The Protective Effects of Universal Healthcare on the Spread and Containment of COVID-19

By

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To my parents, for your everlasting love and support

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Introduction

The COVID-19 pandemic has spread across the entire global community, serving as a stress test on existing healthcare systems around the world. Since the initial outbreak of COVID-19 in late-December 2019, countries have struggled to contain this highly infectious virus, with over 109 million cases and 2.4 million deaths globally as of mid-February 2021.[1] This ongoing global health crisis has occurred during an increased international effort to expand universal healthcare (UHC) around the world. A universal healthcare system would allow for the entirety of a country's population to have access to high quality and financially affordable healthcare. However, currently over half of the world's population does not have access to universal healthcare, including in both low and high-income countries.[2] It is expected that higher levels of universal healthcare in a country's health system would be helpful in limiting the deadliness of COVID-19 by helping reduce compromising comorbidities in the population so people are not as at-risk for severe COVID-19 outcomes. In addition, UHC may also help reduce the spread of COVID-19 by aiding public health efforts through increased coordination and cooperation between differing levels of the healthcare system. Moreover, people living in countries with universal healthcare may have more trust in the healthcare system, making them more likely to support and follow public health measures meant to reduce the spread of COVID-19. In support of the usefulness of UHC, the Director-General of the World Health Organization (WHO) stated in 2017 that the expansion of universal healthcare across the globe would be critical in combating global health crises, such as pandemics.[3] While the COVID-19 pandemic and expansion of universal healthcare have been major topics in public and global health in recent years, there have been very few studies that directly examine the impact of universal healthcare on the control of epidemics and pandemics. Therefore, this thesis serves to connect the two concepts and show the impact of universal healthcare on the containment of the COVID-19 pandemic.

The specific questions this thesis project will answer are:

1. How does the level of universality in a country's healthcare system impact COVID-19 cases, deaths, and tests?
2. What components of UHC are most important for COVID-19 mitigation efforts?

These questions will be addressed by analyzing the relationship between universal healthcare, service coverage, and financial protection and COVID-19 cases, deaths, and tests in over 100 countries through negative binomial regression analysis. Based on this analysis, the thesis argues that UHC is helpful in controlling the COVID-19 pandemic by reducing the number of cases and deaths.

The thesis will begin by exploring the existing literature related to universal healthcare. This section will provide definitions of UHC, explain how service coverage and financial protection are important components of universal healthcare, and show the effect of UHC on healthcare utilization and population health. Then, background will be provided about the COVID-19 pandemic, showing how it began, spreads, and what factors place people at-risk for contracting COVID-19 and dying from it. Finally, the literature review will conclude by analyzing existing evidence on how UHC impacted the control of past infectious disease outbreaks and articulate how little direct research has been done on this topic.

Following the literature review, the methods section will explain how data, in regards to universal healthcare, and COVID-19 cases, deaths, and tests, were compiled and how these data were used to produce the negative binomial regression models. Subsequently, results from the regression analyses will show that universal healthcare, service coverage, and financial protection all had significant negative relationships with COVID-19 cases, deaths, and tests. The discussion section will then propose a number of possible mechanisms to explain the connection between UHC and COVID-19 pandemic control found through regression analysis. This section will also elucidate how these connections are related to the social determinants of health.

As the COVID-19 pandemic continues to evolve, governments and public health officials are searching for health policies that can help address this global crisis. This thesis demonstrates that UHC is negatively associated with both COVID-19 cases and deaths, indicating that the universality of a health system is helpful in controlling the COVID-19 pandemic.

Literature Review

Universal Healthcare Definitions

Universal Healthcare (UHC) has become a major focus of global health policy in recent years, as the extension of universal healthcare to the entirety of the global population by the year 2030 is a sustainable development goal of the United Nations and the World Health Organization (WHO). Despite this emphasis by the United Nations and WHO, half of the world's population does not have access to UHC, including people in both low and high-income countries.[2] For example, within the United States, a considerable portion of the population are uninsured, with an estimated 12.5% of adults being completely uninsured and a further 9.5% having significant gaps in their coverage.[4] Another example is Argentina, which estimates that 36% of its population does not have health insurance.[5] Therefore, in order to realize the benefits of UHC and meet the World Health Organization's goal of worldwide implementation by 2030, it is necessary to analyze how universal healthcare is defined and what conceptualization is most compatible with implementation efforts. Two definitions of universal healthcare emerged from the literature, one that narrowly defines UHC as providing health insurance to all individuals regardless of income and another that asserts that universal healthcare must address quality of care.

A definition of universal healthcare found in the literature takes a narrow approach to the concept of universal healthcare by defining a country's healthcare system as achieving "universal" status when affordable health insurance is provided to the entirety of a country's population regardless of wealth or income.[6–10] Therefore, this definition of UHC prioritizes providing financial protection through the equitable provision of health insurance to a country's population rather than assuring a high quality of care. The sources that conceptualize universal healthcare exclusively through the framework of comprehensive insurance coverage share the common purpose of explaining why certain countries have implemented UHC and others have not. Thus, this definition of universal healthcare is often employed when attempting to implement UHC in a country that currently does not have it.

In contrast, a differing and more expansive definition of UHC has been used by scholars interested in improving quality of care in current UHC systems. This definition argues that for a health system to be truly universal, it needs to ensure that the healthcare provided to its population has high standards of quality.[11–14] The purpose of the scholars using the quality of care approach is to articulate how existing universal healthcare systems can be improved to better influence health outcomes. For example, a study by Das and colleagues shows how people in a number of locations throughout the world, including India, China, and Kenya, have access to affordable healthcare, but their health is not improved due to limited resources and low quality of care.[11] Thus, without high quality of healthcare, access to care may be less effective at improving health outcomes.

Both conceptualizations of universal healthcare point to necessary elements for a full understanding of UHC. The definition of UHC used by the World Health Organization includes aspects of both access and quality. The WHO defines UHC as "all people have access to the health services they need, when and where they need them, without financial hardship. It includes the full range of essential health services, from health promotion to prevention, treatment, rehabilitation, and palliative care."[2] Furthermore, the WHO breaks down universal healthcare into two components that demonstrate issues of access and quality of care, service coverage and financial protection.[15] The creation of service coverage and financial protection metrics allow for the level of universal healthcare to be quantitatively calculated and monitored.

Service Coverage

Service coverage demonstrates the types of medical care that people of a particular country can actually access through that country's healthcare system.[15–18] Thus, service coverage evaluates the quality of care provided by a health system by showing healthcare options routinely available to its population. It is widely agreed in the literature that service coverage should include a variety of types of care, including preventive and acute services.[16–18] However, scholars who create service coverage metrics differ on the specific services to include in the metric and how to weight these treatments when calculating the service coverage score. For example, a service coverage metric created by Hogan and colleagues includes 16 types of indicators that are grouped into four categories, reproductive care, infectious disease control, non-communicable diseases, and service capacity and access.[17] The service coverage metric created by Hogan and colleagues is shown in Figure 1. In contrast, work done by Wagstaff and Neelsen uses eight indicators that are divided into two categories, prevention and treatment. Wagstaff and Neelsen eliminate several indicators used by Hogan and colleagues, such as non-use of tobacco and family planning, arguing that the excluded service coverage indicators were influenced by other factors beyond the health system.[16] Figure 2 displays the service coverage metric produced by Wagstaff and Neelsen. Despite differences in the makeup of the service coverage indicator, scholars believe service coverage is an important component of universal healthcare.

Financial Protection

The other important component used to measure universal healthcare is financial protection. Financial protection shows how affordable healthcare is in a particular health system based on the goal that every person should be able to access needed health services.[15,16,19–21] Therefore, financial protection assesses the propensity of financial barriers to care within a health system. Many financial protection measurements have focused on the percentage of the population that is exposed to catastrophic medical expenses.[15,16,19,20] However, there is disagreement on what should be considered "catastrophic medical expenses." For example, Kawabata and colleagues argue catastrophic medical expenses consist of medical expenses that exceed 40% of a household's income,[19] while Wagstaff and Neelsen and Waters and colleagues say it should be 10% of a household's income.[16,20] Although the scholarly consensus uses catastrophic medical expenses for producing the financial protection metric, research by Moreno-Serra and colleagues articulates a potential weakness with this approach. Specifically, they argue that a focus on catastrophic medical expenses does not include individuals and families who do not use medical care because they know they cannot afford it. These people would not incur catastrophic medical expenses because they would have almost no medical utilization at all, even though they are not financially protected by the healthcare system.[21] While scholars may have disagreements about how financial protection is constructed, there is agreement that it is an important part of universal healthcare systems. Therefore, both the level of service coverage and financial protection in a given country should be included in this analysis on the number of COVID-19 cases, deaths, and tests.

UHC Impact on Healthcare Utilization and Population Health

Many studies have examined the effect of both health insurance expansion and UHC implementation on health across a variety of settings. A review of this literature indicates that UHC and health insurance have a significant association with increasing healthcare utilization, while the evidence base for their impact on population health remains mixed.[22,23] In regards to healthcare utilization, the extension of health insurance has routinely shown a subsequent association with increased healthcare utilization in many different settings. Evidence from the United States, China, and Colombia all show increased healthcare utilization as a result of health insurance access. [24–26] The increase in healthcare utilization has occurred in a number of countries, with differing economic, cultural, and social landscapes. Additionally, the implementation of universal healthcare has a similar effect on increasing healthcare utilization.[27–29] For example, studies of Taiwan and Thailand showed that after universal healthcare was implemented, the previously uninsured populations in these countries had significantly increased usage of both inpatient and outpatient services.[28,29] These studies indicate the direct effect UHC has on increasing healthcare utilization. Furthermore, several studies of the extension of health insurance and UHC have been shown to especially benefit low income and vulnerable populations, such as in Colombia, the United States, and Taiwan.[24,26,27] However, a study of health insurance extension in China found that it was those with high-income who benefitted most from a health insurance expansion program.[30] Likely, the individual details of each country's UHC or health insurance expansion program are determinative of what population groups are most impacted. Overall, the evidence demonstrates that health insurance and UHC cause an increase in healthcare utilization while there is still a debate about which groups benefit most from UHC and health insurance.

Despite the convincing evidence relating UHC and health insurance to healthcare utilization, studies researching the effect of UHC on population health is ambiguous. Several studies have shown a population health benefit to the extension of health insurance and universal healthcare.[31–33] For example, research by Nyman and Barleen showed that self-reported health in Brazil increased after an extension of supplemental health insurance plans, which the authors linked to quicker recovery times for acute and chronic conditions.[32] Additionally, a study by Wang and colleagues demonstrated that an expansion of health insurance in rural China reduced anxiety and depression, as well as pain and discomfort in the general population.[33] In contrast to these studies, other scholarship argues that the extension of health insurance does not affect population health.[27,34,35] For instance, research done by Dow and Schmeer shows that child mortality did not significantly reduce as a result of the implementation of a National Health System in Costa Rica that substantially boosted child insurance rates.[34] In addition, even though Chen and colleagues demonstrate that the implementation of universal healthcare in Taiwan led to increased healthcare utilization among the elderly population, they did not show significant differences in regard to mortality or self-reported health within this population as a result of UHC expansion.[27] Therefore, existing literature is mixed on the effect of UHC and health insurance upon population health and likely indicates that other factors, in conjunction with universal healthcare, can lead to improved population health.

UHC Impact on Past Pandemics and COVID-19

Both universal healthcare and the containment of epidemics and pandemics are currently topics of much importance because of UHC's status as a sustainable development goal with the

United Nations and the continually evolving nature of the COVID-19 pandemic more than a year after it began.[2,36] In an article published in *The Lancet* in 2017, the Director-General of the World Health Organization, Tedros Adhanom Ghebreyesus, argued that the extension of universal healthcare around the world is the best way to prevent and mitigate wide-scale health crises, such as pandemics.[3] Therefore, it is prudent to analyze how these two important topics - UHC and pandemic control - are related to one another. Unfortunately, there are very few studies that directly explore the association between universal healthcare and pandemic containment. However, there have been a few past studies that examine the connection between access to health insurance and exposure to infectious diseases. For example, several studies from the United States and Brazil showed that individuals without health insurance were at greater risk for contracting H1N1 influenza and having an adverse outcome.[37–39] Specifically, evidence from Utah demonstrated that the uninsured had higher rates of infection with H1N1 influenza than the general population.[37] However, further studies from the United States argued that the social determinants of health, such as education level, neighborhood effects, and racial disparities, also played a significant role in a person's exposure to H1N1 influenza.[38,40] For instance, Lowcock and colleagues presented evidence that lower education levels and living in an area with higher deprivation were associated with increased rates of hospitalization due to H1N1 influenza.[40] Additionally, Quinn and colleagues showed that Spanish-speaking Hispanics had the greatest exposure to H1N1, while also having the lowest levels of health insurance and access to healthcare.[38] This evidence taken from a previous pandemic, H1N1 influenza, indicates that health insurance coverage is related to infection rates in a pandemic. However, other factors, such as the social determinants of health, are also highly related to pandemic cases and serious outcomes. While the extension of universal healthcare could help alleviate disparities in healthcare access associated with health, social, and economic inequities, it likely would not entirely address these structural issues, indicating a need for further policies to fully address the impacts social determinants of health have on pandemics.

COVID-19 History

An outbreak of a respiratory illness of unknown cause was first reported and acknowledged in Wuhan, China on December 31, 2019. The outbreak was quickly identified as a new coronavirus (COVID-19) one week later and served as the starting point of a deadly pandemic. By January 20, COVID-19 had spread to three countries beyond China, including Thailand, South Korea, and Japan and a day later the first case outside of Asia was confirmed in the United States. The coronavirus continued to spread across the globe with Africa and South America experiencing their first confirmed cases in February. On March 11, the World Health Organization officially declared that the 2019 coronavirus outbreak was a global pandemic.[36] Since this point, countries around the world have struggled to contain the pandemic, as the global COVID-19 case count and deaths continued to rise. Even though highly effective vaccines were developed and approved for emergency use in the United States in early December of 2020, the global landscape for controlling the pandemic remains uncertain over a year after its start, in part due to variations in national responses to COVID-19 and the discovery of new variants of the coronavirus that are more infectious than the original strain.[42–44]

COVID-19 Characteristics, Transmission, and Symptoms

To design effective health policies that control the spread of COVID-19, it is essential to understand what it is and how it is spread from person to person. COVID-19 is a respiratory disease caused by becoming infected with severe acute respiratory syndrome coronavirus 2 (SARS-CoV-2).[45] Most of the transmission of COVID-19 occurs through exposure to respiratory droplets, produced when a person, already infected with COVID-19, sneezes, coughs, talks, or breathes in close contact of another person. The R-naught (R_0) of COVID-19 is estimated to be between 2-3.[46] Additionally, some transmission of COVID-19 is attributable to airborne transmission, occurring when respiratory droplets stay in the air for minutes or hours at a time. Airborne transmission is more likely to happen in enclosed spaces with little ventilation and can cause infection in cases where there was close contact (within six feet) with an infected person. Moreover, very few cases of COVID-19 are transmitted through contact with contaminated surfaces and contact between people and animals.[47] Additionally, a person infected with COVID-19 does not have to be symptomatic to spread the disease to others. In fact, research by Johansson and colleagues indicates that about 50% of new COVID-19 infections originate from people who are infected with COVID-19 but show no symptoms.[48] Once infected, the symptoms of COVID-19 can take a variety of forms and can onset between 2 and 14 days after a person initially becomes infected. Possible symptoms include fever, cough, loss of taste or smell, congestion, or no symptoms at all, among others.[47] Because of the wide-ranging symptoms of COVID-19, a robust testing program of the general population is advised for minimizing the spread of the virus. UHC would be expected to help with developing and implementing these testing procedures because of its centralized and compulsory medical infrastructure.

COVID-19 Risk Factors

While the symptoms of COVID-19 and their severity vary from person-to-person, COVID-19 can be a deadly illness. In fact, as of mid-February 2021 over 2.4 million people have died from COVID-19 around the globe.[1] A number of factors are likely to make a person more at-risk for a severe COVID-19 outcome. Males, the elderly (aged 65 years and above), and those who smoke exhibit higher risk for serious COVID-19 infections.[49] In addition, chronic health conditions could further endanger an individual if they were to contract COVID-19. These complicating comorbidities include cancer, cardiovascular disease, cerebrovascular disease, chronic obstructive pulmonary disease, diabetes, hypertension, kidney disease, obesity and respiratory disease.[50–52] Furthermore, growing evidence from the United States suggests that racial and ethnic minorities and people of low socioeconomic status (SES) are more likely to become infected with COVID-19 and experience a severe outcome.[53–55] This disproportionate burden of COVID-19 cases and deaths of racial minorities and people of low socioeconomic status is likely due to structural factors and inequalities that the COVID-19 pandemic is exposing. For example, because of structural inequalities, like access to housing, healthcare, and nutrition, as well as disparities in education and employment, these groups are more likely to contract COVID-19 or have complicating comorbidities that place them at higher risk for severe COVID-19 outcomes.[55,56] Structural inequalities cause minorities and people of low SES to work more in what is considered “front-line” or “essential” work, such as in grocery stores, public transit systems, and in healthcare settings, that require them to continue to work in-person. Because they are more likely to be in jobs that cannot be performed virtually or remotely, low SES populations cannot socially distance and risk higher exposure to the coronavirus.[57] The evidence base is extensive to support the notion that many racial/ethnic minorities and people from low SES backgrounds have elevated risk for contracting and dying from COVID-19 due to structural factors and inequalities. The implementation of UHC may help address these structural factors by extending healthcare access to vulnerable populations and reducing inequities in health access.[58,59]

The Importance of Contact Tracing in Controlling Infectious Disease Outbreaks

In addition to minimizing COVID-19 risk factors, UHC could enhance public health responses, such as contact tracing, to the COVID-19 pandemic. Contact tracing is the process of identifying individuals who have been exposed to a person known to be infected with an infectious disease.[60] The purpose of contact tracing is to quickly identify exposed individuals before they further spread the disease to others.[60,61] Contact tracing has proven to be an effective component in the control of past epidemics, such as HIV, tuberculosis, SARS, and smallpox[62–64] and has also shown to be effective in regards to controlling the COVID-19 pandemic as well.[61,65,66] Evidence indicates that the earlier contact tracing can identify and inform potentially exposed individuals, the more effective it is.[66] Innovations in contact tracing have emerged in 2020 to expedite the process of contact tracing, including the use of a software application to perform digital contact tracing.[67] While contact tracing is effective, it does have certain limitations. For example, scholars warn that the effectiveness of contact tracing decreases the more an infectious disease spreads due to the limited capacity and manpower of contact tracing programs.[61,67] Furthermore, prior studies show that contact tracing alone is not sufficient to control the COVID-19 pandemic and is most effective when paired with other public health measures, such as social distancing and self-isolation.[61,65,66] Despite these limitations, contact tracing is an essential part of containing an epidemic or pandemic. This study hypothesizes that UHC would facilitate the contact tracing process by allowing for a centralized and compulsory healthcare infrastructure system to communicate and coordinate between differing parts of the health system.

Filling the Gap in the Literature about UHC and Pandemic Control

In regards to the specific impact of UHC on the COVID-19 pandemic, only one study was identified, with mixed results. Research conducted by Dongarwar and Salihu showed that countries identified as having universal healthcare had fewer number of COVID-19 cases than countries without universal healthcare systems; but they also found that UHC countries had a higher case fatality rate.[41] This indicates that UHC had a protective effect on COVID-19 cases, but not on deaths due to COVID-19. However, this study only examined COVID-19 outcomes through May 6, 2020 and the authors acknowledged that the ongoing nature of the pandemic was a limitation of their study.[41]

The research presented in this thesis serves to fill the extensive gap in the literature on the connection between universal healthcare and pandemic control. This research builds off the initial work of Dongarwar and Salihu by examining a longer time frame of the COVID-19 pandemic and including additional controls in regression analysis. The research presented in this thesis project analyzes the connection between universal healthcare and COVID-19 cases, deaths, and tests. Additionally, this study estimates the association between the component parts of universal healthcare, service coverage and financial protection, and COVID-19 cases, deaths, and tests.

Methods

This study addressed the following empirical questions: How does the level of universality in a country's healthcare system impact COVID-19 cases, deaths, and tests and what components of UHC are most important for COVID-19 mitigation efforts? Based on these research questions, the first objective of the thesis was to show the connection between the level of universality in a country's healthcare system and COVID-19 health outcomes and indicators, such as cases, deaths, and tests. The next objective of the thesis project was to identify which specific aspects of UHC systems are most important for the mitigation of adverse COVID-19 outcomes.

Two main data sets were used to conduct analysis on the relationship between UHC and COVID-19 mitigation. The first data set comes from research conducted by Wagstaff and Neelsen and published in *The Lancet Global Health*. This data set measured the level of universality in a country's health system with two variables, the level of financial protection and the level of health service coverage. This data set surveyed 111 countries and was published in 2019. Specifically, the data set shows the level of financial protection by finding the percentage of the population that incurred catastrophic out-of-pocket health expenses, defined as expenses greater than 10% of a person's consumption or income. Level of service coverage was determined by using a number of preventative indicators, such as antenatal visits, immunizations, breast cancer screenings, and cervical cancer screenings, and treatment indicators, including skilled birth attendance, treatment for acute respiratory infection, treatment for diarrhea, and inpatient admissions. Both the financial protection and service coverage indices produced scores on a scale from 0-100 and were averaged to create a composite score of a UHC system between 0-100 for each country.[16] Figure 2 shows how these three indices were created. All three indices, UHC, service coverage, and financial protection, were used as independent variables during multivariate analysis to determine whether UHC and its component parts impact the number of COVID-19 cases, deaths, and tests.

Coronavirus and COVID-19 health outcomes in individual countries are another important aspect that need to be identified to address the stated research questions. The coronavirus (COVID-19) cases and testing databases, provided by Our World in Data, surveyed these COVID-19 indicators for 211 countries since the start of the coronavirus outbreak, with dates ranging from January 23, 2020 through January 5, 2021. Indicators taken from these data sets that were relevant for multivariate analysis were new daily smoothed cases, deaths, and tests for each country.[68–70] Smoothed new cases, deaths, and tests show the average number of new cases, deaths, and tests for a particular day and the previous 6 days. Smoothed new cases, deaths, and tests were used to eliminate errors in data reporting.

The key independent variables that were used in the analysis were level of universal healthcare, service coverage, and financial protection. The formula used to calculate these three measures was described in detail previously. All three measures are continuous variables on a scale from 0-100. In addition to UHC, service coverage and financial protection were chosen as independent variables to allow for closer examination of the parts of universal healthcare that were most associated with COVID-19 outcomes and indicators.

The key dependent variables that were used in the analysis were smoothed new cases per million, smoothed new deaths per million, and smoothed new tests per thousand. Smoothed new cases, deaths, and tests were adjusted by the population of each country to show cases and deaths per million and tests per thousand. The dependent variables were adjusted by population so the COVID-19 indicators could be compared between countries and not be skewed by the overall population of the country.

Multivariate analysis in the form of a multivariate negative binomial regression was performed to determine the effect of the independent variables, universal healthcare, service coverage and financial protection, on the dependent variables, smoothed new cases per million, smoothed new deaths per million, and smoothed new tests per thousand. The negative binomial regression model was also used so certain control variables could be accounted for in analysis. A negative binomial model adjusts for dispersions of count outcomes that have many cases lower in the distribution and some extreme outliers. Results were reported using incidence rate ratios (IRR), which are exponentiated regression coefficients. Therefore, IRR values greater than 1 would indicate a positive relationship and values less than one show a negative relationship. Variables were determined to have a significant effect if found to have a p-value less than .05. Control variables used in the negative binomial model included each country's continent, human development index score, and percent of the population aged 65 and older. A three-day lag variable was also used on smoothed new cases per million and smoothed new deaths per million. This lag variable could not be used on smoothed tests per thousand because of gaps in testing data. In addition, when the dependent variable was smoothed new cases per million and smoothed new deaths per million, a control variable of smoothed new tests per thousand was included in the negative binomial regression model. This was included to account for variation across countries in levels of testing. The only control variable used that was not a continuous variable was continent, as this variable was categorical. Europe was chosen to be the reference group in this categorical variable, meaning the five other continents shown, Africa, Asia, North America, Oceania, and South America were compared to the reference group Europe. Europe was chosen to be the reference group in this analysis due to the fact that the UHC index shows that European countries have the highest universal healthcare protections of the continents studied.

Results

The following results from the negative binomial regression model address the guiding research questions of this study by showing how universal healthcare, service coverage, and financial protection in a country were associated with a country's COVID-19 cases, deaths, and tests when controlling for various other factors. The analysis of universal healthcare addresses the research question: How does the level of universality in a country's healthcare system impact COVID-19 cases, deaths, and tests? Subsequently, the analysis of service coverage and financial protection indices answer the research question: What components of UHC were most important for COVID-19 mitigation efforts?

Descriptive Statistics

Table 2 shows summary statistics for all continuous variables used in the negative binomial regression model, including all three dependent variables, smoothed new cases per million, smoothed new deaths per million, and smoothed new tests per thousand. Summary statistics displayed in the table consist of total observations, mean, standard deviation, and minimum and maximum values. Financial protection has a higher mean than universal healthcare and service coverage, as well as a small standard deviation, indicating that the dispersion of financial protection is not very large and most countries are grouped together closely near the mean. Additionally, Table 2 shows that smoothed new tests per thousand has fewer observations than both smoothed new cases per million and smoothed new deaths per million, meaning that some countries have COVID-19 case and death numbers available but not testing numbers.

Descriptive statistics for categorical variables used in the negative binomial regression model are found in Table 3. The only categorical variable included as a control in the model is continent and Table 3 displays the 6 continents represented in the model: Africa, Asia, Europe, North America, Oceania, and South America. Table 2 shows that Africa has the most observations, 27.85% of total observations, in the data set, while Oceania has the smallest number of observations, with 2.24%. In fact, 79.05% of observations came from only three continents, Africa, Asia, and Europe.

Impact of Universal Healthcare on Cases, Deaths, and Tests

Results from Table 4 show the association between a country's level of universality in their health system and smoothed new cases per million when controlling for other contributing factors. From the model, universal healthcare has an incidence rate ratio (IRR) value of 0.983 and a p value less than 0.001. Because the IRR value is less than 1, this means that universal healthcare has a significant negative effect on smoothed new cases per million. Moreover, universal healthcare is the only factor included in the model with a significant negative relationship with smoothed new cases per million. The model also shows that smoothed new tests per thousand has a positive significant relationship with smoothed new cases per million with an IRR value of 1.107. This is consistent with the expectation that countries that do more testing identify more cases. Other factors that significantly impact smoothed new cases per million positively include the human development index and the continents of Africa, Asia, North America, and South America.

The next results from the negative binomial regression model are represented in Table 5 and demonstrate the association of the independent variables on smoothed new deaths per million. Universal healthcare has a negative significant relationship with smoothed new deaths per million, as expressed by an IRR value of 0.877 and p value less than 0.001. While, the human development index also has a negative relationship with smoothed new deaths per million, as indicated by an IRR value of 0.333, this relationship is not significant. The control variables that have a positive significant effect on smoothed new deaths per million include the continents of Africa, Asia, North America, and South America, as well as the percentage of the population aged 65 and over and smoothed new tests per thousand.

Results showing the effect of universal healthcare and other controlling variables on smoothed new tests per thousand are placed in Table 6. The table shows that universal healthcare has a significant negative relationship with smoothed new tests per thousand, due to the IRR value of 0.902 and a p value that is less than 0.001. The human development index also has a significant negative relationship with smoothed new tests per thousand. Other factors with significant positive effects on smoothed new tests per thousand include Asia, North America, Oceania, South America, and percent of the population aged 65 and older.

Impact of Service Coverage and Financial Protection on Cases, Deaths, and Tests

Table 7 shows the effect of service coverage, financial protection, and other control variables on smoothed new cases per million. Both service coverage and financial protection have significant negative relationships with smoothed new cases per million. However, the strengths of these negative relationships are different. While the IRR value for service coverage is 0.990, for financial protection it is 0.993. Therefore, service coverage has a stronger negative relationship with smoothed new cases per million. In regard to the control variables, the human development index has the strongest positive association with smoothed new cases per million with an IRR value of 3.395. Additionally, smoothed new tests per thousand and the continents of Africa, Asia, North America, and South America have positive effects on smoothed new cases per million.

Results representing the relationship between smoothed new deaths per million and both service coverage and financial protection are reported in Table 8. Both service coverage and financial protection have a significant negative association with smoothed new deaths per million. The IRR value for service coverage is 0.934 with a p value less than 0.001. Financial protection has a stronger negative relationship with an IRR value of 0.754 and a p value less than

0.001. While service coverage and financial protection are the only factors with a significant negative effect on smoothed new deaths per million, other control variables have a significant positive effect, including percent of population aged 65 and over, smoothed new tests per thousand, and the continents of Africa, Asia, and North America.

Table 9 depicts the results of the model on the dependent variable smoothed new tests per thousand. In this case, service coverage is found to have a stronger negative effect on smoothed new tests per thousand, with an IRR value of 0.943 and a p value less than 0.001. Financial protection has a significant negative association with smoothed new tests per thousand with an IRR of 0.951 and a p value less than 0.001. The model shows the human development index has a significant negative effect on smoothed new tests per thousand, with the model reporting an IRR value of 0.000 and a p value less than 0.001. Other significant factors impacting smoothed new tests per thousand include the continents of Asia, North America, Oceania and South America, as well as percent of the population aged 65 and over.

Discussion

Protective Effects of Universal Healthcare

The findings described in the results section provide interesting insights into the relationship between universal healthcare and COVID-19 cases, deaths, and tests. Using the negative binomial regression model, universal healthcare was found to have a significant, negative association with both smoothed new cases per million and smoothed new deaths per million when controlling for other factors, such as continent, human development index, percentage of the population aged 65 and older, and smoothed new tests per thousand. The negative relationship between universal healthcare and smoothed new cases and deaths per million means that the more universal a country's healthcare system, it would have fewer new cases and deaths per million.

Based on the negative relationship between universal healthcare and smoothed new cases per million, health systems with higher levels of universality provide beneficial effects on minimizing the spread of COVID-19. The countries with the highest measurements of UHC according to the UHC index are Austria, France, Luxembourg, Germany, and Czech Republic. One possible explanation for the protective effect of universal healthcare systems on controlling the spread of COVID-19 is facilitating the process of case identification and contact tracing. Case identification and contact tracing have been shown to be crucial components of reducing the transmission of COVID-19 by informing individuals they have either tested positive for or been exposed to COVID-19 and allowing them to more quickly take precautionary measures, such as self-isolating and wearing a facemask, to ensure they do not spread the virus to others.[65] Universal healthcare can aid the process of case identification and contact tracing, especially in the initial stages of the pandemic. For example, Taiwan was able to mobilize a robust case identification and contact tracing system almost immediately following its first identified COVID-19 case, specifically leveraging a national health database that is part of its universal healthcare system. Taiwan combined its health insurance and customs and immigration databases to identify individuals who were at high risk for contracting COVID-19 based on their travel history and inform providers during clinical visits. Moreover, the Taiwanese case-identification system recommended certain patients test for COVID-19 based on their presenting symptoms. Due in part to its universal healthcare system, Taiwan was able to quickly implement a highly effective case identification and contact tracing system that meaningfully reduced the spread of COVID-19 during the early months of the pandemic, even though Taiwan experiences high level of travel with China, the origin of the COVID-19 outbreak.[71] The example from Taiwan demonstrates how a country's universal healthcare system can be used to contain the spread of a highly infectious disease, such as COVID-19.

In addition to showing protective effects on new case numbers, universal healthcare was shown to be beneficial for preventing new deaths due to COVID-19. A reason for the negative relationship between new COVID-19 deaths and universal healthcare could be that countries with higher levels of universal healthcare have populations with fewer comorbidities. Previous research has shown that people with certain comorbidities, such as cancer, cardiovascular disease, cerebrovascular disease, chronic obstructive pulmonary disease, diabetes, hypertension, kidney disease, obesity and respiratory disease are more susceptible to adverse COVID-19 outcomes.[50–52] The reduction of these comorbidities in a country's population would make people less susceptible to severe COVID-19 outcomes. Evidence from multiple previous studies shows that healthcare utilization increases when universal healthcare programs are implemented. For example, outpatient and inpatient visits significantly increased among previously uninsured populations in both Taiwan and Thailand after each country passed universal healthcare programs.[28,29] Therefore, people with access to health insurance, a fundamental requirement of universal healthcare systems, are more likely to seek medical treatment for health problems they are encountering, rather than let health issues go untreated due to high costs of uninsured care. Controlling these comorbidities before a person becomes infected with COVID-19 can reduce the likelihood of a person dying if they were to contract it.

Furthermore, racial minorities account for a disproportionate amount of COVID-19 cases and deaths in the United States.[53,54] In addition, research indicates that people of low socioeconomic status are more at-risk for contracting COVID-19 and then dying from it.[72,73]

These disparities in COVID-19 cases and deaths are caused by the social determinants of health. Structural inequities, such as disparities in education, employment, housing and healthcare access allow vulnerable populations to be exposed to COVID-19 transmission. These structural factors also cause vulnerable groups to have higher amounts of preexisting comorbidities that have been shown to put people at risk for adverse COVID-19 outcomes.[55,56] The people most likely to benefit from expansions in health insurance access are people of low income and racial and ethnic minorities.[23,74] Universal healthcare expansion would benefit the populations suffering the most from COVID-19 fatalities by beginning to address the social determinants of health by enhancing their access to healthcare. Notably, universal healthcare could lower deaths due to COVID-19 by lowering comorbidities in the population, especially in vulnerable groups, such as racial and ethnic minorities and people of low income. Thus, universal healthcare links the reduction of COVID-19 deaths in society to the advancement of health equity through equal access to health insurance.

Results from the negative binomial regression model provide evidence for the effects of universal healthcare on reducing the spread of COVID-19 and lowering COVID-19 related deaths. However, further study of the effect of universal healthcare on these areas is needed to determine if the mechanisms proposed to explain the connections, such as the assistance in case identification and contact tracing and the reduction of comorbidities, are consistent factors in universal healthcare systems across the world.

Protective Effects of Service Coverage and Financial Protection

Service coverage represents the types of medical care that are actually provided and covered by a country's health system. The service coverage variable used in the negative binomial regression model accounts for both preventive services and acute care treatments. As a result, a health system with more types of services available to its population receives a higher score on the service coverage index. The countries that have the highest levels of service coverage as measured by the service coverage index include Luxembourg, Finland, Sweden, Austria, and France. In contrast, the financial protection metric indicates the monetary exposure of a country's population after accessing medical services. Therefore, a country with a lower percentage of its population experiencing catastrophic expenses after utilizing medical care would receive a higher score on the financial protection index. The countries with the best rating of financial protection are The Gambia, Malaysia, Czech Republic, Zambia, and Honduras.

In regards to the importance of these components of UHC, the results from the negative binomial regression model indicate that both service coverage and financial protection are important to minimizing the spread of COVID-19 and deaths due to COVID-19. Both service coverage and financial protection had significant negative associations with smoothed new cases per million, meaning that as service coverage and financial protection increase, smoothed new cases per million decreases. However, service coverage was found to have a stronger effect on smoothed new cases per million than financial protection. When examining the effect of service coverage and financial protection on smoothed new deaths per million, both service coverage and financial protection had a significant negative relationship with smoothed new deaths per million. In this case, financial protection had a stronger negative effect on smoothed new deaths per million than service coverage.

Service coverage was shown to be the most beneficial of the two studied components of universal healthcare on minimizing the number of smoothed new daily cases. A country with a higher service coverage score provides more types of medical care through its health system, resulting in a system with larger medical infrastructure geared to handle both preventative and acute needs. It is likely that this existing medical infrastructure, especially programs geared toward preventive health, explains the negative association between service coverage and smoothed new cases per million. Countries with a high service coverage score could exploit existing public health programs to more quickly and effectively mobilize a public health campaign aimed at reducing the spread of COVID-19, emphasizing the need to social distance, wear facemasks, and self-isolate when exposed. Additionally, a greater number of citizens in countries with higher service coverage scores interact with a wider variety medical professionals. This enhanced experience with the medical profession may allow people in these countries to more readily accept and adhere to the recommendations of public health officials needed to contain the spread of COVID-19. The authority of public health officials and their guidelines may not be challenged as much in countries with higher service coverage, because more people have been exposed to the medical system and their medical needs are more likely to have been met by that system. It is likely that service coverage relates to lowering the spread of COVID-19 by having a larger existing medical infrastructure to appropriate for the use of a COVID-19 public health campaign, as well as engendering enhanced trust in the medical establishment that encourages people to follow public health recommendations.

While service coverage had a larger association with smoothed new cases per million, financial protection also had a smaller, yet significant negative effect on smoothed new cases per million. It is likely that health systems with greater amounts of financial protection for its citizens also begets larger amounts of trust in the health systems among the population. For example, people may be more willing to cooperate with case identification and contact tracing programs essential to minimizing the spread of COVID-19 if they know that their health system does not frequently cause substantial medical expenses that are left for the patient to cover. On the opposite side, people in health systems with lower levels of financial protection may hesitate to cooperate with contact tracers out of fear that the interaction with the health system could cause a sizable and unaffordable expense. It is imperative that public health officials identify and contain infected and exposed individuals to stop the spread of the virus. The trust in a healthcare system that financial protection creates encourages people to cooperate with public health programs made to minimize the spread of COVID-19.

Both financial protection and service coverage were found to have a significant negative relationship with smoothed new deaths per million using the negative binomial regression model. In this case, however, financial protection had the stronger negative association with smoothed new deaths per million. One potential explanation for the relationship between financial protection and smoothed new deaths per million is the delay in seeking needed medical care due to financial burdens. Previous studies have shown that a lack of health insurance coverage is associated with delays in seeking needed medical care for both chronic diseases and emergency situations and that the extension of insurance results in higher healthcare utilization.[75–78] Systems with little financial protection are likely to see a higher number of people fail to have chronic conditions treated due to the high cost of care. Thus, more people are likely to have comorbidities that place them at higher risk for death if they contract COVID-19. Health systems with higher levels of financial protection, on the other hand, have fewer people delaying needed treatment of chronic conditions due to high costs and would more likely have a population with fewer comorbidities and lower risk for death due to COVID-19. Moreover, financial protection can extend to COVID-19 treatment itself. For example, while most testing for COVID-19 has been made free to the public in the United States, much of the treatment for COVID-19 has not been made free, leaving uninsured or underinsured patients with thousands of dollars of medical bills.[79] Therefore, a person living in a country with little financial protection may be reluctant to seek treatment for COVID-19 due to cost and delay until the prognosis is very serious and leave themselves at a higher chance for death. In contrast, a person in a country with high levels of financial protection would not fear large medical bills and may be more likely to seek treatment sooner and achieve a better outcome. Financial protection likely has a substantial effect on reducing COVID-19 deaths due to the alleviation of financial concern with treatment of both COVID-19 and its relevant comorbidities.

While service coverage's relationship with smoothed new deaths per million is not as strong as financial protection's, it was still a significant negative relationship. Countries with higher levels of service coverage provide more types of medical treatment to its citizens, taking the form of both preventative and acute care. People with access to more health services are more likely to have chronic conditions addressed and controlled. Therefore, a country with higher levels of service coverage will have a population with fewer compromising comorbidities that could lead to more COVID-19 deaths. In the opposite case, countries with a lower service coverage score provide fewer preventative and acute services to its population, leading to a higher percentage of the population accumulating illnesses and chronic diseases that are not treated. These countries will then have more people with comorbidities that leave them at higher risk of a deadly outcome if they were infected with COVID-19. Increased service coverage likely provides protection against COVID-19 deaths by reducing comorbidities among the population.

Overall, both service coverage and financial protection are negatively associated with smoothed COVID-19 cases and deaths per million. The discussion above proposes some possible mechanisms to explain these connections. For example, service coverage could impact smoothed new cases and deaths per million through the build-up of medical infrastructure, increased trust in medical authority, and the reduction of complication causing comorbidities. Additionally, it is suggested that financial protection influences smoothed new cases and deaths per million by reducing the cost of medical expenses among the population, resulting in increased cooperation with public health authorities, a reduction in comorbidities that lead to COVID-19 deaths, and faster seeking of treatment for COVID-19 illnesses. However, more research is required to verify the explanations for these relationships.

Effect of Universal Healthcare, Service Coverage, and Financial Protection on Testing

While universal healthcare, service coverage, and financial protection were all found to be helpful in reducing COVID-19 cases and deaths, these factors were not found to be helpful in regards to increasing testing. In fact, all three factors had significant negative relationships with smoothed new tests per thousand, meaning that a more universal healthcare system, as well as a system with more financial protection and service coverage, actually resulted in fewer tests being performed holding continent, human development index, and percent of the population aged 65 and over constant. The negative relationship between universal healthcare, and its accompanying components, and smoothed new tests per thousand is an unexpected result. It was anticipated that universal healthcare systems would have increased medical capacity to first produce a substantial number of COVID-19 tests and then have the facilities and personnel to undertake a large-scale testing program. While surprising, there are several possible explanations for this finding. First, as shown previously in this study, universal healthcare systems are associated with lower numbers of COVID-19 cases. Therefore, it is possible that fewer tests are needed in countries with a more universal healthcare system simply because fewer people have been infected. To investigate this point, future research should explore testing in universal healthcare systems over time. For example, maybe UHC systems were able to scale up testing capacity quickly and did a substantial amount of testing at the beginning of the pandemic. Then, UHC countries possibly did less testing in the later stages of the pandemic because they did a better job controlling the spread of the virus than countries without universal healthcare. While an interesting potential theory, this analysis goes beyond the scope of this research and should be left to a future study.

Another possible explanation for the negative relationship between universal healthcare and smoothed new tests per thousand is issues with reporting of testing. The data for smoothed new tests per thousand was much more inconsistent than what was used for smoothed new cases and deaths per million with many dates having missing testing data. Additionally, data from 82 countries was used to analyze the effect of universal healthcare on COVID-19 cases and deaths. However, only 79 of these countries also reported the number of tests performed, meaning that several studied countries did not report testing data to go along with cases and deaths. The countries that did not report testing data, in addition to cases and deaths, were Bosnia and Herzegovina, Honduras, and China. While the sample size was large enough to produce a significant result, it does not represent the full range of countries used to analyze the relationship between universal healthcare and cases and deaths, potentially skewing the results. Therefore, it is recommended that more research be completed to determine the effect of universal healthcare on the number of COVID-19 tests done in a country in order to confirm the finding from this study that universal healthcare is actually negatively associated with smoothed new tests per thousand.

Other Significant Factors Associated with COVID-19 Cases, Deaths, and Tests

In addition to the studied dependent variables, universal healthcare, service coverage, and financial protection, several control variables were included in the analysis. These controls included the continent of each country, human development index, the percentage of a country aged 65 and older, smoothed new tests per thousand, and a three-day lag for smoothed new cases per million and smoothed new deaths per million.

A regional control in the form of each studied country's continent was used in the negative binomial regression model. A regional control was included to account for cultural and geographic differences between the continents. Because this variable was categorical, Europe was chosen as the reference category. That means that the IRR values listed for each continent in Tables 3-8 are in comparison to Europe. The results from the model indicate that there were significant differences between the continents in relation to smoothed new cases, deaths, and tests. Specifically, European countries are consistently shown to have the lowest numbers of cases, deaths, and tests after controlling for other factors.

Another control variable used in the analysis was the human development index. Each country is given a score in the human development index based on the three categories of education level, life expectancy, and gross national income per capita.[80] The human development index was used as a control variable in order to give a holistic view of a country's development, beyond just economic indicators. Specifically, the human development index provides a health and education metric in addition to an economic metric. The human development index was found to have a significant positive effect on both smoothed new cases per million and smoothed new tests per thousand indicating that the development level of a country plays a role in the number of COVID-19 cases and tests recorded.

The next control variable used in the regression model was the percentage of the population aged 65 years and older. Previous research has shown that old age is associated with higher risk of death due to COVID-19.[81] Therefore, this control variable was included to account for countries with larger elderly populations. Accordingly, the percentage of the population aged

65 and older was found to have a significant positive relationship with smoothed new deaths per million.

In addition to being its own dependent variable, smoothed new tests per thousand was also used as a control variable when analyzing smoothed new cases and deaths per million. Testing is likely to have a substantial impact on the number of COVID-19 cases and deaths, as higher amounts of tests done results in more cases identified. Also, if more testing is done, more deaths attributed to COVID-19 would be identified. Therefore, it is no surprise that smoothed new tests per thousand has a positive significant relationship with both smoothed new cases and deaths per million.

Finally, a three-day lag control was included in the negative binomial regression model. This variable accounts for the fact that the number of cases, deaths, and tests on one particular day is highly related to the preceding days, based on the course the pandemic is taking in that country. Furthermore, the three-day lag control was used because new cases, deaths, and tests were presented as smoothed, which shows a seven-day average of cases, deaths, and tests.

Limitations

While this analysis provided multiple noteworthy findings regarding universal healthcare and COVID-19 cases, deaths, and testing numbers, there are potential limitations that could impact the reliability of the findings. One of the main problems encountered was issues with accurate and consistent reporting of COVID-19 cases, deaths, and tests in the studied countries, as some countries may have limited resources in regards to testing and data reporting. Therefore, in some instances, low reported COVID-19 case numbers in a country might be caused by a lack of testing or reporting, instead of actual low numbers of people infected with COVID-19. Another weakness was the analysis was limited to 82 countries that had data available for both the universal healthcare index and COVID-19 cases, deaths, and tests. While the study included countries from a variety of regions and income groups, it does not a represent a comprehensive analysis of every country in the world and their response to the COVID-19 pandemic as a function of the universality of their healthcare system. A third weakness of this thesis was that a three-day lag could not be used in the negative binomial regression model when testing for smoothed new tests per thousand. Inconsistencies in the reporting of tests resulted in many dates with missing information regarding testing in the COVID-19 Testing data set. The three-day lag was not able to be used because of this missing information and was excluded from analysis in regards to smoothed new tests per thousand. In addition, another limitation of this study is that it uses exclusively country-level data. The study could fall into "ecological fallacy," as it assumes results about individuals based on population-level data. There could be variation in individual-level data that shows similar or different results from the country-level data.

Main Takeaways

Even though this research contained several limitations, it did show that universal healthcare is a helpful component in reducing the number of COVID-19 cases and deaths. It is likely that this is due to universal healthcare systems increased capacity for contact tracing programs and reduction of complicating comorbidities in the general population. In addition, both service coverage and financial protection, the two parts of universal healthcare, were also found to be helpful in reducing COVID-19 cases and deaths. Much research has also shown that the social determinants of health and the health inequities they produce are drivers of COVID-19 cases and deaths. Therefore, the extension of policies that expand universal healthcare around the world can be seen as measures useful to the control of pandemics that could potentially arise in the future by beginning to address health inequities caused by the social determinants of health.

Universal healthcare can impact the social determinants of health by providing affordable access to high quality healthcare to larger portions of the population, especially vulnerable groups. Overall, universal healthcare can be a critical component in preparing for future pandemics and reducing the harm they cause, especially if it is paired with other social and economic initiatives aimed at eliminating disparities caused by structural inequalities in society.

Conclusion

In recent years, there has been a substantial global effort to extend universal healthcare around the world. The outbreak of the COVID-19 pandemic in December of 2019 and its subsequent escalation into a global health crisis has placed new importance on the mission to expand UHC. Previous research has indicated that while universal healthcare is related to increases in healthcare utilization, its impact on population health remains unclear. Furthermore, a gap in the literature exists in regards to the effect of UHC on pandemic control.

The research done in this thesis project seeks to fill the gap by exploring the relationship between UHC, financial protection, and service coverage and COVID-19 cases, deaths, and tests through negative binomial regression analysis. It also builds off the work done by Dongarwar and Salihu in 2020, which studied the effect of universal healthcare on the COVID-19 pandemic. Dongarwar and Salihu found that UHC was helpful in reducing cases but not in reducing the case-fatality rate. Results from regression analysis show that universal healthcare has a significant negative relationship with COVID-19 cases, deaths, and tests. In addition, both financial protection and service coverage, the two components of UHC, also have a significant negative relationship with COVID-19 cases, deaths, and tests. Like Dongarwar and Salihu, this analysis shows that UHC is helpful in limiting the spread of COVID-19. However, this research differs from Dongarwar and Salihu by showing that UHC is also beneficial in limiting deaths due to COVID-19. In addition, this thesis demonstrates that both component parts of UHC, financial protection and service coverage, are helpful in reducing COVID-19 cases and deaths.

The thesis proposes several mechanisms to explain the helpful effect of universal healthcare upon COVID-19 cases and deaths. One explanation is that the increased medical infrastructure associated with universal healthcare systems allowed for more timely and robust public health responses, such as contact tracing. Another explanation is that UHC reduces comorbidities that are known to be complicating factors in serious COVID-19 outcomes through increased access to affordable and quality healthcare. Prior research has shown that structural inequities in society cause vulnerable groups like racial minorities and people of low socioeconomic status to have higher rates of these comorbidities, and thus increase their exposure to deadly COVID-19 outcomes. Therefore, further implementation of UHC can address pandemic control by improving access to healthcare to vulnerable populations. However, it is likely that other social and economic policies will also need to be advanced, in addition to UHC, to completely address structural inequalities that lead to disparities in exposure to pandemics.

Overall, the ongoing global health crisis due to the COVID-19 pandemic has exposed the weaknesses of current healthcare systems and presents a window of opportunity to push universal healthcare implementation forward. This study shows that UHC is not only a private good, in the fact that it extends health insurance coverage to individuals, but also a public good because it can be helpful in limiting the effects of a pandemic. The devastating nature of the COVID-19 pandemic has brought policymakers' attention to the need to be prepared for potential pandemics and epidemics in the future. Universal healthcare should be considered a crucial part of the strategy to contain future epidemics and pandemics and ensure that the devastating effects of the COVID-19 pandemic are not repeated in another viral outbreak.

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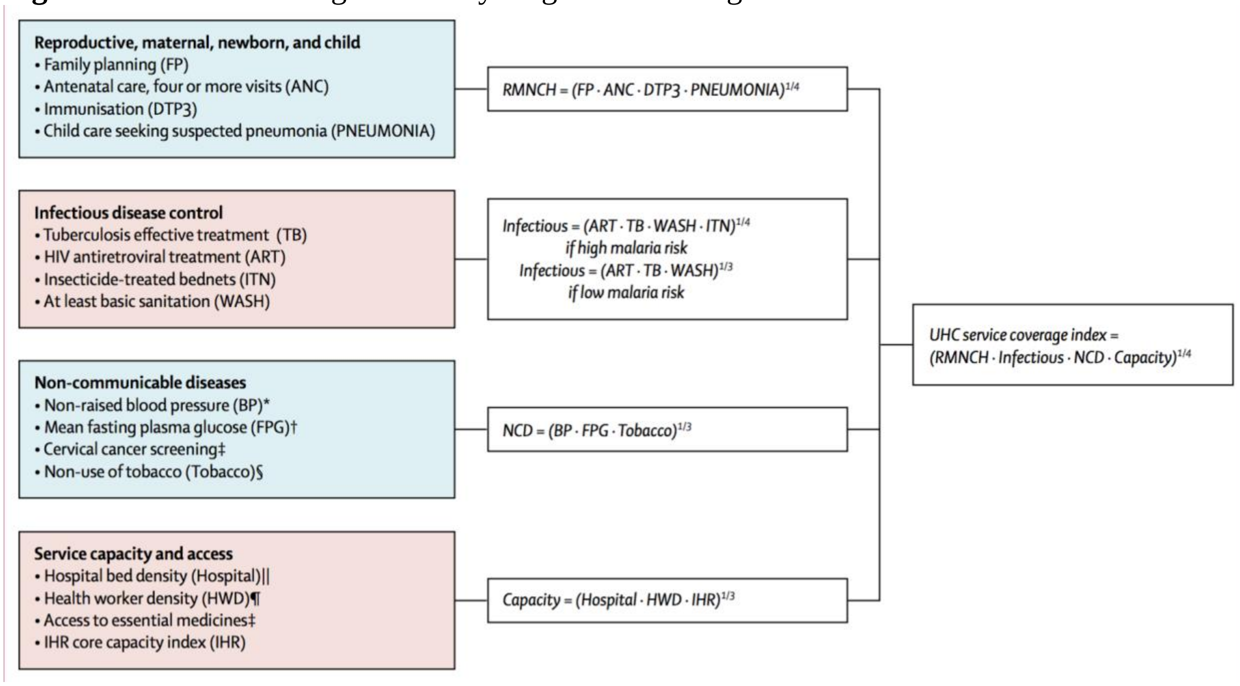
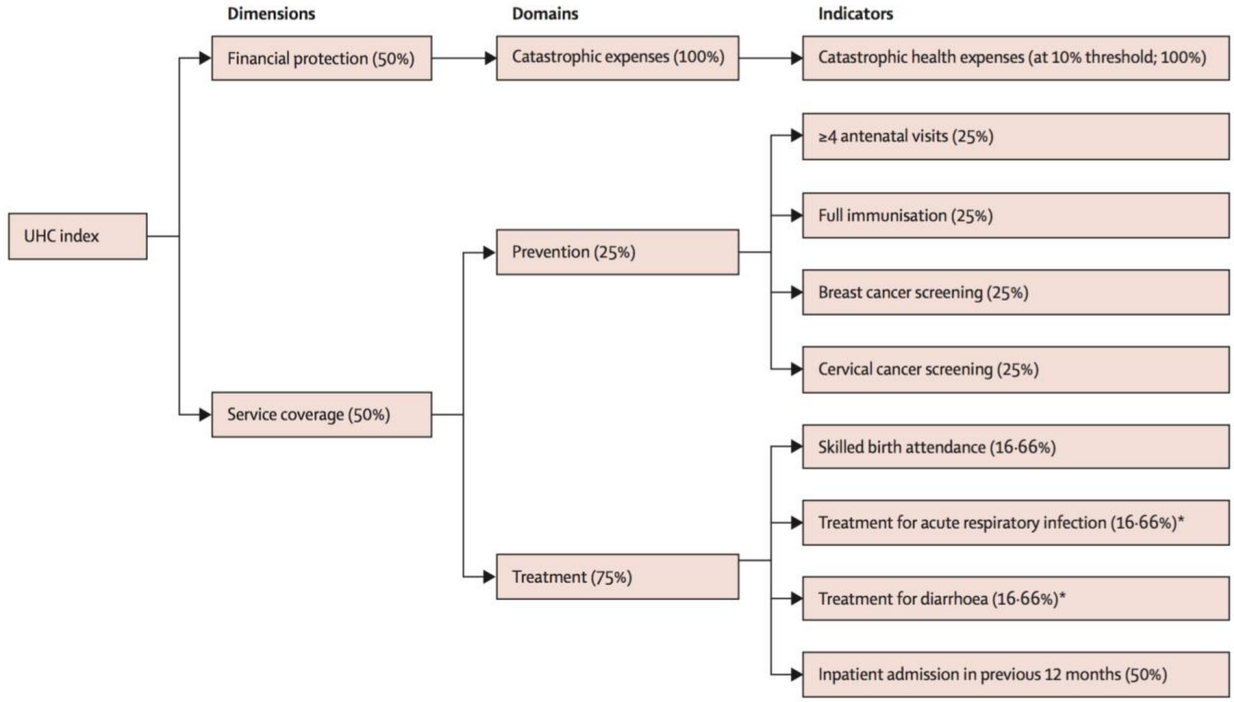
Appendix

Figure 1: Service Coverage Metric by Hogan and colleagues



[a]Figure taken from Hogan et al. (2018)[17]

Figure 2: Universal Healthcare Index by Wagstaff and Neelsen



[a]Figure taken from Wagstaff and Neelsen (2019)[16]

Table 1: Universal Healthcare, Financial Protection, and Service Coverage Indices

Country	UHC	Financial Protection	Service Coverage	Year
Afghanistan	54.723	90.266	33.175	2013
Albania	57.101	84.684	38.502	2012
Argentina	85.048	86.698	83.429	2007
Armenia	57.474	85.026	38.850	2013
Australia	92.117	92.427	91.809	2007
Austria	95.884	98.400	93.432	2010
Azerbaijan	57.571	92.125	35.977	2006
Bangladesh	48.511	91.632	25.682	2013
Belgium	91.482	90.420	92.557	2011
Bosnia and Herzegovina	78.192	91.632	66.724	2009
Brazil	74.931	74.445	75.420	2006
Burkina Faso	56.309	96.674	32.798	2008
Burundi	53.822	97.177	29.810	2013
Cambodia	44.877	80.032	25.164	2012
Canada	92.996	97.514	88.688	2010
Chad	48.717	93.721	25.324	2008
Chile	83.111	82.944	83.279	2015
China	71.093	81.281	62.182	2004
Colombia	72.994	81.533	65.349	2009
Comoros	60.120	91.186	39.638	2006
Congo Dem Rep.	56.023	94.687	33.147	2012
Congo Rep.	71.863	91.425	56.486	2011
Costa Rica	76.498	92.752	63.092	2008
Cote d'Ivoire	36.449	87.994	15.098	2013
Croatia	94.072	97.222	91.025	2010
Cyprus	86.618	85.002	88.265	2011
Czech Republic	95.383	98.941	91.953	2011
Denmark	92.863	97.641	88.318	2015
Dominican Republic	79.006	84.793	73.613	2012
Ecuador	70.318	90.275	54.773	2004
Egypt Arab Rep.	52.153	80.567	33.760	2011
El Salvador	68.730	98.308	48.051	2011
Estonia	87.909	90.610	85.289	2010
Eswatini	52.752	86.611	32.129	2011
Ethiopia	39.495	96.566	16.153	2014
Finland	94.637	95.275	94.003	2014
France	95.809	98.578	93.117	2012
The Gambia	46.957	99.597	22.139	2011

Georgia	55.323	71.563	42.769	2006
Germany	95.418	98.279	92.639	2013
Ghana	67.187	97.888	46.115	2010
Greece	87.375	84.392	90.464	2012
Guatemala	62.684	94.639	41.519	2009
Haiti	46.993	89.512	24.671	2014
Honduras	77.303	98.861	60.445	2008
Hungary	92.746	95.395	90.170	2014
India	57.427	84.681	38.944	2010
Indonesia	51.292	96.007	27.403	2010
Iran Islamic Rep.	75.821	86.369	66.562	2010
Ireland	92.776	94.086	91.484	2015
Israel	91.136	90.921	91.351	2015
Italy	92.968	93.717	92.226	2015
Jamaica	67.699	89.716	51.085	2007
Japan	81.880	95.507	70.198	2015
Jordan	75.569	98.402	58.035	2015
Kazakhstan	77.929	97.753	62.125	2011
Kenya	55.649	94.372	32.816	2011
Korea Rep.	87.352	87.241	87.463	2015
Kosovo	66.095	92.965	46.992	2013
Lao PDR	55.116	96.973	31.326	2010
Latvia	86.261	84.105	88.472	2011
Lithuania	88.136	89.255	87.031	2014
Luxembourg	95.461	96.616	94.320	2010
Madagascar	50.936	98.796	26.261	2006
Malawi	48.412	96.288	24.341	2013
Malaysia	82.001	99.260	67.742	2004
Mali	40.294	95.046	17.083	2014
Malta	86.041	83.980	88.153	2011
Mauritania	56.554	88.903	35.976	2011
Mexico	77.858	95.812	63.269	2011
Moldova	72.151	81.415	63.941	2010
Mongolia	83.664	97.954	71.459	2012
Morocco	52.333	88.743	30.861	2000
Myanmar	45.992	86.177	24.545	2012
Namibia	77.352	98.784	60.569	2010
Nepal	54.839	81.310	36.986	2011
Nicaragua	72.663	79.546	66.376	1999
Niger	48.151	94.840	24.447	2009

Nigeria	42.997	85.011	21.747	2015
Pakistan	55.765	94.960	32.748	2009
Paraguay	70.693	92.330	54.126	2003
Peru	69.210	91.270	52.483	2016
Philippines	65.018	93.781	45.076	2015
Poland	88.258	86.078	90.494	2015
Portugal	87.548	83.381	91.923	2010
Russian Federation	75.773	95.147	60.344	2010
Rwanda	61.378	98.609	38.204	2012
Senegal	56.662	97.644	32.881	2013
Serbia	74.715	91.464	61.033	2012
Sierra Leone	66.780	89.583	49.782	2015
Slovak Republic	91.755	95.672	87.999	2012
Slovenia	93.265	95.220	91.351	2011
South Africa	78.470	98.424	62.561	2007
Spain	89.943	93.871	86.180	2013
Sri Lanka	70.972	95.267	52.873	2013
Sweden	95.067	96.268	93.882	2014
Switzerland	89.603	88.980	90.231	2010
Tajikistan	63.700	85.483	47.467	2014
Tanzania	60.357	96.988	37.561	2012
Thailand	75.263	97.953	57.830	2014
Trinidad and Tobago	79.355	96.771	65.074	2011
Turkey	55.520	96.650	31.893	2001
Uganda	53.516	84.497	33.894	2014
Ukraine	85.423	92.519	78.872	2011
United Kingdom	91.891	98.311	85.891	2012
United States	91.274	93.044	89.538	2015
Uruguay	87.426	95.101	80.370	2005
Uzbekistan	68.041	93.568	49.478	2003
Vietnam	69.895	90.397	54.043	2012
Zambia	54.525	98.929	30.051	2009
Zimbabwe	67.646	97.915	46.735	2010

Table 2: Descriptive Statistics for Continuous Independent and Dependent Variables

Variable	Obs..	Mean.	Std. Dev.	Min	Max
Universal Healthcare	34,448	72.061	16.506	36.449	95.884
Service Coverage	34,448	59.474	24.883	15.098	94.320
Financial Protection	34,448	91.817	6.042	71.563	99.597
Human Development Index	55,212	.716	.154	.354	.953
% Aged 65+	54,022	8.858	6.281	1.144	27.049
Smoothed New Cases per Million	55590	54.909	130.033	0	2648.773
Smoothed New Deaths per Million	55590	.991	2.556	0	63.140
Smoothed New Tests per Thousand	30119	1.072	1.915	0	23.700

Table 3: Descriptive Statistics for Continents

Variable	Freq.	Percent	Cum.
Africa	15,894	27.85	27.85
Asia	14,653	25.67	53.52
Europe	14,571	25.53	79.05
North America	7,006	12.28	91.33
Oceania	1,281	2.24	93.57
South America	3,668	6.43	100.00

Table 4: Negative Binomial Regression Results Predicting Smoothed New Cases per Million by Universal Healthcare

Smoothed New Cases per Million	IRR	[95% Conf. Interval]	
Universal Healthcare	0.983***	0.980	0.987
Continent			
Africa	1.598***	1.434	1.780
Asia	1.158***	1.064	1.260
North America	1.787***	1.644	1.944
Oceania	1.043	0.856	1.271
South America	1.822***	1.673	1.985
Human Development Index	3.931***	2.459	6.285
% Aged 65+	0.998	0.990	1.005
Smoothed New Tests per Thousand	1.107***	1.102	1.113
Smoothed New Cases per Million 3 Day Lag	1.003***	1.003	1.003
Number of Countries	82		
Number of Observations	22,175		

[a]Incident Rate Ratios are exponentiated regression coefficients; * p<.05 ** p<.01 *** p<.001.

Table 5: Negative Binomial Regression Results Predicting Smoothed New Deaths per Million by Universal Helathcare

Smoothed New Deaths per Million	IRR	[95% Conf. Interval]	
Universal Healthcare	0.877***	0.829	0.928
Continent			
Africa	37.427***	10.090	138.832
Asia	88.968***	29.032	272.636
North America	177.700***	43.391	727.732
Oceania	36.288	0.724	1817.832
South America	11.056***	4.679	26.127
Human Development Index	0.333	0.009	12.037
% Aged 65+	1.285***	1.207	1.368
Smoothed New Tests per Thousand	1.204***	1.192	1.215
Smoothed New Deaths per Million 3 Day Lag	1.173***	1.171	1.176
Number of Countries	82		
Number of Observations	22,175		

[a]Incident Rate Ratios are exponentiated regression coefficients; * p<.05 ** p<.01 *** p<.001.

Table 6: Negative Binomial Regression Results Predicting Smoothed New Tests per Thousand by Universal Healthcare

Smoothed New Tests per Thousand	IRR	[95% Conf.	Interval]
Universal Healthcare	0.902***	0.876	0.928
Continent			
Africa	1.211	0.353	4.149
Asia	1.810***	1.257	2.605
North America	17.836***	4.810	66.133
Oceania	234.068**	3.297	16619.047
South America	20.960***	4.047	108.562
Human Development Index	0.000***	0.000	0.001
% Aged 65+	1.180***	1.142	1.218
Number of Countries	79		
Number of Observations	20,462		

[a]Incident Rate Ratios are exponentiated regression coefficients; * p<.05 ** p<.01 *** p<.001.

Table 7: Negative Binomial Regression Results Predicting Smoothed New Cases per Million by Service Coverage and Financial Protection

Smoothed New Cases per Million	IRR	[95% Conf.	Interval]
Service Coverage	0.990***	0.988	0.992
Financial Protection	0.993***	0.989	0.997
Continent			
Africa	1.604***	1.434	1.794
Asia	1.157***	1.060	1.262
North America	1.755***	1.609	1.913
Oceania	1.059	0.869	1.290
South America	1.790***	1.643	1.951
Human Development Index	3.395***	2.105	5.476
% Aged 65+	0.998	0.991	1.006
Smoothed New Tests per Thousand	1.108***	1.102	1.113
Smoothed New Cases per Million 3 Day Lag	1.003***	1.003	1.003
Number of Countries	82		
Number of Observations	22,175		

[a]Incident Rate Ratios are exponentiated regression coefficients; * p<.05 ** p<.01 *** p<.001.

Table 8: Negative Binomial Regression Results Predicting Smoothed New Deaths per Million by Service Coverage and Financial Protection

Smoothed New Deaths per Million	IRR	[95% Conf. Interval]	
Service Coverage	0.934***	0.911	0.958
Financial Protection	0.754***	0.700	0.812
Continent			
Africa	782.324***	150.839	4057.503
Asia	525.121***	129.268	2133.180
North America	735.089***	152.006	3554.829
Oceania	20.374	0.330	1256.523
South America	1.829	0.938	3.566
Human Development Index	0.505	0.008	31.027
% Aged 65+	1.529***	1.396	1.674
Smoothed New Tests per Thousand	1.212***	1.201	1.223
Smoothed New Deaths per Million 3 Day Lag	1.177***	1.174	1.180
Number of Countries	82		
Number of Observations	22,175		

[a]Incident Rate Ratios are exponentiated regression coefficients; * p<.05 ** p<.01 *** p<.001.

Table 9: Negative Binomial Regression Results Predicting Smoothed New Tests per Thousand by Service Coverage and Financial Protection

Smoothed New Tests per Thousand	IRR	[95% Conf.	Interval]
Service Coverage	0.943***	0.926	0.960
Financial Protection	0.951***	0.931	0.972
Continent			
Africa	1.209	0.352	4.152
Asia	1.801***	1.250	2.597
North America	17.016***	4.708	61.506
Oceania	224.986**	3.435	14735.167
South America	19.339***	3.829	97.687
Human Development Index	0.000***	0.000	0.001
% Aged 65+	1.178***	1.141	1.217
Number of Countries	79		
Number of Observations	20,462		

[a]Incident Rate Ratios are exponentiated regression coefficients; * p<.05 ** p<.01 *** p<.001.