Brazil's Mismanagement of the COVID-19 Pandemic Accentuates Inequalities

Fariha Ashraf[1], Theo Brandt[1], Huiwen Chen[1], Eugenie Dicker[1], Anju Meyer[1], Afifa Zahid[1] (*[1]Bard High School Early College, New York, NY, USA)*

Dr. Devon Collins

Abstract

In 9 months, COVID-19 evolved from an outbreak in a Chinese seafood market to a global pandemic, infecting millions worldwide, pushing healthcare systems to their limits, devastating global economies, and ultimately revealing the effectiveness of different countries' responses to the novel virus. Brazil currently has the second-highest number of COVID-19 related cases and deaths, which can be attributed to its controversial and inadequate response to the pandemic. However, Brazil's COVID-19 response has disproportionately affected Brazilians of various socioeconomic and ethnic backgrounds. How has the Brazilian government's response exacerbated the spread of COVID-19, and how has COVID-19 in turn accentuated inequalities in Brazil? Brazil's lack of public health leadership and Bolsonaro's dismissive attitude toward the severity of the virus have intensified disparities in healthcare, which has more negatively impacted Brazilians of lower socioeconomic status and non-white Brazilians. In Brazil, limited clinical and ICU bed availability are rampant concern, with a low percentage of beds available to the public health sector. Bed shortages are accompanied by an insufficient number of mechanical ventilators in multiple Brazilian macroregions. Bolsonaro's piteous attempts to contain the virus have also exacerbated the effects of COVID-19 on Brazil's inhabitants, placing everybody at risk, as Brazil continues to primarily impact Black Brazilians and the indigenous population. Although Brazil has the largest economy in Latin America, a decline in GDP and merchandise trade is also to be expected as a result of COVID-19. Yet, even with the many struggles Brazil faces, it is crucial to acknowledge their progress made in vaccine development, with two partnerships currently in phase 3 of developing a vaccine available to the public. Brazil's underwhelming response to the COVID-19 pandemic has shown the instrumental role governments play in the transmission of the novel coronavirus. Bolsonaro's denial of the virus is his attempt at prioritizing the economy over the pandemic; however, this reaction has not only worsened the effects of COVID-19 in Brazil, but it has also increased inequities in healthcare and the economy.

Introduction

The rapid spread of the Coronavirus Disease 2019(COVID-19), caused by the newly discovered Severe Acute Respiratory Coronavirus 2 (SARS-CoV-2), has led to an unprecedented global public health crisis. The COVID-19 pandemic initiated in Wuhan, China after a cluster of cases of pneumonia of unknown cause was reported on December 31, 2019. While the outbreak spread across Asia, Europe, and other regions in the early months, the first confirmed case of COVID-19 in the South America region did not emerge until February 25, 2020, when the Health Department of São Paulo announced that a 61-year-old Brazilian man who had returned from Lombardy, Italy was tested positive for COVID-19.[1] As the outbreak spreads to every state in Brazil, the country is among the world's epicenters of the COVID-19 pandemic. As of September 4, 2020, COVID-19 has infected more than four million Brazilians, of which over 125,000 resulted in death.[2] Most confirmed cases reported mild to moderate respiratory illness; however, the elderly and those with underlying medical conditions experience a higher probability of developing severe symptoms and prognostic comorbidity[3], which may lead to fatal consequences. Due to Brazil's numerous high-risk groups, the need for intensive care in ICUs is critical. Brazil should have followed lessons from Italy – the size of the aged population is 23.1% in Italy versus 13.5% in Brazil.[4] Italy's experience handling the spike in COVID-19 cases indicated that the following preparedness and containment could have prevented a massive outbreak: a) attend hospitals only when medical care becomes necessary;b) enforce hygienic procedures in hospitals; and c) protect medical workers immediately in cases of potential exposures.[5] Italy imposed a country-wide lockdown as death rates surged; whereas, Brazil significantly delayed shut down despite thousands of new cases and hundreds of new deaths per day. Only a few Brazilian states began ordering lockdown when the single-day death count had reached nearly one thousand. In comparison, New York and several other states in the United States enforced the closure of non-essential businesses and educational institutions soon after the first few deaths of COVID-19. If Brazil had acted swiftly, then it could have avoided some pernicious outcomes of this pandemic.

Discussions about COVID-19 in Brazil must also consider the historical socioeconomic stress in the region. Brazil's long history of socioeconomic inequality stems from racial, gender, and class stratifications defined in the colonial era. The country always ranks in the top ten most unequal countries in the world.[6] This inequality exacerbated the effect COVID-19 has had on the country because it created pre-COVID-19 healthcare disparities between different socioeconomic groups. Researchers analyzing the 2013 National Health Survey emphasized the need to monitor social inequality when developing national health policy. While this study mainly focused on harmful behaviors that lead to non-communicable disease, it shows the relevance social inequalities have in Brazil's healthcare system.[7] Brazil's heterogeneity further complicates its response to COVID-19. This means that the density of the country varies and that the density of a region will determine how it is affected by COVID-19. A theoretical study shows that peak infection and peak mortality rates occur later in urban areas like Sao Paulo or Rio de Janeiro than in rural regions like Amazonas.[8]

Brazil's president, Jair Bolsonaro, has reacted to the COVID-19 pandemic by denying it, promoting unproven therapies, and attacking political opponents.[9] Bolsonaro's administration has The government's response and handling of the COVID-19 pandemic has received criticism

from figures within the health ministry as well as from Brazil's citizens. Bolsonaro's praise for hydroxychloroquine as a treatment for COVID-19 despite the lack of data as well as his defense of vertical isolation to increase herd immunity instead of social distancing led to the dismissal of two health ministers, Dr. Mandetta and Dr. Teich, who were replaced by general Pazuello who militarized leadership in the health ministry.[10] Despite having contracted COVID-19, Bolsonaro continues to downplay the seriousness of the pandemic. Brazil's Federal Supreme Court upholds social distancing policies opposed by Bolsonaro despite advice from scientists to social distance.[11] DespiteBolsonaro administration's denialism and mishandling of the pandemic, other branches of government have imposed a variety of quarantines, lockdowns, mask mandates, and other preventative measures. The government has also been accused of hiding data related to the number of COVID-19 cases and deaths. The website that was recording the number of cases and deaths experienced a blackout, a sign that the government was trying to limit the amount of data that was being made public. The government has also come out with contradicting statements, announcing 1,382 deaths but later revising it to 525.[12]

  With a lack of infrastructure, education, and healthcare resources in certain states, inadequate living conditions have plagued Brazil long before the onset of the pandemic. This research paper aims to describe the hardships faced by Brazil's inhabitants amid a global health crisis and situate the mismanagement in the context of Brazil's economic, social, and political divides. How have socioeconomic and racial inequalities affected the spread of COVID-19, and how has COVID-19 in turn accentuated inequalities in Brazil? To examine the disproportionate impact of the COVID-19 on racial and ethnic groups of color, the first section of this research paper analyzes infection and fatality rates concerning Brazil's admixed population. The second part provides an overview of Brazil's public health sector, including its limited clinical accessibility and insufficient ICU bed availability across multiple socio-demographic regions. The third section emphasizes that Bolsonaro's piteous attempts to contain the virus have also exacerbated the effects of COVID-19 on Brazil's inhabitants, placing everybody at risk, but primarily impacting Black Brazilians and the Indigenous population. The fourth component identifies the economic stress provoked by COVID-19, as well as the financial hardships of lower socioeconomic communities despite state efforts to minimize economic recession. Lastly, it is crucial to acknowledge Brazil's progress in vaccine development in spite of its public health struggles.

Infection and Fatality Rates

  Since the first case of COVID-19 was reported on February 25, 2020 in Brazil, the country has reported 3,317,096 cases and 107,232 deaths as of August 16, 2020.[13] Brazil has the second-highest number of COVID cases and deaths in the world after the United States, which has reported 5,379,914 cases and 169,745 deaths as of August 16, 2020.[14] Brazil's case fatality rate has been on a slow but steady decline since May 14, 2020. The case fatality rate is the ratio of the number of deaths divided by the number of confirmed cases. On August 16, 2020, the reported case fatality rate was 3.2% (fig. 1).[15] The case fatality rate for closed cases, cases that have either resulted in recovery or death, was reported to be 4.27% on August 16, 2020.[16] The case fatality rate is subject to change depending on its context. For example, the case fatality rate for COVID-19 in New Zealand, where fewer people per capita have been diagnosed and killed by COVID-19, is significantly lower than Brazil. Additionally, the case fatality rate for

COVID-19 for younger populations appears to be lower than it is for older populations as data suggests that the elderly are more susceptible to dying from the disease. Case fatality rates are heavily dependent on the accuracy of data. Since case fatality rates use the number of confirmed cases to calculate the ratio, they are based on the assumption that everyone in a population is being tested; however, that is often not the case. Brazil has the second-highest rate of positive COVID tests, at 50.07% daily positivity (fig. 2).[17] For comparison, the United States has a daily positivity rate of 8.87%.[18] The high positivity rate suggests that Brazil has been testing only people with symptoms, those who most likely have the virus. Brazil is ultimately under-testing its population, which severely undermines its calculated case fatality rate. Case fatality rates are prone to either overestimate or underestimate the true fatality rate of a novel disease such as COVID-19.[19] Calculations made using data from closed cases, can result in an overestimate, as the number of closed cases may be smaller because this number does not take into account current cases. Additionally, case fatality rates can overestimate due to the time lag bias that occurs at the beginning of an outbreak. On the other hand, case fatality rates can underestimate when they don't factor in future deaths, which is impossible, and when data from closed cases is used, as it does not consider the current number of cases. However, case fatality rates are a poor reflection of the fatality rate of a disease. The infection fatality rate, which is the ratio of deaths divided by the number of *actual* infections, is a more accurate representation of the fatality rate.[20] The infection fatality rate divides the number of deaths by the actual infections, which is often determined after an epidemic or pandemic, as opposed to the number of confirmed cases which is severely limited by the number of tests. The infection fatality rate is predicted to be significantly lower than the case fatality rate due to limited testing, which suggests that COVID-19 has a much lower mortality rate than what current models suggest.

The president of Brazil, Jair Bolsonaro, and the health administration have been accused of reclassifying deaths and withholding data related to the COVID-19 pandemic in Brazil. According to Fiocruz, a state-run biology foundation in Minas Gerais, only 368 coronavirus related deaths have been reported.[21] However, deaths from severe acute respiratory infections in the state had risen eightfold from 2019 to 2020, suggesting Brazil has been attributing COVID-19 related deaths to other natural causes, which can be seen as a tactic to decrease the mortality rate, which can affect the country's reputation and the evaluation of the country's response to the pandemic.[22] President Bolsonaro and the government have also been accused of withholding data related to COVID in Brazil. In early June, the health ministry removed the website that had been reporting daily statistics related to COVID-19 infections and deaths. When the site was republished, previous data was missing. Additionally, the government has released contradicting data. For example, on June 7, 2020, the government reported 1,382 deaths, but later revised it to 525 claiming the initial figure contained incorrectly reported deaths.[23] Brazil has struggled to provide adequate COVID-19 testing for its citizens. As a result, the WHO has recommended that countries record the number of deaths despite the cause. Excess mortality, the number of deaths that exceed the expected toll based on previous data, can be used to better understand the magnitude of the pandemic. It is estimated that from March 15 to June 6, 62,000 more Brazilians died than expected, suggesting that COVID-19 is responsible for these deaths. [24]

The Brazilian government imposed a variety of measures, such as social distancing, quarantines, and lockdowns in an attempt to slow the spread of COVID. Additional preventative actions have been taken such as sanitation, face mask usage, complete isolation of infected individuals, and flu vaccines.[25] In Sao Paulo state, the transmissibility index was approximately

2.2 before quarantine was imposed. After one month, the number had decreased to 1.4 and after two months it was reported to be 1.2. In the Amazonas state situated in Northern brazil, a quarantine was enforced from March 25 to July 2. Masks were mandatory in public spaces, and some towns were placed on lockdowns. Prior to the quarantine, the reproduction number was approximately 2.83. After a month of quarantine, the number was 1.83 and after two months it was 0.82. Quarantines and other preventive measures have proven successful in decreasing the transmission of COVID-19 in Brazil.

Brazil is an ethnically and socioeconomically diverse country. However, an individual's location in Brazil, which is often associated with a distinct socioeconomic status and ethnicity, appears to influence the rates of mortality. Similar to the rest of the world, survivors of COVID were more likely to be younger, female, and have fewer comorbidities. However, survivors in both the north and central-south regions of Brazil were more likely to be white. Additionally, white Brazilians were more likely to be admitted to the ICU than Pardo Brazilians, who have mixed ethnic ancestries; therefore, the increased death rate in Black and Pardo Brazilians could be related to mismanagement in the health care system. A correlation between ethnic and regional socioeconomic factors appears to have played a role in the smaller chance of survival of younger Pardo and Black Brazilians compared to white Brazilians. Compared to white Brazilians, Pardo and Black Brazilians are typically less financially stable, live in contagion-prone conditions, and less likely to work remotely, ultimately making them more susceptible to COVID-19. Moreover, Pardo and Black Brazilians are more likely to be exposed to COVID-19 risk factors such as indoor pollution and the lack of clean water. These disparities in health care and living conditions can explain the higher risk of death from COVID-19 in populations of poorer regions as well as in Pardo and Black Brazilians.[26]

The Institute for Health Metrics and Evaluation's current projection indicates that by December 1, 2020, Brazil will have recorded 192,511 COVID-19 related deaths (fig. 3). The institute's projection factoring in an ease in mask wearing results in a much higher death toll at 255,574 by December 1, 2020. However, if masks are worn the total number of deaths by December 1 is predicted to reach 167,644. The current projection appears to overestimate the number of deaths by approximately 8,000; however, the confirmed number of deaths caused by COVID-19 is questionable due to the lack of testing and the government's transparency with the data.[27]

Figure 1: Case Fatality Rates for COVID-19 in Brazil, the United States, and the World
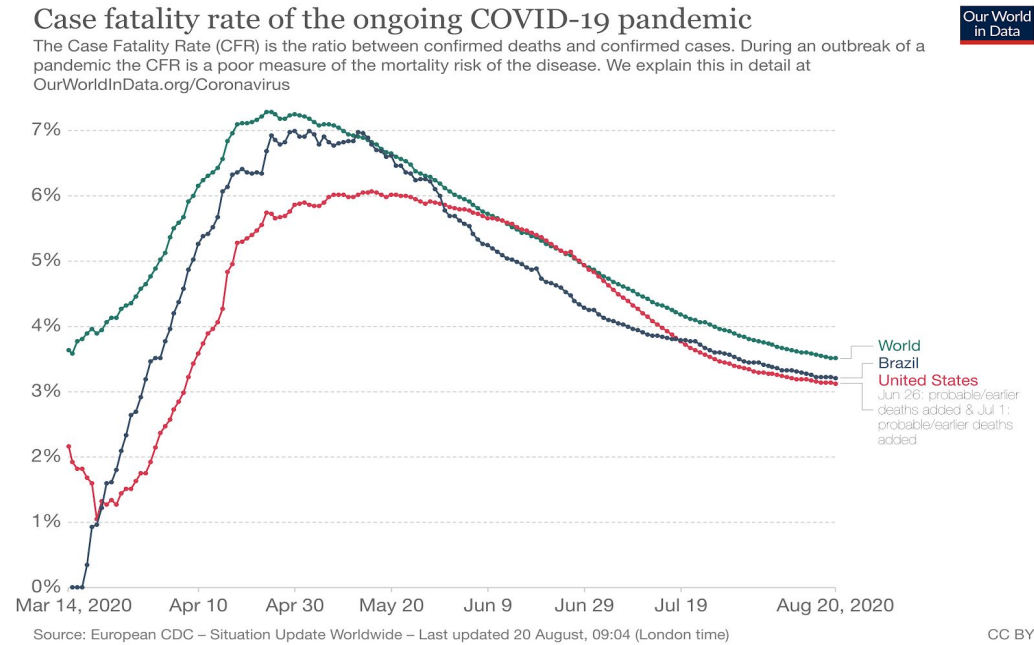

Case fatality rate of the ongoing COVID-19 pandemic

The Case Fatality Rate (CFR) is the ratio between confirmed deaths and confirmed cases. During an outbreak of a pandemic the CFR is a poor measure of the mortality risk of the disease. We explain this in detail at OurWorldInData.org/Coronavirus

Source: European CDC – Situation Update Worldwide – Last updated 20 August, 09:04 (London time)　　　　CC BY

Figure 1 shows the trends in case fatality rates in Brazil, the United States, and the world. The case fatality rate for the world, Brazil, and the United States is 3.5%, 3.2% ,and 3.1%, respectively. Although the United States and Brazil have the first and second-highest confirmed COVID-19 cases and deaths globally, the world's case fatality is slightly higher than the United States and Brazil. The higher rate is most likely due to the case fatality rates in Italy, where a large elderly population increased the number of deaths from COVID-19, and Belgium, where the government decided to include all deaths that were potentially caused by COVID-19 whether or not a test was conducted.

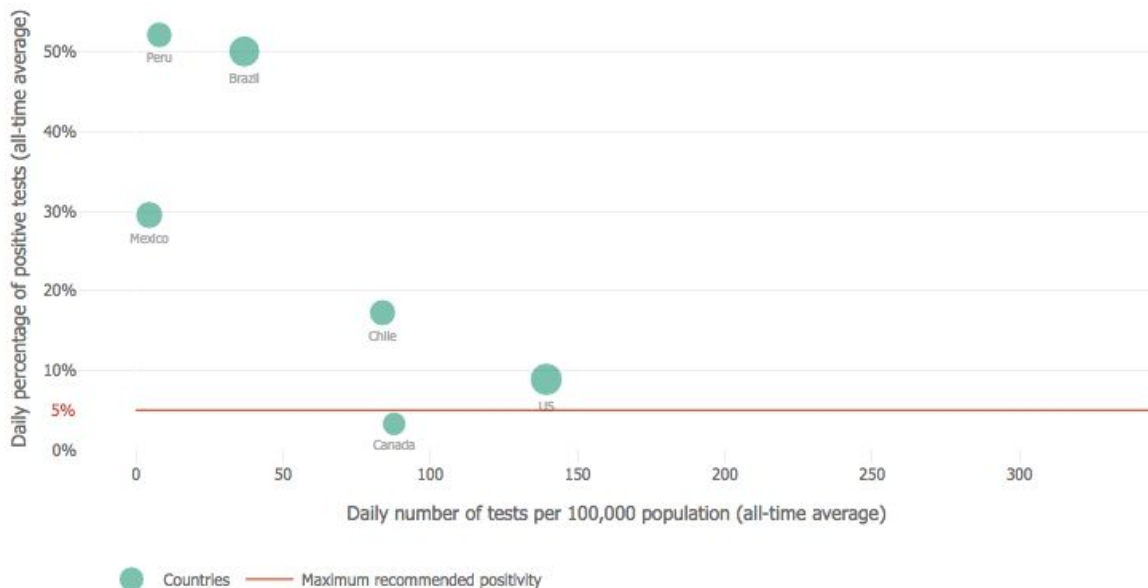Figure 2: Daily Percentage of Positive COVID-19 Tests in the Western Hemisphere

Figure 2 plots the daily percentage of positive tests in the Western hemisphere. Brazil has the second-highest percentage of positive tests in the world at 50.07% daily positive rate suggesting that Brazil has only been testing people who most likely have the virus. Brazil is under testing its population and this is likely resulting in a lower case fatality rate. Although the U.S. leads the world in the number of confirmed COVID-19 cases and deaths, its daily percentage of positive tests is 8.87% suggesting they are conducting more tests than Brazil.

Figure 3: Projected COVID-19 Deaths in Brazil by December 1st
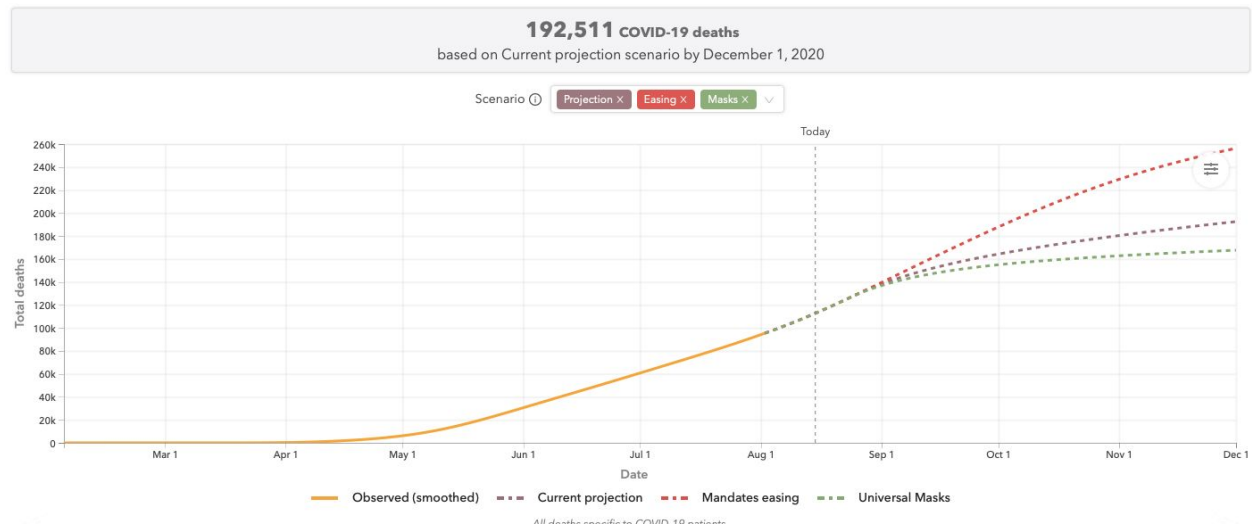

Figure 3 The Institute for Health Metrics and Evaluation's current projection indicates that by December 1, 2020, Brazil will have recorded 192,511 COVID-19 related deaths. The institute's projection factoring in ease in mask wearing results in a death toll at 255,574 by December 1, 2020. However, if masks are worn universally, the total number of deaths by December 1 is predicted to reach 167,644. Enforcing mask mandates leads to significantly fewer predicted deaths from COVID-19.

Hospital Resource Use and Future Models

The COVID-19 pandemic is particularly devastating in poorer areas with an economic downturn and limited access to health services. With cases now topping 3 million, Brazil is a representative example of how the virus impacts healthcare and hospital resources in developing countries. For example, clinical and ICU bed availability is a large concern. In Brazil, the majority of the population receives primary care from the SUS, which is the Brazilian public health system.[28] However, the private health sector maintains the majority of the ICU beds, and they rarely help support the state. Brazil has approximately 270,880 hospital beds (clinical and surgical) and 34,464 adult ICU beds, of which 66% and 48% are available for the public SUS, respectively.[29] The World Health Organization (WHO) recommends that there be 1-3 beds per 10,000 inhabitants. 24/26 states meet those requirements, but this data compiles bed availability from both public and private health systems. If the number of ICU beds at SUS/10,000 inhabitants is considered as opposed to the latter, then only 11 states exceed the minimum recommended by the WHO. These statistics express the challenges faced by certain states with a low SUS/10,000 inhabitant ratio, placing them at risk of state collapse. For example, in Amazonas, the local health system is overwhelmed with high death tolls and mass burials. The situation is so dire that victims' bodies have to be temporarily stored in refrigerated containers.

São Paulo, the epicenter of the COVID-19 crisis in Brazil, as well as Rio de Janeiro are also nearing collapse as they approach 100% ICU bed capacity.

Interestingly, there exists a correlation between the lack of clinical and ICU beds and a lack of mechanical ventilators. Macro-regions that have a supply of less than 0.5 mechanical ventilators/10,000 inhabitants are also the same regions with severe bed shortages. In 2019, Brazil had 57,303 ventilators, of which 72% were available to the public SUS. Out of all of the Brazilian states, the mean number of ventilators per 10,000 people is 2. However, this includes the supply available to the private health sector. Only considering the mechanical ventilators accessible to the public SUS would lower the number to 1.65. In spite of the fact that some states do have enough ventilators for their inhabitants, some macro-regions, such as the Litoral Leste/Jaguaribe region, only have a negligible 0.07 ventilators per 10,000 people. Unequal distribution of resources across macro-regions and states is also a contributing factor to Brazil's poor response to the pandemic.

At the state level, a journal article written by Juliane Fonseca Oliveira et al. noted, "Evaluating the Burden of COVID-19 on Hospital Resources in Bahia, Brazil: A Modeling-Based Analysis of 14.8 Million Individuals." explains how Bahia, located in Northeast Brazil, is being disproportionately affected by the Coronavirus due to unequal distribution of hospital and healthcare investments throughout the state.[30] The article describes a variety of simulations performed in order to study the future behavior of disease transmission in the state and the impact rising cases would have on mortality rates and healthcare infrastructure. The research particularly centered around projecting hospitalization requirements at the state-level, and the effect that non-pharmaceutical interventions could have on bed occupancy. In the absence of adequate social distancing measures, researchers modeled that state level availability for clinical and ICU beds would be exhausted by April 23rd. With the maintenance of Bahia's initial level of intervention (from March to May), researchers predicted that ICU and clinical bed availability would be depleted by May 17th. There are many implications to these projections. For one, these figures demonstrate how the lack of hospital resources, such as beds, strain a lesser-developed healthcare system. In addition, the postulations made by the researchers were fairly accurate. The real world, state-level data obtained on May 4th, 2020 shows that 51.5% of clinical beds and 41.7% of ICU beds in Bahia were in use. Just the simple doubling of real-world bed occupancy data would already result in exceeding the availability of clinical and ICU beds in the state, underscoring the burden imposed by COVID-19 on the healthcare system. Also, in Bahia, the SUS/10,000 inhabitant ratio mentioned in the previous paragraph is only 0.64, far lower than the WHO's recommendation of 1-3 beds per 10,000 people. Lastly, the article concentrated on what could be done after the system has already collapsed, and results from a simulation performed showed that when faced with an already collapsed system, only vigorous measures (that reduce the transmission rate by at least 50%) enforced over at least 2 months are capable of re-establishing hospitalization operation capacity. Alternatively, measures capable of reducing disease transmission by at least 75% over a 2-week period can also be enforced to mitigate the devastating effects of the coronavirus.

Even though Brazil, in general, is being hit hard by the pandemic, it is also important to consider what communities within the country are being affected more than others. In particular, indigenous communities in Brazil are dying from COVID-19 at an alarming rate. Across the country, the leaders from the Kayapó (Paulo Paiakan), Kokama (Messias Kokama) and Arara da Volta Grande (José Carlos Ferreira) tribes have succumbed to the disease.[31] Furthermore, while

the indigenous population is being decimated, the Brazilian government is doing little to assist them, such as leaving their lands open to invasion. Many indigenous leaders across the country say that federal government agencies have not provided them with enough support to manage the pandemic, such as universal access to food and healthcare, which are guaranteed by the law.[32] The government has also not taken any measures to keep out non-indigenous people from coming into indigenous territories so that indigenous communities can isolate themselves without the threat of being invaded by land-grabbers. Brazil has over 900,000 indigenous inhabitants, of over 300 different ethnicities. As of July 24th, 2020, there were 7,946 COVID-19 cases and 177 deaths among indigenous tribes according to the PAHO (Pan American Health Organization).[33] However, the number of deaths is estimated to be much higher due to underreporting. Additionally, Brazilian president Jair Bolsonaro has disparaged indigenous communities on multiple occasions. From the beginning of his campaign, he has clearly stated his plans to open the Amazon up for commerce as well as extinguish territorial protections. From the information presented above, it is made apparent that medical racism is a big contributor to the precarious situation in Brazil. The indigenous population is being denied the basic resources needed to be able to function. Another major concern is the hospital location. For the Kokama people, the nearest hospital location is Tabatinga, which is currently overwhelmed with patients. This means that a lot of indigenous inhabitants who flock there to be treated must be deferred to Manaus, 700 miles away. Many indigenous would rather die in their own homes than travel by plane and risk dying far away from their families. A by-product of their fear of being treated at a hospital is no access to ICU or clinical beds, and mechanical ventilators, leaving people afflicted with severe cases more susceptible to death. Without support from Bolsonaro and his administration, it is tragic and unsurprising that indigenous tribes are being disproportionately affected.

Mitigation Efforts

Brazil's mitigation efforts are fragmented and disunited. Because of political turmoil and the regional diversity of Brazil, the country is simultaneously (and inharmoniously–the country has the second-highest number of cases in the world, following only the U.S.) using a plethora of strategies. The most obvious and fatal is the dissonance between President Jair Bolsonaro's blasé denialism and the Health Ministry's attempts at curtailing the virus. The Ministry of Health declared COVID-19 a national public health emergency on February 3, more than three weeks before the first case (on February 25). Between the declaration and the first recorded case, the country's public health agencies and infectious disease labs developed a plan to contain the virus and established molecular diagnostic facilities.[34] However, Bolsonaro's attitude about the virus is that it is not dangerous (dismissing it as a "little flu") that the media politicized, and therefore any measure to contain the virus is "hysterical." Ultimately, Bolsonaro's dismissal of the virus prevailed over the Ministry of Health's preparedness.[35]

Bolsonaro's late March political squabbles with state governments have ultimately failed to change their policies. On March 20, Bolsonaro stripped states of their authority to restrict people's movements and enforce a quarantine. However, the Supreme Court revoked the executive order only four days later. On March 24, he recommended state governments "go back to normal," but 25 out of Brazil's 27 states kept their restrictions. And on March 26, Bolsonaro again tried limiting states' abilities to contain the virus by exempting churches and lottery houses

from state and municipal social distancing requirements, but a federal court ruled that the federal government couldn't restrict state-level social distancing measures.[36] The turmoil and inconsistency within Bolsonaro's government ultimately regionalized the country's response to the pandemic.

Another force of fragmentation for Brazil's mitigation efforts is interstate heterogeneity. The fifth-largest country in the world by area and sixth-largest population, Brazil's regional diversity poses a challenge in combating COVID-19. Borelli and Góes 2020 conducted a theoretical investigation, using a mathematical model of the virus on each state, highlighting behavioral and economic differences like pre-epidemic population, the number of people employed, and hours worked per household. The results revealed that the heterogeneity of states affected the way the pandemic spread. The peak sizes, peak dates, fatality rates, infection rates, and overall arch of the pandemic differed in all the states.[37] If the virus acts differently because of the economic and behavioral characteristics of each state, state governments should take the social distancing and quarantine measures that work specifically for them. Ideally, Brazil should take a top-down/bottom-up approach to the pandemic in which federally collected data and contact tracing inform the social distancing and quarantine policies of state governments.

While a varied set of responses may suit the needs of a country as diverse as Brazil, a centralized (federal) approach is still necessary to contain the pandemic. By damaging any vestige of a centralized system of contact tracing, Bolsonaro botched efforts to collect information on the pandemic and conduct contact tracing. The national Ministry of Health, which would have organized containment efforts nationally, was unable to implement a system of contact tracing (and even actively contain the virus at all) because of a few key Bolsonaro policies.[38] On March 23, Bolsonaro suspended deadlines to provide information to the public on the spread of the virus and the government's response, dismantling any effort at coherent data-collecting to track the spread of the virus.[39] And then on April 16, he fired his Minister of Health, replacing him with an interim military officer. To this day, there is no permanent Health Minister in Brazil. Furthermore, many states don't have the resources to adequately deal with the pandemic. When states are as heterogeneous as they are in Brazil, resources are unequal and sparse in certain regions. The Ministry of Health should be there to fill the void left by the states but are too underfunded.[40]

An additional problem is a socioeconomic bias in testing and diagnosis. Public health organizations underestimate the spread of the virus in areas of low socioeconomic status. These areas suffer from sparse healthcare infrastructure. And while wealthy residents can move to areas with better diagnosis and healthcare, poor Brazilians suffer from the disparate healthcare system. These disparities and Brazil's inadequate data collection limit researchers' ability to determine what is happening with the virus in Brazil, and even where the virus is spreading.[41]

All of the problems in mitigating COVID-19 in Brazil stem from how authoritarian regimes practice public health. While democracies need healthy and thought-provoking criticism of science, Bolsonaro is anti-science and dismisses the notions of 'truth' and 'evidence.' He touts miracle cures while shying away from any type of mitigation effort. He does this because he sees the lives of indigenous Brazilians and residents of favelas as disposable. Worse than government inaction or corruption, Bolsonaro is so reactionary that he will fail to deal with a pandemic because the pandemic cements social inequality. Quarantine, the top-down mitigation approach that was taken by most countries, does not work for favelas (dense low-income urban neighborhoods) that have poor infrastructure. The situation with favelas is so dire that the

Ministry of Health talked to drug traffickers and militias to curtail COVID-19 in these neighborhoods. When the government doesn't give these 'disposable populations' the right to health, they develop their own mutual aid networks. NGOs that had been active in favelas before the pandemic have been working to integrate their pre-COVID-19 work into their response to the pandemic. Instead of opting for a 'culture of survival' (unsustainable short-term goals), non-governmental entities that hold communal and organizational responsibility have opted for the integrative 'health in adversity' approach which will ultimately strengthen the socioeconomic status of favelas. Not only does social inequality determine mitigation response, but the ways in which communities change in response to the pandemic could reshape Brazil's socioeconomic landscape.[42]

Economic Impact

With a nominal gross domestic product (GDP) of US$1.868 trillion in 2019, Brazil is Latin America's largest economy and the world's ninth-largest economy.[43] Brazil is also among the world's top ten emerging markets, which means it is a developing economy with rapid rates of growth as well as an important contribution to global economies. However, Brazil's economy has encountered an unprecedented downturn as the COVID-19 outbreak provokes disruptive economic activity. It is crucial to make an informed assessment of the range of potential impact of COVID-19 on Brazil's GDP, trade, domestic services, fiscal measures, and debt.

During the Jan-March quarter, Brazil's GDP contracted by 1.5 percent – an economic recession resulted by the markedly lower consumer spending and private investment, while the government spending increased to support the economy.[44] In addition, economists forecasted Brazil's economy to shrink 7.6 percent this year and experience a slow economic recovery in 2021.[45] Since Brazil's emerging market becomes more involved with world economies as it grows, the current global recession represents yet another real challenge for Brazil. In April's Trade Forecast Press Conference, World Trade Organization(WTO) estimated world trade to decline by between 13 percent and 32 percent under optimistic scenarios and pessimistic scenarios, respectively.[46] Although WTO expected trade in services to be the most severely hit sector of international trade, trade in services only accounted for approximately 5.6 percent of Brazil's GDP in 2019.[47]Thus, the country's low contribution in services trade suggests that a shrink in this category would have minimal impact on its GDP. Instead, the sharp declines in merchandise trade – a sector that comprised 22.3 percent of GDP in the previous year – may have a greater economic consequence.[48] As a result of travel restrictions, an increase in international trade costs, and complex supply chain disruption, Brazil's merchandise export is expected to drop 7 percent, while its merchandise import is estimated to decrease 2 percent.[49] As such, merchandise will possibly constitute medium economic damage. However, Brazil's GDP to trade ratio in 2019 was 29 percent – a correlation 30 percent lower than that of the world average.[50] This data defines Brazil's relatively closed market. Therefore, the aggregated data implies that vigorous recovery in global trade and output will unlikely lead to a rapid rebound in Brazil's overall economy.

Brazil needs to focus on strengthening its domestic market in order to lay the foundation for strong and effective recovery. Of the three dominant economic sectors, the services industry, also known as the tertiary sector, is the largest and most important sector in Brazil – it contributed 63.3 percent to the GDP last year.[51] Moreover, the service sector employs 71 percent

of Brazil's workforce.[52] With a large share in the country's economic segment, the service sector is a strong indicator of Brazil's current economic climate and a critical determinant in post-pandemic financial recovery. The implementation of fundamental containment measures, including business and school closure as well as social distancing, have devastated service industries that rely heavily on in-person interactions. As businesses face financial constraints, many companies are pushed toward bankruptcy or significantly reduced workforce, which triggers long-term, detrimental effects. For example, data from the Brazililian Institute of Geography and Statistics in May recorded a total unemployment number of 12.85 million Brazilians – the equivalent of 12.2 percent of the population – with 4.9 million people unemployed during the first quarter.[53]

In response to the surge in confirmed cases and economic collapse, Brazil's Ministry of Economy released a package of R$147.3 billion to save the economy on March 16; meanwhile, President Bolsonaro implemented a plan of R$88.2 billion to strength states and municipalities. [54]

To further minimize the economic struggles of unemployed or low-income Brazilians, the Ministry of Economy announced a series of social assistance benefits –including a scholarship of R$200 given to self-employed professionals who do not receive benefits from the Bolsa Familia and Continuous Cash Benefit programs – on March 21.[55] In hopes to provide emergency financial relief to families living below poverty line (defined as $5.50 per day, PPP), the Brazilian government allocated R$3 billion to aid an additional one million families under its anti-poverty Bolsa Familia program.[56] However, about 41 percent of Brazilians living favelas did not receive the promised aid. Although Brazil has one of the most unequal wealth distributions in the world and COVID-19 disproportionately affected low-income communities, the country's increase in social spending and new social protection programs partially prevented inequality levels from rising. As of June 2020, the generosity of Brazil's cash transfers – welfare programs that aim to reduce poverty through direct transfer payments to people who meet sets of criteria – has increased 140 percent from the pre-COVID19 level.[57] These social protection programs effectively minimized the level of severely impoverished – Brazilians earning less than $1.90 a day – to 3.3 percent of the population, the country's lowest number since 2004 and a 3.6 percent decline from the 2019.[58] In addition, the rate of Brazilians living below the poverty line fell to 21.7 percent, a reduction of approximately 4 percent from 2019. However, it is impossible to sustain the expenditure needed to maintain the record low rate of poverty. In the case that Brazil ends their short-term social protection programs, it would ultimately intensify the economic stress of the lower socioeconomic subpopulation.

A fiscal report from the International Monetary Fund predicts Brazil's gross debt to increase from 89.51 percent of GDP (2019) to 98.24 percent of GDP by the end of 2020 (fig. 4).[59] As a result of abnormal economic activity, Brazil's projected real GDP may drop 9.1 percentage points.[60] The debt elevation is a result of the recession, higher government expenditures, and an overall economic fallout. Although shrinkages in trade and GDP are inevitable, the precise economic impact remains uncertain because it directly correlates with the country's further fiscal measures and the unpredictable nature of this public health crisis.

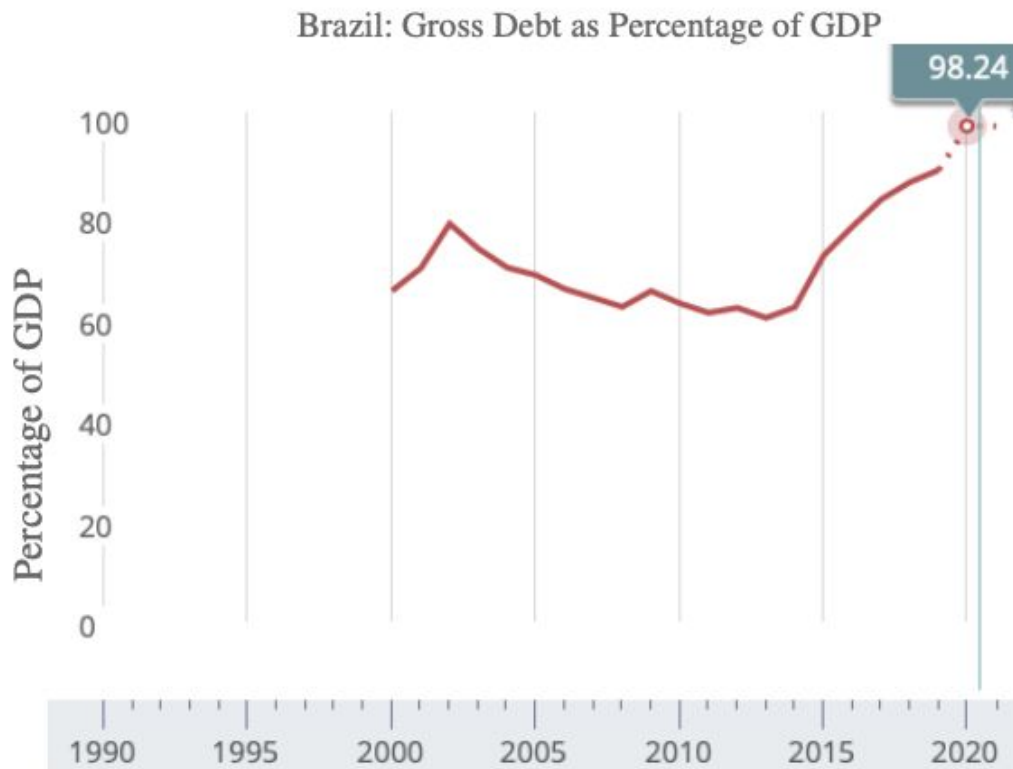Figure 4: A Post-Pandemic Outlook for Brazil's Gross Debt

Figure 4 shows Brazil's real gross debt as a percentage of gross domestic product (GDP) from 2000 to 2020(Q1) in addition to a projected statistic for December 2020. According to the graph, Brazil's gross debt was approximately 89.51% of GDP in 2019, but this number is expected to rise to 98.24 % of GDP by the end of 2020. While the trend from the last five years outlines a slower annual growth rate in gross debt, the projection indicates a dramatic increase in gross debt, which suggests that Brazil's economy will likely worsen.

Treatment and Vaccine Development

In mid-April, the Covid-19 rate in Brazil started to reach higher numbers in the thousands. As of August, there has been a total of at least 3.3 million cases of the virus. While Brazil has been hit particularly hard by COVID-19, second only to the United States, it is in critical stages of vaccine development. However, Brazil has been making an effort to discover a vaccine to control the virus. A lot of research is being done, and multiple vaccine trials are starting to take place in Brazil. In fact, Brazil initiated three ongoing vaccine studies that are evaluated as among the most promising in the world.[61] Brazil is a good testing ground due to the virus still being widespread in the country. The high volumes of COVID-19 patients mean that there will be a large number of volunteers; the higher the number of volunteers, the higher the chance to improve the effectiveness of the vaccine.[62] In addition to the growing number of

COVID-19 cases, Brazil is already the primary global producer for the yellow fever vaccine, making this country globally renowned for its vaccine expertise.[63] These conditions caused Brazil to become the ideal development site for to COVID-19 vaccine.

There are currently two vaccines that have reached phase 3 in the world, two of which are being developed in Brazil. The first of these vaccines was developed by Oxford University in collaboration with AstraZeneca labs. The technical name of this vaccine is ChAdOx1 nCoV-19. ChAdOx1 is a non-replicating common cold vaccine, which was the foundation for this vaccine. ChAdOx1 nCoV-19 is currently being tested on 5000 volunteers at an undisclosed location in Rio de Janeiro, São Paulo.[64] Prior to this, the vaccine has already been tested on animals and smaller groups of people, showing promising results. While this vaccine entered its final phase on July 27, less than a month ago, the Brazilian government is already discussing the production of millions of doses with AstraZeneca.[65] President Bolsanaro has set aside $360 million for a licensing deal with AstraZeneca. These funds will be able to cover up to 100 million doses of the vaccine if proven to be successful. However, at the beginning of the trial, the deal was to provide up to 30 million doses of the vaccine. It has also been said that if the vaccine works, then an additional 70 million vaccines will be produced by this company. The second major vaccine being developed in Brazil was created by China's Sinovac Biotech. Sinovac Biotech is working in partnership with the Brazilian public health center, the Butantan Institute. The vaccine is called CoronaVac. Much like the Oxford vaccine, the Sinovac vaccine entered phase 3 of clinical trials relatively recently, on June 21. 9000 health care workers will receive this vaccine, and the results of this stage are due in 90 days.[66] If the vaccine proves to be effective, the Butantan institute will have the right to produce 120 million doses. In addition to these two vaccines, Brazilian health regulators recently announced that they have approved phase 1,2, and 3 of two new vaccines being developed by Pfizer and BioNTech.[67]

Despite the fight for the right vaccination and on-going trials, Brazil's president Jair Bolsonaro has had controversial responses to the pandemic. Bolsonaro endorsed hydroxychloroquine even when he tested positive for COVID-19.[68] Even though there is no evidence of it working or benefiting anyone in any way, he continues to promote it to Brazil's inhabitants. Additionally, in a recent Facebook Live, he told his followers that a COVID-19 vaccination will not be mandatory once they become available.[69] It will solely be one's choice. While a few have agreed with Bolsonaro and expressed that it is not in the law to require vaccination from COVID-19, many have chosen to disagree with Bolsonaro, arguing that vaccines are necessary to put an end to COVID-19. Aside from these disagreements, a Brazilian technology company announced that they expect to produce the controversial Russian vaccine by mid 2021.[70]

The number of vaccines being developed in Brazil has caused Brazilian officials to become optimistic about their chances of becoming the first country to develop a working vaccine. In fact, they claim that they can finish developing vaccines within a year. However, experts say it will take at least twice as long to develop.[71] When AstraZeneca and Sinovac agreed to develop a vaccine, they promised the Brazilian government and the Sao Paulo state government tens of millions of doses of their respective vaccines and pledged to transfer technology so that Brazil could have the capacity to produce the vaccine domestically in cites such as Fiocruz, in Rio de Janeiro, and Butantan, in São Paulo. These institutions claim that they can produce new vaccines by 2021 with the help of 1.9 billion reals, 355 million dollars, that Brazil's federal government said it would invest in order to produce the AstraZeneca vaccine.[72]

Despite how renowned Brazil's research institute is, its public healthcare system has suffered in recent years, experiencing budget cuts and also fighting against the spread of misinformation. These experiences were so detrimental that 2019 was the first time in 25 years where Brazil didn't fulfill its vaccination goal for any of the shots it routinely administers. Money alone is not enough; experts believe that this process could take up to 10 years due to the difficulty of transferring technology and the underinvestment of the facilities. If Brazil's institutions are unable to meet their goals, not only would that mark yet another failure in President Bolsonaro's efforts to combat the virus, but it would also cause Brazil vulnerable and in desperate need of medical supplies[73].

Conclusion

COVID-19 impacted Brazil in numerous ways. The high infection rate and death toll are due to a plethora of factors: clinical and ICU bed shortages in certain Brazilian states, unequal distribution of mechanical ventilators throughout different macro-regions, as well the refusal of Brazilian president Jair Bolsonaro and his administration to provide proper resources to the indigenous population to combat the pandemic. There are also ethnic and socioeconomic factors that play into the survival rate of different inhabitants; for example, White Brazilians are more likely to survive the disease than Black Brazilians. In addition to socioeconomic inequalities, mitigation efforts made in order to curb disease spread by the Ministry of Health and Bolsonaro have been drastically different: even though the Ministry of Health declared a national emergency weeks before the first case, Bolsonaro has consistently minimized and dismissed the severity of the virus. COVID-19 in Brazil has also impacted the economy. The pandemic has caused an economic recession, and sharp declines in merchandise trade may have a significant impact on Brazil's GDP in 2020. Since the country cannot minimize both death toll and economic impact, Bolsonaro is determined to prioritize economic damage over the lives of Brazilians – this decision further deepens pre-existing inequities. Yet, Brazil's reopening in disregard of record COVID-19 cases and insufficient protection will only exacerbate the pessimistic scenarios. Despite the fact that Brazil is struggling, however, it is in critical stages of vaccine development, with 2 vaccines currently in phase 3.

Bolsonaro's response to the pandemic has consisted of denial, praise for unsupported treatments, and resistance to advice from scientists. Bolsonaro has repeatedly tried to draw attention away from COVID-19 to an issue that he believes needs to be addressed: unemployment. Bolsonaro has attempted to convince residents that unemployment will lead to chaos. Many believe he aims to strengthen the economy in hopes of being re-elected in 2022. Despite having contracted COVID-19, Bolsonaro continues to dismiss the severity of the pandemic and shows no interest in changing his policies to better protect Brazilians. As a result, the legislative and judicial branches, as well as the Federal Supreme Court, have been responsible for enforcing preventative measures in hopes of keeping its citizens safe.[74]

Bolsanoro's authoritarianism in addition to the lack of public health governance has accelerated the damage of the pandemic on marginalized populations, namely Black Brazilians of lower socioeconomic status and Indigenous people. The reality is that approximately 11 million impoverished Brazilians live in favelas where access to recurrent water, basic sanitation, and social rights are not guaranteed.[75] How can a suspected patient of COVID-19 isolate when

the entire family shares a single room? As a result, the death rate from COVID-19 is 2.4 percent in a wealthy neighborhood in Rio de Janeiro, while it is 30.8 percent in the city's northern favelas.[76] This research demonstrates a similar phenomenon among the 16 million Black residents of quilombos who are particularly vulnerable due to marginalization, structural racism, absence of policies, and lack of access to medical services.[77] These deep-rooted inequalities, mostly predating the pandemic, are reflected in the higher death rate for Black Brazilians when compared to white Brazilians despite their similar rates of hospitalization in São Paulo.

Not only is Bolsonaro's government responsible for Brazil's mounting death toll in communities that received insufficient fundings and lacked adequate health care, but it also complicates environmental conservation efforts in the Amazon. Even prior to the pandemic, Bolsonaro's open racist invective against Indigenous groups and aggressive environmental policies[78] have escalated Brazil's Amazon deforestation and threatened the Indigenous people living in the Amazon. Now, in the midst of the coronavirus pandemic, illegal mining and logging operations have already increased the destruction of the Amazon rainforest in April by 64% compared to the same month a year ago.[79] As illegal invaders take advantage of depleted workforce agents and quarantine, they also expose Indigenous residents – many of whom face greater immunological vulnerability and are isolated from medical facilities – in the Amazon region to COVID-19. The government's failure to mitigate the effects of COVID-19 on Indigenous Brazilian populations has been called an "extermination" or "genocide" because of the death of tribal elders and the damage done to tribal culture.[80] The state's inadequate response poses another challenge for Brazil in the future because the country will have to address many of the struggles Indigenous Brazilians are facing. In spite of absent government actions, Indigenous communities, as well as Black Brazilians, have adopted local initiatives to execute containment measures. From drug traffickers to local non-governmental organizations, mutual aid networks enforce disease control, distribute food, supply personal protective equipment, and create sanitary barriers.[81] Although WHO guidelines advised countries to implement a top-down strategy and a series of public health measures – 1) require personal protective equipment; 2) diagnose patients using real-time polymerase chain reaction and social distance; 3) manage contact tracing[82] – the same mitigation policies are currently unfeasible in parts of Brazil. However, the alternative grass-rooted community activism represents the resilience and health in adverse attitudes of local Brazilians in response to the pandemic.

If the projection model is accurate, Brazil will lose 174,104 people to COVID-19 by January 1, 2021, according to estimates. However, Bolsonaro wants people to go back to work and ease mask usage, which would ultimately result in the death of 177,090 Brazilians. Even if Brazil adopts stricter policies such as a universal mask mandate, 160,566 Brazilians will die.[83] In the future, Brazil should take a top-down bottom-up approach to its mitigation approach, meaning that states will make decisions about phasing out quarantine using federally collected data and contact tracing. Because some Brazilian regions don't have the resources to adequately deal with the pandemic, the federal government should be stepping in and helping those regions. Finally, Brazil needs to focus on its favelas and the Amazonas region. These are both poor areas that are hotbeds for COVID-19, and where the virus is most dangerous.

This research contains a few limitations that surfaced and led to a less accurate number of predictions. Firstly, the model predicts possible outcomes but does not consider additional social and environmental variables. In addition, Brazil is a large heterogeneous country – not all states are being hit by COVID-19 in the same way. The research focuses on an overview of Brazil's

mismanagement as a whole country rather than individual Brazilian states and how each state manages the circumstances based on local COVID-19 cases and statewide economic structure. Although the research identifies several variables that contributed to the disproportionate effect of COVID-19 on lower socioeconomic groups and racial minorities, the scarcity of disaggregated data in the context of sociodemographic and ethnicity factors – for example, wealthy white Brazilians in one neighborhood versus Indigenous populations in another part of the same state – hampers potential neighborhood-based analysis of the disproportionate effect of COVID-19 on socio-racial minorities. It is beyond the scope of this research to investigate the influence of genetic compositions and phenotypic expressions on the variability of COVID-19 cases in each region. Therefore, future studies can further examine genetic data by region to determine how genetic diversity contributes to the phenotype response to COVID-19 – the study of genetic expression on multiracial and Indigenous individuals with severe COVID-19 may advance vaccine development.

Acknowledgements

Bibliography

1. Rodriguez-Morales AJ;Gallego V;Escalera-Antezana JP;Méndez CA;Zambrano LI;Franco-Paredes C;Suárez JA;Rodriguez-Enciso HD;Balbin-Ramon GJ;Savio-Larriera E;Risquez A;Cimerman S;, Alfonso J., et al. "COVID-19 in Latin America: The Implications of the First Confirmed Case in Brazil." *Travel Medicine and Infectious Disease*, U.S. National Library of Medicine, 2020, pubmed.ncbi.nlm.nih.gov/32126292/.

2. Johns Hopkins University. "Brazil." *Coronavirus Resource Center*, Johns Hopkins University & Medicine, 2020. www.coronavirus.jhu.edu/region/brazil.

3. Marson, Fernando, and Manoela Ortega. "COVID-19 in Brazil." *Pulmonology*, vol. 26, no. 4, 2020, pp. 241–244., doi:10.1016/j.pulmoe.2020.04.008.

4. Marson, Fernando, and Manoela Ortega. "COVID-19 in Brazil." *Pulmonology*, vol. 26, no. 4, 2020, pp. 241–244., doi:10.1016/j.pulmoe.2020.04.008.

5. Boccia, Stefania, et al. "What Other Countries Can Learn From Italy During the COVID-19 Pandemic." *JAMA Internal Medicine*, vol. 180, no. 7, 2020, p. 927., doi:10.1001/jamainternmed.2020.1447.

6. Victoria Cesar, "Socioeconomic inequalities in Health: Reflections on the academic production from Brazil." *International Journal of Equity in Health* 15, no. 164 (2016). https://www.ncbi.nlm.nih.gov/pmc/articles/PMC5112632/

7. de Azevedo Barros, M.B., Lima, M.G., Medina, L.d. *et al.* Social inequalities in health behaviors among Brazilian adults: National Health Survey, 2013. *Int J Equity Health* 15, 148 (2016). https://doi.org/10.1186/s12939-016-0439-0

8. Urban, Mariana; Saad-Diniz, Eduardo. "Why Brazil's COVID-19 Response is Failing." The Regulatory Review, 22 July 2020. https://www.theregreview.org/2020/06/22/urban-saad-diniz-brazil-covid-19-response-failing/

9. Lotta, Gabriela, et al. "Community Health Workers Reveal COVID-19 Disaster in Brazil." *The Lancet*, vol. 396, no. 10248, 10 July 2020, pp. 365–366., doi:10.1016/s0140-6736(20)31521-x.

10. Ortega, Francisco, and Michael Orsini. "Governing COVID-19 without Government in Brazil: Ignorance, Neoliberal Authoritarianism, and the Collapse of Public Health Leadership." *Global Public Health*, vol. 15, no. 9, 14 July 2020, pp. 1257–1277., doi:10.1080/17441692.2020.1795223.

11. Barberia, Lorena G, and Eduardo J Gómez. "Political and Institutional Perils of Brazil's COVID-19 Crisis." *The Lancet*, vol. 396, no. 10248, 30 July 2020, pp. 367–368., doi:10.1016/s0140-6736(20)31681-0.

12. Londono, Ernesto. "Furious Backlash in Brazil After Ministry Withholds Coronavirus Data." *New York Times*, 8 June 2020, www.nytimes.com/2020/06/08/world/americas/brazil-coronavirus-statistics.html.

13. "New Cases of COVID-19 In World Countries." *Johns Hopkins Coronavirus Resource Center*, coronavirus.jhu.edu/data/new-cases.

14. "COVID-19 Map." *Johns Hopkins Coronavirus Resource Center*, coronavirus.jhu.edu/map.html.

15. Ritchie, Hannah, et al. "Mortality Risk of COVID-19 - Statistics and Research." *Our World in Data*, 16 Aug. 2020, ourworldindata.org/mortality-risk-covid.

16. " Brazil." *Worldometer*, www.worldometers.info/coronavirus/country/brazil/.

17. "How Does Testing in the U.S. Compare to Other Countries?" *Johns Hopkins Coronavirus Resource Center*, coronavirus.jhu.edu/testing/international-comparison.

18. "How Does Testing in the U.S. Compare to Other Countries?" *Johns Hopkins Coronavirus Resource Center*, coronavirus.jhu.edu/testing/international-comparison.

19. Spychalski, Piotr, et al. "Estimating Case Fatality Rates of COVID-19." *The Lancet Infectious Diseases*, vol. 20, no. 7, 31 Mar. 2020, pp. 774–775., doi:10.1016/s1473-3099(20)30246-2.

20. Baqui, Pedro, et al. "Ethnic and Regional Variation in Hospital Mortality from COVID-19 in Brazil." *SSRN Electronic Journal*, vol. 8, no. 8, 2 July 2020, doi:10.2139/ssrn.3606429.

21. Associated Press. "Brazil Government Yanks Virus Death Toll As Data Befuddles Experts ." *Voice of America*, 7 June 2020, www.voanews.com/covid-19-pandemic/brazil-government-yanks-virus-death-toll-data-befuddles -experts.

22. Associated Press. "Brazil Government Yanks Virus Death Toll As Data Befuddles Experts ." *Voice of America*, 7 June 2020, www.voanews.com/covid-19-pandemic/brazil-government-yanks-virus-death-toll-data-befuddles -experts.

23. Londono, Ernesto. "Furious Backlash in Brazil After Ministry Withholds Coronavirus Data." *New York Times*, 8 June 2020, www.nytimes.com/2020/06/08/world/americas/brazil-coronavirus-statistics.html.

24. Marinho, Fatima, et al. "Excess Mortality in Brazil: A Detailed Description of Trends in Mortality During the COVID-19 Pandemic." *Vital Strategies*, 28 July 2020, www.vitalstrategies.org/excess-mortality-in-brazil-a-detailed-description-of-trends-in-mortality- during-the-covid-19-pandemic/.

25. Tang, Yuanji, et al. "Epidemiology of COVID-19 in Brazil: Using a Mathematical Model to Estimate the Outbreak Peak and Temporal Evolution." *Emerging Microbes & Infections*, vol. 9, no. 1, 1 July 2020, pp. 1453–1456., doi:10.1080/22221751.2020.1785337.

26. Baqui, Pedro, et al. "Ethnic and Regional Variation in Hospital Mortality from COVID-19 in Brazil." *SSRN Electronic Journal*, vol. 8, no. 8, 2 July 2020, doi:10.2139/ssrn.3606429.

27. "IHME: COVID-19 Projections." *Institute for Health Metrics and Evaluation*, 16 Aug. 2020, covid19.healthdata.org/united-states-of-america.

28. Palamim, C.V.C. and Marson, F.A.L., 2020. COVID-19 – The Availability of ICU Beds in Brazil during the Onset of Pandemic. *Annals of Global Health*, 86(1), p.100. DOI: http://doi.org/10.5334/aogh.3025

29.   Noronha, K., Guedes, G., Turra, C., Andrade, M., Botega, L., Nogueira, D., Calazans, J., Carvalho, L., Servo, L. and Ferreira, M., 2020. *Pandemia Por COVID-19 No Brasil: Análise Da Demanda E Da Oferta De Leitos Hospitalares E Equipamentos De Ventilação Assistida Segundo Diferentes Cenários*, ttps://www.scielo.br/scielo.php?script=sci_arttext&pid=S0102-311X2020000605004&lng=pt&tlng=en

30. Juliane Fonseca Oliveira, Daniel C. P. Jorge, Rafael V. Veiga, Moreno S. Rodrigues, Matheus F. Torquato, Nivea B. da Silva, Rosemeire L. Fiaconne, Caio P. Castro, Aureliano S. S. Paiva, Luciana L. Cardim, Alan A. S. Amad, Ernesto A. B. F. Lima, Diego S. Souza, Suani T. R. Pinho, Pablo I. P. Ramos, Roberto F. S. Andrade, Rede CoVida Modelling Task-force. *Evaluating the burden of COVID-19 on hospital resources in Bahia, Brazil: A modelling-based analysis of 14.8 million individuals.* medRxiv 2020.05.25.20105213; doi: https://doi.org/10.1101/2020.05.25.20105213

31. Scherer, G., 2020. *Brazil'S Indigenous Hit Especially Hard By COVID-19: Why So Vulnerable?*. [online] Mongabay Environmental News. Available at: <https://news.mongabay.com/2020/06/brazils-indigenous-hit-especially-hard-by-covid-19-why-so-vulnerable/>

32.   Castro, M., 2020. *How Bolsonaro Has Left Brazil's Indigenous People Vulnerable In The Pandemic*. [online] Vox. Available at: <https://www.vox.com/world/21273709/brazil-coronavirus-indigenous-people-covid-19-amazonas>

33. Gamba, L., 2020. *Coronavirus Hitting Indigenous Tribes Hard In Brazil*. [online] Aa.com.tr. Available at: <https://www.aa.com.tr/en/americas/coronavirus-hitting-indigenous-tribes-hard-in-brazil-/1920595#:~:text=7%2C946%20COVID%2D19%20cases%2C%20177,Brazil%2C%20according%20to%20health%20group&text=The%20coronavirus

34. De Souza, Miguel Marciel; Bess, Lewis Fletcher; Faria, Nuno Rodrigues. "Epidemiological and clinical characteristics of the COVID-19 epidemic in Brazil." *Nature Human Behavior* 4, 856-865(2020). https://www.nature.com/articles/s41562-020-0928-4

35. Human Rights Watch. "Brazil: Bolsonaro Sabotages Anti-Covid-19 Efforts." Human Rights Watch, 10 April 2020. https://www.hrw.org/news/2020/04/10/brazil-bolsonaro-sabotages-anti-covid-19-efforts

36. Human Rights Watch. "Brazil: Bolsonaro Sabotages Anti-Covid-19 Efforts." Human Rights Watch, 10 April 2020. https://www.hrw.org/news/2020/04/10/brazil-bolsonaro-sabotages-anti-covid-19-efforts

37. Boreli, Luan; Goes, Geraldo. "Interstate heterogeneity and combatting COVID-19 in Brazil." Vox EU, 1 July 2020.
https://voxeu.org/article/interstate-heterogeneity-and-combatting-covid-19-brazil

38. Urban, Mariana; Saad-Diniz, Eduardo. "Why Brazil's COVID-19 Response is Failing." The Regulatory Review, 22 July 2020.
https://www.theregreview.org/2020/06/22/urban-saad-diniz-brazil-covid-19-response-failing/

39. Human Rights Watch. "Brazil: Bolsonaro Sabotages Anti-Covid-19 Efforts." Human Rights Watch, 10 April 2020.
https://www.hrw.org/news/2020/04/10/brazil-bolsonaro-sabotages-anti-covid-19-efforts

40. Urban, Mariana; Saad-Diniz, Eduardo. "Why Brazil's COVID-19 Response is Failing." *The Regulatory Review*, 22 July 2020.
https://www.theregreview.org/2020/06/22/urban-saad-diniz-brazil-covid-19-response-failing/

41. De Souza, Miguel Marciel; Bess, Lewis Fletcher; Faria, Nuno Rodrigues. "Epidemiological and clinical characteristics of the COVID-19 epidemic in Brazil." *Nature Human Behavior* 4, 856-865(2020). https://www.nature.com/articles/s41562-020-0928-4

42. Ortega, Francisco, and Michael Orsini. "Governing COVID-19 without Government in Brazil: Ignorance, Neoliberal Authoritarianism, and the Collapse of Public Health Leadership." *Global Public Health*, vol. 15, no. 9, 2020, pp. 1257–1277., doi:10.1080/17441692.2020.1795223.

43. World Bank. "Brazil." World Development indicators. *World Bank Group,* 2020, https://data.worldbank.org/country/brazil.

44. Schipani, Andres. "Brazil's First-Quarter GDP Falls 1.5% as Covid-19 Cases Climb." *Financial Times*, 29 May 2020, www.ft.com/content/d0461a1f-84be-4704-91f6-da02d792a810.

45.   Schipani, Andres. "Brazil's First-Quarter GDP Falls 1.5% as Covid-19 Cases Climb." *Financial Times*, 29 May 2020, www.ft.com/content/d0461a1f-84be-4704-91f6-da02d792a810.

46. Azevêdo, DG. "Trade Set to Plunge as COVID-19 Pandemic Upends Global Economy." *World Trade Organization*, 8 Apr. 2020, www.wto.org/english/news_e/pres20_e/pr855_e.htm.

47. Azevêdo, DG. "Trade Set to Plunge as COVID-19 Pandemic Upends Global Economy." *World Trade Organization*, 8 Apr. 2020, www.wto.org/english/news_e/pres20_e/pr855_e.htm.

48. Azevêdo, DG. "Trade Set to Plunge as COVID-19 Pandemic Upends Global Economy." *World Trade Organization*, 8 Apr. 2020, www.wto.org/english/news_e/pres20_e/pr855_e.htm.

49. Azevêdo, DG. "Trade Set to Plunge as COVID-19 Pandemic Upends Global Economy." *World Trade Organization*, 8 Apr. 2020, www.wto.org/english/news_e/pres20_e/pr855_e.htm.

50. World Bank. "Brazil." World Development indicators. *World Bank Group,* 2020, https://data.worldbank.org/country/brazil.

51. World Bank. "Brazil." World Development indicators. *World Bank Group,* 2020, https://data.worldbank.org/country/brazil.

52. Trading Economics. "Brazil GDP From Services 1996-2020." *Trading Economics*, July 2020, tradingeconomics.com/brazil/gdp-from-services.

53. IBEG."Dashboard of Indicators." *Instituto Brasileiro de Geografia e Estatística*, 2020, www.ibge.gov.br/en/indicators.html.

54. Martello, Alexandro. "Coronavírus: Governo Anuncia Pacote De R$ 85,8 Bilhões Para Estados e Municípios." *Economia*, 23 Mar. 2020, g1.globo.com/economia/noticia/2020/03/23/coronavirus-governo-anuncia-pacote-de-r-858-bilho es-para-estados-e-municipios.ghtml.

55. Folha De S.,Paulo. "Contra Pandemia, Governo Vai Distribuir R$ 200 Para Trabalhadores Informais." *UOL*,19 Mar. 2020, www1.folha.uol.com.br/mercado/2020/03/contra-pandemia-governo-vai-distribuir-r-200-para-tra balhadores-informais.shtml.

56. Gentilini, Ugo; Almenfi, Mohamed Bubaker Alsafi; Dale, Pamela; Lopez, Ana Veronica; Mujica Canas, Ingrid Veronica; Cordero, Rodrigo Ernesto Quintana; Zafar, Usama. "Social Protection and Jobs Responses to COVID-19 : A Real-Time Review of Country Measures" COVID-19 Living Paper Washington, D.C. *World Bank Group*, 12 June 2020.
57. Gentilini, Ugo; Almenfi, Mohamed Bubaker Alsafi; Dale, Pamela; Lopez, Ana Veronica; Mujica Canas, Ingrid Veronica; Cordero, Rodrigo Ernesto Quintana; Zafar, Usama. "Social Protection and Jobs Responses to COVID-19 : A Real-Time Review of Country Measures" COVID-19 Living Paper Washington, D.C. *World Bank Group*, 12 June 2020.

58. The Brazilian Report. "Coronavirus Aid Sees Brazil's Poverty Rates Drop to Lowest Level Since 2004." *Wilson Center*, 14 Aug. 2020, www.wilsoncenter.org/blog-post/coronavirus-aid-sees-brazils-poverty-rates-drop-lowest-level-2 004.

59. International Monetary Fund. "Brazil."*Brazil and the IMF*, 2020, www.imf.org/en/Countries/BRA.60. International Monetary Fund. "Brazil."*Brazil and the IMF*, 2020, www.imf.org/en/Countries/BRA.

61. Blankenship, Kyle. "AstraZeneca Bumps up Vaccine Deal with Brazil to $360M with More Doses, Licensing Rights." FiercePharma, 11 Aug. 2020, www.fiercepharma.com/manufacturing/astrazeneca-bumps-up-vaccine-deal-brazil-to-360m-mor e-doses-licensing-rights.

62. Andreoni, Manuela, and Ernesto Londoño. "Coronavirus Crisis Has Made Brazil an Ideal Vaccine Laboratory." The New York Times, The New York Times, 15 Aug. 2020, www.nytimes.com/2020/08/15/world/americas/brazil-coronavirus-vaccine.html.

63. Genot, Louis. "Brazil to Become Testing Ground for Coronavirus Vaccine." Medical Xpress - Medical Research Advances and Health News, Medical Xpress, 7 July 2020, medicalxpress.com/news/2020-07-brazil-ground-coronavirus-vaccine.html.

64. Susin, Photograph by Mauricio. "Oxford Vaccine Enters Final Phase of COVID-19 Trials. Here's What Happens Now." National Geographic, 27 July 2020, www.nationalgeographic.com/science/2020/07/oxford-vaccine-enters-final-phase-of-covid-19-trials-in-brazil-cvd/.www.nationalgeographic.com/science/2020/07/oxford-vaccine-enters-final-phase-of-covid-19-trials-in-brazil-cvd/.

65. "Investigational ChAdOx1 NCoV-19 Vaccine Protects Monkeys against COVID-19 Pneumonia." National Institutes of Health, U.S. Department of Health and Human Services, 15 May 2020, www.nih.gov/news-events/news-releases/investigational-chadox1-ncov-19-vaccine-protects-monkeys-against-covid-19-pneumonia.

66. Almeida, Nelson. "Chinese COVID-19 Vaccine Starts Final Tests In Brazil." Barron's, Barrons, 21 July 2020, www.barrons.com/news/chinese-covid-19-vaccine-starts-final-tests-in-brazil-01595362806.

67. McCoy, Terrence. "Brazil, Ravaged by the Coronavirus, Becomes Key Testing Ground for Vaccine." The Washington Post, WP Company, 2 July 2020, www.washingtonpost.com/world/the_americas/brazil-oxford-astrazeneca-sinovac-coronavirus-vaccine-trials/2020/07/01/53db68fa-bad0-11ea-80b9-40ece9a701dc_story.html.

68. Andreoni, Manuela, and Ernesto Londoño. "Coronavirus Crisis Has Made Brazil an Ideal Vaccine Laboratory."

69. Reuters. "Brazil's Bolsonaro Says COVID-19 Vaccinations Won't Be Mandatory." NBCNews.com, NBCUniversal News Group, 4 Sept. 2020, www.nbcnews.com/news/latino/brazil-s-bolsonaro-says-covid-19-vaccinations-won-t-be-n1239298.

70. Limited, Bangkok Post Public Company. "Chinese Covid-19 Vaccine Starts Final Tests in Brazil." Https://Www.bangkokpost.com, www.bangkokpost.com/world/1955559/chinese-covid-19-vaccine-starts-final-tests-in-brazil.

71. Limited, Bangkok Post Public Company. "Chinese Covid-19 Vaccine Starts Final Tests in Brazil." Https://Www.bangkokpost.com, www.bangkokpost.com/world/1955559/chinese-covid-19-vaccine-starts-final-tests-in-brazil.

72.   Limited, Bangkok Post Public Company. "Chinese Covid-19 Vaccine Starts Final Tests in Brazil." Https://Www.bangkokpost.com, www.bangkokpost.com/world/1955559/chinese-covid-19-vaccine-starts-final-tests-in-brazil.

73.   McCoy, Terrence. "Brazil, Ravaged by the Coronavirus, Becomes Key Testing Ground for Vaccine."

74. Barberia, Lorena G, and Eduardo J Gómez. "Political and Institutional Perils of Brazil's COVID-19 Crisis." *The Lancet*, vol. 396, no. 10248, 30 July 2020, pp. 367–368., doi:10.1016/s0140-6736(20)31681-0.

75. Ortega, Francisco, and Michael Orsini. "Governing COVID-19 without Government in Brazil: Ignorance, Neoliberal Authoritarianism, and the Collapse of Public Health Leadership." *Global Public Health*, vol. 15, no. 9, 2020, pp. 1257–1277., doi:10.1080/17441692.2020.1795223.

76. Ortega, Francisco, and Michael Orsini. "Governing COVID-19 without Government in Brazil: Ignorance, Neoliberal Authoritarianism, and the Collapse of Public Health Leadership." *Global Public Health*, vol. 15, no. 9, 2020, pp. 1257–1277., doi:10.1080/17441692.2020.1795223.

77. Ortega, Francisco, and Michael Orsini. "Governing COVID-19 without Government in Brazil: Ignorance, Neoliberal Authoritarianism, and the Collapse of Public Health Leadership." *Global Public Health*, vol. 15, no. 9, 2020, pp. 1257–1277., doi:10.1080/17441692.2020.1795223.

78. Roberton, Jamie, and Lorand Bodo. "Deforestation of the Amazon Has Soared under Cover of the Coronavirus." *NBCNews.com*, NBCUniversal News Group, 11 May 2020, www.nbcnews.com/science/environment/deforestation-amazon-has-soared-under-cover-coronavirus-n1204451.

79. Simon, Evan, and Aicha Hammar Castano. "Deforestation of Amazon Rainforest Accelerates amid COVID-19 PandemicEvan." *ABC News*, ABC News Network, 6 May 2020, abcnews.go.com/International/deforestation-amazon-rainforest-accelerates-amid-covid-19-pandemic/story?id=70526188

80. Phillips, Dom. "'We are facing extermination': Brazil is losing a generation of indigenous leaders to Covid-19." *The Guardian*, 21 June 2020, https://www.theguardian.com/global-development/2020/jun/21/brazil-losing-generation-indigenous-leaders-covid-19

81. Ortega, Francisco, and Michael Orsini. "Governing COVID-19 without Government in Brazil: Ignorance, Neoliberal Authoritarianism, and the Collapse of Public Health Leadership." *Global Public Health*, vol. 15, no. 9, 2020, pp. 1257–1277., doi:10.1080/17441692.2020.1795223.

82. Marson, Fernando, and Manoela Ortega. "COVID-19 in Brazil." *Pulmonology*, vol. 26, no. 4, 2020, pp. 241–244., doi:10.1016/j.pulmoe.2020.04.008.

83. Institute for Health Metrics and Evaluation. "COVID-19 Projections: Brazil." Accessed September 3 2020. https://covid19.healthdata.org/brazil?view=total-deaths&tab=trend