

An Observational Study Investigating the Association Between Regional Socioeconomic Status
and Availability of COVID-19 Testing in Upstate New York Counties

Luke Kotsides

Rondout Valley High School

S-BMED-005

Abstract

Severe Acute Respiratory Syndrome Coronavirus 2 (SARS-CoV-2), more commonly known as Covid-19, exposed serious weaknesses in health care systems across the world. Some of these flaws were found in the testing system. These issues were thought to be responsible for life-threatening delays throughout the pandemic. To find the root cause of this problem we designed a study to investigate whether people associated with lower socioeconomic status have limited accessibility to Covid-19 testing based on travel times, both walking (WT) and driving (DT). We did this by locating 5 residences, in each census tract examined, and comparing the time, in minutes, that it would take for someone living there to get to the closest testing location. The census tracts were then split into three income ranges (below average, average and above average). Data was examined using a student's t-test with a 95% confidence interval with the average income group being the comparison group. The results for the below average income group were differences in means of 4.73 (0.5831 to 8.8769) DT and 57.08 (1.4639 to 112.6961) WT. The results for the above average income group were differences in means of 1.370 (-2.2847 to 5.0247) DT and 19.860 (-30.8425 to 70.5625), WT, Contrary to former studies, this study suggested that people living in the below average income range had the highest level of accessibility to Covid-19 testing based on travel time. It is important to continue to study the inequalities in our health care system to determine the true cause of inequality.

An Observational Study Investigating the Association Between Regional Socioeconomic Status
and Availability of COVID-19 Testing in Upstate New York Counties

Introduction

Disease is one of, if not, the most potent threats to mankind. Whether it was the bubonic plague, which killed a third of Europe's population in the 1300s, or the polio epidemic in the early 1900s, which could disable people for life, diseases have been ruining and ending lives forever, especially those of the impoverished. Now a new disease is on the stage: Severe Acute Respiratory Syndrome Coronavirus 2 (SARS-CoV-2), more commonly known as Covid-19. Covid-19 is a respiratory disease that was first discovered in Wuhan, China in December 2019. In the months following, Covid-19 rapidly spread worldwide and caused most countries to go into lockdown. In that first year alone, Covid-19 infected an estimated 140 million and killed over 921 thousand worldwide (Bialek 2022; Ciotti 2020). These numbers have only continued to increase as the years have passed; as of July 2023, Covid-19 has infected over 750 million people and killed almost 7 million worldwide according to the world health organization (*World Health Organization, 2020*).

As soon as it became apparent that Covid-19 was a significant problem, creating a test and infrastructure for distribution became a priority (Benda, et, al. 2021). Creating a testing infrastructure is important for three main reasons. First, testing is necessary to keep the general population and public healthcare workers informed; this allows for successful and effective isolation and quarantine orders. Second, testing alerts public health authorities of local COVID-19 infection rates. Third, testing informs healthcare providers of the patient's COVID-19 status so that appropriate treatment may be provided. However, access to testing was initially limited, and results were delayed with some not returning for close to a week.

Since the initial outbreak, new and improved testing methods have become available. There are presently two main ways to test for Covid-19: Nucleic-acid Amplification Tests (NAAT) and antigen tests. NAATs directly probe for the RNA of the virus gathered from the patient's throat or nasal passage using a swab. At the beginning of the pandemic, the CDC named the reverse transcription polymerase chain reaction (RT-PCR) test the “gold standard” for Covid-19 tests with 98-99% accuracy (Esbin, M. N. 2020). However, it is important to note that traditional RT-PCR testing requires a well-established laboratory, that is typically associated with a hospital, pharmacy or Urgent Care center. These labs require highly trained professionals to perform the testing. In addition, these RT-PCR tests take anywhere from 24-48 hours to return results (Zowawi, H. M et al., .2021).

The other type of testing, antigen, is highly available but depending on the methodology used, accuracy ranges from 80-98% (Homza, M et.al 2021) (Lopera, Alzate-Ángel, Díaz, Rugeles, & Aguilar-Jiménez, 2021). These tests also use swabs to detect viral particles. Antigen tests are less expensive and more rapid with results returning within as little as 10 minutes, but they are much less sensitive than NAATs, particularly early in the course of disease.

Although the specific details of each type of testing are not important in this study, it is important to know that NAATs are the best overall type of test, and that the best types of NAATs are found at testing facilities such as hospitals, Urgent Care Centers, pharmacies, and labs. Therefore, these facilities were the targets of this study.

Urgent Care centers were originally introduced in the 1980s as an alternative to primary healthcare physician visits, but were initially not utilized extensively (Yee, 2013). Over the years, especially as emergency departments have become increasingly overcrowded, Urgent Care centers have expanded and become more popular. Since 2020, Urgent Care centers have become

primary locations for Covid-19 testing. Even with the assistance of Urgent Care Centers and pharmacies, there was flooding of the emergency departments during the Covid-19 pandemic, with minor cases causing significant delays in more critical aspects of health care. It is apparent that there are problems with our current healthcare system, but it is less apparent what they are.

In 2021, McElfish et.al described perceived barriers to Covid-19 testing among patients including confusion regarding testing site locations, lack of accessible testing locations, concerns over the pain from nasal swabbing, and the time it takes to receive results. One of these perceived barriers, lack of testing locations, was investigated and was found to be true concerning SES. It was found that residences associated with a lower SES tend to have difficulty accessing Covid-19 testing. However, because there have been many developments since the beginning of Covid-19 and a dearth of reliable information, factors influencing testing disparities should be revisited. Specifically, this study seeks to explore the effects of SES, based on annual income, on testing availability to explore this factor of the healthcare system.

Purpose

To investigate whether people living in census tracts associated with lower socioeconomic status have limited accessibility to Covid-19 testing based on travel time.

Methodology

STUDY OVERVIEW

We will: 1) perform an observational study of publicly recorded data comparing Covid-19 testing availability across census tracts via the use of SES in two counties, Ulster and Saratoga 2) record all the testing locations in these counties and then compare the access to the

testing locations by travel time 3) select, by geographic distribution, 5 residences in each census tract sampled 4) calculate the transportation time, driving time (DT) and walking time (WT), from the 5 residences in each census tract to their nearest testing sites.

STUDY SAMPLE SELECTION

Due to the initial pilot nature of the study, it was limited to the analysis of two upstate counties of New York, Ulster County and Saratoga County (Table 1). These counties were chosen to represent different types of areas such as urban, suburban, and rural, as well as varying SES. To appropriately divide each county, we used census tracts. Each county is made up of census tracts, which all have an average income associated with them. This income will be used for all needed calculations. The census data is gathered from Justice Map, on income setting (justicemap.org).

Table 1:

Coordinates of Counties

County	Ulster	Saratoga
Location	41.8586° N, 74.3118° W	43.0324° N, 73.9360° W

In every census tract 5 residences were selected at random and located on Google Maps (<https://www.google.com/maps>). This was done by splitting the census tract into 4 quadrants and locating the center of each quadrant. Once this was done, the closest residence to the center of each quadrant and the center of the census tract was found and recorded. Once located on Google Maps, the nearest Covid-19 testing locations were compared to the location of the residences. To

find the closest testing location we began by searching for every testing location on Google Maps in that county and surrounding counties, verifying that they are currently open. The location was then saved on the map. This was then repeated until no new testing locations were found in any of the areas.

MEASUREMENTS

Each residence will have the DT and WT to the closest testing location recorded.

ANALYSIS

Once all the data from the residences have been collected and tabulated, we calculated, for each census tract, a mean travel DT and WT. We then compared, for each census tract, the mean travel time by walking and driving and saw if there was a correlation. The correlation determined by separating each of the census tracts into one of three groups based on average income, below average income, average income, and above average income (average is in reference to incomes present in this study not of a larger average i.e., state or nation average). Once this is done a comparison of the income ranges will be made to see if there is any statistical difference using a standard error of the mean calculation. Then a student's t-test to find the difference in the means (from the average income range). The student's t-test will be the primary analysis for this study due to its ability to directly compare different income groups against each other. We will use this test to compare the experimental groups, the above average and the below average income groups, to the control group, the average income group.

In addition to this we also made a scatter plot of all census tracts to determine if there was a significant r-squared value in a linear relationship.

Results

In this study there were a total of 71 census tracts examined throughout the two counties. 45 of those census tracts were in Ulster County (Appendix 1) and 26 were from Saratoga County (Appendix 2). When combined, 24 census tracts were in each of the below average and above average income groups with \$50,072.63 mean annual income (MAI) and \$85,475.21 MAI respectively with the remaining 23 being in the average range, \$67,696.04 MAI (Table 1).

The data from the three groups shows the below average income to have mean travel times of 6.66 minutes and 67.20 minutes for driving and walking respectively, for the average income group it was 11.36 minutes and 124.28 minutes and for the above average income the times were 10.02 minutes and 104.42 minutes (Table 1). The standard errors of the means were 1.26 and 16.42 for the below average income group, 1.64 and 22.41 for the average income group, and .83 and 12.09 for the above average group (Table 1, Table 2). The statistical ranges, with a range of two standard errors of the mean (SEM), were 3.64-8.72 and 34.36-100.04 for below average income, 8.08-14.64 and 79.46-169.10 for average income, and 8.36-11.68 and 80.24-128.60 for above average income (Table 1, Table 2).

The next part of the study was the scatter plot analysis. Breaking this into three separate parts, the first being the graphs from Saratoga County. In these graphs we found the r squared values to be .0028 for WTs and .0005 for DTs along with trend lines equations of $y = 0.0002x + 96.787$ and $y = 8E-06x + 9.7238$ (Graph 1, Graph 2). Next are the Ulster County graphs with r squared values of .0404 and .0246 with trendline equations of $y = 0.001x + 29.114$ and $y = 9E-05x + 2.7941$ (Graph 3, Graph 4). To finish, there are the graphs of all counties with r values of .0206 and .0301 with trend line equations of $y = 0.0008x + 46.842$ and $y = 7E-05x + 4.694$ (Graph 5, Graph 6)

The last part of the data analysis was the students t-test. When comparing the below average group to the average group we found that the difference between the means, in minutes, were 4.73 (0.5831 to 8.8769) and 57.08 (1.4639 to 112.6961). We also found that the above average income group had a difference of the means of 1.370 (-2.2847 to 5.0247) and 19.860 (-30.8425 to 70.5625) (Table 1, Table 2).

Table 1

Statistical data for DT

Income Range	Mean Income	Mean Travel Time in minutes (Statistical Range 2SEM)	Standard Deviation	Standard Error of the Mean	Difference in Means from Standard (Average) With 95% Confidence Intervals	Significance Level (P value)
Below Average	<\$60,446	6.66 (3.64-8.72)	6.19	1.27	4.73 (0.5831 to 8.8769)	.0263
Average	\$60,446-\$75,399	11.39 (8.08-14.64)	7.86	1.64	N/A	1
Above Average	>\$75,399	10.02 (8.36-11.68)	4.07	0.83	1.370 (-2.2847 to 5.0247)	.4542

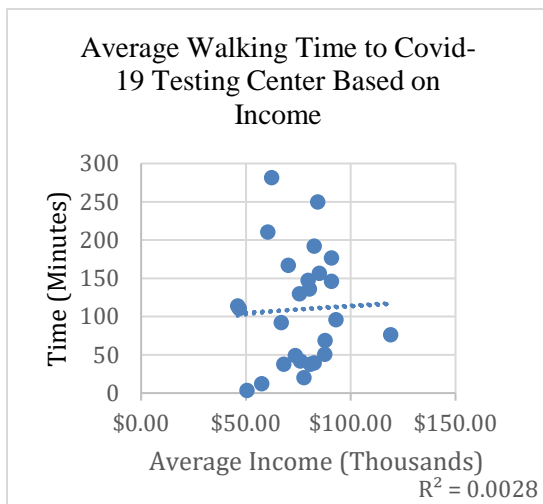
Table 2

Statistical data for WT

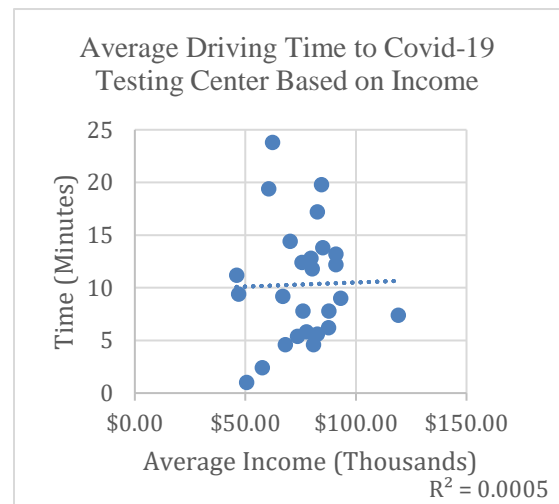
Income Range	Mean Income	Mean Travel Time in minutes (Statistical Range 2SEM)	Standard Deviation	Standard Error of the Mean	Difference in Means from Standard (Average) With 95% Confidence Intervals	Significance Level (P value)
Below Average	<\$60,446	67.20 (34.36-100.04)	80.42	16.42	57.08 (1.4639 to 112.6961)	.0445
Average	\$60,446-\$75,399	124.28 (79.46-169.10)	107.50	22.41	N/A	1
Above Average	>\$75,399	104.42 (80.24-128.60)	59.23	12.09	19.860 (-30.8425 to 70.5625)	.4343

Saratoga County Graphs

Graph 1

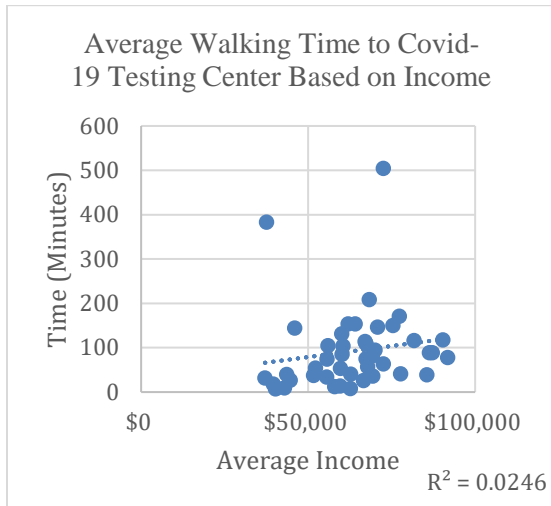


Graph 2

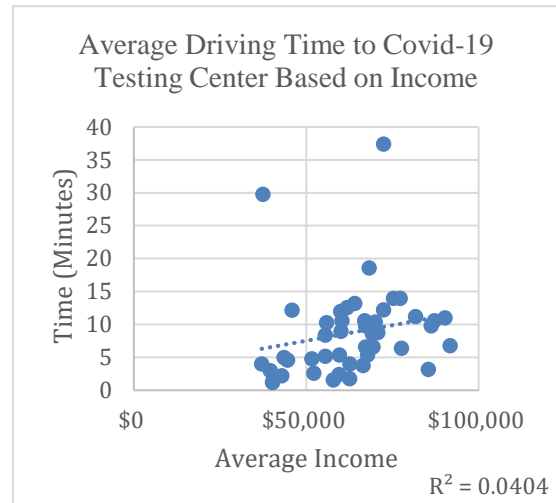


Ulster County Graphs

Graph 3

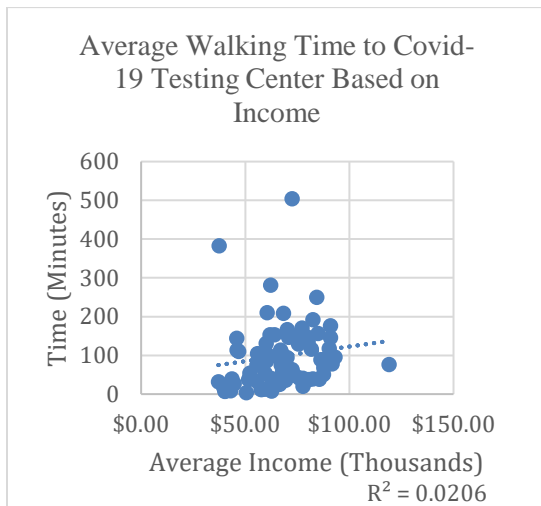


Graph 4

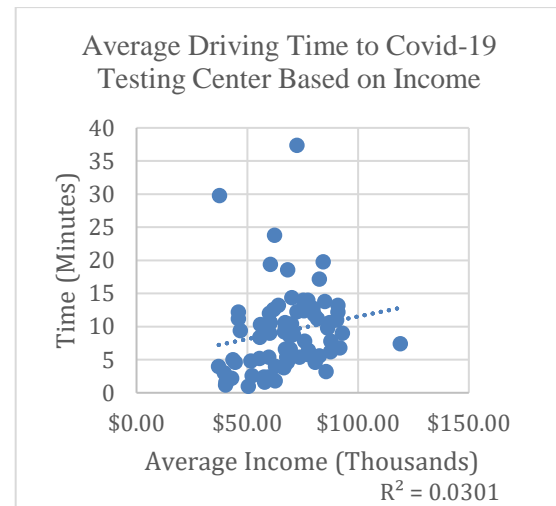


Saratoga and Ulster Graphs

Graph 5



Graph 6



Discussion/Conclusion

The purpose of this study was to see if there is a correlation between SES and availability of Covid-19 testing based on travel times. When conducting this study, the hypothesis was that people living in census tract associated with a lower SES would have less access to Covid-19 testing. Although some of the data analysis displays different levels of confidence, our primary data analysis disproved our hypothesis. Our data suggests that there is a negative correlation between SES and availability of Covid-19 testing. In other words, census tracts with a lower SES appear more likely to have a higher availability of Covid-19 testing than census tracts with higher SES.

Before discussing the data, however, there is the matter of DT versus WT. The first reason we decided to record and analysis both DT and WT was to provide a way of checking our work by comparing against a second set of data. The second purpose of having both DT and WT was to examine if there would be an inequality for people that don't have cars. In each of the three income ranges it came out to be that the WT were at least 10 times those of the DT. This is significant when considering that, as of 2016, the percentage of people below the poverty line without access to a personal vehicle was 19.96% (*IPUMS (integrated public use microdata series) 2018*). This suggests that a significant number of people in the below average income group of this study would have to walk over an hour, while possibly sick, to acquire Covid-19 testing. However, the below average income group also had the lowest mean travel time to testing locations, and because of this the implications are not as significant as they could have been if this wasn't the case.

The first part of the data analysis was a generic standard deviation and SEM comparison. For this part of the study, we found the means (2 SEM), in minutes, to be 6.66 (3.64-8.72) and 67.20 (34.36-100.04) for the below average income, 11.39 (8.08-14.64) and 124.28 (79.46-169.10) for the average income, and 10.02 (8.36-11.68) and 104.42 (80.24-128.60) for the above average income (Tables 1-2). In this analysis all three groups were seen to have overlapped with each other within the 95% confidence interval, suggesting no significant difference between the three groups. However, this is not the primary data examination.

The next part of the data analysis was the graphs. Overall, the graphs present the data for the study in a way that allow us to visualize the trends associated with the data. The important thing about the graphs and the r squared values associated with them is that they all have a positive correlation. However, the r squared values are very close to zero meaning that the analysis of the graphs offers no statistically significant information to the study.

The last, and most important, part of the data analysis was the student's t-test. The students' t-test suggested that there was a statistically significant difference when comparing the below average income group. When comparing the below average group to the average group we found that the differences between the means, in minutes, were 4.73 (0.5831 to 8.8769) and 57.08 (1.4639 to 112.6961). We also found that the above average income group had an insignificant difference in comparison to the average group with a difference of the means of 1.370 (-2.2847 to 5.0247) and 19.860 (-30.8425 to 70.5625). We hypothesized that the above average income group would have a very similar to slightly higher average travel time when compared to the control, and this was exactly what we found. We expected this because business, especially Urgent Care Centers, would try to cater their services towards where the most money is. However, the part that was very surprising was that the below average income group had by

far the lowest mean travel time. As a matter of fact, we hypothesized exactly the opposite. We think that this could be explained by the area that we used for the study.

One of the two counties, Ulster, is mostly a rural area. When conducting the study, it was noticed that most of the census tracts that had lower SES were located very close to small cities or towns. This is also where most of the testing locations were located. Another important thing that may have had an influence on data was that in rural areas, wealthier people tend to be located in more remote locations. This would have driven the travel time for the above average group up. However, this doesn't explain the average income group. The average income group was very close to the above average income in terms of travel time.

The most important development from this study is that it appears that perceived disparity, that is SES in relation to Covid-19 testing availability, is not prevalent. However, this is not the end of this field of study. In the study written by McElfish et.al where he identified these perceived disparities, lack of availability for Covid-19 testing was only one of the four most commonly perceived barriers to Covid-19 testing. Now that this has been investigated it creates many more questions. Most of all being, how does this study apply to other areas. Unfortunately, due to the high amount of work required for the study only a relatively small area was able to be canvased. However, this suggests that there are at least some areas that have adequate testing networks set up. This means that when another endemic occurs it won't be our locational infrastructure that will need to be looked at for more effective testing. Knowing this, we should be able to more effectively distribute our resources and combat the virus more efficiently.

References

- Benda, A., Zerajic, L., Ankita, A., Cleary, E., Park, Y., & Pandey, S. (2021). COVID-19 Testing and Diagnostics: A Review of Commercialized Technologies for Cost, Convenience and Quality of Tests. *Sensors*, 21(19), 6581. <https://doi.org/10.3390/s21196581>
- Bialek, S (2022, August 12). *Estimated covid-19 burden*. Centers for Disease Control and Prevention. Retrieved September 21, 2022, from <https://www.cdc.gov/coronavirus/2019-ncov/cases-updates/burden.html>
- Ciotti, M. (2020). The COVID-19 pandemic. *Critical Reviews in Clinical Laboratory Sciences*, 47(1), 1–4. <https://doi.org/10.1080/10408363.2020.1783198>
- Esbin, M. N., Whitney, O. N., Chong, S., Maurer, A., Darzacq, X., & Tjian, R. (2020). Overcoming the bottleneck to widespread testing: a rapid review of nucleic acid testing approaches for COVID-19 detection. *RNA (New York, N.Y.)*, 26(7) 771–783. <https://doi.org/10.1261/rna.076232.120>
- Hemmer, C., C. J., Löbermann, M., & Reisinger, E. C. (2021). COVID-19: Epidemiologie und Mutationen : Ein Update [COVID-19: epidemiology and mutations : An update]. *Der Radiologe*, 61(10), 880–887. <https://doi.org/10.1007/s00117-021-00909-0>
- Homza, M., Zelena, H., Janosek, J., Tomaskova, H., Jezo, E., Kloudova, A., . . . Prymula, R. (2021). Covid-19 antigen testing: Better than we know? A test accuracy study. *Infectious Diseases*, 53(9), 661–668. doi:10.1080/23744235.2021.1914857

IPUMS (integrated public use microdata series). (2018). *Encyclopedia of the U.S. Census*.

<https://doi.org/10.4135/9781452225272.n94>

Justice Map: Visualize race and income data in your community. (n.d.). Retrieved

October 30, 2022, from <http://www.justicemap.org/>

Lopera, T. J., Alzate-Ángel, J. C., Díaz, F. J., Rugeles, M. T., & Aguilar-Jiménez, W.

(2021). The usefulness of antigen testing in predicting contagiousness in

covid-19. doi:10.1101/2021.10.16.21265067

McElfish, P. A., Purvis, R., James, L. P., Willis, D. E., & Andersen, J. A. (2021).

Perceived Barriers to COVID-19 Testing. *International journal of environmental*

research and public health, 18(5), 2278. <https://doi.org/10.3390/ijerph18052278>

Pruthi, S. (2022, September 9). *Covid-19 diagnostic testing*. Mayo Clinic. Retrieved

October 13, 2022, from <https://www.mayoclinic.org>

World Health Organization. (2020). World Health Organization.

<https://covid19.who.int/?mapFilter=deaths>

Yee, Tracy. "The Surge in Urgent Care Centers: Emergency Department Alternative or

Costly Convenience?" *Health System Change*, 26 Nov. 2013.

Zowawi, H. M., Alenazi, T. H., AlOmair, W. S., Wazzan, A., Alsufayan, A., Hasanain,

R. A., Aldibasi, O. S., Althawadi, S., Altamimi, S. A., Mutabagani, M., Alamri,

M., Almaghrabi, R. S., Al-Abdely, H. M., Memish, Z. A., & Alqahtani, S.

A.(2021). Portable RT-PCR System: a Rapid and Scalable Diagnostic Tool for

COVID-19 Testing. *Journal of clinical microbiology*, 59(5),
e03004-20.<https://doi.org/10.1128/JCM.03004-20>