Analyzing Temporal and Spatial Changes in 311 Noise Complaints During the COVID-19 Pandemic in New York City

Elizabeth Walker
Columbia University
ejw2173@columbia.edu

***Abstract*— During the first months of the COVID-19 pandemic, New York City residents experienced a fundamental shift in their daily lives, including changes to their sonic environments due to stay-at-home orders. This paper studies how 311 noise complaints shifted during the spring of 2020 in New York City compared to previous years. First, I analyze the changes in the frequency and types of noise complaints that occurred across time. Next, I examine the relationship between median income and the change in noise complaints between the spring and summer of 2019 and the spring and summer of 2020. Using these methods, I identified a significant increase in 311 noise complaint calls during the first three months of the pandemic compared to the same period in 2019. Additionally, I observed significant increases in residential, vehicle, and street/sidewalk noises along with a significant decrease in commercial noise from the 2019 period to the 2020 period. Finally, I identified a statistically significant relationship between a zip code's median income and its percentage change in noise complaints during the first six months of the pandemic. These significant findings present a strong argument for the need for noise annoyance interventions across New York City, particularly in low-income communities.**

I. Introduction

New York City has been one of the cities in America that was hardest-hit by the COVID-19 pandemic. Since the pandemic began, at least 1 in 185 city residents have died of COVID-19 as of April 27, 2023 [1]. In March and April of 2020, the city especially faced periods of high stress with the virus reaching an exponential growth rate and field hospitals being set up citywide. Subway ridership plummeted as many residents left in-person work to spend their days on Zoom screens inside small city apartments—at least, those who didn't leave the city. During the period of stay-at-home orders, residents became increasingly exposed to noise around their residence that they might have otherwise avoided during the day, such as a neighbor's television or a car alarm outdoors. If such noise became repetitive or excessive, many residents took to calling the 311 call center, a nonemergency service line created to obtain resident complaint information in New York City. By analyzing the patterns of these noise complaints compared to previous years, valuable information may be gained surrounding the communities most likely to experience noise annoyance and how best to mitigate noise issues which greatly affect quality of life in urban environments. My goal is to analyze the changes in 311 noise complaint type and frequency during the first three to six months of COVID-19 in New York City. In this study, I will be investigating temporal and spatial changes in 311 noise complaints between the periods March 1 to May 31 2019 and March 1 to May 31 2020, and March 1 to August 31, 2019 and March 1 to August 31, 2020. I sourced my 311 noise complaints from an online dataset created by NYC Open Data, entitled "311 Service Requests from 2010 to Present" [2].

The current research assesses the following overarching question: how did the lifestyle changes and stressors introduced by the pandemic influence the frequency and types of 311 noise complaints across New York City? The first proposed hypothesis is that NYC's 311 Call Center received more daily noise complaints in the first three months of the pandemic than the Call Center received in the same three month period during 2019. In addition to an increase in overall noise complaints, we expect to see changes in specific types of noise complaints. The second proposed hypothesis is that NYC's 311 Call Center received fewer daily noise complaints about commercial, vehicle, and street/sidewalk noise in the first three months of the pandemic compared to the same three-month period in 2019. The third proposed hypothesis is that NYC's 311 Call Center received more daily residential noise complaints in the first three months of the pandemic compared to the same three-month period in 2019. Finally, the fourth hypothesis is that there is a relationship between a zip code's median income and its percentage change in overall noise complaints from the six-month 2019 period to the six-month 2020 period.

For this paper, the three-month 2020 period is operationally defined as the period from March 1, 2020 12:00 AM to May 31, 2020 11:59 PM. Meanwhile, the three-month 2019 period is operationally defined as the period from March 1, 2019 12:00 AM to May 31, 2019 11:59 PM. The six-month 2020 period is operationally defined as the period from March 1, 2020 12:00 AM to August 31, 2020 11:59 PM. Meanwhile, the six-month 2019 period is operationally defined as the period from March 1, 2019 12:00 AM to August 31, 2019 11:59 PM. Finally, I operationally define a zip code's median income by its median household income from the American Community Survey 2021 5-year estimates.

II. Related Work

The 311 non-emergency call system was initially built around the country to relieve the congestion in the 911 emergency system from non-emergency calls—issues raised in calls can range from residential noise to plumbing problems. Beyond revealing information about the issues present in a community, 311 data can indicate how a community functions. For instance, 311 calls for interpersonal problems such as noise are a sign that residents in the community are unwilling or unable to resolve local problems themselves. Studying 311 datasets has a range of advantages and disadvantages. Importantly, 311 datasets are typically made widely available and contain high levels of detail. However, 311 callers are not evenly distributed across all zip codes. Typically, certain zip codes and demographics are less likely to utilize the service. For instance, a study of 311 calls over social distance violations in the early pandemic demonstrated that Black and Hispanic communities would be less likely to call in these violations [3]. Additionally, the task of analyzing call volumes is complicated by the ability to call 311 multiple times, resulting in multiple explanations of high call volumes in an area. Interpretations may range from high levels of civic participation to several problems requiring immediate government attention to the presence of overactive users who dominate the local calls in a zip code to some combination of these factors [4]. Finally, while these calls provide geolocation, information about the caller's identity is not available.

From past research, it appears that 311 usage increased during the beginning of the pandemic. A previous study found that the NYC 311 call center received 17 percent more calls between March 28th and September 5th, 2020 than during the same period in 2019 [3]. In terms of noise complaints specifically, London saw significant increases in noise complaints from construction and neighbors; however, housing and demographic factors played a more significant role than actual exposure to road and rail traffic noise [5]. Due to this increase in complaints, city councils in the UK had to release guidance on coping with noise annoyance, demonstrating the distress this noise signified for its residents. Another study conducted in London found that survey respondents perceived a decrease in outside noise but an increase in noise from neighbors such as talking or playing music, resulting in increases in annoyance ratings [6]. However, noise complaints were not evenly dispersed across communities—rather, many cities experience socioeconomically disparate increases in noise complaints. For instance, a New York City study found that census tracts with higher proportions of low-income residents made more monthly noise complaints, particularly in warmer months of the year [7].

These patterns were only exacerbated during the pandemic with the lowest-income quartile of census tracts experiencing a 103 percent increase in noise complaints in July from 2019 to 2020, compared to a mere 29 percent increase in July noise complaints from 2010 to 2019. Determining influencing factors for residential noise increases is crucial, particularly when considering the mental health detriments of noise annoyance. Past studies have confirmed that noise annoyance during the COVID-19 pandemic was positively correlated with stress and anxiety levels [8]. In order to best approach this social issue, it is crucial to observe and understand the patterns of noise complaints in cities. Due to the pandemic's exacerbation of this issue, the data surrounding 311 noise complaints is an excellent place to analyze temporal and spatial trends of noise complaint changes in the contemporary city.

III. Methodology

A. Sourcing Data

To access noise complaint data, I used the "311 Service Requests from 2010 to Present" dataset available from NYC Open Data. The full dataset is approximately 18GB, so I filtered the set to select complaints whose Complaint Type contains the word "Noise," and are between dates 1 January 2018 and 31 December 2022. This five-year range gives us a large enough scope to analyze pre-pandemic, mid-pandemic, and post-pandemic trends. After filtering, I loaded the dataset into a Python3 notebook and dropped most columns from the dataset so that all that remained were "Created Date", "Closed Date", "Complaint Type", "Descriptor", "Incident Zip", "Borough", "Latitude", "Longitude", and "Location". Next, I removed any rows with N/A info. After performing this cleaning with the Pandas library, the data frame contained 3,165,366 rows and 9 columns.

B. Processing Temporal Data

Although the existing 311 dataset includes a vast amount of information, it required additional preprocessing in order to have the necessary information to test my hypotheses. First, I created a "Created Year" column by creating a function to split the "Created Date" string into a list and splice to find the year—I then set the value of "Created Year" for each row as the output of this function. I later repeated this process to develop "Created Month Year", "Created Day Month Year", "Created Hour", and "Created Day of Week" columns in order to better analyze temporal trends in the dataset. To give an example, if the "Created Date" value was "08/20/2019 04:08:54 PM", its "Created Year" value would be 2019, its "Created Month Year" value would be "08, 2019", its "Created Day Month Year" value would be "2019-08/20", its "Created Hour" value would be "16", and its "Created Day of Week" value would be "1" (corresponding with Tuesday in Python DateTime).

C. Processing Spatial Data

In addition to creating new columns to assess noise complaint patterns over time, I also was interested in analyzing spatial noise complaint patterns in New York City. The 311 dataset has a preexisting column to indicate

a caller's zip code, but because five-digit zip codes offer little information or context about a place, I chose to also link each complaint to a specific neighborhood or area of New York City. To accomplish this, I utilized United Hospital Fund codes, a document provided by the New York City government which assigns zip codes to neighborhood names [9]. Although these neighborhoods can be imprecise or missing zip codes, this seemed like an interesting opportunity to analyze changes in different neighborhoods during the pandemic.

In order to assign each noise complaint to a neighborhood, I wrote a for loop to loop through each UHF neighborhood's designated zip codes and assigned a neighborhood value based on the row's "Incident Zip" value. If the zip code of a given complaint did not match any zip code in the UHF document, the Neighborhood value was left blank for that row. Finally, my third hypothesis required analyzing the relationship between a zip code's median income and its percentage change in noise complaints during the first three months of the pandemic from the previous year. For each zip code on the UHF document, I found the median household income from Income by Zip Codes, a website that states that their income statistics are the most current ones available from the US Census Bureau [10]. These values were from the American Community Survey 2021 5-year estimates and are in 2021 inflation-adjusted dollars. I did not add these median household income values directly to my main dataframe, but rather saved it in a separate spreadsheet for later when I would test my third hypothesis.

D. Noise Complaint Aggregation

In order to analyze the changes in noise complaints during the three-month time period at the beginning of the pandemic, I aggregated noise complaints in order to determine the frequency of calls. After creating columns to identify calls by day made and month made, I created two new data frames—one to aggregate the number of calls made in a given month (ex: August 2019—5000) and one to aggregate the calls made on a given date (ex: August 20, 2019—250). Utilizing the first dataset, I was able to collect the number of 311 noise complaints on each day from March 1 to May 31 in both 2019 and 2020—these values will be used for testing my first and second set of hypotheses. Using the second dataset, I collected the number of 311 noise complaints in the time periods March 1 to May 31 2019 and the same time period in 2020 for each zip code in the UHF index codes. Next, I subtracted the number of the 2019 period calls from the number of the 2020 period calls and divided this value by the number of 2019 calls to calculate the percentage change from the 2019 period to the 2020 period (see Figure 1). These values will be used as the response variable when testing my final hypothesis.

$$\%\ Change\ in\ Noise\ Complaints = \frac{\#\ 2020\ Noise\ Complaints - \#\ 2019\ Noise\ Complaints}{\#\ 2019\ Noise\ Complaints}$$

Fig. 1. Formula to calculate percentage change from 2019 noise complaints to 2020 noise complaints.

IV. Results

A. Total Noise Complaint Call Analysis Results

To analyze the changes in all noise complaint calls between the pre-pandemic and pandemic periods, I conducted a paired t-test to determine if there was a significant difference in the mean number of 311 noise complaint calls per day between the March 1 to May 31, 2019 pre-pandemic period and the March 1 to May 31, 2020 pandemic period. I expected there to be a statistically significant increase in the number of daily 311 noise complaint calls during the first three months of the pandemic (March 1 to May 31, 2020) compared to the same March 1 to May 31 period in 2019.

To conduct this test in Python, I entered the number of calls for each day of each period into two arrays and used the T-Test Rel function in the Scipy Stats library to test these two sets for a statistically significant difference between the two time periods. A paired t-test was chosen for examining 311 noise complaints in the same region over two time periods because it is traditionally a significance test used to examine the difference between two variables for the same subject, often when separated by time. I found that this data had a p-value < 0.001, indicating that there was a statistically significant increase in the number of daily 311 noise complaints during the March 1 to May 31, 2020 period (M = 1675.23, SD = 843.41), compared to the same period in 2019 (M = 1348.18, SD = 644.73); t(91) = -3.539, p = 0.0006348 (see Figure 2).

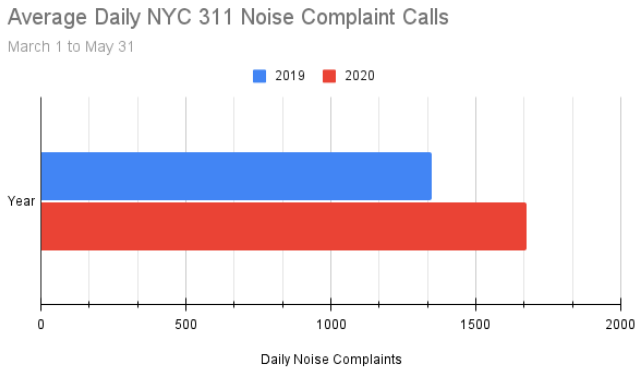

Fig. 2. Average Daily NYC 311 Noise Complaint Calls between March 1 and May 31, 2019 vs 2020.

B. Noise Complaint Call Analysis by Type Results

To analyze the results of noise complaint changes by type, I conducted paired t-tests on four different noise complaint types. I expected three of these noise complaint types ("Noise - Commercial", "Noise - Street/Sidewalk", and "Noise - Vehicle") to experience a statistically significant decrease in daily noise complaints in March 1 to May 31, 2020 compared to the same period in 2019. Meanwhile, I expected there to be a statistically significant increase of daily noise complaints with the type "Noise - Residential" in the 2020 period, compared to the 2019 period. For conducting these tests, I followed the same procedure in Python as above but this time, I ran each test on a dataframe that only contained noise complaints of the specific type for that test. For example, when testing "Noise - Residential" complaints, I aggregated noise complaints for each day of the period for rows where the "Complaint Type" was marked "Noise - Residential".

Upon completing a paired t-test for each of these four noise complaint types (see Figure 3), I found that three of my complaint types ("Noise - Residential", "Noise - Vehicle", "Noise - Street/Sidewalk") experienced a statistically significant increase in daily noise complaints from March 1 to May 31, 2019 to the same period in 2020. Of these three complaint types, I found two p-values $<$ 0.001 level ("Noise - Residential", "Noise-Street/Sidewalk") with the remaining p-value $<$ 0.05 ("Noise - Vehicle"). Meanwhile, only one of my complaint types ("Noise - Commercial") experienced a statistically significant decrease in daily noise complaints from the 2019 period to the 2020 period. For this test, I found a p-value $<$ 0.001.

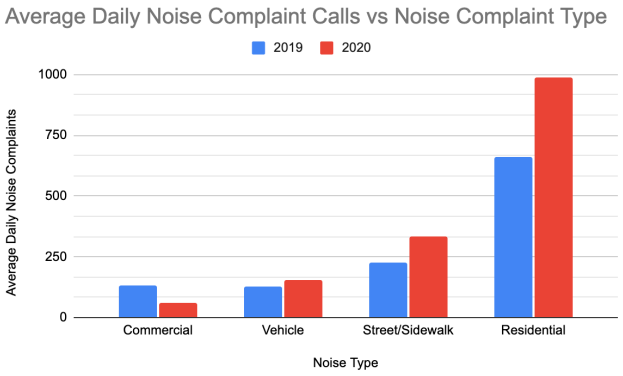

Fig. 3. Average Daily NYC 311 Noise Complaint Calls by Type between March 1 and May 31, 2019 vs 2020.

C. Income vs Percentage Change in Calls Linear Regression Results

Finally, I analyzed whether income levels in a given zip code affected the percentage of change in the amount of 311 noise complaints from the March 1 to August 31 2019 period versus the 2020 period. To determine this relationship between two continuous variables, I used linear regression using average zip code income (sourced earlier from Census data) as my independent variable and the percentage change in the number of noise complaints in that neighborhood between the two periods as my dependent variable. I chose to examine percentage change in noise complaints as a dependent variable in order to control for varying population amounts in different zip codes. First, I removed 10466's data from this test because I found it to be a statistical outlier that would negatively skew the results of this linear regression test—the percentage change in noise complaints for 10466 was more than 3 standard deviations from the mean. In Python, I used the Scipy linear regression model to test my hypothesis, setting my input variable as my list of incomes, and my response variable as my list of corresponding percentage changes in noise complaints between March 1 to August 31 in 2020 vs 2019. Next, I created a linear regression model and fitted it with my independent and dependent variable lists. When I fitted my model (see Figure 4), I found there was an R-squared value of 0.291, and I found that my linear regression model had an intercept of 108.591 and a slope of -0.0006825. Below is a graph of the relationship where the solid line is the regression model's predicted relationship between the independent and dependent variable.

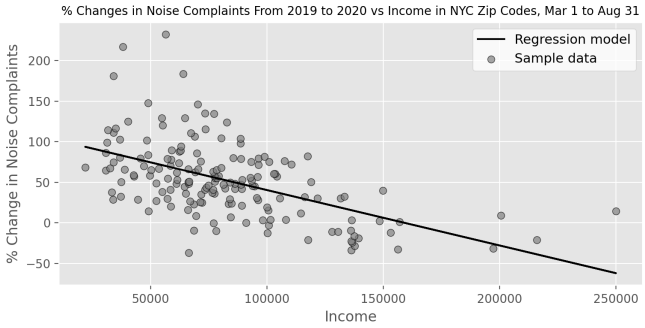

Fig. 4. Relationship Between Percentage Change in Noise Complaints from March 1 to August 31, 2019 versus 2020.

In order to analyze the significance of these results, I used the Python statsmodel API to perform ordinary least squares regression on these results. I found p-values that were statistically significant to the p $<$ 0.001 level for the constant and income variables. As a result, our linear regression model revealed a statistically significant relationship between a zip code's income and its corresponding change in 311 noise complaints from March 1 to August 31, 2019 to March 1 to August 31, 2020.

V. Discussion

A. Total Noise Complaint Call Analysis Discussion

The results of my total noise complaint call analysis showed agreement with my hypothesis regarding total noise complaints in the three-month 2019 period vs the three-month 2020 period. My statistically significant finding was that there was a significant increase in the mean number

of 311 noise complaint calls per day between the March 1 to May 31, 2019 pre-pandemic period and the March 1 to May 31, 2020 pandemic period. Therefore, I am able to reject the null hypothesis that there was no change in the mean number of daily 311 noise complaint calls from March 1 to May 31, 2019 to March 1 to May 31, 2020.

It is interesting to observe from Figure 5 that the number of monthly calls was roughly the same between March 2019 and March 2020, as well as between April 2019 and April 2020. The significant increase in calls over the March 1 to May 31 period from 2019 to 2020 instead derives from the sharp increase in calls from May 2019 to May 2020. One possible explanation for this increase in noise complaints during May may be residents' lives returning to normal as the first wave of the pandemic declined. Additionally, previous studies have shown an annual increase in noise complaints beginning in the warmer months of spring and summer. When I expanded the scope of the time period to six months (March 1 to August 31), I found that this sharp increase beginning in May continued through August, far exceeding the noise complaint frequencies of the previous year.

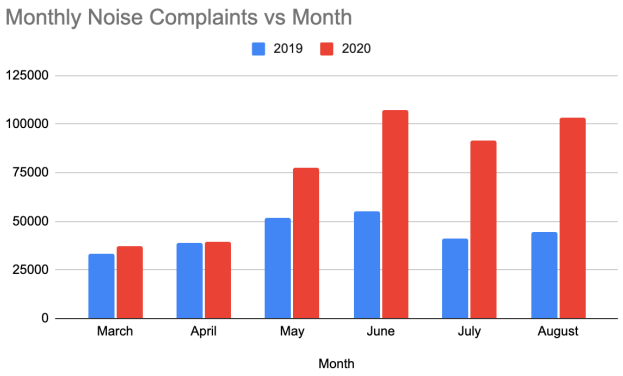

Fig. 5. Total Monthly NYC 311 Noise Complaint Calls for March, April, May, June, July, and August during 2019 vs 2020.

B. Noise Complaint Calls by Type Discussion

The results of my noise complaint calls by type analysis showed partial agreement with my hypotheses regarding changes in noise complaint type frequency in the 2019 period versus the 2020 period. However, while all of our findings in this category were statistically significant, not all of them agreed with the direction of my hypotheses. First, I found that there was a statistically significant decrease in the number of daily average 311 commercial noise complaints and a statistically significant increase in the number of daily average 311 residential noise complaints from the 2019 period to the 2020 period. These two statistically significant findings agreed with the direction of my hypotheses. Meanwhile, I also found statistically significant increases in the number of daily average 311 street/sidewalk noise complaints and in the number of daily average 311 vehicle noise complaints from the 2019 period to the 2020 period. Therefore, we were able to reject the null hypothesis that there would be no changes in daily average commercial, residential, street/sidewalk, and vehicle 311 noise complaints from March 1 to May 31, 2019 to March 1 to May 31, 2020. While I expected there to be a decrease in commercial noise and an increase in residential noise, my findings that there was an increase in street/sidewalk and vehicle noise were surprising to me. Due to the restrictions of New York's stay-at-home orders, I had expected there to be fewer incidents of noise originating from sources outside the home, such as street activity and vehicles. In order to better understand the source of this increase, I examined the breakdown of street/sidewalk (see Figure 6) and vehicle (see Figure 7) complaints by month. Both charts depict an increase in complaints from March 2019 to March 2020, a slight decrease in complaints from April 2019 to April 2020, and a sharp increase from May 2019 to May 2020.

One possible explanation for the number of street/sidewalk noise almost doubling from May 2019 to May 2020 is the implementation of the Open Streets program—a city project started in April 2020 to allocate public spaces, like streets and sidewalks, for physical activity and recreation instead of transportation [11]. A recently published study found that the Open Streets program may have been linked to an increase in street/sidewalk noise complaints in New York City [11]. As a result, this program could have been the cause of the sharp increase in street/sidewalk complaints. Another possible explanation is that as residents exited the lockdown stage of the pandemic, they were more likely to congregate outdoors than indoors due to concern about the contagious nature of COVID-19.

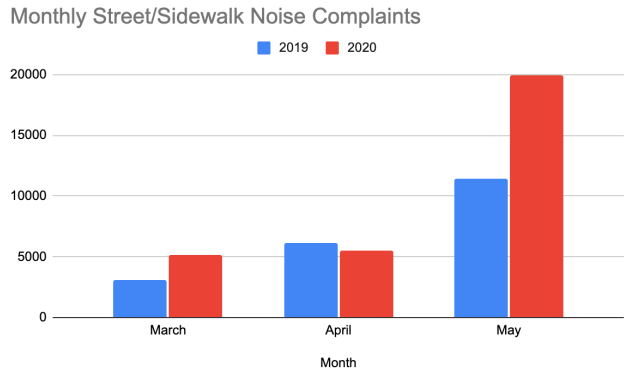

Fig. 6. Monthly NYC 311 Street/Sidewalk Noise Complaint Calls for March, April, and May during 2019 vs 2020.

By contrast, it is more difficult to find a direct explanation for the sharp increase in vehicle noise during the 2020 period. In order to better comprehend these changes, I chose

to analyze how the vehicle noise complaint description values changed from the 2019 period to the 2020 period.

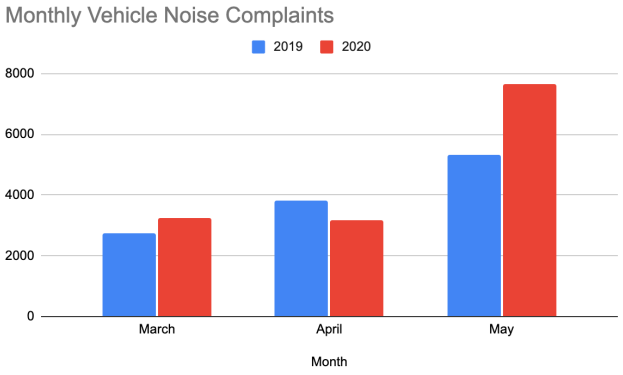

Fig. 7. Monthly NYC 311 Vehicle Noise Complaint Calls for March, April, and May during 2019 vs 2020.

As Figure 8 below depicts, there was a slight increase in complaints mentioning engines idling and a noticeable decrease in complaints mentioning car and truck horns. The lack of noticeable increase in these values may be explained by the reduction in vehicle traffic in New York City during the beginning of the COVID-19 pandemic. To contrast, noise complaints with the descriptor "Car/Truck Music" increased by more than 60 percent increase from the 2019 period to the 2020 period. I believe that this increase in such complaints from 2019 to 2020 is related to residents' increased annoyance in response to vehicle music. During the lockdown period, residents were forced to remain inside and had no agency to remove themselves from the noisy environment. As a result, they may have resorted to 311 noise complaint calls in order to resolve this issue.

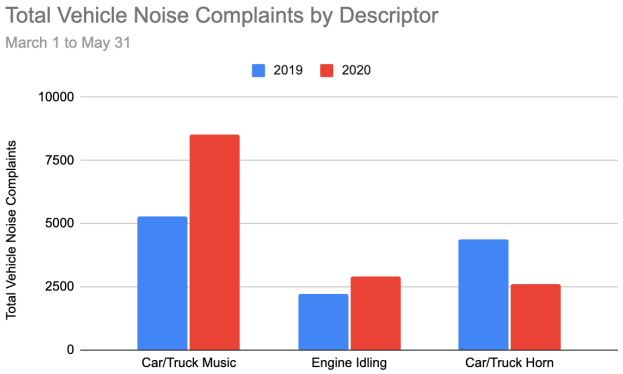

Fig. 8. Monthly NYC 311 Vehicle Noise Complaint Calls for March, April, and May during 2019 vs 2020.

C. Income vs Percentage Change in Calls Linear Regression Discussion

The results of my linear regression analysis showed agreement with my hypothesis regarding the relationship between income and the percentage change in noise complaints in a given zip code during the six-month 2019 period vs the six-month 2020 period. During my linear regression, I found that there was a statistically significant relationship between income and percentage change in noise complaints in a given zip code. This led me to reject my null hypothesis that there was no relationship between income and the percentage change in 311 noise complaints from the March 1 to August 31, 2019 period to the March 1 to August 31, 2020 period.

Because there is an inverse relationship between income and percentage change in noise complaints, as indicated by the negative slope in the linear regression, we can say that as a zip code's income decreases, its change in noise complaints from the six-month 2019 period to the six-month 2020 period increases. As I've previously mentioned, recent studies have shown that noise annoyance during the COVID-19 pandemic was positively correlated with stress and anxiety levels. As a result, this statistically significant relationship between income and change in noise complaints in the start of the pandemic suggests that there were corresponding mental health repercussions for low-income communities during the pandemic. Based on the link between income level and noise increases and the link between noise annoyance and stress, I believe that conducting additional research into noise annoyance prevention in low-income communities would be an interesting follow-up to mitigate the negative effects of excessive noise in urban environments.

VI. Conclusion and Future Work

In conclusion, my study yielded compelling statistically significant results that build upon pre-existing research of increased 311 noise complaints during the COVID-19 pandemic in urban environments. To begin, I identified a significant increase in overall noise complaint calls, residential noise complaint calls, vehicle noise complaint calls, street/sidewalk noise complaint calls made to NYC 311 Call Center from the three-month 2019 period to the three-month 2020 period. Next, I also found a statistically significant decrease in daily average commercial noise complaint calls. Finally, I discovered a statistically significant relationship between a zip code's median income and its percentage change in overall noise complaints. These significant differences between noise complaint frequency during the 2019 and 2020 three-month and six month periods present a strong argument for the increase in noise annoyance across New York City during the COVID-19 pandemic. Furthermore, the statistically significant findings regarding spatial distribution of noise complaints across zip codes provides important insight into the locations within New York City that are most likely to experience the highest levels of noise annoyance.

My various approaches to assessing 311 noise complaint changes in New York City led me to realize the breadth of future research opportunities possible. First, I believe that it would be interesting to further analyze the changes in noise complaint frequency by time of day and day of the week. I already have created some graphs for these changes that I included in the appendix, but it would be great to perform significance testing on these values. Additionally, I believe that my significant findings regarding changes in noise complaint frequency during the three-month and six-month periods of the pandemic deserves expansion into further territory, such as the remainder of 2020 and 2021. While I was able to briefly explore some of these changes in the appendix, it would be very interesting to analyze how noise complaints changed over multiple stages of the pandemic since this time period was far from uniform.

Finally, this paper identified some of the zip codes in New York City that experienced the largest increases in noise complaints during the spring and summer of the pandemic. As a result, I believe that developing noise annoyance mitigation techniques to target low-income areas of New York City, such as Washington Heights and the Northeast Bronx, will provide needed stress reduction to the area's residents. For instance, past studies have found that lower noise levels can be achieved in cities with a higher extent of green space coverage [12]. By further investigating noise prevention techniques like increased greenspace in future work, a practical approach to reducing noise annoyance in low-income communities can hopefully be assessed.

REFERENCES

[1] NewYorkTimes, "Tracking coronavirus in new york city, n.y.: Latest map and case count," 2023, https://www.nytimes.com/interactive/2021/us/new-york-city-new-york-covid-cases.html.

[2] NYCOpenData, "311 service requests from 2010 to present," NYC Open Data, Tech. Rep., 2023, https://www.data.cityofnewyork.us/Social-Services/311-Service-Requests-from-2010-to-Present/erm2-nwe9.

[3] J. Gibbons, J. Chanin, and T.-C. Yang, "Policing a Pandemic in New York City: How Do Community Features Matter in the Location of Social Distancing Violations?" *Social Problems*, 12 2021, spab075. [Online]. Available: https://doi.org/10.1093/socpro/spab075

[4] A. White and K.-S. Trump, "The promises and pitfalls of 311 data," *Urban Affairs Review*, vol. 54, no. 4, pp. 794–823, 2018. [Online]. Available: https://doi.org/10.1177/1078087416673202

[5] H. Tong, F. Aletta, A. Mitchell, T. Oberman, and J. Kang, "Increases in noise complaints during the covid-19 lockdown in spring 2020: A case study in greater london, uk," *Science of The Total Environment*, vol. 785, p. 147213, 2021. [Online]. Available: https://www.sciencedirect.com/science/article/pii/S0048969721022841

[6] P. J. Lee and J. H. Jeong, "Attitudes towards outdoor and neighbour noise during the covid-19 lockdown: A case study in london," *Sustainable Cities and Society*, vol. 67, p. 102768, 2021. [Online]. Available: https://www.sciencedirect.com/science/article/pii/S2210670721000603

[7] B. Ramphal, J. D. Dworkin, D. Pagliaccio, and A. E. Margolis, "Noise complaint patterns in new york city from january 2010 through february 2021: Socioeconomic disparities and covid-19 exacerbations," *Environmental Research*, vol. 206, p. 112254, 2022. [Online]. Available: https://www.sciencedirect.com/science/article/pii/S0013935121015553

[8] A. Şentop Dümen and K. Şaher, "Noise annoyance during COVID-19 lockdown: A research of public opinion before and during the pandemica)," *The Journal of the Acoustical Society of America*, vol. 148, no. 6, pp. 3489–3496, 12 2020. [Online]. Available: https://doi.org/10.1121/10.0002667

[9] UnitedHospitalFund, "United hospital fund codes and united hospital fund map by borough," 2004, https://www.nyc.gov/assets/doh/downloads/pdf/ah/zipcodetable.pdf.

[10] IncomeByZipCode, "Income statistics for new york zip codes," 2023, https://www.incomebyzipcode.com/newyork.

[11] J. Benavides, S. T. Rowland, V. Do, J. Goldsmith, and M.-A. Kioumourtzoglou, "Unintended impacts of the open streets program on noise complaints in new york city," *Environmental Research*, vol. 224, p. 115501, 2023. [Online]. Available: https://www.sciencedirect.com/science/article/pii/S0013935123002931

[12] E. Margaritis and J. Kang, "Relationship between green space-related morphology and noise pollution," *Ecological Indicators*, vol. 72, pp. 921–933, 2017. [Online]. Available: https://www.sciencedirect.com/science/article/pii/S1470160X16305635