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COVID-19 Infection in Hypertensive Patients in Correlation with Race

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COVID-19 INFECTION IN HYPERTENSIVE PATIENTS IN CORRELATION WITH RACE

by

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ABSTRACT

Disparities in healthcare exist in the U.S., particularly between different racial categories. This study investigated the frequency of COVID-19 cases and hypertension cases among five different racial groups (White, Black, Asian, Native American, and Native Hawaiian). The study also examined the correlation between COVID-19 and hypertension. It was hypothesized that, because of genetic predisposition to certain diseases and existing socioeconomic barriers, Black populations would have the highest rates of both COVID-19 and hypertension. It was also proposed that a positive correlation exists between COVID-19 and hypertension frequency. To test this, the Kaiser Family Foundation's data for COVID-19 cases and race were used in conjunction with Census population data to determine if COVID-19 case frequency means differ by race. The America's Health Rankings data for hypertension and race were used to determine if hypertension frequency means differ by race. The statistical analysis used for both aims was one-way ANOVA. Lastly, the correlation between hypertension and COVID-19 was found by calculating the Kendall's Tau-b Coefficient. For each ANOVA procedure, there was a statistically significant difference between the means of each dataset. The Kendall's Tau-b Coefficient for COVID-19 and hypertension was a small positive number. It can be concluded that the percentages of both hypertension and COVID-19 cases differ by race and that there is a slightly positive correlation between hypertension and COVID-19. As expected, Black individuals had the highest mean rates of hypertension; however, the highest COVID-19 case frequency was found in Native Americans. On this basis, it can be proposed that, though a correlation exists between hypertension and COVID-19, other factors also contribute to increased infection with COVID-19, and that they should be investigated.

DEDICATION

This thesis is dedicated to my parents and my grandmother. Your determination, wisdom, and standards for excellence are an inspiration to me always.

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I would like to acknowledge and thank those who have supported me in this thesis as well as throughout my progress toward my undergraduate degree.

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TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

CHAPTER ONE: INTRODUCTION

In the past year, the COVID-19 virus has increased its spread from one infected individual to affect the majority of existing countries and territories. This has transformed its status into that of a pandemic. Its effects have been observed in the United States of America, which essentially became the disease's epicenter in late March of 2020. The country currently has the leading number of COVID-19 infection cases and deaths worldwide [1]. It is important to note that social and health factors have contributed to the spread of the virus in the United States of America. Parallels have been previously drawn between disease distribution and race, and some types of diseases have been shown to increase the incidence of others. According to recent studies, hypertension is one of the diseases thought to have some correlation with COVID-19 rates. Based on these observations, this project investigated the correlations between COVID-19 frequency and race, between hypertension frequency and race, and between COVID-19 and hypertension rates.

COVID-19

Epidemiology

The origin and distribution of the severe acute respiratory syndrome coronavirus 2 (SARS-CoV2), also referred to as COVID-19, from Wuhan, China has been differentiated by several important identifying characteristics. In part, the virus has been distinguished by its high horizontal transmission frequency, which indicates that it spreads rapidly between members of the population (even to different countries) [2]. The horizontal transmission frequency can be quantified by the virus's disease transmission reproduction number, which was found to be approximately 3. This substantially exceeds the hypothetical accepted number that serves to reflect the end of virus transmission, proving that the transmission is high enough to cause continuous increases in the frequency of cases [3]. Another identifying indicator of COVID-19 is the severity of the disease, which can be measured with the case fatality rate. This term refers to the percentage of deaths that result from the spread of the disease within a particular set time frame. The concepts of transmission and the severity of COVID-19 will be further expanded upon in the next section, which concerns the potential symptoms and risks of conditions that are associated with COVID-19.

Symptoms and Severity

The symptoms attributed to COVID-19 have been gradually discovered in conjunction with its continuous spread and include the following: fever, coughing, loss of smell and taste, and difficulty breathing [4]. However, these have been shown to have a wide range of variation. The coronavirus symptoms have presented themselves with multiple degrees of severity, including the asymptomatic, mild, severe, and critical conditions [5]. On the extreme end of the spectrum, the critical condition can ultimately result in shock as well as respiratory failure and organ failure [5]. This is preceded by elevated respiratory rates and difficulty breathing, which results in hypoxia [1]. In contrast, the asymptomatic response is typically characterized by a comparatively weaker immune response than that observed in the more severe conditions associated with the disease [6]. This lack of reaction by the immune system causes symptoms to be virtually absent.

Although the more severe manifestations of the virus can lead to consequences such as hospitalization and death, the asymptomatic nature of it can also cause tangible harm. This occurs through involuntary transmission by individuals who are unaware of their status, thus increasing the potential for infecting others. In addition, the virus's period of incubation can range from 14 up to 24 days, further increasing the likelihood of transmission without prior knowledge of initial infection [7, 8, 9]. To mitigate the negative effects of the virus, particularly those that result from transmission that occurs without previous host awareness of infection status, a variety of preventative strategies have been implemented and will be expanded upon in the following section.

Prevention Protocol

As stated by the Centers for Disease Control and Prevention (CDC), there are various options that have been suggested for preventing the spread of COVID-19 throughout the United States of America. Four categories of these preventative strategies will be examined in this section, and they are the following: precautions taken in the healthcare system, source control, physical distancing, and vaccination. An example of the precautionary measures found in healthcare would be the triage protocol, which concerns the urgency of a patient's visit and generally involves the prioritization of patients with more severe conditions, while those with less severe symptoms are advised to remain at home [10]. Another example would be the increased use of Telehealth, which has also been employed to decrease patients' physical visits [10]. The term “source control” refers to preventing the virus from reaching the environment. This includes use of masks (sometimes by mandate) in order to prevent the escape of droplets that spread from coughing and sneezing, as well as personal protective equipment (PPE) as it is used by healthcare professionals; this also applies to hand-washing recommendations [10]. Yet another method used to prevent the spread of the virus is physical distancing, which encourages individuals to remain at home to prevent infection and proposes a six-foot distance between people in public [10]. This term is also used to refer to the closing policy mandated for many businesses (as part of the “shut-down” of individual states), as well as the quarantine process that infected individuals often undergo to prevent the spread of disease to the population. Another category of prevention is vaccination, which has been offered by three major sources at this time: Pfizer, Moderna, and Johnson & Johnson. The first two are mRNA vaccines, while the latter is a more traditional viral load vaccine [11]. There are also ongoing trials being held to test the efficacy of other vaccines. The methods mentioned above are all employed to control the rate of transmission in order to improve outcomes, but in the event of a positive result, there are treatments that have been developed to improve patients’ chances of survival. However, these will not be discussed in this thesis because of the primary focus being on disease transmission and infection rates.

Population Factors and Social Determinants

The prevention options of COVID-19 are mentioned for several reasons. First, possible population differences in infection may be explained by the attitudes that certain groups hold towards COVID-19 and, more generally, medicine as a whole. The adoption (or rejection) of the practices recommended to reduce viral spread has the potential make a significant difference in the pattern and density of infection. In addition to the reason mentioned above, the COVID-19 protocols and treatment options must also be considered in terms of their availability to different sectors of the population. Physician availability and access to medical facilities and resources has historically been shown to differ among various groups [12]. This would conceivably also have an effect on virus distribution, particularly in the number of hospitalizations and deaths.

The emphasis in this project on social group-specific factors and attitudes towards prevention and treatment as well as medical accessibility levels has been largely supported by current events. Conditions of unrest in the U.S. have manifested themselves through increasing protests against racial injustice, divisive political rallies, and other movements and discussions concerning various population groups [13]. The relevance of such social debates is twofold. First, there is the effect of increased gatherings and person-to-person contact. These populous, often community-centric events have been shown to lead to an influx of COVID-19 cases [13]. Secondly, there is the effect of population-wide decision making. The prevalence of particular values and ideologies in certain communities may affect the response to certain regulations or protocols, impacting the incidence of disease [14]. The relevance of socioeconomic factors will be expanded upon below.

Among the many changes that have been brought about by the coronavirus, the impact on the economic growth of many countries, including the United States of America, has been particularly pronounced. In order to curtail the spread of the virus, there has been a continuous increase in shut-down policies and regulations from state and federal governments. These new policies have been successful in slowing the speed of transmission of the virus [15]. However, they have also been detrimental to the economic state of the country and the rest of the world. For example, the government regulations have placed small businesses in a vulnerable position by limiting public gatherings and scaling down operation of companies. The number of business owners in the U.S. decreased by over three million from February to April of 2020 [16]. The businesses that have remained open employ individuals referred to as “essential workers” who have an increased exposure to disease, which further contributes to the spread of the coronavirus. There has also been considerable uncertainty and social unrest in the country during this period, which has played a role in the overall decline of the stock market [17]. These effects, along with multiple other consequences that have resulted from the spread of COVID-19, have, without a doubt, had an extreme effect on citizens of the country; this has altered their lifestyles, income levels, and health and general well-being.

Unequivocally, COVID-19 and recent events have also strongly affected the attitudes of racial groups in the United States of America. Following the inception of pandemic development, perceived injustices against marginalized racial groups have become major causes for social instability and unrest (which were mentioned above). Though there have already been multiple movements in favor of racial equality in the United States in past years, these have continuously increased in prominence [18]. This is possibly related to contributing factors such as the spread of coronavirus, the proximity of the presidential election, and the recent increase in publicized deaths linked to police activity [19]. The social turmoil from these events has played a part in leading to an increase in public demonstrations. One notable example in recent times is the Black Lives Matter movement, which has an increase in protestors since the start of the pandemic [18]. This phenomenon of growth in attendance is a major factor that has been met with contradicting opinions, which have arisen in light of the increased protests. Those in opposition to the movement have claimed that the increased protests are in violation of social distancing protocols and that they have majorly contributed to the continuing spread of infection through the population. However, some evidence indicates the possibility that the increase in cases from the protests was compensated by the behavior of individuals who purposely stayed at home to avoid infection [20]. In any case, this social turmoil is a representation of tension from several underlying causes, and it demonstrates a significant divide in the opinions and backgrounds of citizens of the country. These differences may potentially extend into multiple areas, including the risks and consequences presented by the advent of COVID-19 in relation to different groups in the population.

It has been established that there are stark disparities present in the field of health, and these are strongly determined by the economic or social groups to which an individual belongs. In fact, there is a connection between socioeconomic status, race, and ethnicity, as well as the way in which these categories relate to health [21]. When looking at differences in socioeconomic status and income in the population, it is evident there are worse health outcomes faced by people considered to be on the lower end of the spectrum [21]. The same is true for certain racial groups, particularly for African Americans; this pattern can largely be ascribed to a history of slavery and discrimination in the United States of America [21]. However, there are also ongoing factors that have been shown to affect the health outcomes of different populations. Overall, health disparities can be attributed to a large number of interrelated sources, which include but are not limited to the conditions experienced during childhood, environmental stressors and toxins, and lifestyle choices [21]. These factors can ultimately result in health complications, and they are correlated with a heightened risk of disease and infection.

Certain social groups are more likely to be exposed to unfavorable factors, which increases their susceptibility to infection [21]. This conclusion is especially pertinent within the context of the recent pandemic. For this reason, it is important to determine and analyze the differing effects that COVID-19 has had on varying subsectors of the population and how these effects have been exacerbated by existing social and economic disadvantages. This project analyzed whether a difference exists in the frequency of COVID-19 cases and deaths between particular racial populations, which was the expected result given the findings of previous research. Our hypothesis was that African Americans would show the highest rates for COVID-19 infection.

Hypertension

Diseases are sometimes found to be more common among certain populations with the possibility of having a heightened presence in individuals of specific races [22]. This may stem from genetic predisposition, or, as stated in the above section, from lack of access to resources and healthy lifestyle options. Because of this, investigating the relationship between race and diseases is one way to understand the causes behind increased diagnoses. One disease that may be analyzed in such a way is hypertension, which is the most common risk factor for cardiovascular events [23]. It is caused by the chronic pressure of blood against the walls of arteries and is influenced by blood volume and arterial resistance to the flow of blood [23]. The long-term effects of hypertension include organ stress and damage from the body's immune response, and these negative effects are exacerbated in individuals with a genetic predisposition for hypertension [24]. Apart from genetic factors, hypertension has been thought to develop from lifestyle factors, which include a low frequency of exercise, consumption of tobacco and alcohol, abnormal sodium and potassium levels in the diet, and stress [23]. There is a potential for interaction between race and hypertension, which prompts the investigation of the nature of this correlation and whether it differs significantly between different racial groups. Additionally, hypertension itself can act as a factor that affects health outcomes, as seen through its effect on the immune system. For this reason, hypertension's comorbidity with COVID-19 was examined in this project through the analysis of the correlation between the two factors. Our hypothesis was that African Americans would have the highest rates of hypertension. We also hypothesized that the variables of COVID-19 and hypertension would share a positive correlation.

Specific Aims

The first aim in this project concerned the relationship between race and certain diseases. Statewide COVID-19 rates were compared by race to determine if a correlation existed between race and COVID-19. Similarly, the second part of the first aim involved the comparison of hypertension rates by race to determine if a correlation existed between race and hypertension. The second aim investigated the correlation between statewide COVID-19 cases and hypertension cases; this was evaluated separately from the variable of race.

CHAPTER TWO: METHODS

Datasets

The datasets for the aims were publicly available and were obtained from the Kaiser Family Foundation (KFF), America's Health Rankings, the CDC, and the Census population data for each state. This project was designated by the IRB as a non-human study.

COVID-19 and Race

The Kaiser Family Foundation dataset contained information for the percentage of state COVID-19 cases by race as well as the percentage of each race in the total population for each state. The racial categories included were White, Black, Asian, Native American and Native Hawaiian. Since the data included the percentages of COVID-19 cases for certain races in the population but did not include the percentage of the affected population within each race, additional calculations were necessary. To accomplish this, the KFF state COVID-19 case percentages by race were multiplied by the total number of COVID-19 cases by state (obtained from the CDC). Next, the KFF state race percentages were multiplied by the total populations for each state (obtained from the Census data). The ratio of the two resulting values was found in order to determine the mean percentage of those infected with COVID-19 within each racial category by state. These percentages can be seen in Table 1 as they are distributed by race. In addition, the mean of the existing state values can be viewed in the boxplot shown in Figure 1.

Hypertension

The America's Health Rankings dataset described the frequency of hypertension among different racial populations by state. The data already accounted for race percentages in the population, so there were minimal additional calculations required. The percentages of hypertension for each racial group can be viewed in Table 2. The percentage of hypertension cases in the U.S. by race was found by creating a boxplot of the present state values; this is reflected in Figure 2.

Statistical Analyses

ANOVA

Each dataset (organized by separate state entries) was analyzed individually through one-way ANOVA to determine whether a statistically significant difference existed within each dependent variable based on the independent variable of race. This method of statistical analysis contrasts the variance found among various groups with the variances found within the groups themselves [24]. If the probability value, α, is found to be less than a designated "significant" value of 0.05, then the null hypothesis can be disproved, meaning that a difference can be found between the population means. The three assumptions for performing ANOVA were the following: a normal distribution, the existence of a similar variance between different groups, and the existence of independent data points. The first two assumptions had to be satisfied by completing Levene's Test and observing the dataset boxplots, respectively, while the third assumption held true based on the method of data collection. After the ANOVA was completed, the post-hoc Tukey HSD

Test was performed to compare each of the conditions among themselves. The ANOVA and Tukey HSD Test were both conducted through RStudio, a statistical software package.

Kendall Rank Correlation Coefficient

For the second aim, Kendall's Tau-b Coefficient was used to determine the nature of the correlation between the dependent variables of hypertension and COVID-19. The assumptions of this test are that both of the variables are continuous and that the relationship between the variables is monotonic (though this is not a strict assumption); the use of this test was valid because the dataset fulfilled the assumptions. This specific test was also chosen because of its relatively high tolerance for outliers, which were present in the dataset. The Kendall Rank Correlation Coefficient was found using RStudio.

CHAPTER THREE: RESULTS AND DISCUSSION

For the COVID-19 percentage data, Levene's Test was used to fail to reject the null hypothesis, satisfying the assumption for homogeneity of variances. The boxplot determined that the distribution of the data was relatively normal, confirming the remaining assumption (Figure 1). According to the results of the ANOVA, the race of the sample population used during data collection had a statistically significant impact on the presence of COVID-19 infection. This was at the $p<.05$ level for the following conditions: [$F(4,151)= 19.69$, $p=4.62e-13$]. The Tukey HSD Test shown in Figure 3 gives the output of the test, while Table 3 gives the exact similarities and differences between each of the conditions based on the p-values that were obtained.

For the hypertension percentage data, Levene's Test was also used. There was a failure to reject the null hypothesis, again satisfying the assumption for homogeneity of variances. The boxplot for this dataset also determined that the distribution was relatively normal, confirming the second assumption (Figure 2). According to the results of the ANOVA, the race of the sample population used during data collection had a statistically significant impact on the presence of hypertension in patients. This was at the $p<.05$ level for the following conditions: [$F(4,151)= 52.47$, $p=2e-16$]. The Tukey HSD Test output is shown in Figure 4, and Table 4 shows the exact similarities and differences between the conditions that were found from the p-values.

It can be seen in Figure 3 that, for COVID-19 cases, the Native American population had the highest mean and the Black population had the second highest mean. This was followed by the Native Hawaiian population. There was a slight gap between this and the next group, which was the White population, while the Asian population could be associated with the lowest mean. Figure 4 shows that, for hypertension, the Black population had the highest mean and the White population had the second highest mean. The next highest population mean was for Native Americans, followed by Native Hawaiians, while the Asian population had the lowest mean once again.

Finally, the Kendall Rank Correlation Coefficient was found to be $\tau = 0.2611868$. This value, which is located on a scale from -1 to 1, indicates a slightly positive correlation between the dependent variables of COVID-19 cases and hypertension. A plot of the correlation between these variables is also represented in Figure 5; however, this graph does not necessarily reflect the Kendall Tau results directly.

State	Rate of COVID-19 Cases in White Population	Rate of COVID-19 Cases in Black Population	Rate of COVID-19 Cases in Asian Population	Rate of COVID-19 Cases in Native American Population	Rate of COVID-19 Cases in Native Hawaiian Population
AL	0.083655876	0.109106737	NA	NA	NA
AK	0.04534786	0.116353061	NA	0.134452426	NA
AZ	0.094007868	0.112809442	0.075206294	0.169214162	NA
AR	0.101708894	0.128738381	NA	NA	NA
CA	0.049049056	0.07063064	0.041201207	NA	NA
CO	0.05971269	0.075193758	0.050129172	NA	NA
CT	0.055616246	0.087776945	0.031918889	NA	NA
DE	0.073774061	0.098186568	NA	NA	NA
DC	0.036852873	0.061904198	NA	NA	NA
FL	0.066579587	0.082336756	NA	NA	NA
GA	0.086612202	0.098917436	NA	NA	NA
HI	0.015666732	0.056894974	0.015171993	NA	NA
ID	0.092235191	NA	NA	0.19315134	NA
IL	0.083360436	0.087440246	0.047083209	NA	NA
IN	0.092750865	0.087730162	NA	NA	NA
IA	0.111979505	0.134018025	0.10721442	NA	NA
KS	0.103708493	0.101296668	0.067531112	NA	NA
KY	0.089319557	0.091421194	NA	NA	NA
LA	0.079534783	0.098855733	NA	NA	NA
ME	0.032374263	NA	NA	NA	NA
MD	0.051035185	0.07017338	0.031896991	NA	NA
MA	0.057333047	0.093604975	0.046802488	NA	NA
MI	0.058727589	0.065344783	0.043563188	NA	NA
MN	0.078762047	0.129629203	0.086419469	NA	NA
MS	0.094459935	0.09970771	NA	NA	NA
MO	0.065805062	0.085312491	NA	NA	NA
MT	0.085510572	NA	NA	0.104584969	NA
NE	0.108233281	0.083667975	0.104584969	0.17244632	NA
NV	0.073843345	0.085152686	0.095796771	NA	NA
NH	0.050422627	NA	NA	NA	NA
NJ	0.070286507	0.082837669	0.045184183	NA	NA

NM	0.050388519	0.088779772	NA	0.207152801	NA
NC	0.075463052	0.082765928	NA	NA	NA
ND	0.130057629	NA	NA	0.153519005	NA
OH	0.077191255	0.090313768	0.083366555	NA	NA
OK	0.111449122	0.108436984	0.108436984	0.176210099	NA
OR	0.026405147	0.055719335	0.029716979	0.074292446	NA
PA	0.075376957	0.093594448	0.055153871	NA	NA
RI	0.095097349	0.160759804	0.080379902	NA	NA
SC	0.087629365	0.101227025	NA	NA	NA
SD	0.121571853	NA	NA	0.207685249	NA
TN	0.109688354	0.107001731	NA	NA	NA
TX	0.08314331	0.145875311	0.018426355	NA	NA
UT	0.104502265	0.116445381	0.116445381	NA	NA
VT	0.023533694	NA	NA	NA	NA
VA	0.058231345	0.079095613	0.039034198	NA	NA
WA	0.031803622	0.067582696	0.030036754	0.090110262	NA
WV	0.074032431	0.098709909	NA	NA	NA
WI	0.102760481	0.124220501	NA	NA	NA
WY	0.094486652	NA	NA	0.330703281	NA

"NA" was used to represent values that were not available on state websites as well as disease rates that were below 1% of the population.

Table 1. COVID-19 State Percentages by Race

State	Rate of Hypertension in White Population	Rate of Hypertension in Black Population	Rate of Hypertension in Asian Population	Rate of Hypertension in Native American Population	Rate of Hypertension in Native Hawaiian Population
AL	0.424	0.477	NA	NA	NA
AK	0.329	0.411	NA	0.36	NA
AZ	0.361	0.487	0.183	0.309	NA
AR	0.419	0.493	NA	NA	NA
CA	0.326	0.387	0.211	NA	NA
CO	0.261	0.369	0.13	NA	NA
CT	0.318	0.431	0.166	NA	NA
DE	0.388	0.421	NA	NA	NA
DC	0.185	0.419	NA	NA	NA
FL	0.379	0.359	NA	NA	NA
GA	0.352	0.42	NA	NA	NA
HI	0.262	0.275	0.359	NA	0.294
ID	0.313	NA	NA	0.498	NA
IL	0.346	0.384	0.162	NA	NA
IN	0.351	0.445	NA	NA	NA
IA	0.33	0.379	0.124	NA	NA
KS	0.347	0.479	0.233	NA	NA
KY	0.418	0.449	NA	NA	NA
LA	0.389	0.434	NA	NA	NA
ME	0.364	NA	NA	NA	NA
MD	0.353	0.409	0.201	NA	NA
MA	0.3	0.31	0.123	NA	NA
MI	0.352	0.427	0.152	NA	NA
MN	0.303	0.249	0.145	NA	NA
MS	0.429	0.47	NA	NA	NA
MO	0.312	0.342	NA	NA	NA
MT	0.293	NA	NA	0.355	NA
NE	0.326	0.338	0.194	0.439	NA
NV	0.369	0.323	0.368	NA	NA
NH	0.321	NA	NA	NA	NA
NJ	0.343	0.412	0.254	NA	NA

NM	0.355	0.423	NA	0.306	NA
NC	0.354	0.457	NA	0.54	NA
ND	0.306	NA	NA	0.393	NA
OH	0.343	0.436	0.108	NA	NA
OK	0.391	0.444	0.283	0.392	NA
OR	0.324	0.37	0.214	0.338	NA
PA	0.342	0.433	0.153	NA	NA
RI	0.343	0.357	0.152	NA	NA
SC	0.384	0.443	NA	NA	NA
SD	0.315	NA	NA	0.313	NA
TN	0.392	0.464	NA	NA	NA
TX	0.358	0.396	0.183	NA	NA
UT	0.268	0.249	0.158	NA	NA
VT	0.303	NA	NA	NA	NA
VA	0.343	0.453	0.138	NA	NA
WA	0.325	0.338	0.217	0.354	NA
WV	0.44	0.41	NA	NA	NA
WI	0.321	0.366	NA	NA	NA
WY	0.318	NA	NA	0.275	NA

"NA" was used to represent values that were not available on state websites as well as disease rates that were below 1% of the population.

Table 2. Hypertension State Percentages by Race

Distinct From One Another	Black - White	Native American - White	Asian - Black	Native American - Black	Native American - Asian
The Same As One Another	Asian - White	Native Hawaiian - White	Native Hawaiian - Black	Native Hawaiian - Asian	Native Hawaiian - Native American

Table 3. COVID-19 and Race Tukey HSD Analysis

Distinct From One Another	Native American - White	Native American - Black						
The Same As One Another	Black - White	Asian - White	Native Hawaiian - Black	Native Hawaiian - Native American	Native Hawaiian - Asian	Native American - Asian	Native Hawaiian - White	Asian - Black

Table 4. Hypertension and Race Tukey HSD Analysis

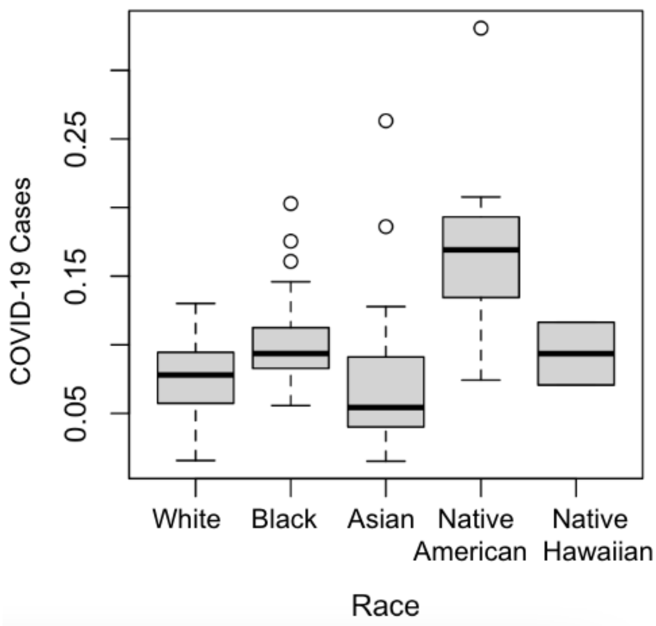

Figure 1. Boxplot of COVID-19 Cases by Race

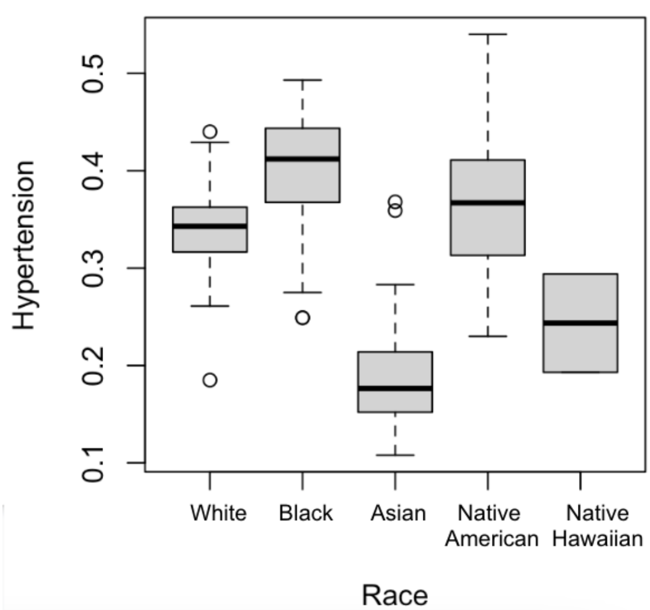

Figure 2. Boxplot of Hypertension by Race

	diff	lwr	upr	p adj
Black - White	0.024306113	0.003040757	0.045571470	0.0163219
Asian - White	-0.006989957	-0.028625775	0.014645862	0.8994858
Native American - White	0.091997982	0.059411736	0.124584228	0.0000000
Native Hawaiian - White	0.017898805	-0.057579547	0.093377157	0.9655200
Asian - Black	-0.031296070	-0.053252725	-0.009339416	0.0011796
Native American - Black	0.067691869	0.034891724	0.100492013	0.0000006
Native Hawaiian - Black	-0.006407308	-0.081978253	0.069163636	0.9993284
Native American - Asian	0.098987939	0.065946409	0.132029469	0.0000000
Native Hawaiian - Asian	0.024888762	-0.050787264	0.100564788	0.8934414
Native Hawaiian - Native American	-0.074099177	-0.153601477	0.005403123	0.0805301

Figure 3. Tukey HSD Output for COVID-19 Cases and Race

	diff	lwr	upr	p adj
Black - White	0.05924852	0.02441665	0.094080390	0.0000574
Asian - White	-0.14899925	-0.18954131	-0.108457186	0.0000000
Native American - White	0.03136275	-0.00588647	0.068611960	0.1427924
Native Hawaiian - White	-0.09746078	-0.21873544	0.023813872	0.1783835
Asian - Black	-0.20824776	-0.25004387	-0.166451655	0.0000000
Native American - Black	-0.02788577	-0.06649614	0.010724590	0.2738732
Native Hawaiian - Black	-0.15670930	-0.27840893	-0.035009678	0.0045313
Native American - Asian	0.18036199	0.13653096	0.224193023	0.0000000
Native Hawaiian - Asian	0.05153846	-0.07191678	0.174993708	0.7780930
Native Hawaiian - Native American	-0.12882353	-0.25123694	-0.006410118	0.0337817

Figure 4. Tukey HSD Output for Hypertension and Race

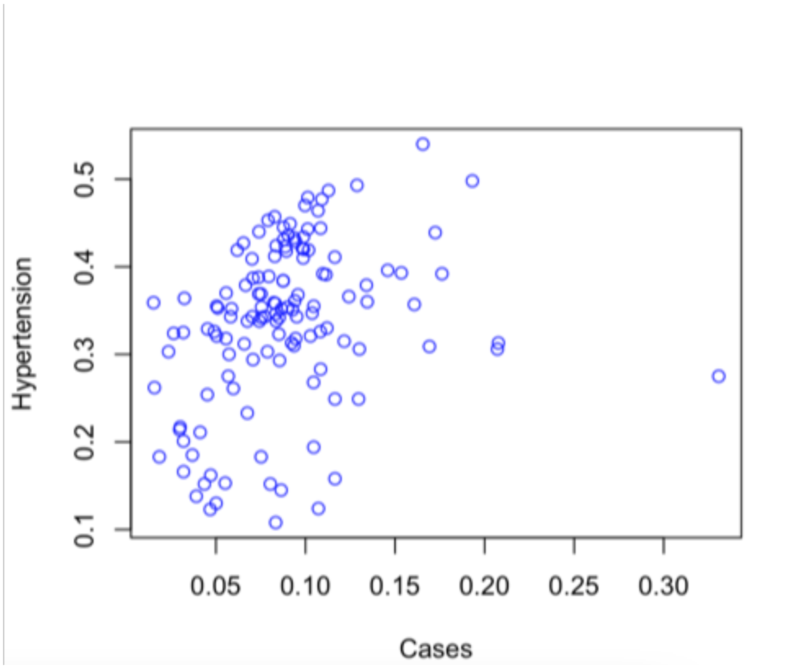

Figure 5. Relationship between Hypertension and COVID-19

CHAPTER FOUR: CONCLUSION

To conclude, this thesis has focused on examining the impact of race on COVID-19 case frequency, the impact of race on hypertension rates, and the correlation between COVID-19 cases and hypertension. It involved the use of ANOVA to analyze whether the impact of race is statistically significant, and the Kendall Rank Correlation Coefficient was used to determine the strength of the relationship between hypertension and COVID-19.

Based on the results, it can be confirmed that the rates of COVID-19 cases and hypertension are each affected by race in a way that is statistically significant. This supports the conclusion that race has a relationship to the frequency of COVID-19 infection and hypertension in a population. It is also clear that a positive correlation exists between hypertension and COVID-19.

It was previously hypothesized that the Black population would have the highest rates for both COVID-19 cases and hypertension. According to the results of this study, the Black population indeed has the highest prevalence of hypertension. However, the individual means and the Tukey HSD Test showed that Native American population suffers from the highest rates of COVID-19. Based on existing literature, it is likely that this unequal disease distribution stems from the lack of equal access to resources by underserved populations, especially in indigenous communities. Since COVID-19 has developed rather recently, its ill effects may also be reflected more strongly in these populations because the treatments and prevention methods are still so limited in scope and distribution. A further investigation of this phenomenon could utilize a survey to assess the time it takes for these populations to receive medical care in order determine what external factors could be contributing to the unequal prevalence of COVID-19 infection.

Since it was also concluded that hypertension and COVID-19 cases have a positive correlation, a follow-up study for this aim could be to analyze the correlation in the severity of each of these diseases. For example, COVID-19 patient hospitalization could be analyzed through the history of hospitalization for hypertension complications. Additionally, since predisposition to hypertension causes increased severity of the condition, a study could be performed on the symptoms of COVID-19 experienced by people with non-genetic hypertension versus people with a genetic predisposition.

It is clear that there are many variables that can still be assessed and studies that can be performed as a follow-up to the conclusions drawn from this project. The results of this study have served to demonstrate a significant difference in COVID-19 and hypertension rates based on race as well as a positive correlation between COVID-19 and hypertension.

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