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Japan’s COVID 19 Infection Rate: A Focus on Tokyo Neighborhoods

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Japan’s COVID 19 Infection Rate:
A Focus on Tokyo Neighborhoods

by

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A thesis submitted in partial fulfillment of the requirements for the degree of
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ABSTRACT

This thesis asks, are neighborhood demographic and economic variables connected to COVID-19 infection rates in Tokyo, Japan? I hypothesize that variation in urbanization and neighborhood demographics account for Japan’s low, though not uniform COVID-19 infection rates. This thesis applies several anthropological perspectives: The biocultural perspective because I look at epidemiology of COVID 19 considering socio-cultural, economic, and ecological factors as well as biological susceptibilities. The critical biocultural perspective because I look at how structures of power and inequality may impact health and healthcare access. Biomedical/applied anthropology, well placed to study the current epidemiologic situation of COVID 19 in Japan and any other society with differential access to medical care and exposure to pathogens because its perspectives point out the factors which impede access to health care, even in countries with socialized medicine. Results of these analyses showed significant differences between levels of urbanization, age groups within levels of urbanization, and four demographic variables that are significantly associated with the increase of COVID-19 infections.
LITERATURE REVIEW & THEORY

Introduction

In late December of 2019, SARS-Cov-2 emerged out of Wuhan, China and quickly spread across the globe. The name SARS-Cov-2 can be broken down as Severe Acute Respiratory Syndrome Coronavirus 2 (Umakanthan et al. 2020). As of January 12th, 2019 novel betacoronavirus was cited as the causative agent for the disease (Kahn et al 2020). While the world has experienced other severe Coronaviruses before such as SARS-CoV and MERS-CoV; SARS-Cov-2 quickly emerged to be more infectious (Ovsyannikova et al. 2020).

The name Coronavirus has its Latin roots in the word corona meaning crown, a reference to the S protein spikes that cover the virus’s surface. Coronaviruses stand as one of the largest groups of viruses in the world found within the order Nidovirales. The Latin root of Nido in Nidovirales meaning ‘nest’ and references the ability of this virus to create an enclosed set subgenomic mRNA (Helmy et al. 2020). Coronavirus is similarly included in the suborder Cornidovirineae, and the family Coronaviridae (Helmy et al. 2020). This virus is also known by the name of COVID19 in reference to Coronavirus Disease 2019, which will be used throughout this paper.

COVID19 is a positive single strand RNA (ssRNA) virus which primary mode of viral transmission is human-human transmissions either directly, through close contact, droplets from sneezing and coughing, or indirectly through fomites (i.e., objects that have the live virus after an infected person has gotten droplets on the object). These objects can be door handles, handrails, masks, plastics and many other materials on which the virus can exist for an extended period of
time. Both direct and indirect transmissions can occur through, infected, pre-symptomatic, and asymptomatic individuals (Umakanthan et al. 2020), (World Health Organization 2020). The highly contagious nature of the virus through human-human transmission allowed the virus to quickly and aggressively sweep across the globe in a short amount of time relative to other coronaviruses (Kahn et al 2020).

Due to the highly transmissible nature of this virus via airborne means, many countries in the world made the decision to enter lockdown, which refers to “large scale physical distancing measures and movement restrictions…” (World Health Organization 2020). Unlike many other countries, “Japan's national and local governments do not have the legal power to impose lockdown measures” (Normile 2020) yet, Japan has maintained and managed a relatively low COVID19 infection rate nationwide (Iwasaki and Grubaugh 2020, Shibusawa et al. 2021, Dudden 2020).

According to the CDC, as of October 21, 2021, Japan had a cumulative COVID19 infection rate of 1375.7 per 100,000 people, and a death rate of 14.6 per 100,000 people (CDC n.d). Tokyo’s special wards alone, have a population of 9.273 million people (as of 2015), of which there had only been 377,305 COVID19 infections and 3,113 COVID19 deaths as of October 21, 2021. A more recent update to these data shows that as of May 30th, 2022, Japan has recorded 8.82 million COVID19 infections and 30,580 COVID19 deaths

In the United States there is ecologically different access to resources that has further manifested through the COVID19 pandemic. The ability to access resources and the ability to solve health problems is increasingly dependent on socioeconomic status. For the African American population living in the United States, the COVID19 pandemic has been referred to as a “perfect storm” (Sanchez, 2020). With the rise of the COVID19 pandemic many of the
structural and socioeconomic inequalities that disproportionately affect minority populations every day, have been brought to the surface. In the United States, minority populations face increased barriers to access healthcare, education, employment, and nutrition due to structural racism and systematic discrimination which were then further exacerbated during the COVID19 pandemic (Singu et al. 2020; Robincaux and Sauerland, 2021).

Through applied anthropology I ask if similar trends are expressed in Tokyo by using an approach that asks why some neighborhoods have higher rates of infections than others. Following statistical analysis, I interviewed a public health official in Japan to gain a better understanding of healthcare access and how different levels of urban and rural environments can impact access.

In this thesis, I assess if neighborhood demographic and economic variables in Tokyo, Japan are connected to COVID19 infections. If so, I examine which variables can best explain the differences in infection rates. Additionally, this thesis is presented as preliminary research for a future dissertation involving COVID19. Benefits of this research include, assessing socioeconomic, and demographic contributors to COVID19 infection. Furthermore, this research will contribute to the discussion of healthcare access in Japan, which is relevant to several cultural settings. The variables whose influence on COVID-19 epidemiology I will test consist of, population, age, labor force, number of taxpayers (per income), geographical district, household type, healthcare facilities, and level of urbanization.

Limitations to this research consist of the inability to access some Japanese data, lack of data confirming a genetic protection from COVID19 in Japan, limits on Japanese genetic data, and the lack of data on present ethnic populations within Japan. Data was compiled and analyzed over a period of one year.
COVID19 is a positive single strand RNA virus and can be divided into four different parts displayed in figure 1\(^1\). The First, on the virus’s coating there is the (S) spike protein, which can be found on the outside of the virus and is essential to the virus’s ability to attach to the hosts’ cells, both infected and uninfected. This protein is what gives ‘corona’ its crown-like imagery. Second the (M) membrane protein provides structure and shape to the virus. Third, the (E) envelope small membrane protein also provides structure and shape to a lesser degree. Fourth, the (N) Nucleoprotein aids in transcription and assembly by forming the RNA complex for the virus (Umakanthan et al. 2020).

\(^1\) Images in this chapter have been previously published by the Centers for Disease Control and Prevention. (https://phil.cdc.gov/Details.aspx?pid=23313) The use of these images is with permissions.
Infection caused by COVID19 depends on the S proteins of the virus and the angiotensin-converting enzyme 2 (ACE2) receptors of the host. The infection of host cells by COVID19 occurs through pH- and receptor mediated endocytosis, in which the S proteins of the COVID19 virus locates and binds to the ACE2 receptors, located on the host cell’s surface (Kahn et al. 2020). From there, the virus propagates, if it is not met with a swift immune response. It is important to note that while there is a high expression of ACE2 receptors in tissues located in the lungs, these receptors are also located on cells through the body (Umakanthan et al. 2020). Thus, COVID19 is an infectious disease that has the ability to infect and damage multiple types of tissue and organs and is not limited to affecting only the lungs (Shi et al. 2020). It is hypothesized that children produce higher immunity to the COVID19 infection due to having fewer ACE2 receptors than adults (Meyerowitz et al. 2020).

Human-Human transmission has been cited as the main source of viral transfer. This transmission form includes droplet contact through coughing, sneezing, saliva, and even singing. COVID19 can also exist for extended periods of time (up to 72 hours) on various surfaces, with the virus on plastics and stainless steel having a half-life of roughly six hours. Disinfectants, however, have proven to be an effective combatant to COVID19 on nonliving surfaces (Meyerowitz et al. 2020).

Acute respiratory distress symptom (ARDS) is the most widely associated cause of death in COVID19 patients with severe symptoms. ARDS occurs when the lungs’ air sacks become damaged and start to flood with fluid from the blood vessels, which ultimately leads to low blood oxygen in the body as the lungs reach a point where they can no longer expand to facilitate normal oxygen and carbon dioxide exchange. This is caused due to damage to the surfactant in the lungs- the liquid that allows the lungs to expand (NIH n.d).
This cause of death is not limited to COVID19, as it is also associated with SARS-CoV, MERS-CoV, and other highly pathogenic influenza viruses as well. Patients who have a high viral load and severe symptoms present are also more prone to experiencing cytokine release syndrome (CRS), an inflammatory response that releases a large number of cytokines, known as a cytokine storm into the blood. CRS can often lead to ARDS, creating multiple organ failures and ultimately death (Fakhroo et al. 2020, NIH n.d).

**Innate Immunity and Resistance to COVID19**

It is important to note that there are several forms of immunity regarding COVID19 including both acquired and innate. For this discussion on genetic factors, I will only focus on innate immunity. At the time of writing some possible forms of genetic resistance to COVID19 have been discovered in different populations. These primarily include host enzymes, especially ACE2, but also some HLA variants and genes involved in histone regulation (Y. Chen, Shan, & Qian, 2020; Fakhroo et al. 2020; Nguyen et al., 2020 as cited In Mohammadpour et al. 2021).

During the infection process ACE2 as previously discussed, plays an important role in viral infection as the primary mode of viral entry into the cells of the host, but two other host enzymes: TMPRSS2 (transmembrane serine protease 2) and furin, while discussed less might also be just as important (Fakhroo et al. 2020). As previously mentioned, while ACE2 is found in high frequency in the lungs, it can also be found all over the body. The presence of single nucleotide polymorphs (SNPs) in the ACE2 gene’s coding region presents the capability of variation in alleles, with some of these variations presenting some risk and protective variants. K31R and Y83H are two variants that may offer protection against COVID19 and can be found in higher frequency within Asian populations. (Fakhroo et al. 2020). Although a previous study by (Y. Chen, Shan, & Qian, 2020), found that Asian populations did not have any distinct ACE2
expressions (Y. Chen, Shan, & Qian, 2020 as cited in Mohammadpour 2021). Alternatively, a possible risk variant T921 was found prominently in populations with European decent. Past studies have identified that in patients with severe COVID19 the expression of ACE2 in their lungs was upregulated, that is the presence of ACE2 enzymes in the lungs was increased (Fakhroo et al. 2020). The upregulation of ACE2 was found to be TMPRSS2 just like ACE2 has been found to also play a role in the entry of viruses (COVID19) into the cell of the host (National Center for Biotechnology Information, 2022). Therefore, it would stand to reason that any variation present in these enzymes may also help or hinder the entry of viruses, COVID19 in particular. Leading to variation in COVID19 susceptibility and or resistance. Some research into TMPRSS2 pertaining to COVID19 resistance and susceptibility has already been done. One study has suggested that a prevalent polymorphisms of TMPRSS2 (p.Val160Met (rs12329760)) may explain some of the difference in genetic susceptibility to COVID19, as well as differences in the development of other health risk factors such as cancer (Hou et al. 2020). TMPRSS2 fusion with the ERG gene may also explain gender differences in COVID19 susceptibility. Beyond underlying sex specific behaviors such as smoking being more common in men, TMPRSS2’s connection to prostate cancer and higher TMPRSS2 expression being associated with higher susceptibility to the influenza virus may explain why higher COVID19 susceptibility is also found in males (Stopsack et al. 2020).

Furin is an enzyme that is abundantly found in several tissues across the body. When COVID19 binds to the membrane of the hosts cell with its S-protein spikes, the process is activated by an enzyme like furin (Hasan et al. 2020). Furin in general is not unknown to play a part in general viral pathogenesis (Whittaker 2021). However, within the S-protein spikes of the COVID19 virus there are four distinct amino acids (PRRA) that is exclusive to COVID19 and
not found in other coronaviruses. The addition of these four amino acids creates a furin cleavage site that may impact infection and how the disease progresses in vivo (Zhang et al. 2021). However, it is important to note that this research is extremely new and ongoing, thus it is subject to change under the presentation of new information.

Finally, the HLA system presents a large opportunity for polymorphisms and as such, it would stand to reason that some of these variants may also play a role in COVID19 resistance and susceptibility. Due to the variation present in the HLA system and the fact that all HLA genotypes have the ability to bind themselves to COVID19 peptides it is possible that some variants may be able to provide some resistance or susceptibility to COVID19. One silico analysis cited the variant HLA-B*46:01 for COVID19 resistance, as less peptide bonding sites on this variant present less opportunities for infection. (Nguyen et al., 2020 as cited In Mohammadpour et al. 2021).

In sum, research in this area is still new, and changing due to the production of new information. For many of the innate-resistance paths there was conflicting information about the presence of resistance or susceptibility. Further exploration into these pathways will be beneficial research not just for COVID19 but other future and current diseases with similar infection methods.
COMMON PRE-EXISTING CONDITIONS AND THE RESULTING HEALTH EFFECTS DUE TO COVID19

Age

With the rise of better medical and public health knowledge, human life expectancy has expanded through the last 100 years (Roser et al. 2019). This rise of new medical knowledge and technology has helped facilitate an environment in which more individuals are able to coexist longer with chronic long-term conditions that were previously life threatening such as diabetes and cardiovascular diseases (Warraich et al. 2017; McCourt School of Public Policy. 2019). However, it is important to note that environmental factors still heavily impact whether a longer lifespan will translate into longer healthy years lived (Hansen and Kennedy, 2016; Johns Hopkins, 2014; Warraich et al 2017; Hajat and Stein, 2018). Older age is associated with higher mortality not only due to COVID19, but also to other coronaviruses and influenza viruses in the past (Muller et al. 2020).

Older age in regard to the COVID19 pandemic has been associated with higher mortality rates in both men and women (Yanez et al. 2020). The older a person is, the more at-risk they become for severe side effects caused by COVID19. An increased age is associated with leading to adverse outcomes from COVID19, even independent from the presence of pre-existing conditions (Muller et al. 2020) This can be due to many events that accompany the natural aging process such as immunosenescence, which is the natural decline of the immune system in an aging individual, or inflammaging, which is an increase in immune system inflammation (Yanez et al. 2020). This can also be influenced by environmental factors, such as the ability to access
healthcare, and differences in socioeconomic status. For this reason, I also consider demographic and socioeconomic factors alongside age in my analysis. One study conducted with 21 countries with the highest COVID19 cases found a significant association between COVID19 mortality and older age in 16 countries. Variation in healthcare access, presence of pre-existing conditions, and socioeconomic status may all contribute to the variation of COVID19 mortality and older age association found within these countries (Yanez et al. 2020). With older age also comes more chronic conditions that may increase the risk of worse COVID19 outcomes as older adults are more likely to have chronic conditions that are considered risk factors such as diabetes, asthma, hypertension, and more (McCourt School of Public Policy, 2019). Research conducted across England, Scotland and Wales also found that increased risk factors in older adults also correlated to increased COVID19 mortality. It was additionally found that independent of these risk factors older age was still correlated with higher COVID19 mortality (Ho et al. 2020).

According to the Population Reference Bureau, 26 percent of Japan’s total population was over 65 years of age as of 2015 (Scommegna 2019). By this measure, Japan has the oldest population in the world. However, despite having the world’s oldest population Japan has kept their COVID19 mortality and infection rates relatively low (as of May 30th 2022 Japan has recorded 8.82 million COVID19 infections and 30,580 COVID19 deaths) (Iwasaki and Grubaugh 2020, Shibusawa et al. 2021, Dudden 2020).

Obesity

Obesity is also positively correlated with increased severity of COVID19 symptoms. Almost all countries have seen a rise in obesity and have a population of +20% that fall under the category of being overweight or obese (Popkin et al. 2020). Lifestyle changes associated with the COVID 19 pandemic may have additionally contributed to being overweight or obese, as many
people restricted their outdoors activities (Popkin et al. 2020). Obesity additionally places pressure on the body’s immune system that can lead to a higher severity in COVID19 symptoms and also presents a connection to the previously mentioned cytokine storm, as obesity is an inflammatory state (Fakhroo et al. 2020). The CDC further states that obesity can triple an adult’s chances of worse COVID19 symptoms and that a higher BMI (Body Mass Index) can increase the chances of COVID19 symptoms that will require hospitalization. (Centers for Disease Control and Prevention, 2022).

However, it is important to note that while obesity is on the rise all over the globe, it also can disproportionately affect minority populations (Popkin et al. 2020). This is extremely important to consider as the CDC states that high obesity rates in both Hispanic and non-Hispanic Black adults may make worse COVID19 outcomes more likely for these populations. Data gathered by the CDC from 2018-2020 showed that in the United States, 40.7 percent of Non-Hispanic Black adults and 35.2 percent of Hispanic adults reported themselves as being obese compared to just 30.3 percent of white adults (Centers for Disease Control and Prevention 2022). These higher rates of obesity found in primarily minority populations can be heavily influenced by environmental factors to no fault of the individual. This can happen through policy and structural conditions where populations live, physical environment, and socioeconomic status. It is important to note this pandemic continues to highlight the disproportionate health equity in the United States (Centers for Disease Control and Prevention, 2022). One example can be found in so-called food swamps, which are locations where unhealthy food choices dominate an area. These areas are primarily found in disproportionately low-income and minority neighborhoods. Research has found that these food swamps may play a large part in the ability to predict obesity rates (Cooksey-Stowers et al. 2017).
Beyond information provided by the CDC, there is increasing evidence that obesity can lead to worse COVID19 symptoms (Popkin et al. 2020). Research conducted in Mexico with data obtained from the Mexican Ministry of Health (Hernández-Garduño 2020) found that obesity was the highest risk factor predictor for COVID19 with populations only reporting one comorbidity. Another nationwide study of a COVID19 cohort in Denmark found that when age and sex were controlled for, obesity was still listed among other risk factors associated with COVID19 mortality or severe COVID19 symptoms (Reilev et al. 2020). Moreover, a study conducted nationally in Israel also found obesity to be another risk factor associated with increased COVID19 susceptibility (Yanover et al. 2020). It is important to note that much of this research is still ongoing as we continue to learn more about COVID19 and how it interacts with the environment and the population.

*Type Two Diabetes*

Type two diabetes is the most common type of diabetes and occurs when the human body has a high amount of blood glucose and is unable to regulate insulin. Blood glucose serves as the body’s energy source, and with type two diabetes the high amount of blood glucose left in the body cannot reach the cells. This can then result in tiredness, increased hunger, increased thirst and even numbness in the hands and feet. Type two diabetes also has a connection to obesity as being overweight, obese, or not physically active can directly lead to the development of type two diabetes (NIH n.d., American Diabetes Association n.d.). A connection between diabetes and virus susceptibility has already been established in other coronaviruses such as MERS-CoV and SARS-CoV. Diabetes has been a largely presence in patients with COVID19 (Fakhroo et al. 2020).
In the previously mentioned study in Denmark, diabetes was also named among other co-morbidities that were associated with COVID19 mortality or severe COVID19 symptoms. Among the patients that were hospitalized for COVID19, 19 percent had diabetes (Reilev et al. 2020). Research by (Hernández-Garduño 2020) also showed that diabetes was the second highest predictor for COVID19 in Mexico with populations that only reported one comorbidity (Hernández-Garduño 2020). However, many studies like the ones above do not differentiate between type 1 and type 2. Nevertheless, a whole population study conducted in England by (Barron et al. 2020), found that when type 1 and type 2 were separated and adjusted for age, they were both independently found in association with in-hospital COVID19 deaths (Barron et al. 2020). Type 2 diabetes in general is associated decreased immunity which makes the individual more susceptible to infections and COVID19 seems to be no different (Rajpal et al. 2020).

Cardiovascular Diseases

Cardiovascular diseases (CVDs) are a group of disorders that affect the heart and blood vessels. They include heart attacks and stroke caused by the blockage of blood flow to the heart or brain (WHO 2013). CVD events are increasingly linked to increased severe COVID19 outcomes, but research is still new and ongoing. One study examining risk factors associated with COVID19 mortality in England found that cardiovascular disease among other pre-existing conditions was associated with increased COVID19 mortality (Williamson et al. 2020). Patients with cardiovascular diseases may be more likely to experience worse COVID19 symptoms due to the prevalence of ACE2 receptors in the lungs and the heart (Zheng et al. 2020). Which as previously mentioned, the ACE2 receptor serves as the primary mode of infection (Kahn et al. 2020). COVID19 infection may also lead to may also lead to myocardial damage. That is, damage to the heart muscles. Some of the reported symptoms patients experience when infected
with COVID19 are tightness in the chest and heart palpitations. Further supporting this assessment, data from the National Health Commission of China showed that in patients with no cardiovascular diseases that passed away from COVID19, 11.8 percent still experienced significant damage to their hearts (Zheng et al. 2020).

Additionally, as with the other pre-existing conditions mentioned, it is interesting to note that many of the studies that cited obesity as a risk factor for more severe COVID19 outcomes, also list CVDs as well. Such as the case with (Yanover et al. 2020). Notably, CVD events do not seem to be limited to the COVID19 infection window, as one study conducted by Zhou et al. 2020 in China found that increased cardiac events after COVID19 infection were associated with preexisting CVDs (Zhou et al. 2020).

Furthermore, both SARS and MERS also saw CVD events as a common comorbidity, so it is likely that COVID19 will also follow this trend (Clerkin et al. 2020). It is also important to note that CVDs are the number one cause of death around the world and are also associated with obesity, diabetes, and inactivity which may explain why some studies also cite both risk factors (WHO 2013; Hendren et al. 2020). Obesity is also one of several risk factors associated with the development of CVDs, whether that be due to biological, environmental, socioeconomic, and/or psychosocial factors like the ones previously mentioned (Powell-Wiley et al. 2021). Other risk factors include an unhealthy diet, and low physical activity. (WHO 2013)

Due to how COVID19 infects the host cells (binding to the ACE2 receptors), COVID19 infections can also cause myocardial damage to the host (Zheng et al 2020). Large amounts of ACE2 receptors are not only found in the lungs, but in the cardiovascular system as well which may indicate that COVID19 may have the ability to cause, or further cause damage to the heart (Zheng et al. 2020). Previously, MERS was found to be able to cause acute myocarditis and heart
failure, and due to the similar pathogenicity to COVID19 this may be the case here as well (Zheng et al. 2020). Just like many other underlying conditions, presence of CVDs have been associated with more severe COVID19 symptoms and adverse prognosis as well (Zheng et al. 2020).

**Vaccine Hesitancy in Japan**

Despite ranking as one of the healthiest countries in the world in terms of lifespan and healthy years lived (Kuwabara et al. 2014), Japan has a long history of vaccine hesitancy that has already produced negative outcomes. Vaccine hesitancy and the resulting vaccine gaps in Japan has contributed to increased numbers of vaccine preventable diseases (VPD) such as the recent 2012-2013 Rubella outbreak (Nakayama 2013).

Prior to Japan’s 2012 rubella outbreak, the government broke up the MMR (Measles, Mumps, Rubella) vaccine into separate vaccines for Measles, Mumps, and Rubella (Kuwabara et al. 2014). Rubella vaccinations from 1962–1978 were selectively only given to junior high school-aged girls because of the possibility of congenital rubella syndrome (CRS), that devastatingly affects child development during pregnancy. Paired with the practice of only vaccinating females for Rubella, the subsequent outbreak disproportionality affected males who were not vaccinated, and ultimately led to 14,344 cases of Rubella and 45 cases of CRS (Hori et al. 2021).

Skepticism surrounding vaccinations in Japan traces back to 1975 when two infant deaths occurred 24 hours after receiving the DTwP (diphtheria, tetanus-toxoid, and whole cell pertussis) vaccine. This event led the government to suspend the DTwP license and raise the vaccination age (Kuwabara et al. 2014). It also spurred vaccination rates in children to drop (10% in 1976) and rates of pertussis (‘whooping cough’) death to climb from a 1974 case rate of 393 and death
rate of zero to 13,000 cases and 41 deaths in a subsequent 1979 outbreak (CDC 2018).

Skepticism in a government body, that then leads to vaccine hesitancy in a population is not a problem unique to Japan and can be seen as a reoccurring theme across the globe, including the USA (Larson 2020).

Through the influence of “group think”, which McDougall (1920, as cited in Larson 2020) describes as the shared emotions and beliefs of crowds, and a growing distrust in government and healthcare professionals, vaccine hesitancy can easily take root as has been obvious in the United States over the last several years (Larson 2020, McDougall 1920, as cited in Larson 2020). The human papilloma virus (HPV) vaccine’s proactive implementation was suspended due to public pressure and belief that it was causing harm in young girls. No connection between the vaccine and harm to those receiving it was ever established, but the trust between the public and medical practitioners was further damaged as a result (Larson 2020). The suspension went against recommendations by the WHO and other health organizations, but Japan carried on with them regardless. The suspension of this program in Japan caused skepticism in the vaccine to rise and vaccination rates to plunge to a rate of 0.3 percent in 2016. This was a large drop in a vaccination rate that was previously 70 percent in 2013 (Larson 2020).

Japan’s vaccine hesitancy is not a self-contained problem, as international travel has also been an important factor in spreading Vaccine Preventable Diseases (VPDs) from Japan. According to Kuwabara et al. 204 VPD cases consisting of measles, mumps, and rubella were brought to Hawaii by Japanese travelers between 1994 and 2013 (Kuwabara et al. 2014).

With the emergence of COVID19 there is increased focus on Japan’s ‘vaccine gap’ and how that might intersect with the Japanese population’s willingness to receive the COVID19 vaccine as it becomes more widely available. This ‘vaccine gap’ can be seen as a literal gap in
which from 1993 to 2007 Japan only introduced two new vaccines to their market. These two vaccines consisted of a vaccine that was a combination of measles and rubella, as well as a hepatitis A vaccine (Kuwabara et al. 2014). In contrast during the same timeframe, the US introduced seventeen vaccines (Kuwabara et al. 2014). The ‘vaccine gap’ can also be used to describe the fact that Japan’s vaccination program lags behind others in developed countries (Saitoh and Okabe 2012). This gap remained to be seen as Japan rolled out their delayed COVID-19 vaccine program., as of May 13th, 2021 only the Pfizer vaccine had been approved for distribution and only by doctors and nurses, which has led to only 1% of the population being fully vaccinated (Normile 2021). However, two recent studies investigating the willingness of the Japanese population to receive the vaccine found that more than 62% of the surveyed participants were willing to receive the COVID-19 vaccine when it becomes available (Machida et al. 2021, Yoda and Katsuyama 2020).

A more recent update on the vaccination status of the Japanese population regarding the COVID-19 pandemic, has revealed that despite a late start to their vaccination program Japan has had a consistent rise in fully vaccinated individuals as shown in Figure 2 (see page 18). The Prime Minister and his Cabinet recommends vaccinations, as the benefits will outweigh the side effects and confirms that the vaccine is safe to take. Despite the history of vaccine hesitancy in Japan, as of May 17th, 2022, the share of people who completed the initial COVID19 vaccination protocol according to Our World In data, is 80.8 percent of the Japanese population (OWID n.d).

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2 Images in this chapter have been previously published by the Official Website of the Prime Minister of Japan and His Cabinet (https://japan.kantei.go.jp/ongoingtopics/vaccine.html) and Our World in Data. The use of these images is with permissions.
Prefecture specific data provided by the Tokyo Metropolitan Government Bureau of Social Welfare and Public Health shows that when broken down by age, individuals 80 years or older account for the highest inoculation rate with a 91.5 percent inoculation rate for a third COVID19 vaccine dosage. The age group of 65+ in Tokyo has a third COVID19 vaccine dosage rate of 87.5 percent which is very similar to the national rate of 89.2 percent. As of June 3rd, 2022, 59.7 percent of the population in Japan has received a third COVID19 vaccination, and 81.0 percent has received their second (Tokyo Metropolitan Government Bureau of Social Welfare and Public Health, 2022).

Figure 2. Population in Japan fully vaccinated for COVID19 (Our World In Data. n.d)
CRITICAL BIOCULTURAL THEORY

Biocultural theory tells us there are many different variables that can affect human biology and that many of those variables are connected to the environments we live in. This theory becomes critical when physical and sociocultural environments take on a life of their own and leave a greater (negative) impact through relations of power, inequality, and the ability to access resources (Leatherman and Goodman 2011). These socioeconomic factors influence health throughout a person’s life and can negatively affect generations to come through exposure to environmental stress and anxiety (Amato et al. 2020). In general, the surrounding socioeconomic environment has the ability to influence disease and illness that is then manifested and inherited into families who exist within those environments (Amato et al. 2021). Structural disparities in early life can influence biology well into adulthood, one example being the affect environment has on the gut microbiome. The gut microbiome plays an important part in our health, and just as we can be influenced by our environment, so can the gut microbiome. The composition of each person’s gut microbiome is directly influenced by the foods we eat, the medications we use, and the environment we live within. Which means when populations face structured racism, health inequalities, and other forms of discrimination, that create stress, it is reflected in the gut microbiome and can increase health risks in adults as they age (Amato et al. 2021). In pregnant mothers the gut microbiome is not just important before and during pregnancy, but also after it (Amato et al. 2021).

Infants born through c section (cesarean) are more common in minority populations. As such, these babies do not have an opportunity to be exposed to the microbes of the mother. Low
Socioeconomic status may also pressure new mothers to return to work quickly, and as such they are not able to breastfeed or share as much skin-to-skin contact with their infant. Breastfeeding and skin-to-skin contact are two more ways in which the mother can share her microbes with the newly born infant and help build a healthy gut biome (Amato et al. 2021).

With the emergence of the COVID-19 pandemic, many people are now facing increased stress on top of any stressors they may have experienced prior to the pandemic. There are many other theoretical approaches to examining the interactions between humans and pathogens such as One Health and Ecosocial approaches which are rising in popularity (Friedler 2021).

It’s important to note that both One Health and Eco health do not have one definitive definition, and no consensus has been reached among researchers (Lerner and Berg, 2017) and both approaches share many similarities like their emphasis on a holistic approach to health, and how they easily open themselves to interdisciplinary research (Lerner and Berg, 2017). However, differences in their areas of focus can be used to tell them apart.

One health has a focus on both human and animal health and the environment (Lerner and Berg, 2017). Due to its background in disease management with humans and animals, one health has been relevant to the COVID19 pandemic when looking to examine the connections between humans, animals, and the environments they exist within (Centers for Disease Control and Prevention, 2021). EcoHealth on the other had does not focus so much on animal health, although it still is considered alongside it. Instead, EcoHealth has a much bigger emphasis on the environment and how the environment can shape human health and well-being (Harrison et al. 2019).

However, these approaches still primarily focus on the environment and not the resulting biology (Friedler 2021). For that reason, I employed the critical biocultural approach. The critical
biocultural approach is uniquely situated in its interdisciplinary ability to address how the socioeconomic environment implants itself under the skin and is passed down through generations. The critical biocultural approach postulates that the lived experience can create biology and that knowledge of power structures are critical to understanding the created environment and the biological impacts on the populations that live within it. Put simply, the critical biocultural approach looks to examine how a population embodies their environment “under the skin” especially during moments of critical human growth and development (Leatherman and Hoke 2017).

The critical biocultural approach has been implemented more recently to examine how diet, nutrition, and migration are influenced by the overarching role of globalization, and the politicization of health and nutrition (Himmelgreen et al. 2014), as well as examining how structures of race and racism influence human biology through the presence of stress (Miller 2022). These studies so far highlight the importance of examining not only the environment (both physical and socio structural) and biology, but how they are intertwined and the results of this entanglement.

I argue in this thesis that neighborhood demographics are vital to understanding biosocial inheritance patterns in an environment that has been further altered with the presence of widespread disease. Especially regarding increased stress in communities as a direct result of the COVID-19 pandemic. Not all communities experience the same stressors equally, and for many communities, social adversity and structural racism has long been propagating the inheritance of generational disease (Hoke and McDade 2015). It is for this reason that it would not be untrue to say that even if we overcome the current COVID-19 pandemic, the biological effects of the disease will still be felt for many generations to come (Hoke and McDade 2015).
Within the United States it has been well documented that the COVID-19 pandemic has disproportionately affected minority populations through lack of social service and healthcare access (Abraham et al. 2021, Baptiste et al 2020, Maness et al. 2021, Robichaux et al. 2021, Singu et al. 2020). Prior to the pandemic many minority populations already were afflicted by health inequalities, and African Americans in particular are disproportionately impacted by COVID19 deaths in the United States (Alcendor 2020). Many African Americans faced increased COVID19 exposure and limited ability to social distance during the COVID19 pandemic; and while African Americans make up just 13.4 percent of the population, they are broadly represented in jobs within the service sector which limits the ability to social distance and work from home (Robichaux et al. 2021). The African American population also accounts for the majority of COVID19 deaths in some cities and states despite making up a minority of the population. In Chicago, African Americans make up 30 percent of the population, however they also account for 70 percent of COVID19 deaths. Even more rural areas are not free from this trend as in the state of Louisiana, African Americans make up 32.2 percent of the population, but account for 70.5 percent of the COVID19 deaths (Sanchez, 2020; Alcendor 2020). Barriers to healthcare are present for many populations, but in the United States, the ability to obtain insurance presents an extra hurdle that is not prevalent in countries with universal healthcare. With the ability to access healthcare so closely tied to socioeconomic status many members of minority populations hesitate to seek it out (Singu et al. 2020). One study by Gallup showed that within the COVID19 pandemic 14 percent of adults in the United States due to financial burden would avoid seeking healthcare for a fever and a dry cough (Witters 2020). By not seeking regular healthcare, small problems can become worse and chronic conditions can go unaddressed (Singu et al. 2020).
Furthermore, different stages of life are important to consider alongside socioeconomic stress and patterns of infectious disease manifestations as different age groups can occupy different niches of the same environment, (much like several species of birds who are able to occupy the same tree). Different age groups tend to engage in different activities, and age-related behaviors can impact how a disease can spread. Thus, (to an extent) through our actions we can influence the path of a pandemic (Friedler 2021).

One study by (Kim and Crimmins 2020) conducted during the first three months of the pandemic, found that older populations were more likely to modify their behavior to suggested COVID19 guidelines such as masking and social distancing while also engaging in less risky behavior after two months. On the other hand, younger populations were less likely to modify their behaviors. Research by (Hutchins et al. 2020) also confirmed this trend with younger populations being less likely to practice social distancing recommendations such as avoiding crowded places or postponing social events. This disregard for social distancing recommendations may have played a part in increased COVID19 cases for this age group in June 2020 (Hutchins et al. 2020). From this I consider age groups an important variable to consider beyond mortality risk, as it is likely that the actions and behaviors of certain groups may have the ability (to an extent) to influence the spread of the virus.

Stress and Urbanization in Japan

The examination of stress is interdisciplinary in nature. Stress can be examined from different angles and disciplines. Thus, critical biocultural theory is well suited to address not only stress, but stress in relation to pandemics and pathogens. The presence of stress is known to interact with disease through immunosuppression which can contribute to a higher change of infection (Friedler 2021). The creation of a higher stress environments through the pandemic is
something that should be noted as even though I will not be measuring intergenerational stress it is important to know that this is an important factor keeping people in poor health. During a pandemic everyone becomes susceptible to worse mental health regardless of infection status and with that comes stress (Okubo et al. 2021; Su and Patti. 2019; Parrettini et al. 2020). Due to COVID-19’s highly contagious nature, most of the world has already felt the impacts of its presence to some extent at this point in time.

Japan in particular saw evidence of a rising mental health crisis after a series of celebrity suicides occurred once the first state of emergency (discussed further in government policy) was lifted (Okubo et al. 2021). This number of suicides continues to rise the longer the pandemic has progressed, to the point that in October 2020 the number of suicides in Japan (2,158) surpassed the actual mortality count of COVID-19 (Shibusawa et al. 2022). From this rise in psychological distress, it is apparent that mental health in Japan and the impacts that come of it are of concern and should be addressed, as any form of psychological distress has the potential to have negative impacts on the body the longer it persists. It is especially important that this rise in stress is addressed because stress influences the transmissions of maternal and paternal ill health into the offspring (Amato et al. 2021; Su and Patti. 2019; Parrettini et al. 2020). The causes of ill health into the offspring can be seen through both psychosocial stress and nutrition access that accompany socioeconomic disparities. Exposure to these stressors and the nutritional status of the parents are just as important as exposure to these stressors in early life development, as the offspring will often reflect the health of the mother during gestation. An increase in stress during gestation can increase the chances of fetal cortisol exposure in the offspring which can impair development (Kuzawa 2020).
The stress caused by the COVID19 pandemic can and has manifested itself in many ways and in many forms, as well as targeted specific people, occupations, and families. Healthcare workers especially have faced increased stress and burnout through the environmental shift caused by the pandemic (Sasaki et al 2021). Healthcare workers who work in ICU (intensive care units) and/or emergency response environments in general have been shown to face increased burnout. Burnout or burnout syndrome (BOS) can be defined as a lack of incentive and interest in a job due to excessive levels of fatigue for an extended period of time, which in a healthcare setting can result in a lower quality of medical care and medical errors that can have detrimental impacts on patients (Talaee et al. 2020). With any globally impacting infectious disease healthcare workers fall under increased pressure and stress that can quickly turn into burnout, the COVID19 pandemic being no different (Maunder et al. 2006), as many healthcare workers assume more risk due to needing to be in contact with infected patients for extended periods of time (Talaee et al. 2020).

In more urban areas there may also be a higher demand for healthcare due to having a higher population to account for. Urban areas also tend to have less living space, which may result in increased stress for larger families forced to stay inside together, or for multiple people trying to work from home and not having the space to spread out. This also includes the physical structure of the home itself, which if occupied by many people without good insulation can produce a noisy environment (Okubo et al 2021).

On the other hand, increased social isolation and loneliness can also lead to a high stress environment. Older people who live in rural and less urban environments may be disproportionately affected by stress as a result of increased social isolation and loneliness. Stress is important to consider within this perspective in the COVID19 pandemic, as chronic stress can
lead to inflammation, which in turn can make an individual more susceptible to disease (Cohen et al. 2012).

One study conducted during the COVID-19 pandemic measuring chronic inflammation biomarkers in Japan showed that primarily men who were classified as isolated and lonely experienced chronic inflammation (Koyama et al. 2021). In a letter to the editor (Aihara and Kiyoshi 2021) detail that older adults experienced slightly increased depression symptoms during the COVID-19 pandemic, and older adults with dementia were especially vulnerable to increased depression symptoms (Aihara and Kiyoshi 2021).

Another study with participants over the age of 50, also observed that males were more prone to inflammation through an increase in concentrations of CRP, fibrinogen and ferritin due to loneliness. This may indicate that like stress, loneliness and social isolation can also manifest biological outcomes (Vingeliene et al. 2019). Additionally, for older individuals who either live alone or with only their spouse in rural areas, they may be dependent on family that does not live with them or live close to them. Increased isolation may be brought about by COVID-19 precautions and social distancing practices that have been implemented and encouraged with more urban environments in mind (Ohta et al. 2021; Koyama et al. 2021).

Individuals who depend on other people for transportation, not just for healthcare, but to access other resources such as groceries, may be less likely to ask for rides with COVID-19 fears and social distancing requests (Syed et al. 2013, Ohta et al. 2021). It is important to note that this situation is more likely to occur in more rural and less urbanized environments where public transportation is unreliable (Ohta et al. 2021). For these reasons, I also consider levels of urbanization in tandem with COVID-19 infections, healthcare access, socioeconomic variables, household types, and neighborhood demographics. In this thesis I focus my examination on the
family and the social areas, as they are the niche where the intersection of biosocial inheritance and current neighborhood demographics occur. I also examine levels of urbanization in tandem with COVID19 infection, to determine differences in infection rate between urban and less urban areas. Finally, through my interview with a healthcare professional I detail environmental factors that contribute to an environment in which there is still inequal access to healthcare resources in rural Japan.

**COVID19 and Families in Japan**

Family in Japan has no set shape, and just like in the United States, it can be diverse and varied in its structure. Within contemporary Japan there is a rise in single occupant households, often in the form of students and people entering the workforce. Nuclear families and married-couple only households are also on the rise. However, unmarried couple households are not, and neither are households containing a child and unmarried mother. Multigenerational families in Japan consist of at least three generations of a family living together and while on the decline in post-war, are still a commonplace fixture in Japan (Brown n.d.). Multigenerational families tend to be more common in the more rural areas of Japan, as their larger sizes are not as compatible with the small living spaces commonly found in Tokyo or other major urban areas.

In regards to the COVID19 pandemic, COVID19’s primary mode of transmission is through human-human contact. In response, many countries placed ‘social distancing’ as one of the main recommendations to mitigate the spread of the virus. However, it is important to note that in the United States the ability to social distance is a privilege linked to socioeconomic status (Maness et al. 2021), and research conducted by the Pew Research Center shows that in the United States, minority populations are more likely to live in multigenerational households
compared to White Americans, with financial issues being the top reason as to why (Cohn et al. 2022).

Unlike in Japan, where multigenerational families are more common in rural areas due to having the space to comfortably grow and support three generations, this may not be the case in the United States. In the USA, families under financial stress, or even roommates who must share small, enclosed living spaces are more common reasons why people share a common space. It is for this reason I place a focus on the family structure regarding COVID19 infection because it may not be people living together that is the problem, rather the circumstances around it.

This is not to say that family life in Japan has not been impacted by the COVID19 pandemic, rather family life in Japan in general has become increasingly impacted. Many marginalized and already vulnerable populations in Japan, much like in the United States face increased hardships as more financial struggles emerged as many in person social services were suspended or curtailed due to the infectious nature of COVID-19 (Shibusawa et al 2021).

In addition to altered lifestyles due to the COVID19 pandemic many milestone moments celebrating different stages of life for many families have had to be curtailed or skipped altogether. While missed milestone moments may seem superficial in the light of the current pandemic, it is these moments that connect generations and strengthen relationships with communal ritual and extended family. Missed moments are missed opportunities to grow as a family unit. For families who do not reside together, the forced separation can also be an added stress and increase anxieties, while on the other hand small living spaces and limited mobility in urban areas can also increase tensions and anxiety within the home (Shibusawa et al. 2021).
Unlike with other natural disasters in Japan (like earthquakes or tsunamis), finding in-person volunteer help has been made harder, due to the highly transmissible nature of the COVID19 virus. The main point to take away is that many families and individuals are in need of social services, but due to the lack of in-person aid, help is limited (Shibusawa et al. 2021).
GOVERNMENT POLICY

At A National Level

Throughout the COVID-19 pandemic, Japan has seen three different Prime Ministers in power. Prime Minister Abe Shinzō (2012-2020) oversaw the very beginning of the pandemic, Prime Minister Yoshihide Suga (2020-2021) was in office for one year after the pandemic had started, and Prime Minister Fumio Kishida took office in October 2021. Prime Minister Abe Shinzō was Japan’s longest serving Prime Minister of nearly eight years before he stepped down in 2020 due to ill health (Denyer, S., & Crawshaw, D., 2020.; Rich, M., 2020.). He was replaced with Prime Minister Yoshihide Suga, who made the decision to step down one year after being instated due to a large drop in popularity and increased anger over his handling of the COVID19 pandemic in Japan (Gunia, A., 2021.; Rich, M., 2021.), leading the way to Prime Minister Fumio Kishida to take office and is who currently (June 5th, 2022) is in power. All three of them belonged to the Liberal Democratic Party (LDP) in Japan, (which despite the name is a conservative political party). The LDP was formed by fusing two conservative parties in 1955 and have almost consistently maintained power ever since (Crespo 1995, 200).

Pre-pandemic, the already commonplace use of masks and common everyday behaviors such as not kissing and hugging friends and family may have helped spare Japan the worst of the initial first wave of the pandemic. January 12th 2019 saw novel betacoronavirus declared as the causative agent for the disease (Kahn et al 2020), and by March 11th the WHO officially specified the COVID19 outbreak as a pandemic (Watanabe 2020). By late February in Japan there was a mask shortage, an odd phenomenon in a country with a usual abundance of them.
‘Abenomask’ (Abe’s Mask) was a program set into motion on April 1st, 2020, in an attempt to improve the mask shortage situation. However, the Japanese people were not pleased with this program, as only two cloth masks (that were too small for many people) were sent to each household. This presented a difficult situation for many of Japan’s multigenerational households or any household that contained more than two members. This policy also did not account for marginally housed and homeless populations because it required a registered address to receive the two masks (Dudden 2020). Although the ‘Abenomask’ program was ultimately not successful, it still sent a government message that mask usage was encouraged and supported as a way to mitigate the spread of COVID19 in Japan.

On April 7th, 2020, the first of many states of emergency was announced for a few select prefectures (Saitama, Chiba, Tokyo, Kanagawa, Osaka, Hyogo and Fukuoka). Because Japan’s government does not have the power to legally enforce a lockdown, which WHO defines as “large scale physical distancing measures and movement restrictions…” (World Health Organization 2020), Japan enacted ‘states of emergency’ consisting of requests made by the government and an increased awareness of risky behavior. City governments were able to request that businesses, including department stores, and theme parks close by 8 pm. Restaurants were also encouraged to close and stop serving alcohol by 8 pm and encourage take out options instead of sit-down service. Places of work were similarly encouraged to allow work from home at this time to prevent crowding in the office and mass use of public transport.

On April 16th, 2020, these measures were extended nationwide, only to be formally ended on May 25, 2020. However, there were, and exist other states of emergency announced afterwards that included only select areas of Japan. Tokyo has consistently been included in every one of Japan’s enacted states of emergency.
Figure 3. Three criteria for lifting state of emergency (PMHC 2021)

The most recent state of emergency was announced on February 26th, 2021 and included only a few select prefectures of Japan (Saitama, Chiba, Tokyo, and Kanagawa.) as of November 2nd, 2021 (PMHC 2021). A more recent update has saw a quasi-state of emergency be implemented for 13 prefectures which was extended to include 18 prefectures (Tokyo included for both) on January 27, 2022 which enabled local governments to implement some COVID19 protection measures, such as asking businesses to close early. However, due to COVID19 cases being on the decline, this quasi-state of emergency was allowed to expire for all prefectures as of March 21 2022 (“Japan fully lifts COVID” 2022; U.S Mission Japan, 2022).

However, despite the state of emergency being lifted for most of Japan some prefectures are still encouraging COVID-19 restrictions (Lee 2021, Normile 2020). The lifting of restrictions
is dependent on the assessment of the three criteria: “the state of infections, medical treatment structure, and monitoring structure.” Displayed in figure 3 (PMHC 2021) (See page 32). First criteria ‘The state of infections’ requires COVID19 cases to be consistently decreasing and for cumulative case numbers to be ‘roughly 0.5 persons per 100,000 people each week. The second criteria ‘Medical Service System’ requires patients with severe COVID19 symptoms to be decreasing, the condition of hospital beds and an established system that can quickly respond to an increase in patients. Finally, the third criteria calls for PCR (polymerase chain reaction) testing to be quickly accomplished by doctors (PMHC 2021).

Ultimately, because no lockdown could be legally enforced, the responsibility of public health was placed in the hands of the citizens (Dudden 2020). This resulted in the emergence of the Three C’s as shown in figure 4 (See page 34). Since then, Japan has focused on containing the spread of COVID-19 through centering on ‘Clusters’. The CDC defines Clusters in non-healthcare worksites to be two or more cases among workers over a 14-day period due to being in a shared space (Prioritizing non-healthcare… 2020). However, in practice the definition clusters regarding Japan’s Cluster-based Approach does not have a definitive definition. Rather, it generally refers to multiple COVID19 cases stemming from one specific location (PMHC 2021).

To combat the potential presence of clusters, the Japanese government created the social distancing campaign *Avoid the “Three C’s”*, that being Closed spaces, Crowded places, and Close contact settings. Japan also created a three-pillar method that heavily focused on

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3 Images in this chapter have been previously published by the Official Website of the Prime Minister of Japan and His Cabinet (https://japan.kantei.go.jp/ongoingtopics/vaccine.html) and Our World in Data. The use of these images is with permissions.
preventative measures to suppress the transmission of COVID19 and minimize any socio-economic damage caused by it.

Figure 4. The Three C’s government flyer. (PMHC 2021)

The three pillars consist of 1. Early detection, early response, 2. Early diagnosis and care, 3. Behavior modification (Figure 5, see page 35) The goal of following these three pillars is to identify and control the spread of clusters so they do not go on to create more clusters while strengthening the ability of the medical system to quickly respond to outbreaks (PMHC

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4 Images in this chapter have been previously published by the Official Website of the Prime Minister of Japan and His Cabinet (https://japan.kantei.go.jp/ongoingtopics/vaccine.html) and Our World in Data. The use of these images is with permissions.
The Three C’s campaign is a vital part of the behavior modification pillar method in use (Amengual, O., & Atsumi, T. 2021), (PMHC 2021).

**Figure 5. The three pillars of basic strategy (PMHC 2021)**

At the same time Japan has not yet needed to mandate the closing of schools, an exception being the end of February 2020 during the initial first wave (Amengual, O., & Atsumi, T. 2021) and many businesses remain open as usual.

Another response to the COVID19 pandemic by Japan’s government that remains to be ongoing includes a strict international travel lock down. Being an island nation, it is perhaps easier to control the amount and means of travel into and out of the country. According to the U.S Embassy and Consulates in Japan (2021), while there remains to be no curfew for citizens or restrictions on travel across Japanese cities and prefectures the Japanese government continues to restrict international travel (U.S Mission Japan 2021). Travel for short term and travel for
tourism as of December 28, 2020, is not permitted. S. Nakamoto, a resident in Kobe (personal communication, 2020) stated that even civilian mail was not being sent out of country for a period of time. Additionally, for visitors who were able to enter Japan, a negative COVID19 test must be taken and presented within 72 hours of flight departure and all visitors must quarantine for 14 days (COVID-19 information. 2021).

**Government Policy at a Prefecture level**

Tokyo has followed in the Japanese government’s footsteps by actively encouraging compliance with the Three C’s and by promoting vaccination. Tokyo engages in “Request to the Residents” as an alternative to restrictive measures. Much like most of Japan’s handling of the pandemic so far, this places most of the public health responsibilities in the hands of the citizens without enforcing a true lockdown. As the Japanese Government previously identified, a lot of the focus is placed on ‘clusters’ and avoiding them. A cluster is created in an area where the 3 C’s overlap such as a restaurant, train, or karaoke room. Flyers like the ones in figure 6\(^5\) (See page 37) and 4 have been distributed across Japan, and behavior modification has been encouraged by the government. This includes things like encouraging ‘coughing manners’, correct handwashing practices (Figure 6), and avoiding certain situations that can lead to more clusters (figure 4).

\(^5\) Images in this chapter have been previously published by the Official Website of the Prime Minister of Japan and His Cabinet (https://japan.kantei.go.jp/ongoingtopics/vaccine.html) and Our World in Data. The use of these images is with permissions.
Figure 6. COVID-19 Countermeasures Public Awareness Flyer (PMHC 2021)
MATERIALS AND METHODS

IRB Approval

This research was carried out using open-source data from WHO, CDC, The Japanese government, the Japanese census, and other Japanese government organizations (Statistic Bureau of Japan, 2021, Tokyo Metropolitan Government, 2021, Prime Minister and His Cabinet (PMHC), 2021).

IRB approval from the USF IRB board was requested for the use of census data, and three follow up interviews with health officials in Japan to assess and aid in explaining the data produced with this study. For this thesis I was able to interview one willing participant. The number assigned to these studies were STUDY003706 regarding census data which was assigned a determination of not human subjects research and approved on 1/21/2022. The second IRB submitted was STUDY003705 regarding interviews with public health officials and was assigned a Notification of Approval on 1/14/2022. STUDY03706 can be found in Appendix D and STUDY003705 can be found in Appendix E.

Data Collection

The primary source for population data comes from the 2015 Population Census for Japan (Statistics Bureau of Japan 2015). Since 1920 the Japanese Population census has been conducted almost every five years. The 2015 census includes the entirety of Japan with the exceptions of several islands (Habomai-gunto, Shikotan-to, Kunashiri-to and Etorofu-to, Take-shima in Okinoshima-cho, Oki-gun Shimane-ken) due to the Regulation for the Execution of the Population Census Act implemented in 1980 (Statistics Bureau of Japan 2015).
Households were visited by a local enumerator and presented with an ID and password for online responses. Households were then able to submit their census information online for a window of 10 days (September 10 to September 20), after which a paper version was delivered by the enumerator if an online census was not submitted. These paper versions could be returned to the enumerator in person or by post. If a household was not home or available for this timeframe the enumerator gathered information on the household members through interviews with their neighbors. This information included name, sex, and other household members (Statistics Bureau of Japan 2015).

General mortality data was obtained through the Vital Statistics Survey (Ministry of Health, Labor, and Welfare. N.d). This survey is conducted annually and records data from January 1st to December 31st. These data consist of births, deaths, marriages, divorces, and fetal death in Japan for individuals with Japanese nationality. The municipal head is required to report these data under a notification period of 7 to 14 days depending on the event that is being reported (Ministry of Health, Labor, and Welfare. N.d).

COVID-19 infection data were obtained through each prefecture’s government website. Tokyo recorded daily cumulative numbers for each of their 62 areas. These areas include 23 special wards, 26 cities, 3 towns, 1 village (The Izu Islands and the Ogasawara Islands include 2 towns and 7 villages). A cutoff date of November 30th, 2021 was established, and no further updates were made to the COVID-19 infection totals for each prefecture.

For population data gathered from the 2015 population census the unit of analysis is also Tokyo’s 62 areas. For each, I have quantitative variables such as population size, number of people under age 15, number of people between 15 and 64, and number of people over 65, cumulative infection rate, number of nuclear and multigenerational households (discussed
below), number of hospitals and clinics, and employment status supplemented by the 2019 general mortality data and current COVID19 infection data. Data sources can be referenced in Table 1, age groups and abbreviations can be referenced in Table 2. And household types and stipulations can be referenced in Table 3.

Table 1. Sources For Tokyo Data

<table>
<thead>
<tr>
<th>Type Of Data</th>
<th>Source</th>
<th>Data Type</th>
<th>N</th>
</tr>
</thead>
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<tr>
<td>Census</td>
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<td>23 special wards, 26 cities, 3 towns, 1 village (The Izu Islands and the Ogasawara Islands include 2 towns and 7 villages)</td>
<td></td>
</tr>
<tr>
<td>(Household Type, age, employment status)</td>
<td>e-Stat (2015)</td>
<td>Count</td>
<td>62</td>
</tr>
</tbody>
</table>

Table 2. Age Groups and Abbreviations Used

<table>
<thead>
<tr>
<th>Abbreviation</th>
<th>Represented Group</th>
</tr>
</thead>
<tbody>
<tr>
<td>(&lt;15)</td>
<td>Under 15 years of age</td>
</tr>
<tr>
<td>(15-64)</td>
<td>Between 15 and 64 years of age</td>
</tr>
<tr>
<td>(&gt;65)</td>
<td>Over 65 years of age</td>
</tr>
</tbody>
</table>
Table 3. Stipulations For Grouping the Five Household Types

<table>
<thead>
<tr>
<th>Family Type</th>
<th>Stipulations</th>
</tr>
</thead>
<tbody>
<tr>
<td>Nuclear</td>
<td>A couple only</td>
</tr>
<tr>
<td></td>
<td>A couple and their child(ren)</td>
</tr>
<tr>
<td></td>
<td>A father and their child(ren)</td>
</tr>
<tr>
<td></td>
<td>A mother and their child(ren)</td>
</tr>
<tr>
<td></td>
<td>A brother and sister household</td>
</tr>
<tr>
<td>Multigenerational</td>
<td>A couple, their children, and parents</td>
</tr>
<tr>
<td></td>
<td>A couple, their children, and a single parent</td>
</tr>
<tr>
<td></td>
<td>A couple and other relatives</td>
</tr>
<tr>
<td></td>
<td>A couple, their children, and other relatives</td>
</tr>
<tr>
<td></td>
<td>A couple, their children, their parents, and other relatives</td>
</tr>
<tr>
<td>Single</td>
<td>A one person household</td>
</tr>
<tr>
<td>Aged Household</td>
<td>A couple and parents</td>
</tr>
<tr>
<td></td>
<td>A couple and a single parent</td>
</tr>
<tr>
<td></td>
<td>A couple, their parents, and other relatives</td>
</tr>
<tr>
<td>Unknown</td>
<td>Non relatives</td>
</tr>
<tr>
<td></td>
<td>An unclassified household</td>
</tr>
<tr>
<td></td>
<td>An unknown household type</td>
</tr>
</tbody>
</table>

After the 1985 Japanese census, households were classified by two distinct categories, “private households” and “institutional households,” Private households were used exclusively for this thesis and exclude school dormitories, inmates of social institutions, hospital residents, Self-Defense Force residents, and others who reside in unusual living spaces (Statistics Bureau of Japan 2015). The 2015 population census sorts different family types into 16 categories and several groups (multigenerational, nuclear, and single). Using these groups as a guideline, I formed two new ones (aged and unknown) from the 16 categories given.

This thesis examined the following family types; one person households which consist of a single person. Nuclear households which can include any combination of: a couple, a couple and their child(ren), parent(s) and their child(ren), and sibling families. Despite the
categorization of the 2015 census, I also consider a household consisting of a brother and sister to be part of a nuclear family. Aged households, consisting of any combination of a couple and parent(s) without children. Finally, I also examine multigenerational families. Multigenerational families do not have a distinct category, but I consider a multigenerational family to be a family with three direct family generations living together. These household numbers include counts for children, adults, and the elderly. Every person counted in each prefecture for the 2015 census is represented in some way within these family types.

Furthermore, the 2021 Statistical Handbook of Japan identified that in the 2015 Population Census 55.9 percent of private households in all of Japan consist of nuclear families and 34.6 percent consist of one-person households. In the 1960’s the average size of a household began to decline from its mid-1950s high of 5 members, dropping down to 2.33 members in 2015 (Statistics Bureau of Japan 2015). Furthermore, according to the Statistics bureau of Japan (2015), private elderly households (members over the age of 65), make up to 40.7 percent of all private households. Of these elderly households, approximately two times as many were peopled by females than by males (Statistics Bureau of Japan 2015). This leads us to expect that the results will show a higher frequency of nuclear and one person households in the locations I will examine. This also leads me to expect a higher frequency of members represented in the 65+ age group category.

Although this study took place in 2021, a majority of these census data were obtained in 2015 from the population census and 2019 at the latest date from the vitality survey. Therefore, a major limitation to these data is they may not reflect the full extent of the COVID-19 impact yet.

In this thesis I used multiple regression analysis to determine what neighborhood demographic variables have impacted and influenced COVID-19 infections in Tokyo. For this
analysis all these variables have been standardized either by dividing them by total region area or total regional population and then standardizing by multiplying by 1000 where the formula reads as such: (Variable/total) *1000). By standardizing these variables, I am able to bring these variables to a common, standard format for both the larger and more rural cities, towns and villages of Tokyo alongside the more compact urban areas of the 23 Tokyo special wards in the city. This type of standardization is commonly done in demographic analysis (Preston et al 2001).

Before regression analysis was started, the correlation among the dependent variable (the standardized infection rate of each region) with all the independent variables was analyzed. Only two correlations were significant: This low level of correlation between the dependent and independent variables suggests that the regression model may not achieve a high explanatory value of the dependent variable. Plots of the dependent and the independent variables were obtained and no obvious violation of the assumption of regression analysis were observed (Sokal and Rohlf, 1995). For this analysis the urban types of towns (n= 5) and villages (n=8) were combined into one urban group due to their small case size (n=13). The descriptive statistics for this analysis are displayed in table 4.

All data used in any of these analyses going forward have been standardized. For that reason, I will not refer to the variables as “standardized unemployment” or “standardized nuclear families”, because it is understood that the reader knows that all variables in Tokyo have been standardized as explained above.

Following statistical analysis, I consulted with a Japanese Public Health Care expert whose contact was facilitated through the University of South Florida’s College of Public Health. This participant was interviewed for approximately 45-60 minutes regarding how they perceive
the differences in health care access in Hokkaido (one of Japan’s most rural prefectures) and in urban Tokyo. This interview allowed us to obtain explanations for both differences and similarities, I found between the two regions and gave an insider context to our results. Interview questions can be found in Appendix B and the recruitment email can be found in Appendix C.
RESULTS

Table 4. Descriptive Statistics of Standard infections by three levels of urbanization standardized by 1000

<table>
<thead>
<tr>
<th>Variable</th>
<th>Median</th>
<th>Mean</th>
<th>SE</th>
<th>St. Dev.</th>
<th>N</th>
</tr>
</thead>
<tbody>
<tr>
<td>Wards</td>
<td>28.251</td>
<td>32.058</td>
<td>1.587</td>
<td>7.613</td>
<td>23</td>
</tr>
<tr>
<td>Cities</td>
<td>16.548</td>
<td>16.601</td>
<td>0.473</td>
<td>2.414</td>
<td>26</td>
</tr>
<tr>
<td>Towns and Villages</td>
<td>5.238</td>
<td>5.637</td>
<td>1.047</td>
<td>3.775</td>
<td>13</td>
</tr>
</tbody>
</table>

Wards level of urbanization was determined following the 2015 population census, which records densely inhabited districts (DID) (Statistics Bureau of Japan (n.d.)). According to the census, wards have the highest level of urbanization by population, followed by cities, towns, and villages. From results shown in table 4, I am able to observe from each variable’s respective median value, that as the level of urbanization increases, so do standardized infections. A more in-depth look at descriptive statistics of the variables considered to be of the most interest by urbanization level (standardized by population) can be viewed in Appendix A.

These data were then used to test the following hypothesis:

H₀: The level of urbanization does not affect the standardized infection rate.
H₁: The level of urbanization does affect the standardized infection rate

If I accept the alternative hypothesis, then I will consider socioeconomic variables that may be influencing different rates of COVID19 infections in Tokyo neighborhoods. To test this hypothesis, I use a Kruskal-Wallis test, The results of which are displayed in table 5.
Table 5. Results of Kruskal-Wallis Test

<table>
<thead>
<tr>
<th>Chi-Square</th>
<th>DF</th>
<th>Pr &gt; ChiSq</th>
</tr>
</thead>
<tbody>
<tr>
<td>52.7192</td>
<td>2</td>
<td>&lt;.0001</td>
</tr>
</tbody>
</table>

The results of the Kruskal-Wallis test allow us to reject our null hypothesis with great confidence ($p<.0001$) and accept the null hypothesis: $H_1$: The level of urbanization does affect the standardized infection rate. A boxplot displaying these results can be seen in figure 7.

![Distribution of Wilcoxon Scores for StInfections]

**Figure 7. A boxplot displaying the results of Kruskal-Wallis Test**

Following the urbanization level analysis, I also determine if the age categories are independent of the urbanization level. The null hypothesis is that: the distribution of people by age categories is independent of level of urbanization. The alternative hypothesis is that the
distribution of people by age category is NOT independent from level of urbanization. The results of the chi square test lead me to reject the null hypothesis ($X^2 = 14.1457$, df = 6, $p < 0.0281$).

Due to the pronounced differences discovered between villages and towns compared to cities and wards, plotting these results in a way that would meaningfully display the variation within and between each category was quite difficult. As a result of this, I then examined the differences between each category. From this analysis I discovered that the two least urbanized regions (towns and villages) were not significantly different from each other ($X^2 = 0.078$, df = 2, $p = 0.9961$). For this reason, I combined them into one group ‘towns and villages’, which in figure 8 (see page 48) is labeled as ‘12’. When the null hypothesis, “The frequency of people of different age categories in wards divided by three levels of urbanization is equal” was tested, it was again rejected ($X^2=14.1364$, df=4, $p=0.0069$). Although these results are still difficult to see, they are displayed in figure 8 where the age groups are coded as: 1=<15, 2=15-64, and 3=65+.

To further obtain clarity, I plot ‘towns and villages’ against cities and against wards separately. From this analysis I discovered that the frequency of age categories in towns and villages (group 12), and cities are not significantly different either ($X^2 = 2.2184$, df = 2, $p = 0.3298$). In contrast, the frequency of age categories differed significantly between the two most urbanized levels (3-cities and 4-wards): ($X^2 = 10.759$, 2 df, $p=0.0046$). An analysis of how the age group of 15-64 is distributed in cities and wards indicates that out of the 66.94 percent of people in the working age category, 46.22 percent are found in the most urban level of wards, and only 19.73 percent are found in cities (the second highest urbanization level).

From this I can determine that the dense and high-level urban wards are attracting a high number of working-age individuals, but that most working-age people are concentrated in the
most urbanized wards. Indeed, this point was made by the public health official whom I interviewed.

![Figure 8](image_url)

*Figure 8. A Bar graph displaying the distribution of age groups across three levels of urbanization*

Following these tests, I perform a regression analysis, whose purpose is to explain the variation of standardized infection rate in the Tokyo wards. The final model was chosen based on the principle of parsimony (the fewest number of predictors), trying to increase the $R^2_{adj}$ (where this is preferred to the $R^2$, which does not consider the number of predictors), decreasing the mean square error (MSE), and finding a model whose Mallow’s $CP \approx$ number of predictors +1. I tried backward, forward, and stepwise selection regression procedures. While inputting the independent variables, when there was extreme collinearity, I only selected one variable from the
group of highly correlated variables. These variables were swapped out and rotated to ensure all variables were still tested. This was important when considering all medical facilities where hospitals and clinics had extreme collinearity. However, groups of interest such as family type and the three age groups were all included in every run. When using the backwards procedure, all independent variables were entered (minus those removed due to collinearity). When using the forward and stepwise procedures the F-to enter had to be decreased to a low level that allowed variables to be entered and removed, namely 0.025.

The regression analysis ANOVA, displayed in table 6. Indicates that the final entire model is significant at the <.0001 level and that the model explains a significant amount of variation of in the standardized infections. The adjusted R square (0.41) is similar to the non-adjusted R square meaning I am not over-specifying the model. The results of the parameter estimates are displayed in table 7.

<table>
<thead>
<tr>
<th>DF</th>
<th>Sum of Squares</th>
<th>Mean Square</th>
<th>F</th>
<th>Pr&gt;F</th>
<th>R-Square</th>
<th>Adjusted R-Square</th>
</tr>
</thead>
<tbody>
<tr>
<td>4</td>
<td>3550.465</td>
<td>887.616</td>
<td>11.61</td>
<td>&lt;.0001</td>
<td>0.44</td>
<td>0.41</td>
</tr>
</tbody>
</table>

Table 6. Regression Model ANOVA results

Table 7. Parameter Estimates

<table>
<thead>
<tr>
<th>Variable</th>
<th>DF</th>
<th>Parameter Estimate</th>
<th>Standard Error</th>
<th>TOL</th>
<th>VIF</th>
</tr>
</thead>
<tbody>
<tr>
<td>Intercept</td>
<td>1</td>
<td>37.869</td>
<td>6.886</td>
<td></td>
<td>0</td>
</tr>
<tr>
<td>&lt;15 Industry Workers</td>
<td>1</td>
<td>-0.156</td>
<td>0.059</td>
<td>0.876</td>
<td>1.142</td>
</tr>
<tr>
<td>Taxpayers</td>
<td>1</td>
<td>-4.052</td>
<td>1.188</td>
<td>0.000</td>
<td>2592.011</td>
</tr>
<tr>
<td>Foreign Population</td>
<td>1</td>
<td>2.462</td>
<td>0.897</td>
<td>0.000</td>
<td>2901.647</td>
</tr>
<tr>
<td></td>
<td>1</td>
<td>8.668</td>
<td>3.346</td>
<td>0.009</td>
<td>112.107</td>
</tr>
</tbody>
</table>
From this analysis I was able to identify four variables of interest that were either positively or negatively associated with COVID19 infections when these variables are increased by one unit. When standardized number of individuals under 15 years of age (<15) increases by one unit, COVID19 infections decrease by (-0.156) units. Industry workers follow a similar pattern. When this variable is increased by one-unit, COVID19 infections decrease by (-4.052) units.

On the other hand, COVID19 infections were found to increase when associated with two variables. First, when taxpayers increase by one unit, COVID19 infections also increase by (2.426) units. Secondly, when foreign residents increase by one unit, COVID19 infections also increase by (8.668) units. I presume that taxpayers are people of working age, and more likely to engage in social interactions. Unfortunately, I do not know if the foreign residents are foreign students, foreign workers or both.

*Interview With a Public Health Official*

Finally, to help contextualize our results, I interviewed one willing public health official who is an assistant professor within a Department of Social Medicine in Japan. Our interviewee also had experience living in both more rural Hokkaido and more urban Tokyo.

When asked about healthcare access, it was noted that the path to receiving medical care is much easier in Japan than in the United States due to residents having universal healthcare. Typically, if healthcare is needed, citizens will visit their local family clinic, but any clinic is accessible as admission is not controlled by insurance providers like in the United States. In Japan everyone can get the same consultation, treatment, and medication. For individuals requiring more assistance in Tokyo, a request can be made to the local government to access government provided support systems.
When asked about barriers to receiving healthcare, neither ethnicity nor gender, were factors considered to be a barrier in the ability to obtain healthcare in Hokkaido. However, in Hokkaido, populations that live outside of Sapporo and Asahikawa (the second largest city in Hokkaido) face barriers in the form of rural geography as a result of less population density and cold weather. For those living in these rural areas, healthcare access is ALWAYS a problem, driving becomes mandatory if an individual needs healthcare and that commute is often at least 30 mins to an hour. Additionally, clinic doctors might not always be available all day, forcing individuals to work around limited hours of operation.

Regarding Asahikawa our interviewee “X” stated: “…it’s okay, but if I drive a car, you know 30 minutes from my city there’s nothing, there are more cows than people actually so it’s a very rural area then those living in such a rural area, you know access to healthcare is always a problem, you know everyone has to drive a car at least 30 minutes, 1 hour, and even if you go to the nearest clinic the doctor is not available sometimes all day.”

The other major barrier to healthcare in Hokkaido is the weather. Hokkaido experiences weather similar to the northern part of the United States, and their winter temperatures seldom reach over 30 °F (-1.11 °C). As a result, driving can become very dangerous, especially for the elderly who inhabit most of these rural areas.

Additionally, the lack of doctors in these rural areas is a big problem not just in Hokkaido, but all across Japan especially as Japan’s population continues to age. For many medical students, after graduating they wish to remain in the city leading to an unequal distribution of doctors in rural areas. The result is some villages do not have a doctor, forcing individuals to commute further for medical care.
Worth mentioning is prior to the COVID-19 pandemic, Influenza was a large problem in Hokkaido every winter season, not only due to the weather, but also contributed to by people not wearing masks. Influenza was prevalent enough that many offices are regularly forced to close due to outbreaks.

Regarding demographical differences between Hokkaido and Tokyo the population size was mentioned as being very different between the two prefectures. Hokkaido as a prefecture contains as many as 5.2 million residents compared to the 13 million residents who reside in Tokyo. Geographically, of those 5.2 million people who live in Hokkaido, 40 percent or 2 million people, live in the 5th largest city of Japan, Sapporo. It is for that reason when we consider health and healthcare access in Hokkaido, we must divide the prefecture into Sapporo and the rest of Hokkaido that contains the more rural areas.

Regarding household type, it was noted that in more urban areas there is less space leading to smaller family sizes, but in these rural areas in Hokkaido where more space is available multigenerational families can be more common. Family types were seen as having both positives and negatives associated with them. While an increased amount of people residing in one area can increase transmission, there were positives to be seen as well. For individuals who live together, members can easily consult with their families for advice, in the big cities where people are less likely to live with others there is less of an ability to do the same.

It was also noted that a majority of people who live in Hokkaido, enjoy living there and do not want to move off the island. The culture in Hokkaido can be very different from the rest of Japan due to its isolated status and history of the Ainu people and immigration. Additionally, unlike the main island of Japan (Honshu) travel between prefectures is not easily accessible for the people of Hokkaido as a plane is required.
When asked about reasons that might contribute to different levels of COVID-19 infection between the two prefectures it was noted that COVID19 outbreaks in Hokkaido consistently happen two weeks after outbreaks in Tokyo. Here, the thought is that when an outbreak occurs in Tokyo many people leave the prefecture and two weeks later the outbreak occurs in Hokkaido. Hokkaido may also be higher than Tokyo due to the weather being much colder. Many of the infections happened in Sapporo, which again reiterates the point in that when we consider COVID-19 outbreaks in Hokkaido we must examine Sapporo and the rest of Hokkaido.

Furthermore, in the opinion of my interviewee, despite heavy train usage in the population and mass commuting on the regular, the infection rate in Tokyo remains relatively low. As of May 30th, 2022, Tokyo has recorded 1.54M COVID19 infections and 4,496 COVID19 deaths. At the same time, Hokkaido has recorded 358K COVID19 infections and 2,062 COVID19 deaths (“Number of infected people by prefecture.” N.d.; Tokyo Metropolitan Government, n.d.).

This may be due to train etiquette in Japan, where quiet traveling and sleeping are commonplace. In Hokkaido cars are a much more prominent form of transportation and the lack of contact with others while commuting may have made an impact here as well.
LIMITATIONS

Limitations to this study are first and foremost the fact that this pandemic is still ongoing, and infection and mortality counts are subject to change. This analysis was also limited to only demographic factors that were recorded in the census and by national and city government bodies. Unfortunate, by being dependent on census data, we do not know the people behind the statistic and some of the categories provided by the census were limiting in the true variation and diversity of the Japanese population. I was also limited to private households with this study and were not able to examine the impact of COVID19 infections regarding institutional housing such as geriatric care facilities such as nursing homes. As mentioned by our public health official there are some culturally influenced behaviors present in Japan that may have aided in providing some resistance to mass infection. While this thesis could not explore them at this time, it has been made a goal for further research. Regarding biological variable that may have had an impact on COVID19 infection and mortality rates, innate resistance and other genetic factors regarding increased immunity or susceptibility to COVID19 have started to be explored (Y. Chen, Shan, & Qian, 2020; Fakhroo et al. 2020; Nguyen et al., 2020 as cited In Mohammadpour et al. 2021) but this research remains to be very new and not much is known for certain. Finally, the very general reporting of mortality data was a large limitation in discussing the full impact of the COVID19 pandemic, as I am not able to identify where these people lived in order to add them to our neighborhood assessment.
DISCUSSION

This thesis was done with the main goal to examine the socioeconomic factors that may have influenced the spread of COVID19 in Tokyo neighborhoods in Japan, as the built environment in which people occupy has a large influence on both daily and generational health. This environment is shaped by relations of power, access to resources and the ability to respond to life events (Madhav et al. 2020). COVID-19 is one of many present-day health problems that is affecting the global population and to fully understand its impacts we must understand how socioeconomic factors influence health throughout a person’s lived life and what may be inherited by future generations (Amato et al. 2021).

In many situations the socioeconomic environment can determine the outcome when it comes to disease manifestation, and in many cases members of a populations do not share the same environment. Simply put, some environments have more limitations on how an individual can respond to problems and adapt to life events than others. This is a large problem when we consider that some environments have more barriers to healthcare and health for certain individuals than others. This research is important, as to ensure that the entire population can receive healthcare access and a high quality of life we must first understand where barriers lie so we might create solutions on how to remove them.

Results of the Kruskal-Wallis test allowed us to reject our null hypothesis with great confidence (p<.0001) and accept the null hypothesis: H1: The level of urbanization does affect the standardized infection rate. Through this test I found a highly significant difference in terms
of urbanization, as when urbanization increases so does infection rate. As previously shown with both table 5. And figure 7. This is a highly significant trend. Levels of urbanization and differences between them are important to consider as different demographics and environmental factors have influence on the populations that live within them. Even if an issue is universal, such as the manifestation of stress in a pandemic, how it manifests can change based upon the level of urbanization present in an environment (Amato et al. 2020; Okubo et al. 2021; Ohta et al. 2021). Thus, there is no blanket solution to this problem. One recommendation going forward for the current COVID-19 pandemic in Japan, is better standard precautionary measures for rural citizens and rural environments (Ohta et al 2021). The rural environmental niche is different from more urban ones and the universal preventative measures for COVID-19, (Closed spaces, Crowded places, and Close Contact areas (3C’s)) are not prominent in rural areas to begin with. Each level of urbanization should be considered on the merits of its own niche to meet the needs of its residents especially when it comes to healthcare policy and preventative measures.

The results of the age analysis displayed in figure 8 further highlight the importance of considering different levels of urbanization when making health policy, because different levels are not all inhabited by populations of the same age ratio. While towns and villages were determined to be not significantly different from each other ($X^2 = 0.078$, df = 2, $p = 0.9961$), there was a significant difference between the two most urbanized and most populated levels (cities and wards): ($X^2 = 10.759$, 2 df, $p=0.0046$).

Regarding the COVID19 pandemic, age is also a preexisting condition that can impact specific niches of a population more than others. When an outbreak occurs, older aged individuals can be at a higher mortality risk due to increased risk factors that often accompany
older age in general. Even independent from risk factors, just being an older age can place individuals at a higher COVID-19 mortality risk (Ho et al. 2020).

Furthermore, as previously mentioned different age groups may have the ability to influence the path of a pandemic (to an extent) due to their behavioral patterns. Regarding the COVID-19 pandemic, previous research found that in the United States, younger populations were less likely to modify their behaviors and listen to social distancing requests (Kim and Crimmins 2020, Hutchins et al. 2020). Working age individuals may also be more likely to be in closer contact with other people through commuting and working in an office with others in a high urban setting where once again, an increased presence of crowded places, and close contact may lead to any virus spreading more easily within this age group if it is similar to COVID-19.

Results of this regression analysis produced four variables of interest. First, the parameter associated with people who are under 15 years of age (school year children) is -0.156 units, which indicates that as the number of people under 15 years of age increases by one unit, the rate of infection decreases by -0.156 units. Since individuals under the age of 15 do not often live alone we can consider them to be a majority of a family unit of some sort. Larger families may be more likely to live outside extremely urban areas, and as a result, have less close contact with other individuals. As mentioned by our public health expert, bigger and multigenerational families are more common in more rural areas because they are not confined to the small living spaces of compact urban areas. We can also consider communication and close contact with family members regarding the willingness to receive the COVID-19 vaccine. As discussed with our public health expert, one of the perks of living with your family is that they can provide you
with medical advice. Despite Japan’s history of vaccine hesitancy COVID-19 vaccination uptake was high once the program was rolled out.

One study conducted by Machida (2021) showed “Willingness to protect others by getting oneself vaccinated” was rated highly as one of the reasons to get the COVID-19 vaccine by most of the respondents regardless of their vaccination stance. This may also be related to the fact that the individuals who were rated as highly likely to take the COVID-19 vaccine (n=1836) a majority (n=1518) live with other people (Machida 2021). Families especially with elderly members may be more likely to take the vaccine to protect the relatives they live with, but this advice can also work both ways as younger generations in the household may also be able to encourage older and more vaccine hesitant generations to receive the vaccine.

This regression equation also incorporated a parameter indicating that as the number of industry workers standardized by area increases by one unit, the number of infections decreases by -4.05 units. One possible explanation for this is that in heavily industrialized regions, industry workers tend to have more access to (or be required to take) vaccines. As most industry workers are adults, they may also have more of an ability to receive a vaccine based upon age alone which may explain why the infection decrease is much higher than children under 15. Moreover, here the standardization was by area, not by population. It is also possible that in these industrial areas there are fewer inhabitants.

It is worth noting that the environmental geography itself may also play a role in lower COVID-19 infection rates for these variables as some of the areas examined in this analysis (while minimal n=9) can be found on islands consisting only of towns (n=2) and villages (n=7). The more isolated status of residents here may help contribute to a lower COVID-19 infection rate due to less close contact with others.
Next, our regression analysis identified that the number of taxpayers (by income) standardized by population increased by one unit, the number of standardized infections increases by 2.46 units. This variable may simply indicate that there are more taxpayers (per income) residing in a given neighborhood. More close contact with other individuals has been cited as one of the main ways COVID-19 transfers (Human-human contact). As taxpayers do not tend to be children, this may also be an indication that this infection increase is found within the more compact and urban areas where living spaces are smaller and single or small family sizes are more likely. Our model is clearly differentiating between children (the first variable, whose parameter is negative), and taxpayers (whose parameter is positive).

Finally, as the number of foreigner inhabitants divided by population increases by 8.66 units, the number of infections increases by one unit. We do not know who is encapsulated within the category of foreign inhabitant and what their socio-economic and demographic characteristics are. Nevertheless, it is important to note that for this analysis, this (8.66) is the highest infection increase we recorded.

It is interesting to note that this analysis did not identify a connection between high local rates of elderly individuals and an increase in COVID-19 infection. Age is especially important to consider, as exposure to an environment does not stop at physical location. Different ages can all be exposed to different environments within one geographical area (Zhang et al. 2021). This result comes despite the fact that older age has been well established as a pre-existing condition that increases the chances of worse COVID-19 symptoms, and Japan has the largest population in the world over the age of 65. This may be due to an elderly-focused government vaccination campaign and the fact that many elderly citizens did take the vaccine. Interesting to note, as of writing (3/31/2022) our world in data shows that 80 percent (79.9) of Japan is fully vaccinated
against COVID-19. This high level of vaccine uptake may be contributing to the ongoing low
COVID19 infection rate.

*Healthcare Access In Japan*

Based upon the interview with a public health official in Japan one of the main take away
points was the largely rural environment of Hokkaido is seen as one of the main barriers to
healthcare. As such, there are some areas without a doctor present, meaning residents must travel
if they need care. These rural areas of Hokkaido also do not have a reliable transportation system
the way that Tokyo and Sapporo do. Thus, it is on the individual to get from point A to point B.
This can be dangerous if the individual is older, the individual is ill, the weather is harsh, the
drive is long, or some combination of all. Age especially is an important factor to consider, as
many older people have a harder time driving a car let alone driving a car across rural Hokkaido
in a harsh winter weather and Japan’s aged population is the largest in the world. Not to mention
the average commute to obtain healthcare was cited to be within 30 minutes to an hour.

Additionally, while not mentioned in this interview, from this information we were able
to consider that in rural areas a multigenerational family type (and even just a larger family size
if we want to be more general) may be more beneficial in the grand scheme of obtaining
healthcare access. As previously mentioned, the elderly population is likely to have a harder time
driving from the rural areas to the larger cities to obtain healthcare regardless of the current
weather. Residents who cannot drive and who live in rural areas in general tend to face increased
barriers preventing them from accessing healthcare. A family member who is ill, (disabled?), or
injured may also find it difficult to drive themselves safely to a healthcare facility. The elderly
population is also more likely to need more frequent healthcare due to their age. The presence of
younger family members at home may help make these trip easier and more frequent if needed.
It was noted that unlike in the city where family types are small due to space confinements, rural families may have more of an opportunity to grow and provide different levels of social support. Furthermore, our interviewee mentioned that when considering healthcare access in Hokkaido, we must consider Sapporo (the 5th largest in Japan) and the rest of Hokkaido separately. This observation further highlights the stark differences between urbanization levels, the need to examine them within their own rights, and the variation in ability to access healthcare due to location.

Finally, it was also noted that Pre-COVID-19, influenza outbreaks in the winter, arguably the most dangerous season for elderly patients to be commuting to the city, were extremely frequent to the extent that businesses would temporarily close to accommodate the outbreaks. It is possible that these influenza outbreaks would also be driving higher rates of commuting individuals into the city for medical care in the most dangerous season to be driving in due to the weather and lack of locally available care. All this goes to say that there are still barriers to healthcare access that may have impacted the ability of rural residents to obtain healthcare and during the COVID19 pandemic. Barriers to receive healthcare may also be barriers to receive testing, and vaccinations (of which three doses have been made available in Japan so far). This is important to note not just for the COVID19 pandemic, but for any current and/or future respiratory disease as well.

One option going forward is to provide some of these rural towns with high elderly populations better access to public transportation that would help mitigate some of the dangers of travel mentioned above. One letter to the editor was written by Kotani (2020) in response to another article detailing rural healthcare access in Korea (Choi et al. 2019). In this letter, the situation of Japan’s rural population and the need for better public transportation was reiterated,
and of importance to this research it was further mentioned that public transportation policies for rural Japanese populations in need of healthcare have not yet been fully explored in Japan. (Kotani 2020).

Barriers to transportation should always be considered in tandem with barriers to healthcare access. A lack of reliable transportation can make obtaining regular, specialty, and emergency medical care services harder. In general, this connection is especially important to consider for those with pre-existing and chronic conditions, low-income and uninsured individuals. Consideration for certain life stages is important as well. The elderly population who due to their age often require more frequent care and treatment and minors who, like the elderly, often depend on other individuals to provide transportation to obtain medical services.

Additionally, as a majority of COVID-19 cases are coming from more urban areas, some residents of rural areas may also think twice about commuting to the city to obtain healthcare for something that is perceived as a minor issue. However, skipping and or foregoing healthcare can exacerbate current chronic conditions or increase the risk of something minor turning into something much more serious (Syed et al. 2013).

Ideally the solution would be to bring a doctor into some of these more rural towns, but as we were told, a lot of younger people with medical education wish to remain in the larger city areas. This is not a problem exclusively in Hokkaido, but in all rural areas of Japan. So, if we cannot bring the doctor to the village, perhaps we can focus on making it easier to bring the village to the doctor. This approach is especially important for the populations of Hokkaido as they face extra barriers to healthcare due to the physical environment.

Additionally, providing an alternative way to commute to the city for individuals who may have a hard time driving in general would make the commute less stressful for them and
make the roads safer for other drivers. These commuting pathways can also work both ways. By establishing easier travel access and better commuting routes, more doctors may become more willing to move their practices into these more rural areas. Especially if they have an easier and stress-free way to return to the city.

Ultimately, A focus on a public transportation system with emphasis on rural areas with large elderly populations may make it easier for more frequent trips to the doctor to happen for without encouraging families to relocate from their homes and make the commute safer and less stressful for the individual seeking care especially in the winter months. Furthermore, an improved transportation system might also encourage medical professionals to commute into these more rural areas providing more low-density locations with an easier access and shorter commute to obtain medical care.

This research is significant because it was able to identify that different levels of urbanization are significantly different regarding COVID19 infection rates in Tokyo. This research further highlights the importance of taking levels of urbanization into consideration when making health policies for both current and future respiratory diseases as one universal policy does not always fit every environment. This research further highlights that although a country may have universal healthcare, it may not universally be able to be accessed by everyone. Barriers for rural residents present major obstacles for residents looking to obtain healthcare, especially for older residents.

Following approval, I plan to submit an abstract of my research to the American Association of Biological Anthropologists and a full paper to a relevant journal.
CONCLUSIONS

Since the start of the COVID19 pandemic, Japan has been able to maintain a relatively low infection rate, and in this thesis, I looked for possible reasons why. Through critical biocultural theory I was able to address the impacts of physical and sociocultural environments through demographics and detail how the environment can “get under the skin” and stay there for generations. Family and the social areas were of focus, as this is the niche where the intersection of biosocial inheritance and current neighborhood demographics occur.

The results of this study indicate that levels of urbanization are significantly different regarding COVID19 infection rates, and despite the age group of 65+ being well correlated with COVID19 susceptibility, this analysis found no association. Finally, even in countries that have universal healthcare, there are still barriers to obtaining healthcare and health services that primarily affect rural and elderly populations. The problem of rural vs urban healthcare is seen not only across Japan but is also prominent in other countries like the United States as well.

Through this thesis I was able to identify several areas where future applied bio-medical anthropological research can be beneficial, not just in the scope of the current pandemic. This thesis only scratches the surface of why Japan’s COVID19 infection rate is so low.

Going forward, this thesis study is presented as steppingstone research for future research on COVID19 impacts with a larger focus on cultural and biological factors that may have contributed to a relatively low COVID19 infection rate. Overall, gaining a better understanding on how Japan was able to maintain a relatively low COVID19 infection rate at the start of the
pandemic and how this information can be applied to current and future respiratory disease responses is of anthropological interest.
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GRAPHIC IMAGE CITATIONS


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APPENDIX A. Descriptive Statistics for Variables Of Interest By Level of Urbanization
## Wards (Most Urban)

<table>
<thead>
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<th>Mean</th>
<th>St. Error</th>
<th>Std. Deviation</th>
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<td>15-64</td>
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<td>Taxpayers</td>
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## Cities

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<th>Std. Deviation</th>
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## Towns and Villages (Least Urban)

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<th>Std. Deviation</th>
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APPENDIX B. Interview questions for Japanese healthcare professionals
1. If someone becomes sick in Japan, what options do people have to access health care?

2. In Tokyo what are barriers that may be preventing people from obtaining healthcare? Such as, unemployment, poverty, or pre-existing conditions that make travel hard?

3. In Hokkaido what are barriers that may be preventing people from obtaining healthcare? Such as, unemployment, poverty, or pre-existing conditions that make travel hard?

4. Are all people in Japan able to receive the same treatment by doctors and other healthcare workers? Do any biases exist (for example, regarding gender, age, ethnicity?)

5. How do you think the healthcare system in Hokkaido compares to that in Tokyo?)

6. Do you think multigenerational families have an advantage when it comes to healthcare, such as being able to provide more social support?

7. Do you think that people in Hokkaido tend to have different family structures from those in Tokyo?

8. Please tell us anything else you might think might be influencing the COVID-19 infection rates in Tokyo and in Hokkaido.

APPENDIX C. IRB Recruitment Email
Dear Blank,

I am reaching out to you on behalf of the University of South Florida’s Anthropology department regarding a research study I am conducting concerning perceived differences in health care access, and COVID-19 infection rates in Hokkaido and in Tokyo. This study has been examined by the USF Institutional Review Board (IRB) and was given the number (003705). Potential benefits of this research include a better understanding of the socio-cultural, demographic and economic forces that affect COVID-19 transmission in the two areas of Japan. The Principal Investigator of the project is Dr. Lorena Madrigal. This project is the bases a Masters’ thesis of one of her students.

I am contacting you because you are a public health care expert residing in Japan. If you are between the ages of 18-65, we would like to request an interview, ranging from 45-60 minutes at a time of your choosing (Japan is 14 hours ahead of Tampa). You will not incur any cost by participating in this study nor will you will receive any payment or other compensation for taking part in this study. We will be happy to share with you a link to the finished Masters’ thesis after the research project is completed.

Please reply to this email if you wish to participate in this project. If you would like us to provide a Japanese translator, we will. At the start of the interview, we will obtain your verbal consent to participate in the study. Please tell us if you prefer to use zoom or skype. We will also ask you if you consent to be videotaped, audiotaped, or if you want us to take hand-written notes.

We thank you for your time and consideration. Sincerely,

Professor. Department of Anthropology. University of South Florida. AAAS Fellow. USF Kosove Society Distinguished Undergraduate Teaching and Service Professorship for 2021. Tampa, FL. 33620. Fax: (813) 974-2668. madrigal@usf.edu.

APPENDIX D: IRB Determination of Not Human Subjects Research 87
Notification of Not Human Research Determination

To: Lorena Madrigal

Link: STUDY003706

P.I.: Lorena Madrigal

Title: COVID19 Infection Rates in Japan:

Description: The IRB reviewed this submission and assigned a determination of not human subjects research. For additional details, click on the link above to access the project workspace.

APPENDIX E: IRB Submission Approval
To: Lauren Koerner
Link: STUDY003705
P.I.: Lorena Madrigal
Title: The covid 19 experience in Hokkaido and Tokyo.
Description: This submission has been approved. You can access the correspondence letter using the following link:

STUDY3705_Initial_1.18.22.pdf(0.01)

To review additional details, click the link above to access the project workspace.

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CDC-INFO; Topic Copyright Information; [CDC-2395751-S7N6F2] CRM:06169114

CDCInfo <cdcinfo@cdcinquiry.ommicrosoft.com>

Mon 2/14/2022 1:12 PM
To: Lauren Koeper

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APPENDIX F: Permissions Appendices
### Appendix F3: Specific Image CDC Information

| Description: | This illustration, created at the Centers for Disease Control and Prevention (CDC), reveals ultrastructural morphology exhibited by coronaviruses. Note the spikes that adorn the outer surface of the virus, which impart the look of a corona surrounding the virion, when viewed electron microscopically. In this view, the protein particles E, S, and M, also located on the outer surface of the particle, have all been labeled as well. A novel coronavirus, named Severe Acute Respiratory Syndrome coronavirus 2 (SARS-CoV-2), was identified as the cause of an outbreak of respiratory illness first detected in Wuhan, China in 2019. The illness caused by this virus has been named coronavirus disease 2019 (COVID-19). |
| High Resolution: | [Click here for hi-resolution image (23.41 MB)] |
| Content Providers(s): | CDC/ Alissa Eckert, MSM; Dan Higgins, MAMS |
| Creation Date: | 2020 |
| Photo Credit: | Alissa Eckert, MSM; Dan Higgins, MAMS |

| Categories: | CDC Organization |
| MeSH: | Diseases |
| | Virus Diseases |
| | RNA Virus Infections |
| | Nidovirales Infections |
| | Coronaviridae Infections |
| | Coronavirus Infections |
| Geographic Locations: | Asia |
| | Far East |
| | China |
| Organisms: | Virus |
| | RNA Virus |
| | Nidovirales |
| | Coronaviridae |
| | Coronavirus |

| Copyright Restrictions: | None - This image is in the public domain and thus free of any copyright restrictions. |

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Note: In early 2019 we changed our Creative Commons license from “By Attribution-Share Alike” (CC-BY-SA) to “By Attribution” (CC-BY). Some of our static charts still have the CC-BY-SA mark in the bottom right corner. You can disregard this, and consider all our work as licensed under CC-BY.
Appendix F5: Copyright information for Prime Minister of Japan and His Cabinet

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2. Users should indicate clearly that the link(s) they create are to "the Official Website of the Prime Minister of Japan and His Cabinet." (This does not require prior notification to the Cabinet Secretariat.)

3. When a link is created, users are requested to ensure that the link to the website does not open as a frame within another website, but opens as a new window.

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