

# The Heterogeneity of National Responses to the COVID-19 Pandemic: a Mixed-method Study

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## Research Article

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**The Heterogeneity of National Responses to the COVID-19 Pandemic: a mixed-method study**

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## Abstract

**Background:** COVID-19 has quickly spread to all corners of the world since its emergence in Wuhan, China in December of 2019. The disease burden has been heterogeneous across regions of the world, with Americas leading in cumulative cases and deaths, followed by Europe, Southeast Asia, Eastern Mediterranean, Africa and Western Pacific. Initial responses to COVID-19 also varied between governments, ranging from proactive containment to delayed intervention. Understanding these variabilities allow high burden countries to learn from low burden countries on ways to create more sustainable response plans in the future.

**Methods:** This study used a mixed-method approach to perform cross-country comparisons of pandemic responses. The chosen countries for this study were the US, Brazil, Germany, Australia, South Korea and Thailand; they were selected based on their income level, relative COVID-19 burden and geographic location. To rationalize the clinical variability between these six countries, a list of 14 indicators was established to systematically assess the countries' preparedness, actual response, and overall socioeconomic and demographic profile in the context of COVID-19.

**Results:** As of December 1<sup>st</sup>, 2020, the US had the highest cases per million, followed by Brazil, Germany, Australia, South Korea and Thailand. The same ranking was observed for the countries' deaths per million statistics. Cross-national comparison suggests that there were nine indicators to explain epidemiological differences between the countries, and they were 1) leadership, governance and coordination of response, 2) communication, 3) community engagement, 4) multisectoral actions, 5) public health capacity, 6) universal health coverage, 7) medical services and hospital capacity, 8) demography and 9) burden of non-communicable diseases.

**Conclusion:** The COVID-19 pandemic manifests varied outcomes due to differences in countries' vulnerability, preparedness and response. Our study rationalizes why South Korea, Thailand, Australia and Germany performed better than the US and Brazil. By identifying the strengths of low burden countries and weaknesses of hotspot countries, we elucidate specific factors constituting an effective pandemic response that can be adopted by leaders in preparation for re-emerging public health threats.

**Keywords:** COVID-19, pandemic response, preparedness, cross-country comparison, United States, Brazil, Germany, Australia, South Korea, Thailand

## Background

The coronavirus disease of 2019 (COVID-19) was first reported in Wuhan city of the Hubei Province in China around late December 2019.(1) It was not until one month after the initial outbreak that the World Health Organization (WHO) declared the situation as a global health emergency.(2) Within the span of a year, the virus was traced in every corner across the globe, surpassing 83 million total confirmed cases and 1.8 million total confirmed deaths by 31 December 2020.(3)

The burden of COVID-19 has been heterogeneous across regions of the world: Americas (45,345,051 cumulative cases and 1,047,171 deaths), Europe (34,276,814 cumulative cases and 745,590 deaths), Southeast Asia (12,856,723 cumulative cases and 197,707 deaths), Eastern Mediterranean (5,669,940 cumulative cases and 134,189 deaths), Africa (2,570,474 cumulative cases and 62,504 deaths), Western Pacific (1,420,024 cumulative cases and 24,588 deaths).(4) Overall, Americas has the largest cumulative number of cases, followed by Europe, South-East Asia, Eastern Mediterranean and Africa. The Western Pacific region has the least epidemiological epidemic.(4) This has revealed inequalities in healthcare access and inadequacies in health infrastructures, even amongst countries ranked highest in preparedness on the Global Health Security Index.(5)

Initial outbreak responses varied greatly between governments, ranging from proactive and comprehensive in some to delayed and disorderly in others. While many existing studies strive to understand and reflect on how individual countries could have handled the pandemic differently, there is a lack of research that systematically compares and contrasts pandemic responses in different parts of the world. In this paper, we aim to fill the knowledge gap by understanding the strengths of low burden countries and weaknesses of hotspot countries. We

will consider nine action areas, which can be adopted by leaders to develop more effective pandemic response plans in preparation for future public health threats, to review the response in different countries. By understanding these factors, high burden countries can learn from low burden countries and be better prepared for future epidemics.

## **Methods**

### ***Research Design***

This study was conducted through a mixed-method approach that integrated quantitative and qualitative secondary data. The following steps were included in the research process: (i) methodically selecting six countries to be included in the study, (ii) gathering epidemiological data for those countries, (iii) conducting literature review of qualitative secondary data and (iv) systematically evaluating key indicators to compare and contrast the countries' performances. Using this procedure, our study not only explains the variability of the COVID-19 pandemic in different countries around the world, but also elucidates specific factors that constitute an effective and sustainable pandemic response.

### ***Country Selection***

Out of all the countries in the world, six countries were selected for the purposes of this study, and they were chosen based on three factors: income level, relative COVID-19 outcome and geographic region. Firstly, selection was limited to countries belonging in the high-income and upper-middle-income categories because more cases and deaths have been recorded in those countries than in low-income countries. This is due to the prevalence of air travel that contributed to early onset and widespread transmission of COVID-19 among those high-income

and upper-middle-income countries.(6) Another rationale behind the observed differences in case number is the availability of COVID-19 tests. High-income and upper-middle-income countries have more sufficient resources dedicated toward testing than do lower-middle-income and low-income countries.(7)

Of the high-income and upper-middle-income countries, we further narrowed the selection down to six countries that not only reflected stark contrasts in pandemic outcomes, but also offered geographic and demographic diversity to the study. For instance, the United States (US) and Brazil are the largest populations in North and South Americas, respectively, and they are both COVID-19 hotspots as of January of 2021. Meanwhile, Germany and Australia are the largest populations in the European Union (EU) and the Oceania, respectively, and they both have medium disease burden. Finally, South Korea and Thailand are both countries in Asia that reflect geographic proximity to China, but paradoxically have relatively low disease burden. Choosing these six countries not only allows us to investigate why certain countries are hit harder by the disease, but also establishes a valuable opportunity for hotspot countries to learn from low burden countries and make improvements on their pandemic responses.

### ***Indicators***

The comprehensive COVID-19 dataset is publicly available on the *Our World in Data* website. For the purposes of this study, we used it to obtain numerical data on the six selected countries' total cases, total cases per million, total deaths, total deaths per million and total tests per 1,000. Using the total cases and total deaths data, we then calculated the case fatality rates (CFRs).

To explain the clinical variability between the six chosen countries, a list of 14 indicators was established to systematically assess each country's preparedness, actual pandemic response, and overall socioeconomic and demographic profile in the context of COVID-19. The 14 indicators used in this study include: 1) Universal Health Coverage Index, 2) public health capacity, 3) Global Health Security Index, 4) International Health Regulation and Joint External Evaluation, 5) leadership, governance and coordination of response, 6) community mobilization and engagement, 7) communication, 8) testing, quarantines and social distancing guidelines, 9) medical services at primary health care facilities and hospitals, 10) multisectoral actions and continuity of essential services, 11) social protection services, 12) absolute and relative poverty status, 13) demography, and 14) burden of communicable and non-communicable diseases. Comparing and contrasting the chosen countries through these multifaceted lenses bring forth a better understanding of what is entailed in a successful pandemic response. Moreover, systematically evaluating these indicators allows us to rationalize why some countries have high disease burden, while other countries are faring better under the pandemic.

### ***Data Sources***

This study utilized both quantitative and qualitative secondary data. First, we used the "GDP per capita" dataset from the *World Bank* website to categorize countries into high-income, upper-middle-income, lower-middle-income and low-income statuses. For the purposes of this study, we narrowed the options to high-income and upper-middle-income countries. Secondly, we accessed epidemiological data on confirmed cases, cases per million, confirmed deaths, deaths per million and testing per 1,000 through the *Our World in Data* website's complete

COVID-19 dataset. The CFRs for the six chosen countries were then calculated using the descriptive statistics provided by the dataset. Both datasets are publicly accessible.

To systematically evaluate countries based on the 14 aforementioned indicators, exploratory qualitative data analysis was performed. In this study, qualitative secondary data was obtained from peer-reviewed journals, online newspaper articles, government reports and publications by public health-related associations, such as the WHO.

## Results

### *Epidemiological Findings*

Table 1 displays the statistics and categorizes the countries based on their income status and relative COVID-19 burden level. As of December 1<sup>st</sup>, 2020, the US had the highest cases per million, followed by Brazil, Germany, Australia, South Korea and Thailand. The same ranking was observed for the six countries' deaths per million statistics. In terms of CFR, which is the ratio of deaths to confirmed cases, Australia had the highest value, followed by Brazil, the US, Germany, South Korea and Thailand. Testing data was not uniformly updated in all six countries. However, the most updated record as of December 1<sup>st</sup>, 2020 showed that the US had the highest total tests per 1,000 population, followed by Australia, Germany, South Korea, Brazil and Thailand.(3)

**Table 1. Number of COVID-19 total cases, total cases per million, total deaths, total deaths per million, CFR and total tests per 1,000 from the onset of the pandemic \*until December 1<sup>st</sup>, 2020.(3, 8)**

Income	Burden	Country	Total Cases	Total Cases per Million	Total Deaths	Total Deaths per Million	CFR (%)	Total Tests per 1,000
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High	High	US	13,825,093	41,767.319	271,003	818.734	1.960226	603.342
	Medium	Germany	1,094,678	13,065.486	17,177	205.015	1.569137	343.129 (*as of 29 Nov 2020)
		Australia	27,923	1,095.025	908	35.608	3.2518	393.117
	Low	South Korea	35,163	685.851	526	10.26	1.495891	58.887
Middle	High	Brazil	6,386,787	30,047.068	173,817	817.734	2.721509	30.21 (*as of 19 Sep 2020)
	Low	Thailand	4,026	57.679	60	0.86	1.490313	18.722

### ***COVID-19 Cases and Cases per Million***

There were five indicators that helped explain the variability of COVID-19 cases and cases per million statistics in the six countries. They were: 1) leadership, governance and coordination of response, 2) communication, 3) community engagement, 4) multisectoral actions and 5) public health capacity. Effective use of these action areas constituted a successful pandemic response that yielded relatively low caseload.

#### **Leadership, Governance and Coordination of Response**

Governments across the world have managed the COVID-19 pandemic on different timelines due to contrasting public health infrastructures, political motivations and economic challenges. For instance, the South Korean and Thai administrations responded to this pandemic early on with swift communication between the central and local governments. Both countries recognized the importance of rapid countermeasures against infectious diseases after widespread devastation during the Severe Acute Respiratory Syndrome (SARS) epidemic in 2003 and the Middle East Respiratory Syndrome (MERS) outbreak in 2015.(9, 10) Having learned from past flaws, the South Korean administration strengthened its public health capacity through a series of institutional reforms. In particular, the Ministry of Health and Welfare increased the number of

epidemiologists, improved staff training for global health threats and established specific hospitals dedicated to treating patients with infectious diseases.(9, 11) By the time the first COVID-19 case was confirmed on 20 January 2020, the South Korean government was already prepared to activate the Emergency Use Authorization (EUA) system and accelerate test kit production. Furthermore, the nation fine-tuned a five-level social distancing scheme detailing specific guidelines that should be adopted by the general public based on the scale of the community outbreak.(9) Comparably, the Thai government also expanded its health workforce to include over 1,000 local surveillance teams that conducted outbreak investigation, contact tracing and testing across the country. The administration was also strict on mask-wearing in public spaces, physical distancing of more than two meters and practicing basic hand hygiene since the start of COVID-19 transmissions.(12)

Making decisions with objectivity and cautiousness is crucial during a public health emergency. Chancellor Angela Merkel, for instance, embodied this quality as she led the German administration through the COVID-19 pandemic. Coming from a science background, Chancellor Merkel is a proponent of decision-making based on data-driven updates, often sharing suggestions made by those with more expertise in infectious diseases than herself.(13) Similarly, Australia's success in managing COVID-19 spread was attributed to its leadership's inclination to trust public health experts. Even though individual Australian states and territories had the autonomy to set their own social distancing guidelines, the overall approach was characterized as being a well-coordinated national response.(14) Moreover, the Australian government largely suspended political conflict in order to divert full attention towards fighting the crisis at hand.(15) Regardless of political affiliation, authorities from different regions

continued to learn from each other and worked together to enforce interstate traveling restrictions that minimized cross-state transmissions.(14)

Meanwhile, the Trump administration in the US and the Bolsonaro administration in Brazil demonstrated drastically different characteristics in their COVID-19 response compared to the aforementioned governments. Rather than heavy interventions, both governments opted for a laissez-faire approach as an attempt to keep the economy afloat.(16, 17) Unfortunately, the lack of hierarchy between the federal and state levels caused physical distancing, mask-wearing and reopening guidelines to be misaligned across the two nations, which weakened their overall response plans. Both presidents largely rejected data-driven inputs from their own infectious disease experts. In fact, President Bolsonaro encouraged large public gatherings, interacted with fellow Brazilians without wearing a mask, and promoted potential medical benefits of the anti-malarial medication, hydroxychloroquine, as an effective COVID-19 treatment despite the lack of scientific backing.(18) Similarly, President Trump endorsed healthcare facilities to stock up on hydroxychloroquine and was not seen wearing a mask in public until 11 July 2020.(19, 20) Instead of discouraging social gatherings, President Trump held large-scale rallies for his presidential campaign that was projected to have resulted in over 30,000 cases.(21) With a lack of past epidemic experience, both leaders responded to this pandemic with a denialistic attitude that not only raised people's distrust of scientists, but also further divided the nation.(22) All in all, the political leaders' disorderly guidelines and misleading opinions have significantly delayed the US and Brazil from overcoming the COVID-19 crisis.

### Communication

When the government communicates frequently and transparently with the general public, civilians are more likely to build trust in the policies being put in place. This was well demonstrated by South Korea and Thailand's initial pandemic response. In January of 2020, both governments began to extensively deliver coronavirus briefings and social media campaigns. Daily news broadcasts invited health experts to inform the public of surveillance summaries and fact-based intervention plans. Multilingual interpretations of COVID-19-related information were offered to enhance everyone's understanding of personal hygiene measures and epidemiological statistics. Furthermore, both administrations strictly prohibited the propagation of misinformation, which were tracked down immediately and addressed at news briefings.(9, 12) The South Korean, Thai and Australian governments were also commendable for their efforts to alleviate the public's concern through ongoing two-way communication. This was possible with the establishment of call centers that offered not only health information, but also mental health services to counter increased pandemic-induced anxiety.(9, 12, 23) In Germany, the reputable Robert Koch Institute (RKI) published data consistently, which provided a steady flow of scientific information to the community.(24) There was also a podcast called the "Das Coronavirus-Update" that was listened to by millions of German people; it effectively shared research-based ideas through an easily consumable medium.(13)

Besides television and social media outlets, computer software advancements served an integral role in the circulation of COVID-19 alerts. For instance, the South Korean government used big data to share information about the travel history of confirmed cases through smartphone safety notifications.(9) The South Korean and Thai governments both utilized mobile platforms to monitor symptoms of individuals under the compulsory 14-day quarantine.(12) In Germany, people embraced the "Corona-Warn-App," a digital contact tracing

software developed by the RKI, which contributed to the nation's success relative to other EU countries early on in the pandemic.(13)

On the other hand, during the early stages of the pandemic, the American government showed a lack of clarity and honesty in its communication with the public. In March of 2020, President Trump conducted daily press conferences and used his social media platforms to lower the perceived risk that the virus was posing on the nation. Unfortunately, his optimistic stance diverged from those of infectious disease experts and public health officials.(25) There was also widespread misinformation about anti-malarial medicines and their impact on COVID-19 susceptibility, which caused confusion and false expectation to grow amongst Americans.(26) Concurrently, Brazil was having its own political infighting that left the population polarized and apprehensive as well. Even though some Brazilian mayors attempted to follow proper public health measures, they were regarded as political oppositions by President Bolsonaro.(17) As the political climate continued to worsen in Brazil, publication of comprehensive epidemiological reports ceased, and the president continued to dissuade people from taking the vaccine when one becomes available in Brazil.(27, 28) In summary, it is evident that consistent and truthful two-way communication between the administration and the general public is an important determinant in a country's COVID-19 outcome. Even though big data technology raises some degree of privacy concerns, when used appropriately, it has the potential to assist in digital contact tracing and surveillance. Conversely, using technological advancement and social media with the malintent to spread misinformation can lead to flawed hygiene behaviors and increased caseload.

### Community Engagement and Multisectoral Actions

Having a comprehensive government response alone was insufficient to contain the spread of the virus. To effectively minimize case counts, it was also crucial for citizens to make personal sacrifices for the greater public health's good, and for economic and social sectors to make contributions to the prevention effort. In Thailand, daily coronavirus briefings created a general awareness of the situation's seriousness, leading to people's commitment towards protecting themselves and others from the disease. On the local level, Thai village leaders helped facilitate home quarantines and enforced community-based monitoring, such as thermo-scanning and mask-wearing on public transportations and at crowd gatherings. Furthermore, the reopening plan was carefully constructed after consulting with public health experts and stakeholders from both public and private sectors.(12) Meanwhile, South Korea never underwent a complete lockdown of cities or provinces. However, school systems did phase into online platforms in April of 2020 to protect the health and safety of students, teachers and their families. In general, stay-at-home campaigns were well-received by the South Korean population. Citizens cooperated with contact tracers and abided by the government's decisions because people had learned from past mistakes during the MERS outbreak.(9) According to a survey conducted by the Institute for Future Government, 84% of South Koreans were willing to sacrifice digital privacy for public health security.(29)

Similarly, Australia's success in containing the initial clusters, as well as the subsequent outbreaks in Victoria and South Australia, were attributed to the citizens' engagement in preventative measures. A large majority of Australians were proactive about following policies established by the provincial governments, such as hotel-quarantining, mask-wearing and mass testing.(14) Relative to comparable Organization for Economic Co-operation and Development (OECD) economies, the Australian economy experienced one of the least striking downturn

throughout the pandemic due to generous stimulus packages aimed at promoting cash flow amongst small and medium-sized businesses.(30) Like the Australian government, the German administration's response towards lockdown-induced economic damage was quick and generous. Instead of letting employees file for unemployment, a short-term work program called "Kurzarbeit" was initiated to let employees work fewer hours every week and still receive up to 87% of their usual payroll.(31) Although there was a certain degree of backlash against COVID-19 safety measures and vaccinations by conspiracy theorists and anti-vaxxers, many Germans still came together to produce makeshift face coverings during times of severe mask shortages in the nation.(13, 32) With that said, Thailand, South Korea, Australia and Germany exemplified that, when multisectoral actions worked in harmony, the government and the population could reach a balance between preserving individual rights and optimizing public health.

On the other hand, the US witnessed poor multisectoral support and an absence of community engagement. Firstly, American polling revealed a strong partisan divide regarding the COVID-19 outbreak, meaning that a significant portion of the population was in denial of the situation's severity. These individuals' lack of cooperation with basic mask-wearing and physical distancing guidelines prevented the country as a whole from flattening the curve since spring of 2020.(20) Secondly, it was equally worrisome to observe that, after months of being on lockdown while seeing news about gun violence and police brutality, many Americans seemed to have become numb towards the virus's danger and even developed a willingness to accept mass death as an inevitable part of the country's history.(20) Thirdly, the US multisectoral response was ineffective because individual states operated on variable timelines for lockdowns, curfews and school closures. For instance, some universities that attempted to reopen for in-person learning without cautious planning in advance suffered major outbreaks.(33) Blunt lockdown

policies also escalated the unemployment rate up to 14.7% in April of 2020.(34) And in spite of the government passing a US \$2 trillion economic stimulus bill to soften the pandemic's negative economic impact, small businesses were not prioritized to receive loans over large, politically-affiliated corporations.(19, 35)

In Brazil, President Bolsonaro shared the same anti-science sentiment that polarized the society into supporters versus critics of his actions.(17) In fact, Brazilian polling showed an increasing percentage of respondents that did not intend on receiving the COVID-19 vaccine when one becomes available.(18) The nation's flawed multisectoral actions also paralleled with those in the US. Like many American state governments, the Brazilian administration lifted restrictions and allowed for businesses to reopen before cases stabilized at a safer level. As a result, many people began to participate in social gatherings and behaved under the assumption that they were invincible, causing cases to skyrocket again in the later months of 2020.(36) In addition, even though Brazil emerged from 2020 with the least economic recession in Latin America, emergency assistance funds were poorly allocated domestically, often going toward major firms rather than the more severely impacted small and medium-sized companies.(17, 37)

### Public Health Capacity and Response

Shortage of personal protective equipment (PPE) was prevalent at the start of the pandemic as people across the world scrambled to stockpile face coverings and hand sanitizers. With that said, a government's capacity to adapt promptly, gather ample resources, establish a well-prepared health workforce, and fiscally support health infrastructures is key in the framework of public health capacity.(38) Evidence shows that public health capacity strongly correlates with a country's ability to contain the spread of infectious diseases.

When the first case of COVID-19 was confirmed in South Korea, the government did not hesitate to activate the EUA system and allocate budgets toward test kit production well before the virus reached many other countries. South Korea's impressive testing capacity and testing turnaround time were attributed to an organized collaboration between the public and private sectors.<sup>(9)</sup> Moreover, South Korea pioneered the use of drive-through screening clinics, which eventually became a model to be followed by other countries around the world.<sup>(39)</sup> After the MERS epidemic in 2015, the government emphasized more on expanding the health workforce and increasing the funding from US \$62 million to US \$175 million. As a result, there were no noticeable shortages in the number of frontline healthcare providers as of September 2020.<sup>(9)</sup> These improvements in public health capacity made essential supplies and services accessible even to the more vulnerable populations in South Korea, including homeless people and non-citizens.<sup>(9)</sup>

The German government also approached the pandemic with an aggressive early testing strategy. In fact, researchers at the Charité Hospital in Berlin, Germany began developing one of the first COVID-19 tests before the WHO officially declared the virus's transmissibility.<sup>(40)</sup> Like South Korea, the German administration mobilized both public and private labs to scale up the testing capacity; approximately 200 facilities indicated robust capacity for COVID-19 testing.<sup>(24)</sup> By February of 2020, the administration had mandated all insurance companies to pay for COVID-19 tests, ensuring that they were obtainable by everyone residing in Germany. In addition, with the asset of universal health coverage, German patients had relatively minimal out-of-pocket spending when receiving treatments.<sup>(41)</sup>

Compared to South Korea and Germany, Thailand started off with a relatively lower testing capacity. There were only two laboratories conducting COVID-19 tests at first, but the

number quickly grew to over 200 certified facilities that could process 10,000 to 100,000 tests per day.(42) The government also required all travelers to undergo testing on the seventh and fourteenth days of their compulsory 14-day quarantines.(9) In the past four decades, the majority of Thailand's health education was carried out by a group of over one million village health volunteers (VHVs) that supported primary health services on a community level. Once COVID-19 became known, these dedicated VHVs began informing Thai civilians of prevention measures, while handing out face masks and hand sanitizers.(43) At nearly every hospital, negative pressure chambers were installed to collect patients' nasal swabs. The medical teams were also divided into two groups that each worked for 14 days, which allowed for a 14-day quarantine in the event that a team member became infected with the virus.(9) Like South Korea and Germany, Thailand is home to universal health coverage, offering access to COVID-19 testing and treatment at private and public institutions for free. With such a vast team of health promoters and a rapidly improved capacity for testing and tracing, Thailand did not record a single local transmission between 25 May 2020 and 22 October 2020.(9)

Australia was also a proponent of mass testing, eventually becoming a country with one of the highest tests per 1,000 population in the world.(44) At the start of the COVID-19 pandemic, the Australian government allocated over AUD \$750 million to fund its testing capacity.(45) Virologists began expanding the scope of surveillance in April of 2020, allowing more people in the community to become eligible to receive the COVID-19 test.(46) Furthermore, with the intent to care for vulnerable populations in rural parts of Australia, the government rapidly set up over 150 respiratory clinics in the countryside, which costed over AUD \$171 million to operate.(45)

As evidenced by countries with low and medium COVID-19 case burden, the capacity to finance services, establish a strong health workforce, and perform mass testing is key in order to grasp the true extent of community spread and, in turn, prevent larger outbreaks from happening. Unfortunately, these measures were not observed in the US. In February, test kits were being delivered to state labs across the nation. However, many of those tests were later found to give faulty diagnoses.(47) As a result, the nation lost crucial weeks before the first wave, when the few early cases could have been identified and contact traced. As of 1 December 2020, the US already caught up on mass testing and was performing the second most COVID-19 tests per million amongst the countries most severely impacted by the pandemic, only falling short of the United Kingdom (UK). Nevertheless, the feat to catch up on testing occurred beyond the point of attaining full control of the spread.(19) Interestingly, despite the US spending nearly twice as much on healthcare as an average OECD country, its healthcare workforce was paradoxically understaffed. With a shortage of physicians and nurses qualified to treat COVID-19, the existing staff members must face the horror of surging caseload.(48, 49)

At the same end of the burden spectrum, the Brazilian administration was denounced for its negligence to set up a surveillance network at the start of the pandemic. In March of 2020, the Brazilian health minister advised against mass testing, considering it a waste of public funding.(50) By July of 2020, Brazil was rolling out coronavirus tests 10 times slower than the US. Their accuracies were further compromised by the federal government's decision to use rapid serological tests instead of the more accurate polymerase chain reaction tests.(17, 51) Furthermore, the public health capacity in different municipalities varied greatly. A considerable number of Brazilian regions were receiving less funding from the federal government due to political tension with the leadership.(52) As the country struggled to import the necessary PPE,

unprotected frontline health workers visiting rural areas of Brazil might have unintentionally exposed the vulnerable Indigenous populations they intended to care for with the virus.(18) All in all, the American and Brazilian public health capacities were insufficiently prepared to fight COVID-19. Both countries lost weeks in February to invest in reliable testing and tracing systems. Ultimately, the lost opportunity culminated in unstoppable summer surges and record-breaking case counts towards the end of 2020.

### ***COVID-19 Deaths and Deaths per Million***

There were four main indicators that explained the variability of COVID-19 deaths and deaths per million in the six countries. They were: 1) universal health coverage, 2) medical services and hospital capacity, 3) demography and 4) burden of non-communicable diseases.

#### Universal Health Coverage

COVID-19 shed light on health inequalities and underscored the need for universal health coverage (UHC) to lessen cost barriers that hinder people's access to lifesaving treatments during a pandemic. Thailand, for instance, is one of the few middle-income countries to have achieved universal healthcare by 2002. Thai citizens choose from one of three public health insurance options: 1) the Civil Servant Medical Benefit Scheme for civil servants and their families, 2) the Social Security Scheme for private employees and 3) the Universal Coverage Scheme. During the COVID-19 pandemic, all individuals residing in Thailand were granted access to testing and intensive care treatment at local public and private facilities for free, regardless of insurance enrolment or citizenship status. Foreign patients without private

insurance received equally high quality care, fully paid for by government contingency funds.(12)

In Germany, health insurance has been compulsory for the entire population since 2009. 90% of the population are covered under the public “statutory health insurance” (SHI), while the remaining 10% opt for “private health insurance” (PHI). The SHI requires employers to contribute towards half of the employees’ health insurance, and it offers basic coverage through any one of around 100 non-profit funds. Meanwhile, the PHI is used by self-employed individuals and high-income employees; it provides a larger selection of providers and faster access to non-emergency services.(53) In May of 2020, the German government also opened up intensive care unit (ICU) beds to patients from neighboring EU countries, on top of already providing free COVID-19 testing and treatment for anyone residing in Germany.(24) Out of the six countries in this study, Germany has the largest population cohort above the age of 65, meaning that more individuals are at high risk of dying from the virus. However, with effective use of UHC, the country saw relatively limited COVID-19 mortality amongst the elderly population, which explained why its CFR was much lower than those of comparable countries.(24)

Australia’s UHC has been characterized as one of the most comprehensive insurance plans in the world, and its framework is comparable to the previously discussed German insurance schemes. That is, the Australian system also follows a two-tiered structure in which private health insurance works in tandem with Medicare. Most Australian citizens and permanent residents have universal coverage through Medicare, which is funded by income tax surcharge and government expenditure. Private health insurance strives to fill those gaps within Medicare by offering faster access to non-urgent services and a larger selection of health providers that are

not necessarily subsidized through Medicare; these include pharmacists, optometrists, dentists and physical therapists.(54) During the COVID-19 pandemic, treatment and testing charges were waived for every individual living in Australia, including overseas travelers that were not eligible for Medicare and had inadequate travel insurance coverage. This benefit allowed people to receive thorough COVID-19 care regardless of their financial and citizenship statuses.(55)

In South Korea, all citizens are covered under the National Health Insurance (NHI). With this centralized, single-fund health system, medical resources can be mobilized in a more streamlined fashion during health emergencies.(9) The NHI follows a framework similar to the German social insurance system in the sense that health insurance contribution for an employed person is proportional to income level and shared equally between the employee and employer. Meanwhile, insurance for a self-employed person is based on the individual's income and property ownership.(56) During the COVID-19 pandemic, all South Korean citizens were eligible for free testing and treatment. The government also made it a priority to provide the same services for free to vulnerable populations, such as homeless people and immigrants without legal status.(12)

Brazil also has UHC through a tax-funded system called the Sistema Único de Saúde (SUS), which was created in 1988 when the Brazilian constitution defined health as a universal right. All individuals living in Brazil regardless of citizenship status are covered under this system, which entails free access to all forms of health services, namely, primary care, hospital care, outpatient specialty care, mental health care, dental care, physical therapy, optometry, and pharmaceuticals. At the same time, approximately 25% of Brazilian citizens opt for private health insurance through their employment to receive care with shorter wait times.(57) Unfortunately, the SUS has a long history of being underfunded. When COVID-19 cases began

to rise in Brazil, this issue became even more apparent and pertinent; while middle to high income families could afford private health insurance to receive COVID-19 treatment sooner, the larger majority of the population must use the SUS if they fall critically ill, and be faced with potential staff and supply shortages.(58) In summary, even though Brazil has UHC, the SUS's continuous underfunding not only exposed underlying socioeconomic inequalities, but also prevented the nation from saving hundreds of thousands of lives.

Unlike most OECD countries, the US does not have universal healthcare. Instead, health coverage is offered through various social insurance programs and private health insurances. The former includes programs like Medicare, Medicaid, Children's Health Insurance and the Veterans Health Administration. The latter can be accessed either through an employer-sponsored program or purchased on an individual basis. Typically, employer-sponsored health insurances are purchased by businesses as part of the employees' benefit package, and this was how approximately 55.4% of Americans were covered in 2019.(59) Unfortunately, the US is ranked first for healthcare expenditure per capita in the world, spending nearly twice as much as the average OECD country.(60) High costs are primarily driven by the use of advanced medical technologies, the increase in chronic disease prevalence burdening Medicare, and the unreasonably high administrative costs that make up more than one-third of healthcare spending.(61) With that said, these systemic flaws prevented many Americans from affording basic health services, making them highly vulnerable during the COVID-19 pandemic. Without UHC, critically ill patients were not inclined to seek medical help or follow through with treatment due to fear of incurring major medical debts.(62) This situation was exacerbated by the staggering unemployment rate, which caused as many as 7.7 million Americans to lose their employer-sponsored insurances by June of 2020.(63) As of January of 2021, the US recorded the

highest COVID-19 death toll in the world. In summary, having a resilient health care system centered around UHC is essential to effectively manage a pandemic and produce more favorable health outcomes.

### Medical Services and Hospital Capacity

COVID-19 posed unprecedented challenges for medical systems globally. The need to prioritize the pandemic response inadvertently compromised non-urgent health services and raised people's fear of acquiring the virus during clinic and pharmacy visits. This was a predicament that would inevitably increase morbidity and mortality rates in other illnesses. To combat this drawback, countries have embraced the use of video-conferencing software to enable telemedicine consultations between patients and primary care physicians.(64) Furthermore, South Korea, Thailand, Australia and the US began to offer free postal delivery of prescription drugs to minimize in-person contact.(9, 12, 65, 66)

Most countries around the world experienced shortages of hospital beds during the initial surge in cases. However, a few noteworthy countries effectively expanded their medical infrastructures to curb mortalities caused by capacity strain. South Korea, for instance, has one of the highest numbers of hospital beds per capita relative to other OECD nations, standing at 12.3 beds per 1,000 population.(67) Even though South Korea experienced a brief shortage of ICU beds during the peak of the Daegu outbreak in February of 2020, the inadequacy was quickly managed with the help of “residential treatment centers” that were built to accommodate patients with lower risk symptoms.(9) On a similar note, in Thailand, mild and asymptomatic cases were isolated in designated field hospitals and private dormitories such that ICU beds could remain available for patients requiring more acute care.(12) Likewise, the Australian government poured

AUD \$171 million into the maintenance of over 150 respiratory clinics that redirected patients with non-urgent symptoms away from the emergency rooms.(45) Meanwhile, Germany has the highest number of hospital beds per 1,000 population out of all the European countries and ranks within the top five EU nations for the number of doctors and nurses per 1,000 population. With careful stepwise planning, its hospital system was able to take in COVID-19 patients from other EU nations, while gradually increasing its hospital bed capacity to resume certain elective surgeries.(24, 68, 69)

Brazil also attempted to expand its healthcare capacity by building additional hospital wards.(70) Despite adding hospital beds at an unprecedented speed, local emergency rooms struggled to keep up with the growing hospitalization rate. In fact, hospital and funeral systems in the Amazons were oversaturated to the point of collapsing twice in 2020; many patients of those regions continued to die of asphyxiation due to oxygen shortages in the ICUs.(71) As of January of 2021, Brazil held the world's second highest COVID-19 death toll, only surpassed by the US.(72) Inevitably, the distressing hospitalization rate took a toll on Brazil's frontline medical staff as well, as the nation recorded the highest death rate of nurses infected by COVID-19 in the world.(17)

Meanwhile, in the US, New York became the first COVID-19 hotspots in March of 2020. Healthcare personnel were diverted to support hard-hit regions, and the Javits Center was converted into a medical facility to accommodate 2,000 extra beds.(19) New York's adversity became not only a learning opportunity, but also a grim warning for the rest of the nation to strengthen hospital capacity. In response, President Trump authorized use of the Defense Production Act to accelerate the production of ventilators.(19) However, with cases surging during summer and holiday months, the country faced a new challenge. Hospitals had an ample

reserve of available ventilators, but not nearly enough ICU doctors, respiratory therapists and pulmonologists with proper training to treat the number of critically ill patients that were being admitted.(73) To make matters worse, frontline health workers were also getting infected at an alarming rate. Emergency rooms had to turn away patients with urgent need on a daily basis, regardless of the type of illness.(74) Like in Brazil, the American health systems were being pushed to the brink of collapse.

### Life Expectancy and Burden of Non-Communicable Diseases

A country's demographic profile and disease burden can reflect how the country will fare during public health crises. For instance, comparing data from Table 1 and 2 reveals a negative correlation between the countries' life expectancies and total deaths per million from COVID-19. In particular, Americans have a much shorter life expectancy than do people living in other high-income countries, and the US has continued to rank first in COVID-19 death toll and deaths per million.(75) At the same time, we can also compare the countries' disability-adjusted life year (DALY), which quantifies the number of years lost due to disabilities, illnesses or premature deaths in a population. For the purposes of this study, we specifically examined the DALYs for non-communicable diseases (NCDs), the most common of which were cardiovascular diseases, cancers, respiratory diseases and metabolic diseases.(76) Table 2 shows that the US and Brazil both have abnormally high burden of NCDs relative to other countries in their respective income category, which reflects in the positive correlation between NCD DALYs and total deaths per million from COVID-19.

**Table 2. Life expectancy in 2019 and non-communicable disease disability-adjusted life years in 2017 from the US, Germany, Australia, South Korea, Brazil and Thailand.(8, 76, 77)**

Income	Burden	Country	Life expectancy in 2019 (years)	NCD DALYs (years lost per 100,000 people) in 2017
High	High	US	78.9	19,742.58
	Medium	Germany	81.3	16,560.72
		Australia	83.4	15,280.05
	Low	South Korea	83.0	13,333.71
Middle	High	Brazil	75.9	19,290.94
	Low	Thailand	77.2	16,135.48

## Discussion

The epidemiology of COVID-19 is variable in different countries around the world. While the US and Brazil witnessed skyrocketing case and death counts, countries like South Korea, Thailand, Australia and Germany experienced relatively lower disease burden. The heterogeneous outcomes can be attributed to a number of factors, which include response coordination, communication, public health capacity, universal health coverage, hospital capacity, life expectancy and burden of NCDs. Understanding how these factors play a role in pandemic responses allows hard hit countries to learn from lower burden countries and become better prepared for re-emerging outbreaks.

Over the course of the pandemic, governments around the world increased the rigor of their intervention plans in hopes of containing the virus. Our study shows that countries governed by leaders who took rapid actions, provided generous welfare support, and synchronized policies with scientific observations were most effective at curtailing case counts. This is consistent with other study's findings, which praise countries like New Zealand for its early lockdown. Similarly, Singapore has been commended for learning from past disease outbreaks and establishing a multi-ministry COVID-19 taskforce before its first confirmed case.(78) Other researchers also agree that, although lockdowns and closures should be urgently

implemented to curb transmissions, building healthy behaviors on the individual level and fostering compliance on the community level are just as fundamental, which cannot be accomplished unless leaders gain the trust of the general public through transparent communication.(79) In addition, our study concluded the importance of having a strong public health capacity in order to effectively locate confirmed cases and halt further infections. This idea is shared by the WHO, which has openly criticized countries that did not prioritize testing and tracing early on. Countries like the UK and Haiti, for instance, were unable to scale up their surveillance networks quickly enough, and they ended up with uncontrollable spread of the virus caused by individuals who were not eligible to be tested from the start.(2, 80)

In life and death situations, many COVID-19 patients chose to leave the hospital because they could not afford to seek further medical attention. With that said, our findings illuminate the need for all countries to set up a well-funded UHC scheme that protects vulnerable families from giving up on treatments. This is in agreement with other studies' findings. A report examining Italy's COVID-19 outcome points out that, even though Italy has had UHC since 1978, the system has weakened under years of budgetary cuts. Moreover, the large group of irregular migrants in Italy was not registered under the UHC and faced difficulty in accessing COVID-19 screening.(81) In addition to using UHC to overcome health inequalities, other studies have concluded that the ability to expand medical infrastructures for clinical surge is key in curtailing COVID-19 deaths, as well as mortalities associated with other illnesses. One study mentions that the UK entered the pandemic with a low number of beds and physicians per capita relative to other OECD countries.(82) A year after the pandemic's onset, the UK already recorded higher deaths per million than all six countries in our study.(3) Finally, we found an interesting

correlation between NCD DALYs and COVID-19 mortality rates. An article in the British Medical Journal has addressed that, despite the overall CFR of COVID-19 being low, individuals with underlying illnesses are much more likely to suffer from severe symptoms ending in mortality.(83) Of all NCDs, the most common comorbidities associated with unfavorable COVID-19 outcomes are hypertension, chronic cardiovascular disease, diabetes and chronic cerebrovascular disease.(84) Similar to the way NCD DALYs predict COVID-19 CFR, the average life expectancy can also reflect the overall welfare system of a country and is inextricably related to COVID-19 mortalities.(85)

The results from this study are subject to certain limitations. Firstly, there was likely an underestimation in the number of COVID-19 cases each day because some countries had insufficient testing resources or showed negligence towards reporting accurate diagnostic records. Secondly, the death count was possibly skewed because every country followed its own protocol to define mortalities caused by COVID-19 infection; some countries only examined clinical presentations, while others relied on positive laboratory tests to confirm deaths.(86) Public health authorities have reasoned that heterogeneity in reporting guidelines is likely to be politically motivated.(87)

At the same time, other caveats exist when comparing COVID-19 statistics across different countries. For one, patients with chronic diseases made less frequent hospital visits during the pandemic, hindering them from receiving proper care for otherwise curable diseases. In countries with high disease burden, emergency services were overwhelmed with COVID-19 patients, making first responders unavailable to respond to other common types of life-

threatening events. Conversely, stay-at-home orders decreased traveling and likely reduced mortality caused by traffic accidents. All in all, given the variation in reporting mortality statistics and the underestimation of cases, cross-country comparisons of COVID-19 fatality rates should be done with caution.

## **Conclusions**

The pandemic of COVID-19 has variable effects across countries due to differences in their vulnerability, preparedness and response. Initiating healthy behavioral changes on the individual level requires governments to not only earn the trust of the general public through transparent communication, but also have trust in the scientific community themselves. Investing in public health capacity is an irreplaceable asset because early mass testing and contact tracing are needed to gain control of infectious diseases. Likewise, investing in hospital capacity in the long-term proves to be lifesaving when cases do surge out of control. While we are still far from achieving UHC globally, allocating generous funds toward welfare programs and taking gradual steps to eliminate health inequalities show promise in decreasing comorbidity, increasing life expectancy and minimizing overall disease mortality. These research findings offer valuable lessons to prevent and control COVID-19 and prepare for future epidemics if countries are proactively adapting and implementing them.

## **Abbreviations**

**COVID-19:** coronavirus disease of 2019

**WHO:** World Health Organization

**US:** United States

**EU:** European Union

**CFR:** case fatality rate

**SARS:** Severe Acute Respiratory Syndrome

**MERS:** Middle East Respiratory Syndrome

**EUA:** Emergency Use Authorization

**RKI:** Robert Koch Institute

**OECD:** Organization for Economic Co-operation and Development

**PPE:** personal protective equipment

**VHV:** village health volunteer

**UK:** United Kingdom

**UHC:** universal health coverage

**SHI:** statutory health insurance

**PHI:** private health insurance

**ICU:** intensive care unit

**NHI:** National Health Insurance

**SUS:** Sistema Único de Saúde

**DALY:** disability-adjusted life year

**NCD:** non-communicable disease

## **Declarations**

### **Ethics approval and consent to participate**

Not applicable.

### **Consent for publication**

Not applicable.

### **Availability of data and materials**

The datasets supporting the analyses of this study are publicly available on the *Our World in Data* website (<https://ourworldindata.org/coronavirus-data>) and the *World Bank* website (<https://data.worldbank.org/indicator/NY.GDP.PCAP.CD>). The qualitative secondary data used to support the study's findings are publicly available and cited in the References.

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The authors declare no competing interests.

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### **Authors' contributions**

Y.A. conceptualized the design of this report. Y.C. performed data collection and literature search. Y.C. and Y.A. collaborated on data interpretation. Y.C. was responsible for synthesizing secondary data and drafting the manuscript. Y.A. critically revised and provided comments on the manuscript. All authors have read and approved the final version for publication.

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