# MAPPING THE COVID-19 PANDEMIC IN STATEN ISLAND

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# Contents

## ABSTRACT

COVID-19 is a respiratory virus that spreads through person-to-person contact. This virus has taken a toll on the world; New York City is one area that has been heavily affected by the virus. Out of the five boroughs in New York City, Staten Island has been affected the most by COVID-19. In this capstone research paper, I examine the uneven geography of COVID-19 in Staten Island by answering three questions; Where are the locations with high-risk transmission? Where are the vulnerable people? Where are the healthcare facilities that can support people with COVID-19?

To answer these questions, I utilize Geographic Information Systems (GIS) to identify, visualize, and analyze unique ecological and social relationships. I created maps and performed spatial analysis using Quantum GIS (QGIS), which is a desktop opensource application that allows the user to view, edit, and analyze geospatial data. The specific type of maps I develop are choropleth maps, a mapping technique that uses graded differences in shading, color, or symbology to define average values of some property or quantity.

My findings indicate that certain zip codes of Staten Island have higher amounts of COVID-19 cases due to the density, or the congestion of residents within that zip code. I have also found that elderly individuals, over the age of 65, are the most susceptible to contracting COVID-19 and require the most attention to protect. Finally, zip codes that host a greater number of vaccination centers result in those zip codes with a lower number of COVID-19 cases.

## INTRODUCTION

The global COVID-19 pandemic has an uneven geography. Certain parts of the world have more cases than others, as well as some groups of people are more vulnerable or at greater risks than the rest. In the U.S., New York City had the largest number of reported cumulative cases and deaths as of April 2020, barely a month after the lockdown (Maroko 2020)[1]. Furthermore, within the city and across the five boroughs of The Bronx, Manhattan, Brooklyn, Queens, and Staten Island, the latter had the highest percentage of COVID-19 cases (NYC Department of Health 2020)[2].

In this article, I examine some of the key sources of the uneven geographies of the global COVID-19 pandemic. Focusing on Staten Island as a case study, I ask: *1) Where are the locations with high-risk transmission? 2) Where are the vulnerable people? 3) Where are the healthcare facilities that can support people with COVID-19?* Using Geographic Information Systems (GIS) and spatial analysis, I investigate the social and spatial (human and environmental) factors that contribute to the increase in the number of cases in Staten Island while also attending to the uneven distribution and geographic patterns of COVID-19 within the borough.

Specifically, I created maps that integrated quantitative data of COVID-19 cases in Staten Island between February 2020 and May 2021 with key demographic and spatial features in Staten Island, such as population density, age, and location of vaccination centers, to better understand the geographic patterns of the spread of COVID-19 in the borough. My findings

reveal that zip codes with a great number of residents likely have higher percentages of COVID-19 cases, individuals over the age of 65 are the most susceptible to COVID-19, as well as zip codes having a higher quantity of vaccination centers have a lower percentage of COVID-19 cases. These findings contribute to our understanding of the uneven geographies of the global COVID-19 pandemic, as well as inform borough-specific decisions and policies in addressing COVID-19 and preventing new cases.

The article is organized in four parts. In the first part, I illustrate the context of COVID-19 and Staten Island as a borough in New York City. The second part, I describe the data that I have used as well as which methods I have conducted for my analysis. In the third part, I describe the general findings as well as dissect each geographic pattern. Finally, in the conclusion I summarize the key findings and elaborate on future GIS research.

## CONTEXT

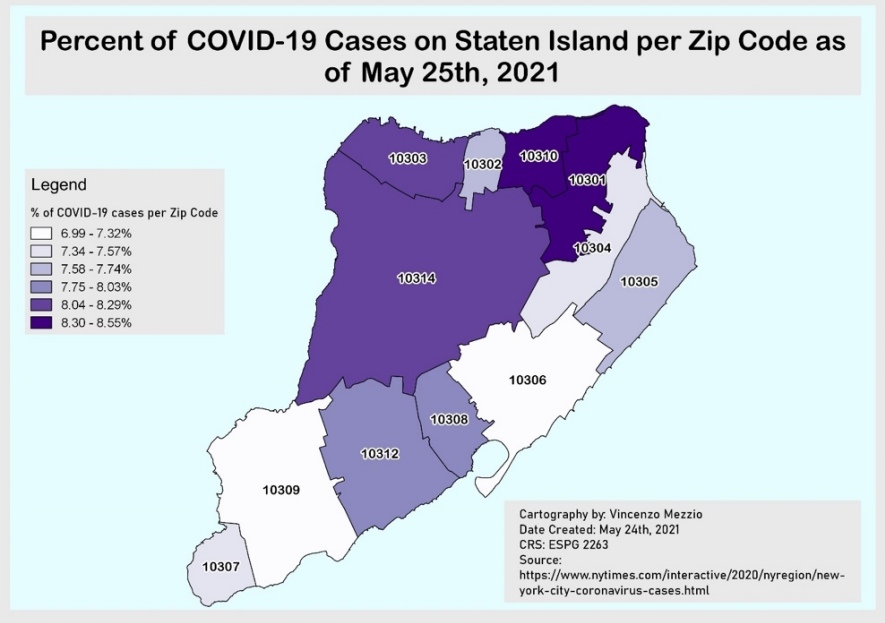
COVID-19 is a virus that spreads through person-to-person contact (CDC 2021)[3]. According to Madeeha S Waleed (2020), "[COVID-19] is highly resistant, staying on surfaces for days and in the air for hours … COVID-19 can also spread through the ocular medium (eyes) as infected droplets may contaminate conjunctiva (mucous) and cause infection"[4]. Further, as a respiratory virus, COVID-19 would have a massive impact on individuals whose bodies are unable to combat the virus due to medical conditions (CDC 2022)[5].

Patterns of the spread of COVID-19 are both social and spatial. On the one hand, individuals over the age of 65 years old or the elderly at greater risks. Thus, they require extra protection and assistance to keep them safe from the virus. On the other hand, areas with higher density tend to have higher rates of cases. As stated by Andrew R Maroko (2020), "social interaction and physical proximity of infected and susceptible individuals [are] the basis of community transmission of [COVID-19] it stands to reason that denser areas would be more rapidly and severely impacted than low-population areas"[1]. Thus, people per square mile is an important factor in the spread of COVID-19 due to the idea of people in overall closer proximities are more likely to contract and spread the virus. Even if a zip code originally did not have many COVID-19 cases, the idea is that one individual could contract the virus and spread it among the community in tight proximities.

This implies that individuals would be able to protect themselves by distancing themselves from contact with other individuals. In New York City, the spread of COVID-19 was

unavoidable due to the density in the city and the number of elderly people. Residents required the necessary assistance to combat the virus and to isolate themselves through social distancing and quarantine (CDC 2021)[6]. Once the medical industry was able to produce a vaccine for the virus, this was the second way of being able to combat COVID-19. Vaccination centers distribute the vaccine, so if a local zip code is vacant of vaccination centers, individuals would not be able to get vaccinated.

In New York City, Staten Island had the highest percentage of COVID-19 cases relative to population. Staten Island is often referred to by New York City residents as a "suburban" borough. Staten Island is organized by the North Shore, South Shore, and Mid-Island neighborhoods. The majority of the borough includes single family homes, townhouses, and condos. The North Shore includes the vast majority of residences; especially multifamily homes in which many individuals have close contact with one another. It includes zip codes such as 10301 and 10304, which include multifamily housing projects such as the Stapleton Houses (MyNYCHA Developments n.d.)[7]. Meanwhile, Staten Island is home to a multitude of public parks. The vast majority of parks are on Mid-Island and South Shores of the borough. The North Shore lacks an abundance of parks making up for it with a large quantity of residences (Tom Crimmins Realty n.d.)[8].




**Reference Map 1**: Percent of COVID-19 cases per zip code.

Map 1 illustrates each zip code and the range of COVID-19 cases in Staten Island between February 2020 and May 25th, 2021. Zip codes with a dark color represent a higher percentage of COVID-19 cases while the lighter color zip codes represent less percentages of COVID-19 cases. The top four zip codes with the highest percentages of COVID-19 cases in Staten Island are 10301, 10310, 10303, and 10314. The "North Shore" includes the zip codes 10310 and 10301 within the list of zip codes with the highest percentages of COVID-19 cases.

Zip codes 10310 and 10301 have the highest percentage COVID-19 cases within the range 8.30 – 8.55% of the population. The range was calculated by taking the population of the zip code and dividing it by the number of COVID-19 cases within that zip code. The percentage of COVID-19 cases in 10310 is the population count of 23,441 divided by the number of COVID-19 cases which is 2,812 to give us the result of 8.28% of COVID-19 cases within that zip code.

Zip codes 10305 and 10306 have some of the highest number of COVID-19 cases within the borough being 5,631 and 7,554 COVID-19 cases respectively. When taking the total population and dividing it by the number of COVID-19 cases, 10306 has 6.99% of COVID-19 cases within the borough and 10305 has 7.61%.

## DATA AND METHODOLOGY

I examine a set of social, public health, and economic data related to COVID-19 on Staten Island. Building upon my preliminary research (Mezzio 2021)[9], I collected, organized, examined, and mapped data such as COVID-19 cases, deaths, hospitalizations, vaccinations, and social workers in Staten Island. I used the dataset of the total count of COVID-19 cases, cases per 100,000 people, deaths, and deaths per 100,000 people until May 25th, 2021, from the *New York Times* (2021)[2]. This count includes all five boroughs in New York City as well as being able to filter by specific zip codes. This research includes data solely from the zip codes in Staten Island. I also used open access geospatial data, specifically the zip code shapefile data from ZipAtlas, which provides up-to-date data (ZipAtlas n.d.)[10]. I also used the geospatial data of Staten Island using a shapefile from NYC's Open Data (NYC Open Data n.d.)[11].

For my methodology, I utilize Geographic Information Systems (GIS) to identify, visualize, and analyze unique ecological and social relationships that shape human and environmental phenomena. GIS allows researchers to integrate a variety of factors such as population or environmental factors as well as mapping, which will reveal new information and contribute to our understanding of the geography of COVID-19 on Staten Island. Maria Brovelli and Serena Coetzee (2021) argue that geospatial data is useful in understanding the global COVID-19 pandemic. Specifically, through the use of GIS and open geospatial data, GIS analysts and scholars can "predict how the disease will spread, prevent and mitigate the spread of the disease, strengthen social preparedness and response to the disease, and monitor and

communicate the spread of the disease at different scales" (Brovelli and Serena Coetzee 2021: 33)[12].

In this research, I created maps and performed spatial analysis using Quantum GIS (QGIS n.d.)[13], a free and open-source GIS software. QGIS is a desktop opensource application that allows the user to view, edit, and analyze geospatial data. Through QGIS, I created choropleth maps, a mapping technique that uses graded differences in shading, color, or symbology to define average values of some property or quantity. To do this, I utilized a graduated data classification method Quantile or Equal Count. This method divides the data to create an equal number of units or ranges(the graduated colors in each zip code). I also customized the color scheme to visualize the different data ranges. The Quantile method was able to easily divide the twelve zip codes in Staten Island to six different ranges for each map. In visualizing all of the data points, I took each data point from the corresponding sources and zip codes and include the values into the shapefile's attribute table.

## FINDINGS AND ANALYSIS

Zip codes in Staten Island with higher rates of congestion, elderly people, and less vaccination centers have a higher percentage of COVID-19 cases and vice versa. Table 1 demonstrates all data points in each zip code.

| Zip Code | Population | COVID-19 Cases | Percent of COVID-19 cases | Percent of Seniors | People / Square Mile | Number of Vaccine Centers | Rooms / Home |
|---|---|---|---|---|---|---|---|
| 10314 | 92523 | 11171 | 8.28% | 12.73% | 6550.27 | 9 | 5.8 |
| 10312 | 61052 | 7753 | 7.87% | 9.43% | 7013.96 | 3 | 6.3 |
| 10310 | 23441 | 2812 | 8.34% | 10.83% | 12829.03 | 1 | 5.4 |
| 10309 | 32939 | 4611 | 7.14% | 7.74% | 3862.03 | 3 | 6.2 |
| 10308 | 29820 | 3749 | 7.95% | 11.72% | 14230.06 | 2 | 6 |
| 10307 | 14912 | 2025 | 7.36% | 8.64% | 7091.02 | 2 | 6 |
| 10306 | 52806 | 7554 | 6.99% | 15.06% | 7104.18 | 4 | 5.5 |
| 10305 | 42856 | 5631 | 7.61% | 13.22% | 8962.46 | 3 | 5.1 |
| 10304 | 41886 | 5574 | 7.51% | 11.53% | 10617.85 | 1 | 4.9 |
| 10303 | 26512 | 3235 | 8.19% | 7.5% | 5426 | 3 | 4.9 |
| 10302 | 18484 | 2430 | 7.60% | 11.48% | 13875.4 | 4 | 5.2 |
| 10301 | 38904 | 4547 | 8.55% | 12.26% | 10327.23 | 6 | 4.3 |

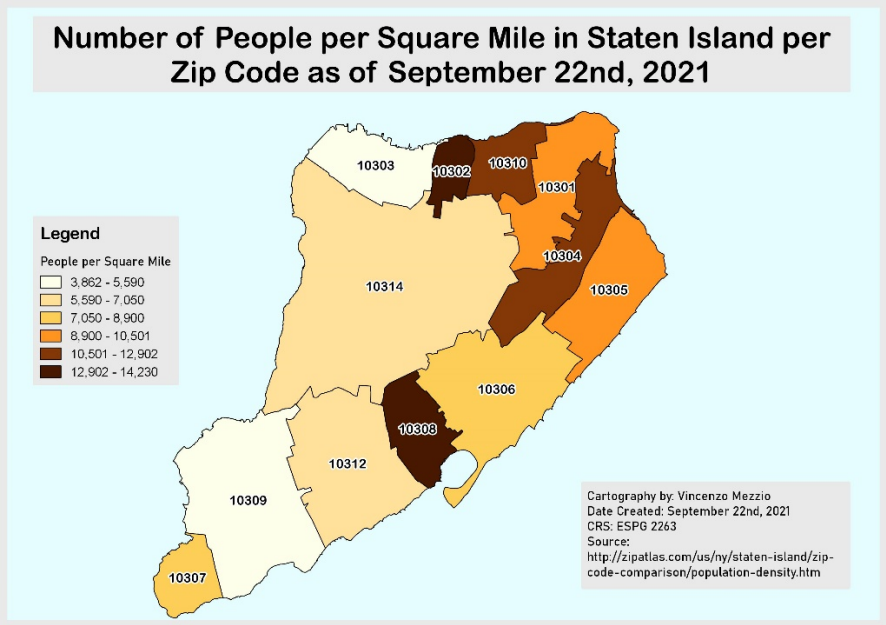
**Table 1 - Important Data Points**

Table 1 displays the population or the total count of individuals living in the specified zip code as of May 25th, 2021. COVID-19 cases are the number of confirmed cases per zip code as of May 25th, 2021. Percentage of COVID-19 cases takes the population of the zip code and divides it by the number of COVID-19 cases within that zip code. The percentage of seniors over 65 years old column is an estimate representing the average number seniors out of all individuals living in households as of October 15th, 2021. People per square mile similarly is an estimate of individuals living in households within a square mile as of September 22nd, 2021. The number of vaccine centers is a count of all vaccine centers points within each zip code on Map 11 as of September 11th, 2021. Rooms per home is an average of the count of rooms per home within each zip code as of October 25th, 2021.

In the following section, I discuss each of the three factors in detail.

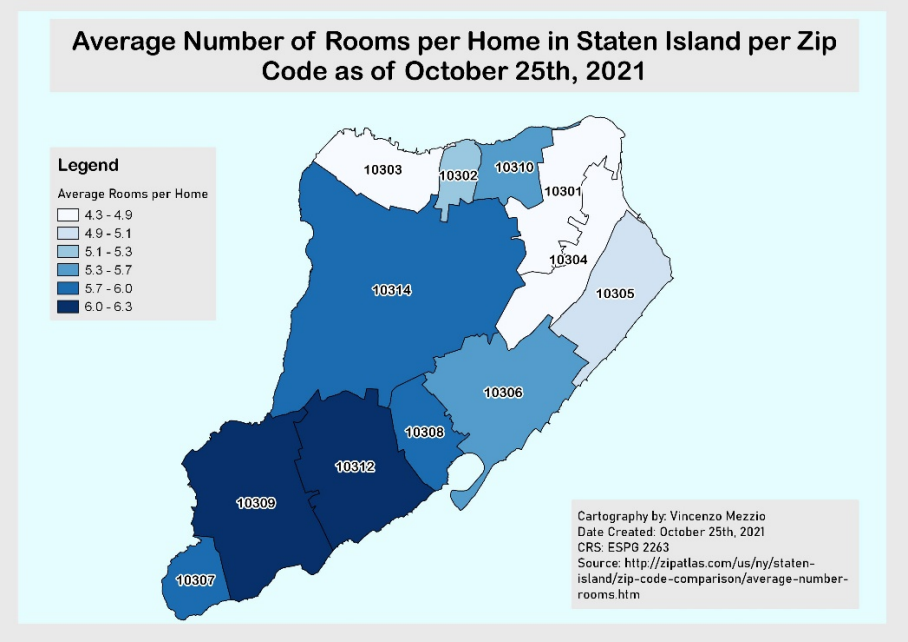
***DENSITY***

I define density in this study as how compact the population is in each zip code. If a zip code includes more residents in close proximities (such as square miles), that zip code would be considered dense.




**Reference Map 13**: People per Square Mile per zip code.

The map presents an average count of how many residents are within one square mile in each zip code of Staten Island. This is important to visualize the proximity of residents. Similar to Map 1, a zip code with a darker color represents more residents per square mile and thus greater density for that zip code. Zip codes 10302 and 10308 are the densest. This correlates with Map 1; 10308 is in the third highest percentile of percentage of COVID-19 cases and 10302 is in the fourth highest percentile of percentage of COVID-19 cases. The zip codes with the highest percentiles of COVID-19, 10310 and 10301, are also dense as demonstrated by Map 13. 10310 is in the second highest percentile of number of people per square mile and 10301 is in the third highest percentile of number of people per square mile. Both maps demonstrate a direct correlation between percentages of COVID-19 cases and density of a zip code.




**Reference Map 16**: Average Number of Rooms per Home per zip code.

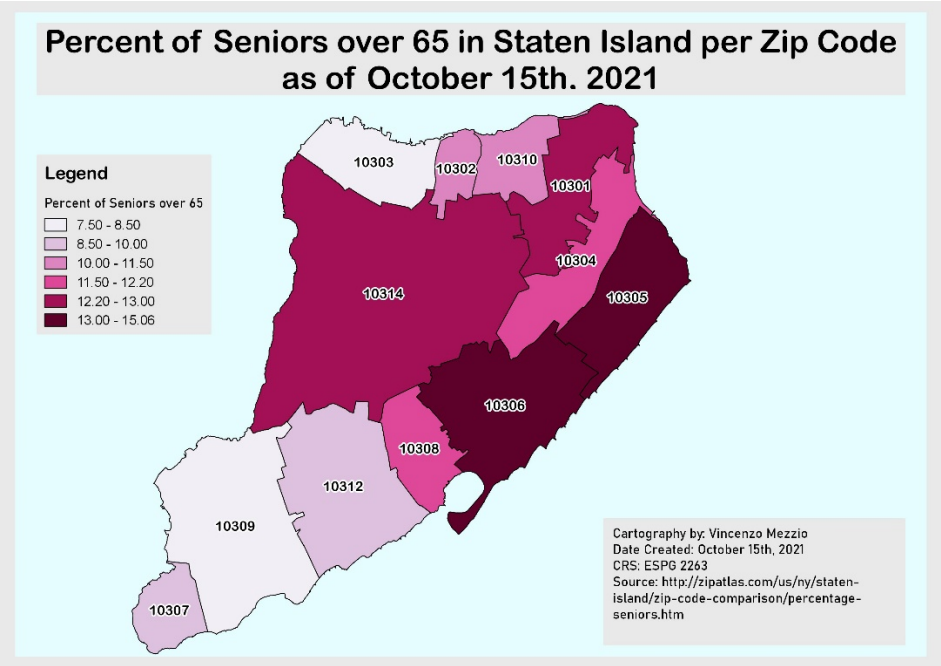
This map lists the average number of rooms out of all homes in each zip code in Staten Island. The average was calculated by dividing the total number of rooms with the number of homes per zip code.

In Map 16, it can be assumed that a house with a larger number of rooms more likely has a greater number of residents living in them. We can assume then, that 10309 and 10312 have the largest density of individuals living in one residence. 10312's large density correlates with Map 1, Percentage of COVID-19 cases per zip code; This zip code has one the largest percentages of COVID-19 cases, most likely stemming from the density of homes. However, 10309 does not have as high of a percentage of COVID-19 cases as 10312 does, although both zip codes have a large density of residents per home.

***ELDERLY***

Individuals vulnerable to COVID-19 are not limited to dense neighborhoods. Seniors are classified as being above the age of 65 and in this study, are identified as vulnerable; it is important to map this data.

Elderly individuals, especially with existing medical conditions, are also at greater risks of getting COVID-19.




**Reference Map 15**: Percent of Seniors over 65 per zip code.

The map visualizes the percentage of seniors, calculated by dividing the total population with the number of seniors in each zip code of Staten Island. Staten Island is most certainly a borough with elderly population, in fact, the zip codes 10314 and 10301 have the third highest percentile of elderly residents throughout the borough. The zip codes 10305 and 10306 have the largest percentile of seniors.

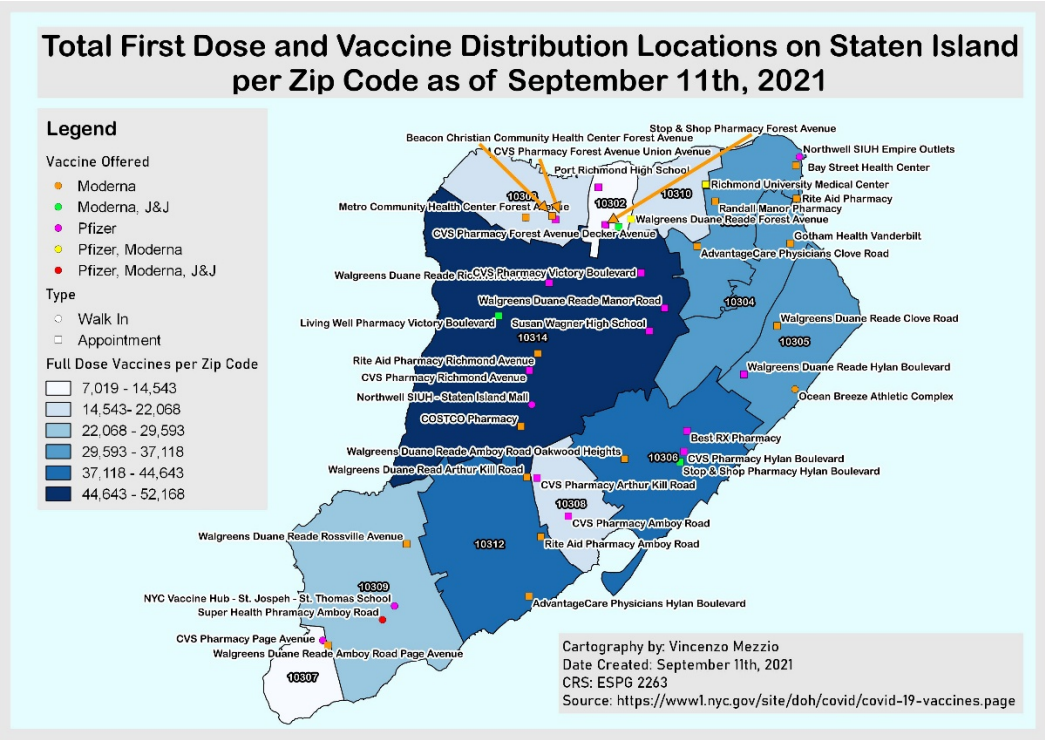
These groups of people are the most vulnerable due to COVID-19 being an airborne virus, people in closer proximity have a greater chance of contracting and spreading COVID-19, whether the individuals spread it in a crowded home or dense neighborhood (CDC 2021)[3]. "Prevalence of crowded housing and percentage of workers in healthcare service occupations-are significant positive predictors of COVID-19 infection rates"(Credit 2020)[14]. "Household overcrowding, and average household size are associated with the number of face masking violations … individuals who violate the mandate [can be fined up to] $1,000 … individuals can report a face masking violation to authorities and the police department will enforce face masking or take actions to fix a violation as appropriate"(Yang 2021)[15].

Seniors have a greater risk due to their potential conditions of having a weakened immune system thus being incapable of fighting COVID-19(CDC 2022)[5]. The senior group, according to the Center for Disease Control (CDC) estimates that "63.1% of adults older than age 60 have hypertension, 38% of [seniors] have chronic kidney disease (CKD), and 26.8% of [seniors] have diabetes … [thus, it can be] hypothesized that older individuals with such comorbidities may have an elevated risk and experience a more severe course of infection with [COVID-19]"(Shahid 2020)[16].

A significant number of seniors are affected with a weakened immune system making them a group of people that would greatly be affected by COVID-19. This is backed up by data in which individuals in New York City who contracted COVID-19, "75% with the confirmed

laboratory test had two or more underlying conditions"(Thompson 2020)[17]. In fact, "COVID-19 mortality rates per 100,000 were 65.43 for the urban and 50.78 for rural counties … diabetes rates were significantly associated with higher mortality [rates] … in urban counties" (Rajib, 2021)[18].

## *VACCINATION CENTERS*




**Reference Map 11**: Vaccination Distribution Locations per zip code.

This map displays all locations that distribute COVID-19 vaccines as of September 11th, 2021. This map demonstrates every area that provides COVID-19 vaccines as well as a breakdown by an individual being required to schedule an appointment, or be allowed to walk in, as well as types of COVID-19 vaccines that are offered.

These locations are broken down by which vaccine is offered (from Pfizer, Moderna, Johnson & Johnson, as well as combination of vaccines offered). The locations are also divided by which require an appointment or are walk ins. The map also displays the number of individuals who received the full vaccine (two doses) per zip code. A zip code with a darker color denotes more individuals have received the vaccine.

Zip code 10314, as one of the highest percentage of COVID-19 cases, has the most vaccination centers in the borough and thus have the highest number of residents receiving the vaccine. Vaccination availability is our third factor in understanding the distribution patterns of COVID-19 in Staten Island.

Zip code 10306 with four vaccination centers as opposed to 10305 with three vaccination centers, thus resulting in 10306 with a lower percentage of COVID-19 cases compared to 10305. 10306 having more vaccination centers also leads to the zip code having more individuals getting vaccinated compared to 10305. 10306 has more than 37,000 individuals vaccinated while 10305 has only more than 29,000 individuals vaccinated. 10306 is performing a better job in protecting the seniors by having more vaccination centers available within the zip code; both 10306 and 10305 are important to note due to their large capacity of elderly individuals living within these specific zip codes.

The vaccine itself is imperative to protecting the elderly; according to Moyet (2021), “Immunity against [COVID-19] appears to be persistent in [the] elderly … with a good post

vaccination response [who had already shown symptoms of COVID-19] but a notably diminished response [by those who had not shown symptoms of COVID-19] … suggesting the need for supplementary doses"[19].

10309 as a discrepancy can seemingly be traced to Map 11, Vaccination Centers; 10309 has three vaccination centers in proximity as well as two bordering 10307, while 10312 has only three vaccine centers that are well spread apart. Due to the availability and variety of vaccination centers in 10309, this zip code has a lower percentage of COVID-19 cases as compared to 10312. 10309 has 7.14% of COVID-19 cases while 10312 has 7.87% of COVID-19 cases. This information demonstrates that a zip code with many vaccination centers could lead to a zip code having fewer overall percentages of COVID-19 cases.

Some other great examples are the zip codes 10302, 10305, and 10306. 10302 has four vaccination centers resulting in this zip code being in one of the lowest percentile of COVID-19 cases specifically having 7.60% of COVID-19 cases in the zip code. 10305 produces similar results with three vaccination centers and 7.61% of COVID-19 cases as well as 10306 having four vaccination centers with 6.99% of COVID-19 cases. 10306 has more vaccination centers as compared to 10309, thus having an overall lower percentage of COVID-19 cases. Although 10302 has more vaccination centers than 10309, 10302's COVID-19 case percentage is 0.46% greater than 10309. This could be due to the density of people per square mile in Map 13. 10309 has approximately 3,800 per square mile while 10302 has 13,800 people per square mile.

Vaccination centers can assist in reducing COVID-19 cases; however, dense zip codes are still the most prone to high concentration of infection.

Although, 10314 has the highest number of vaccination centers out of every borough being nine centers, this zip code is in one of the highest percentile of COVID-19 cases having 7.87% of cases. If we refer to Map 16, the average number of rooms per home, 10314 is in the second largest percentile of rooms per home between 5.7 to 6 rooms. Essentially, zip codes with the largest densities via home size will most likely result in the most COVID-19 cases within the zip code; there is a priority for availability of vaccination centers within dense zip codes such as 10314 and 10312. 10309 and 10306 prove that more vaccination centers within the zip code have the chance to minimize the percentage of COVID-19 cases.

A zip code with many vaccination centers will have more individuals receive the vaccine. This is certainly true in 10314, having the most amount of vaccination centers being nine, as well as having the greatest number of individuals receive the vaccine within the range of 44,000 to 52,000 individuals. 10307 shows the opposite effect; this area has two vaccination centers on the border of the zip code resulting in the lowest number of individuals who have received the vaccine between the range of 7,000 and 14,000. Out of all the forty vaccination centers on Staten Island (as of September 11$^{th}$, 2021), six of these vaccination centers allow individuals to walk-in and receive the vaccine without an appointment. 10309 has two vaccination centers that are walk-ins out of the three vaccination centers within the zip code.

It is apparent that many vaccination centers require individuals to schedule an appointment for the COVID-19 vaccine due to popularity and potential overcrowding of the vaccination center or due to a lack of availability of COVID-19 vaccines. Mayor De Blasio is aware of increased vaccination rates with walk-in vaccination centers stating, “We did not have the kinds of lines we were worried about that might be a problem [volume of individuals receiving the COVID-19 vaccine] so we are quite confident we can accommodate a much higher volume of walk ins” (Gothamist 2021)[20].

Walk-in vaccination centers are certainly very convenient for Staten Islanders as proven by 10309, plus they have the potential to influence individuals to receive the vaccine. Although, the best basis for persuading individuals to receive the vaccine is to simply have an abundant availability of vaccination centers across the borough as proven by zip codes 10314 and 10312 in Map 11. In fact, “COVID-19 severity risk would be associated with influenza vaccine uptake … [which was] highest among residents most vulnerable to severe complications from influenza … campaign strategies [for influenza vaccine] that have shown to be successful include convenient, easy access vaccinations” (Moreland, 2021)[21]. 10314 has the largest number of vaccination centers and this zip code has the greatest number of individuals vaccinated. Individuals who receive the vaccine assist in getting closer to country wide immunity. “Public officials suggest that about 80 to 85% of Americans would need to be vaccinated for the country to achieve herd immunity (Rosenbaum 2021)[22].

The most popular vaccinations are between Pfizer and Moderna according to Map 11. On Staten Island, seventeen of the vaccination centers offer only Pfizer vaccines while fourteen of these locations offer only Moderna vaccines. 10314 offers Pfizer vaccines in two-thirds of the vaccination centers within the zip code. Vaccination centers mainly offering Pfizer vaccines assist in increasing the total count of individuals receiving the COVID-19 vaccine as seen in zip codes 10314 and 10306. Moderna vaccines are also popular as seen in zip codes 10301, 10304, 10305, and 10312. In fact, 10304 and 10312 solely offer Moderna vaccines resulting in the zip codes being in the top three percentiles of individuals receiving the vaccine.

## CONCLUSION

In this article, I discovered that zip codes in Staten Island have high percentages of COVID-19 cases due to high density, as seen in 10308 and 10312. Zip codes with the most vulnerable people are those with high concentration of elderly individuals, which require the most care as seen in zip codes 10305 and 10306. Finally, zip codes with more vaccination centers results in less percentages of COVID-19 cases as seen in 10306 compared to 10305.

These findings can assist in COVID-19 policymaking by determining key areas that are the most susceptible to COVID-19. Viruses spread quick and while it is important to protect everyone, certain areas require extra attention. This analysis can be applied to any city, state, or even country. The findings of this research can help reduce COVID-19 cases with more vaccination centers as proven by the zip code 10309, having a low number of COVID-19 cases and an abundance of vaccination centers.

Future research with GIS on COVID-19 could zoom in on which vaccination centers receiving the COVID-19 vaccine benefit the most. For instance, in Staten Island, 10307 does not have a great deal of vaccination centers, however, the zip code 10310 would greatly benefit having more vaccination centers since it currently has only two vaccination centers and is one of the zip codes with the highest percentages of COVID-19 cases.

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