Table 5: Numbers of Deaths in 2020 and 2021 and their increases

Country	Number of confirmed cases in 2020	Total confirmed cases in 2021	Cases increase in 2021	Number of deaths in 2020	Number of deaths in 2021	Accumulated. Deaths per 10000
BRA	7681032	22291839	14610807	195072	424262	59.70
CHN	93679	115168	21489	4634	2	0.46
DNK	163479	802397	638918	1298	1969	0.27
DEU	1719737	7150422	5430685	33071	78854	9.36
IND	10286709	34861579	24574870	148994	332492	44.83
MEX	1426094	3979723	2553629	125807	173621	27.75

PHL	474064	2843979	2369915	9244	42260	3.83
RWA	8383	111786	103403	92	1258	0.13
KOR	61769	635253	573484	917	4708	0.25
THA	6884	2223435	2216551	61	21637	1.67
GBR	2488780	12937886	10449106	73512	75112	13.67
USA	20191325	54835643	34644318	351039	474890	69.98
VEN	113558	444635	331077	1028	4300	0.45
ZMB	20725	254274	233549	388	3346	0.36

Source: WHO Coronavirus (COVID-19) Dashboard (2022-06-20)

When it came to June 2022, it was evident that the pandemic had undergone four waves with the highest number of daily confirmed cases reported on Jan 17, 2022 (23.27 million). The highest number of daily deaths was reported on January 18, 2021. However, there were several spikes of 95820 deaths on April 26, 2021, 71320 deaths on August 23, 2021, and 77031 deaths on February 7, 2022.

There was no guarantee that the death rate would improve for the rest of the year (See Table 5).

When the trends of COVID-19 deaths were scrutinized, there were certain models with which countries could be categorized. For example, some countries had the highest spike in the middle of 2021, like the United Kingdom and Brazil (See Figures 6a & 6b).

Figure 6a: COVID-19 Deaths in the United Kingdom (2020-2021)
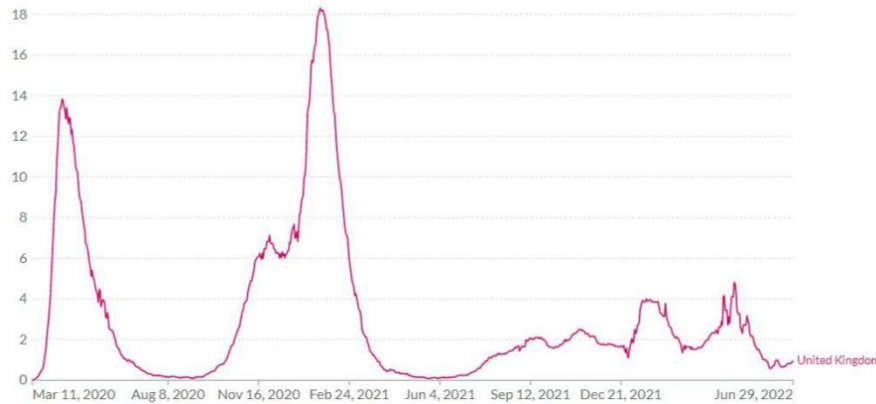
Source: WHO Coronavirus (COVID-19) Dashboard (2022-06-20)

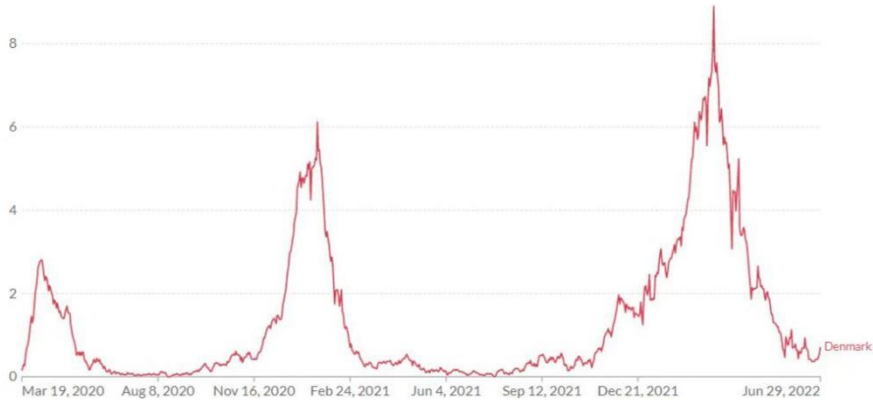**Figure 6b:** COVID-19 Deaths in Brazil (2020-2021)
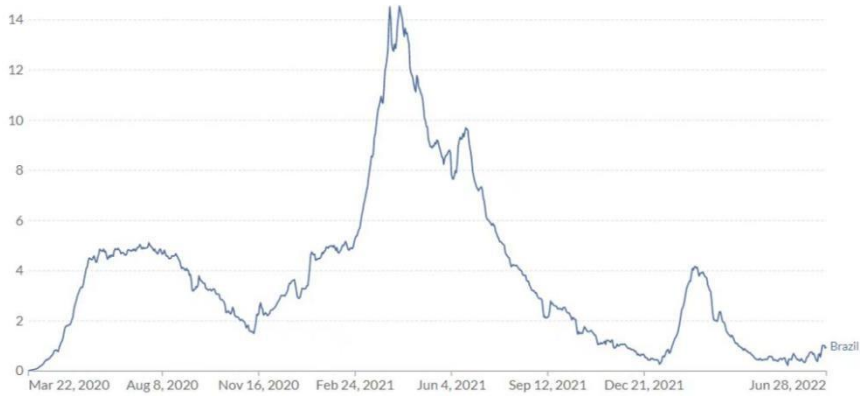
Source: WHO Coronavirus (COVID-19) Dashboard (2022-06-20)

Meanwhile, another model showed a tri-modal distribution with 3 spikes and the latest spike in 2022. Country examples were Denmark and the United States, although they were very different in the size of deaths (See Figure 7a & 7b).

Figure 7a: COVID-19 Deaths in Denmark (2020-2021)

Source: WHO Coronavirus (COVID-19) Dashboard (2022-06-20)

Figure 7b: COVID-19 Deaths in the United States (2020-2021)
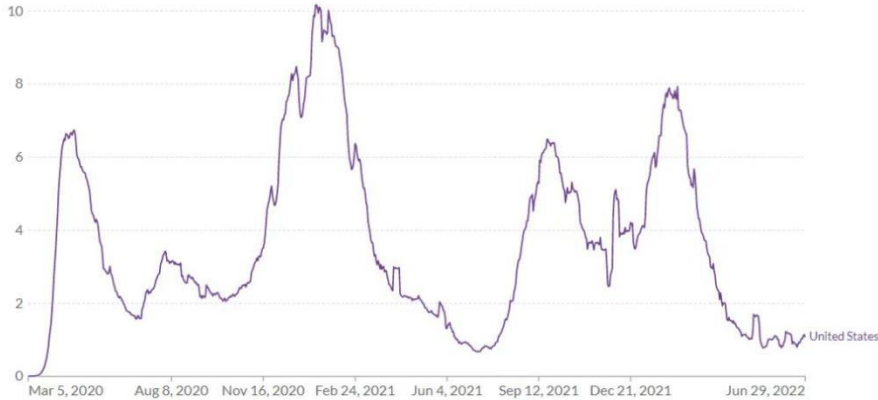
Source: WHO Coronavirus (COVID-19) Dashboard (2022-06-20)

A further Hierarchical Cluster Analysis was conducted using Ward's Method with Death rates (per 10000) to examine the countries' health performances (See Figure 8).

The plot depicted that India, Mexico, Brazil, and the United States had the highest number of deaths per 10000 or the highest death rates. The countries with the lowest death rates were Venezuela and China.

**Figure 8:** Constellation Plot of Deaths per 10000 (2021)
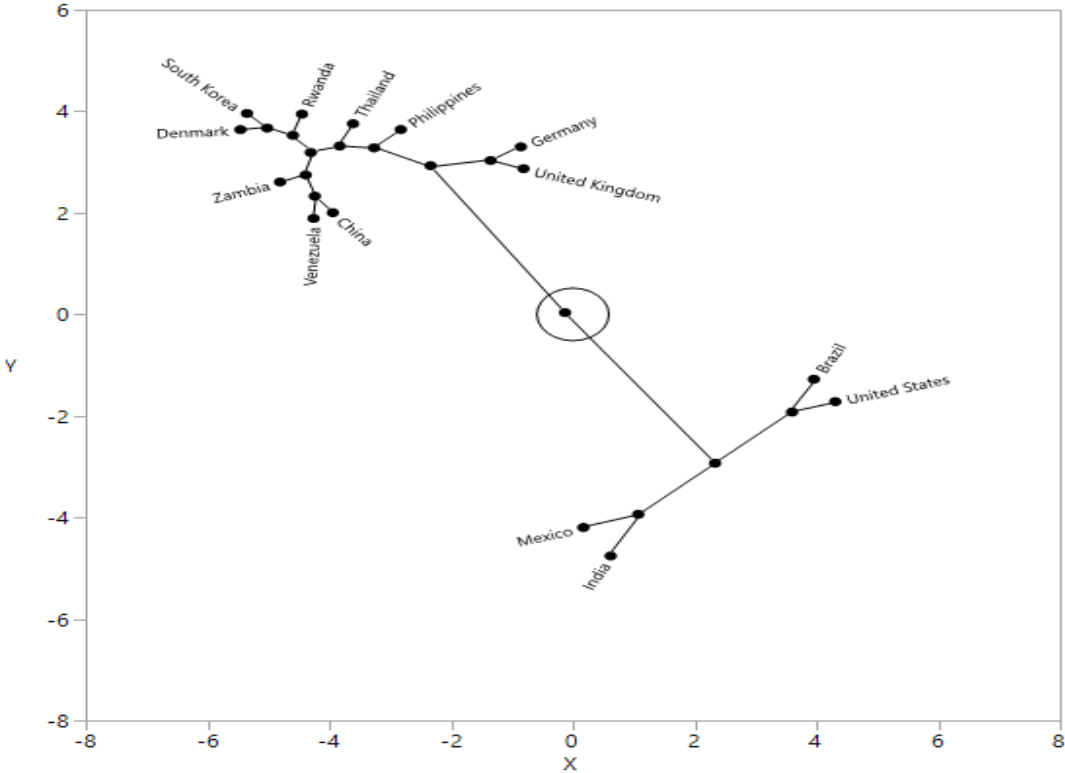
In 2021, one significant change in the pandemic scenario was the availability of vaccination. When vaccination became scientifically possible, its provision was regarded as the responsivity of the State. Vaccination became the number one priority in terms of government responses to COVID-19. While vaccines developed by different countries varied in their effectiveness, the notion of full vaccination in terms of effectiveness level was more meaningful than the number of doses (s) taken. The effective level is counted as the completion of the first protocol. Full vaccination rates of the 14 countries are shown in Table 6. It was surprising that the United States, which has the most advanced pharmaceutical technologies, did not achieve a higher than 70% rate of full vaccination. Meanwhile, South Korea, China, and Denmark achieved very high rates of full vaccination.

The Constellation Plot developed by hierarchical cluster analysis for vaccination is shown in Figure 9.

Figure 9: Constellation Plot of Full Vaccination by 2021-12-31
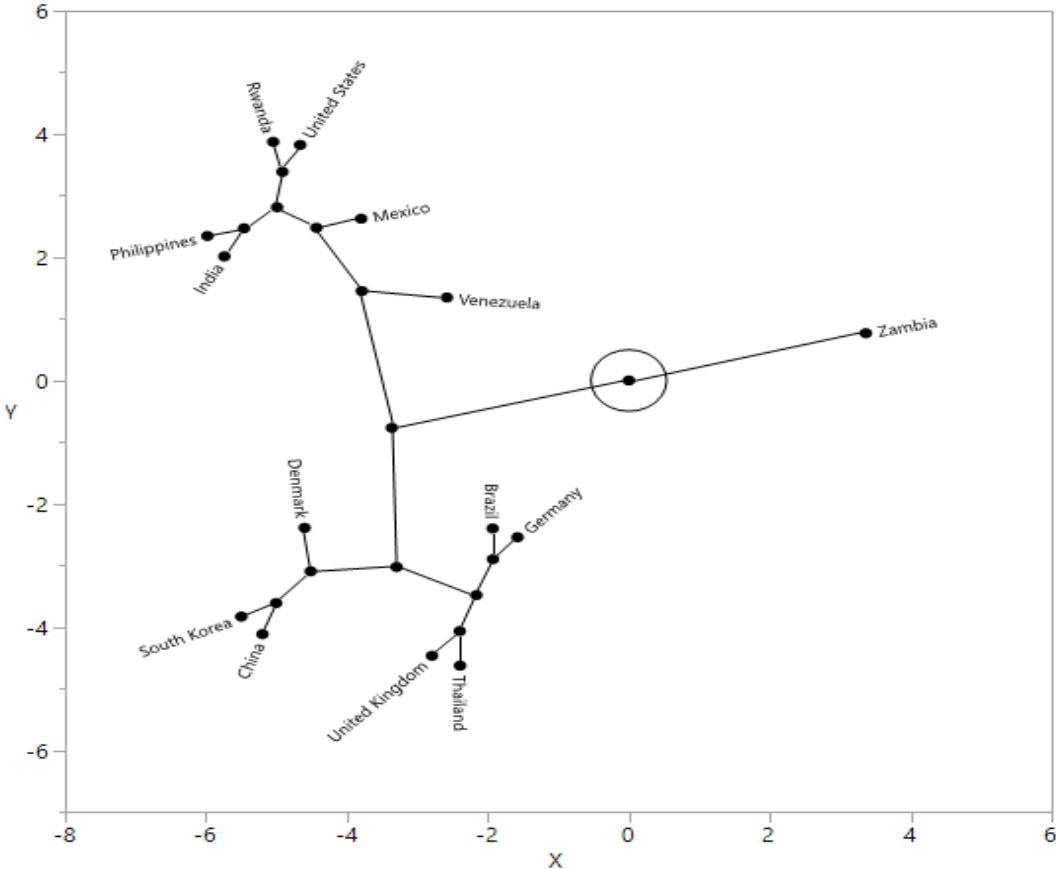
An additional analysis of compiled data for the 14 countries involved the Health index scores and ranks from the GHSI indices, the average monthly scores of stringency in 2021 from the OXCGRT COVID-19 Government Responses Tracker, and the number of deaths, death rates, and ranks from the WHO. It indicated that no single factor could predict health outcomes (See Table 6). Perhaps high death rates could only be avoided when the country achieved vaccination higher than 70% and continued to impose medium to high stringency. Counter-examples were countries with very young populations. Moreover, for countries like Denmark and the United States, high spikes also occurred in 2022. As sickness death is a delayed effect, further analysis with the inclusion of 2022 data is required for these countries.

Table 6: Health capacities, Vaccination, Stringency, and COVID-19 Deaths in 2021

Country	% of Age (0-14 / 60+)	Health Services (GHSI Rank)	Fully Vaccinated	Average Stringency	Accumulated. Deaths per 10000	Rank in Health Outcomes
BRA	20.07/14.00	45.0 (33)	76.90	61.06	59.70	13
CHN	17.7/17.4	45.7 (30)	86.11	71.22	0.46	6
DNK	16.3/26.1	63.8 (5)	82.16	49.57	0.27	3
DEU	14.0/28.6	48.2 (22)	77.56	67.14	9.36	9
IND	26.2/10.1	42.7 (36)	64.91	68.72	44.83	12
MEX	25.8/11.2	49.6 (24)	62.01	49.19	27.75	11
PHL	30.0/8.6	38.2 (47)	63.89	67.60	3.83	8
RWA	39.5/5.1	24.1 (89)	65.84	60.33	0.13	1
KOR	12.5/23.2	58.7 (13)	86.81	52.66	0.25	2
THA	16.6/19.2	70.5 (2)	75.33	55.48	1.67	7
GBR	17.7/24.4	59.8 (11)	73.45	58.75	13.67	10
USA	18.4/22.9	73.8 (1)	66.09	57.79	69.98	14
VEN	27.3/12.1	19.7 (180)	50.24	77.13	0.45	5
ZMB	44.0/3.4	28.6 (134)	15.97	41.27	0.36	4

Sources: JHU-Global Health Security Index, OXCGRT COVID-19 Government Responses Tracker, and WHO Coronavirus (COVID-19) Dashboard.

Discussion

One important consideration about the "Sufficient Level of Immunity" to curb the virus spread. It was estimated around 70% or higher [19]. Most of the 14 countries have not yet reached this "significant" level of vaccination even in July 2022. Three countries had a full vaccination rate of over 80%, namely China, South Korea, and Denmark. Brazil, Thailand, and Germany were in the range of above 70%. The United Kingdom was close with 69.5% but the United States had 63%. This might be one of the reasons why the number of confirmed cases and deaths globally in 2021 doubled that of 2020, and a number of spikes still occurred in 2022.

An additional hierarchical cluster analysis was conducted to examine how the countries could be clustered when both stringency and death rates were considered (See Figure 10).

Figure 10: Constellation Plot of Mean Stringency and Deaths in 2021
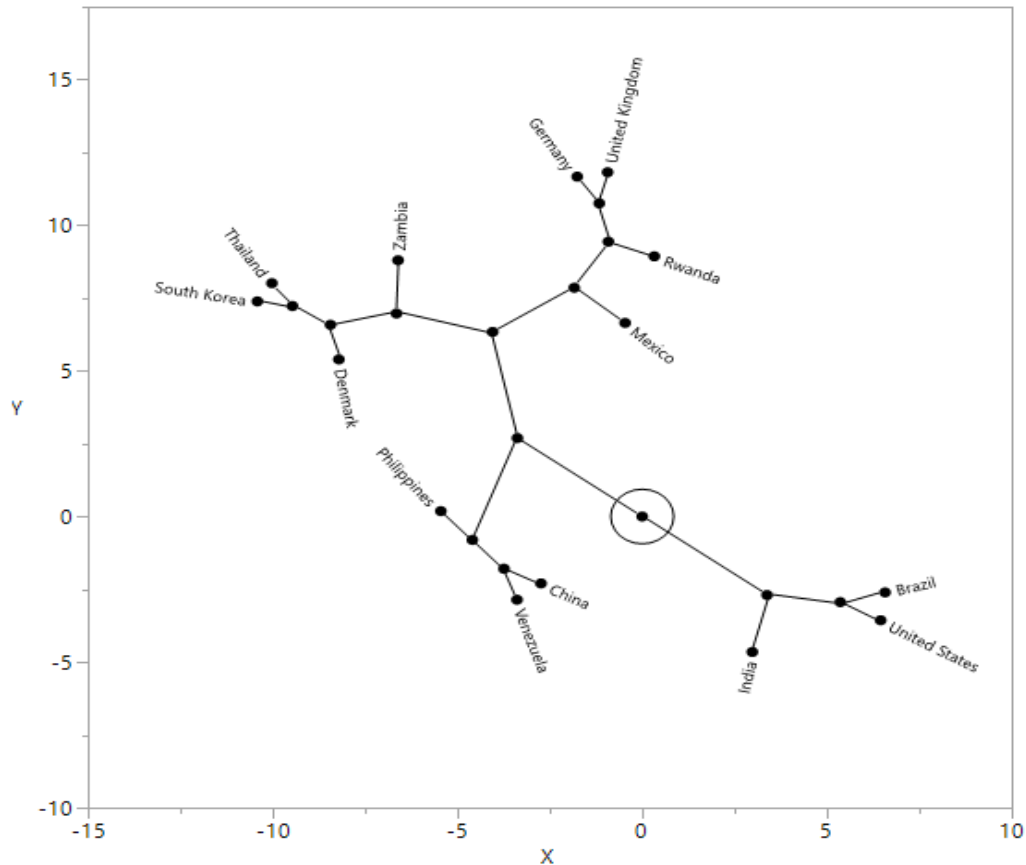
The constellation plot in Fig 10 depicted that India, Brazil, and the United States were similar in their stringency policies and also a high level of death rates (69.98, 59.7, and 44.83 per 10000 respectively). Mexico and the United Kingdom, with death rates of 27.75 and 13.67 per 10000, ranked fourth and fifth respectively. All other countries have only less than 10 per 10000 death rates.

In reviewing the pool of indicators included by the JHU Global Health Security Index and the OXCGRT Government Response Index, and other social economic indicators like GDP, population size, and structure, a new conceptualization of their relationships with health outcomes gradually emerged.

1) It is observed that attack rate and death rate were not related to health services capacities as ranked by GHSI.

2) Countries with very young populations, like Rwanda and Zambia, were spared from high rates of COVID-19-related deaths;

3) Stringency alone did not predict good results. The two countries with the highest stringency measures, Venezuela (Average Stringency score 77.13) and China (Average Stringency score 71.22）were successful in protecting their people from high death rates as of Dec 31, 2021. However, India, having an average stringency score of 68.72, or in the 3rd place of stringency measures, recorded a death rate of 44.8 per 10000. Therefore stringency is a necessary but not sufficient condition;

4) Most countries employed a double barrels approach by increasing the vaccination rate to make room for stringency allowance. South Korea, China, Denmark, Germany, Thailand, and even the United Kingdom all achieved a

higher than 70% full vaccination rate in the population. Brazil too had 76.9% of its people fully vaccinated, however, it still had a very high death rate of 59.7 per 10000. Therefore, Brazil served as a counter-example to the theory of double insurance of vaccination plus stringency. The data could also be interpreted in the opposite way. Lower stringency in many countries was a result of a drop in death rates after March 2021 (Refer to Figures 6a, 6b, 7a, and 7b).
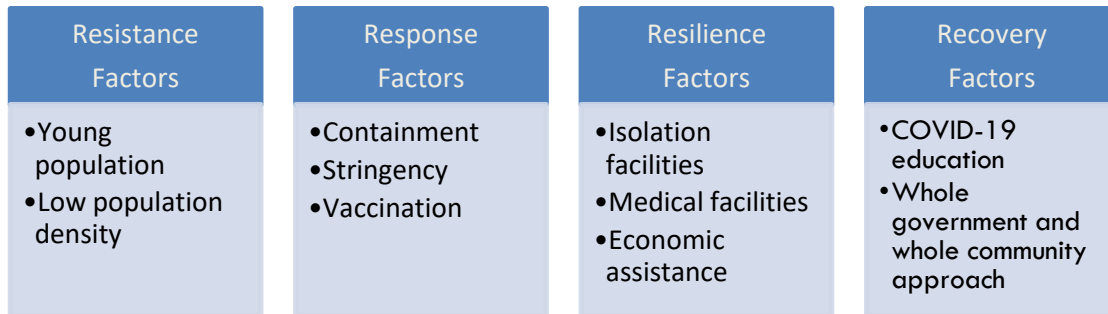
5) Health outcomes were neither predictable by stringency nor vaccination alone. Effective prevention occurred only when an integrated approach, similar to the concept of cocktail medication for AIDS, or highly active antiretroviral therapy, was adopted. Moreover, the doses of vaccination and stringency had to be applied at specific levels for their efficacy to be realized and sustained;

6) For countries that did not have the means for heavy investments in health care, particularly ICU facilities, or those which could not even afford a universal and free vaccination, the only alternative was a non-pharmaceutical approach in terms of stringent social isolation practices. This was a smart approach for the agricultural communities.

The following model is proposed as an attempt to explain the phenomenon:

Figure 11: Four Layers of COVID-19 Resistance, Response, Resilience, and Recovery Model

Resistance Factors	Response Factors	Resilience Factors	Recovery Factors
•Young population •Low population density	•Containment •Stringency •Vaccination	•Isolation facilities •Medical facilities •Economic assistance	•COVID-19 education •Whole government and whole community approach

Due to the scope of this paper, it was not possible to take into account the mutation of COVID-19 or the health education and community mobilization of governments during the pandemic. Nevertheless, even with rapid mutations of the coronavirus, government responses will still be vaccination and stringency, unless effective pharmaceutical cures are identified, tested, and cheaply available [20].

Another important factor that impact, if not determine, the success of these measures is the population's willingness to participate. Measuring people's willingness to vaccinate, Trent et al. (2022) found that 70% in London, 71% in NYC, 72% in Sydney, 76% in Phoenix, and 78% in Melbourne constitute the proportions of people ready to take the COVID-19 vaccine [21]. The situation could even be worse in other areas where public health education is minimal. For instance, Owusu (2021) observes the lack of compliance among Ghanaians with government restrictions [22]. Indeed, he intimates that the poor economic conditions made it harder for people to follow the COVID-19 restrictions. Loomba S. et al, (2020) believe that the rejection of vaccination in the US and United Kingdom mostly stems from misinformation [23]. Not

only the willingness to vaccinate but also, compliance with all public health restrictions and protocols would be a determining factor if we are to have a safer world in the years ahead.

Conclusion

Vaccination is a proven medical approach to protect the community from public health crises, but universal vaccination is not just a medical issue. It depends on political, economic, and social factors as well as universal health and welfare coverage. Demographic factors that come into play are aging, urbanization, and family size. In short, vaccination and stringency are both necessary but insufficient conditions for containing a pandemic. Further research is necessary for managing public health crises in a globalized era.

References

[1] The Novel Coronavirus Pneumonia Emergency Response Epidemiology Team. The Epidemiological Characteristics of an Outbreak of 2019 Novel Coronavirus Diseases (COVID-19) — China, 2020 [J]. *China CDC Weekly*, 2020, 2(8): 113-122. doi: 10.46234/ccdcw2020.032

[2] World Health Organization. Rolling Updates on Coronavirus disease *(COVID-19), Updated July 30, 2020.* (2020a) Extracted from: https://www.who.int/emergencies/diseases/novel-coronavirus-2019/events-as-they-happen

[3] John Hopkins University. COVID-19 Map. Coronavirus Resource Center. (2020a) Available from: https://coronavirus.jhu.edu/map.html.

[4] Wang, X. Y. WHO expert speaks out on China epidemic response. *China Daily*, 2020-02-25. Extracted from: http://www.chinadaily.com.cn/a/202002/25/WS5e54f1baa31012821727a3a1.html

[5] Tian, Wei. "How China managed the COVID-19 pandemic." *Asian Economic Papers* 20, no. 1 (2021): 75-101.

[6] Pan, A., Liu, L., Wang, C., Guo, H., Hao, X., & Wang, Q. Association of public health interventions with the epidemiology of the covid-19 outbreak in Wuhan, China. *The Journal of the American Medical Association, 323*(19). 2020.

[7] Mills, S. (2020): COVID-19, Public Health Measures, Legal Considerations: A Medical Perspective, *Judicial Review*, DOI: 10.1080/10854681.2020.1760575 Available at: https://doi.org/10.1080/10854681.2020.1760575

[8] Johns Hopkins University. Bloomberg School of Public Health, *Inaugural Global Health Security Index Finds Significant Gaps in Preparedness for Epidemics and Pandemics.* Oct 24, 2019. Available from: https://www.jhsph.edu/news/news-releases/2019/inaugural-global-health-security-index-finds-significant-gaps-in-preparedness-for-epidemics-and-pandemics.html.

[9] Oxford University. Coronavirus Government Response Tracker. 2020. Available from: https://www.bsg.ox.ac.uk/research/research-projects/coronavirus-government-response-tracker.

[10] Wong, H. C. J. Government Emergency Responses During the COVID-19 Pandemic in the Context of Health Emergency and Disaster Risk Management: A Comparative Study. In Zhao, X. S., Wong, H. C. J., Monaco, E., Lowe, C. & Corbett, J. ed., *COVID-19 Pandemic, Crisis Responses and the Changing World Perspectives in Humanities and Social Sciences*, Springer Nature, Singapore. 2021.

[11] Meek, A. My fingers are crossed that this prediction from Dr. Fauci comes true. *CNN*, October 29th, 2020 at 12:41 AM

[12] China Daily Global, 2020-12-17. COVID-19 vaccines 'not a silver bullet': WHO. https://global.chinadaily.com.cn/a/202012/17/WS5fdb0eb4a31024ad0ba9c6ed.html

[13] Xinhuanet. New Delta variant mutation of COVID-19 confirmed in Japan. 2020-08-31. Available from: http://www.xinhuanet.com/english/2021-08/31/c_1310159349.htm

[14] World Health Organization. (2020b). *WHO Coronavirus Disease (COVID-19) Dashboard.* Available at: https://portal.who.int/report/eios-covid19-counts/#display=Countries_and_Territories&nrow=2&ncol=3&arr=row&pg=1&labels=cur_death_who&sort=cur_death_who;desc&filter=&sidebar=4&fv=cur_death_who

[15] Ritchie, H., Mathieu, E., Rodés-Guirao, L., Appel, C., Giattino, C., Ortiz-Ospina, E., Hasell, J., Macdonald, B., Beltekian, D., & Roser, M.. Coronavirus Pandemic (COVID-19). *OurWorldInData.org.* 2020. Retrieved from: https://ourworldindata.org/coronavirus

[16] Fauci, A. Fauci says herd immunity could require nearly 90% to get coronavirus vaccine. GMA Network, December 25, 2020 2:41am. Available

from:
https://www.gmanetwork.com/news/news/world/769337/fauci-says-herd-immunity-could-require-nearly-90-to-get-coronavirus-vaccine/story/

[17] World Health Organization. (2020d). *Considerations in adjusting public health and social measures in the context of COVID-19 Interim guidance*. Available at:
https://apps.who.int/iris/bitstream/handle/10665/331773/WHO-2019-nCoV-Adjusting_PH_measures-2020.1-eng.pdf

[18] Hale, T. et al. (2020a). *Lockdown rollback checklist: Do countries meet WHO recommendations for rolling back lockdown?* University of Oxford, Blavatnik School of Government, Working Paper Version 4.0, June 1, 2020. Available at: https://www.bsg.ox.ac.uk/sites/default/files/2020-06/Lockdown%20Rollback%20Checklist%20v4.pdf

[19] GMA Network (2020-12-25). Fauci says herd immunity could require nearly 90% to get coronavirus vaccine. Available from:
https://www.gmanetwork.com/news/news/world/769337/fauci-says-herd-immunity-could-require-nearly-90-to-get-coronavirus-vaccine/story/

[20] Rose, J. (2020) COVID-19 will mutate what does it mean to a vaccine? Healthline, Available from:
https://www.healthline.com/health-news/what-to-know-about-mutation-and-covid-19

[21] Trent, M., Seale, H., Chughtai, A. A., Salmon, D., & MacIntyre, C. R. Trust in government, intention to vaccinate and COVID-19 vaccine hesitancy: A comparative survey of five large cities in the United States, United Kingdom, and Australia. *Vaccine, 40*(17), 2498-2505. 2022.

[22] Owusu, G. Fighting the Invisible Enemy—COVID-19: How Ghana Fared. In *COVID-19 Pandemic, Crisis Responses and the Changing World*. 2021. (pp. 173-187). Springer, Singapore.

[23] Loomba, Sahil, Alexandre de Figueiredo, Simon J. Piatek, Kristen de Graaf, and Heidi J. Larson. "Measuring the impact of COVID-19 vaccine misinformation on vaccination intent in the UK and USA." *Nature human behaviour 5*, no. 3 (2021): 337-348.