Introduction

New York City (NYC) is one of the noisiest cities in the world. It has been estimated that 90% of adults in NYC are exposed to excessive noise levels. In the last year, NYC citizens have lodged more than 60,000 complaints with the city authorities regarding excessive noise in their precinct using the 311 service, a non-emergency call in municipal services facility provided by NYC government. These complaint numbers have been swelling over the years aggregating at about 3.4 million since 2003.

NYC enacted the Noise Control Code to reign in noise pollution in 1972. An amendment was added to make the code more exhaustive in 2005 which came to effect on July 1, 2007. The stipulations of the Noise Code which are aimed towards lowering noise pollution in the city must be abided by contractors, music venues, and other contributors. The Department of Environmental Protection (DEP) is tasked with enforcing the code.

NYC has an expansive geography populated with over 8 million residents and about 1 million buildings. Effectively responding to all the noise pollution complaints in the city is a demanding job, requiring long commutes which are made even more arduous by the fact that DEP has a team of only 50 officers. This team is also tasked with air quality inspections, further dividing the human resources available. As a result, only half of about 50,000 complaints received in the 2015 calendar year were inspected, with less than 20% of the inspections resulting in a ticket.

Why noise pollution is problematic?

Numerous medical studies have established that exposure to excessive noise is linked with adverse health effects. It has been associated with an increased risk of hypertension, coronary heart disease, psychological stress, annoyance, and sleep disturbance in adults. While for children, noise pollution exposure has been documented to induce cognitive impacts and psychological stress.

A noise exposure study published in BioMed Central by researchers from John Hopkins University, University of California (San Francisco) and University of Michigan measured noise levels at 99 street sites located throughout NYC, along with data on time, location, and sources of environmental noise, and found that the mean street noise level was 73.4 dBA, with substantial spatial variation (range 55.8-95.0 dBA). The US Environmental Protection Agency (EPA) has set a 24-hour (daily) exposure limit for the noise of 70 dBA, which indicates that an average New York City citizen is chronically exposed to above this daily limit of 70 dBA, believed to be sufficient to cause noise-induced hearing loss. Furthermore, studies have established that even below this level, unreasonable noise can lead to health problems.

Understandably DEP has labelled excessive noise as the number one quality of life issue for New York City residents and is working towards enforcing the ambitious Noise Code of the city.

NYC Noise Code

The Noise Code was created to reduce “the making, creation or maintenance of excessive and unreasonable and prohibited noises within the city affects and is a menace to public health, comfort, convenience, safety, welfare and the prosperity of the people of the city”. The code defines permissible noise levels from various activities based on time and location. It further outlines remedial measures and penalties for violation.

Challenge for CUSP

CUSP has been tasked with assisting DEP inspectors to optimize enforcement of the city’s Noise Code via efficient redistribution of current resources and identifying possibilities of tapping into new resource pools. Using the rich complaint data available from the 311 database and other data sets like building permit data, socioeconomic, demographic and weather data from NYC Open Data portal and the US census among others, CUSP aims to identify trends and patterns in the lodging of noise related complaints which may empower the DEP in their decision-making.

Given that there are multiple sources of noise in the city that exist independent of each other, but may or may not be sharing the same spatial-temporal proximity, the data analysis was carried by clubbing noise complaints based on the main source cited by the citizen. It is also understood that the complaints are highly subjective and can be highly influenced by an individual's perception of excessive noise, and are not necessarily reflective of statutorily defined noise control limits. Similarly, the absence of noise complaints is no indication of a quieter environment as it might be a reflection of nature of residential occupancy of the neighborhood; maybe there are no residents, or residents have a higher tolerance for noise, or may be residents are not aware of the 311 service facility. Keeping all these constraints in consideration the team at CUSP has proposed strategies not just to reduce the number of noise complaints in NYC, but to progressively make it a healthier city for its residents and visitors with reasonable noise levels.

Issues with Construction Noise

The DEP received 60,741 noise complaints from August 29, 2015, through to August 29, 2016. 66.8% (40,585) of such complaints were related to construction. NYC’s Open Data Department of Building (DOB) Permit Issuance and 311 Service Request datasets were used to conduct an analysis of neighborhood sensitivity to construction noise. We segmented the number of construction noise complaints and the number of DOB permits by zip code. Our analysis of each zip code’s sensitivity to construction sites can inform the DEP of how to best allocate resources and target enforcement efforts.

Construction sites were quantified with a count of the DOB’s work permits between August 29, 2015 and August 29, 2016. This is a viable metric to evaluate construction because DOB’s

catalog records work on buildings such as ‘Demolition and Removal (DM)’ and ‘Construction Equipment (EQ)’. 311 Noise Service Requests handled by the DEP were the quantifying metric for population sensitivity to noise. We chose to segment the relative sensitivity of noise by population zip code because both 311 Service Request data and DOB Permit Issuance data included such information. This resolution could then be compared to population data from the US Census.

After counting building permits and construction noise complaints in each NYC zip code, a noise sensitivity index was created. To create such an index, several assumptions were made about both datasets. As mentioned above, building permits were issued for a variety of tasks, however, for the scope of this project each permit was treated the same. We also assumed that if a building permit was issued, then work which contributed to noise pollution was conducted for each day the permit was active. We made assumptions about the 311 Service Request data as well. We assumed that 311 construction noise complaints were reported by individuals who live in the zip code that the complaint was lodged. The project did not account for temporal population changes.

The daily average rate of construction complaint per capita in NYC zip codes over the past year was almost zero. There was a wide range of daily complaints though, with zip codes 10128, 10016, 10019, and 11201 being the most sensitive to construction noise. Daily complaints in each of these regions was three or more.

The DEP can target enforcement efforts of construction noise pollution to the four above-referenced zip codes (10128, 10016, 10019, and 11201), which are most sensitive to noise. In these areas, the DEP can take preventive measures to ensure that proper noise protocols are followed. Buildings with work permits should be evaluated for compliance with noise mitigation plans and construction equipment should be examined for sufficient noise-reducing apparati. Longer-term efforts at the DEP can focus on treating groups of adjacent construction sites as a ‘cluster’ of noise with different noise pollution mitigation plans than those which regulate singular construction sites.

Economic Aspects

We compared the number of per capita complaints per census tract to the per capita income level of its inhabitants in order to identify a pattern between number of complaints and income tier (please refer to chart “Complaints per 1000 Residents by Income and Borough” above). This analysis reveals that areas with a higher income population register a higher volume of per capita noise complaints On average, with NYC residents with per capita incomes greater than $50,000 reporting nearly 7 times as many noise violations as NYC residents with per capita incomes under $50,000. Since we were not able to control for actual noise conditions, we further grouped residents by borough under the assumption that conditions within a borough are more similar than they may be citywide. While Staten Island and Queens registered a decline in complaints for incomes above $50,000, we believe this is due to a smaller number of

observations in those tiers which may uniquely lie in quieter areas. The initial analysis also suggests that income brackets up to $20,000 as well as the $30k to $40k tier (except in Manhattan) appear to have the lowest number of per capita noise complaints within the boroughs.

Understanding the economic patterns will help the DEP to assess whether the lower number of per capita noise complaints within the lower income brackets is due to underreporting (less calls) from residents even when dealing with the same hazardous noise conditions. DEP may consider installing sensors to objectively identify the degree of noise pollution in an area and perhaps identify underreporting in economically disadvantaged areas. Then this may be used to develop a model to develop a system of prioritization to ensure that lower income areas are being adequately serviced despite lower complaint levels. The information gathered from the sensors could be used to increase efficiency by grouping resources and actions according to reported and sensor-based noise levels. For the sensor-based noise intelligence DEP may consider awareness raising campaigns and lead with community-led actions for noise mitigation, such as community boards (s. section further below).

Issues with Dog Barking Noise

The DEP also received 7,945 dog barking complaints between June 1, 2015 and June 30, 2016. 311 Service Request data recorded the number of dog barking complaints and the National Oceanic and Atmospheric Administration's Open Data source cataloged maximum and minimum daily temperatures in NYC. A linear regression model determined there was a statistically significant correlation between the daily rate of dog barking complaints and the average daily NYC temperature on a seasonal cycle.

Two major trends were observed as a result of the statistical analysis. First, the average daily complaints of dog barking noise changed with temperature fluctuations between September 1, 2015 through June 30, 2016. Higher temperatures correlated with more dog barking complaints. The second major observation was the drastic dip in the average number of dog barking complaints for the summer months of 2015 as compared to summer daily temperatures and compared to average daily dog barking complaints. These trends can be seen in the plot of 'Dog Barking Noise Complaint vs Time' and are also visually depicted in a heat map. This information could be valuable for staffing purposes at the DEP. The agency can anticipate a lower demand for dog barking inspection during the summer months, and can increase its volume of inspectors in preparation for the spring.

One of the limitations of the analysis between dog barking complaints and weather is the time range of the data set. The analysis did not consider year over year changes, it is only a snapshot of the larger trends that exist over time. The analysis would be more robust if historical data was included.

Involving communities and business improvement districts (BIDs) :

Studying the heatmap of noise complaints by zip code it was observed that the neighbourhoods lodging most complaints are also the ones which co-exist or are adjacent to commercial setups. This general observation presents the opportunity to explore the possibility of enlisting the help of local community/business organizations to mobilize their own resources to address and solve the noise related issues.

Business improvement districts (BIDs) have been identified as one of the agents who can double up as 'noise controlling entities' by DEP. BIDs are defined areas within which businesses are required to pay an additional tax (or levy) in order to fund projects within the district's boundaries, including additional sanitation, maintenance and other services complimentary to city agencies. These services also include noise mitigation within the boundaries of their districts. There are currently 67 BIDs in NYC.

Since noise pollution levels are known to have negative impact on businesses and real estates, it is in the best interest of BIDs to invest in controlling noise within their precinct. To facilitate and encourage BIDs to take more aggressive measures, CUSP proposes a ranking matrix based on the number of noise complaints registered in each BID and its adjacent neighborhoods. This matrix will help fuel healthy competition between BIDs and hopefully will bring down noise levels over the course of time.

CUSP has tentatively created the ranking of BIDs based on noise complaints per zip code per business improvement district. This ranking matrix has certain limitations for the time being, like Staten Island BIDs, for example, will receive less noise complaints because of less population density. However, this can be improved upon as more data points become available in near future. It could be a useful tool to raise awareness among BIDs and encourage them to become healthier areas of noise-mitigated neighborhoods.

This system can be further strengthened by involving local community networks like community boards and block associations to act as watchdogs for their adjacent BIDs. Proactive community engagement could create social pressure along with enabling environment for BIDs to tackle noise mitigation within and around themselves. The DEP can create a Noise Mitigation Challenge by encouraging local community organizations tackle their noise mitigation from "bottom-up" (by creating local awareness campaigns, helping to increase the number of noise complaints) - this will help to lighten the burden on DEP inspectors.

Recommendations for the DEP

The Department of Environmental Protection is tasked with enforcing a variety of noise complaints across a vast geographic space with only 50 inspectors. Data-driven insights about noise complaint patterns across NYC inform the agency about how to best allocate its constrained resources.

To enforce dog barking complaints, the DEP can plan its staffing based on anticipated volume of such complaints over time. Based on a temporal analysis, the DEP should expect more dog barking complaints in the spring. Staffing plans can respond accordingly.

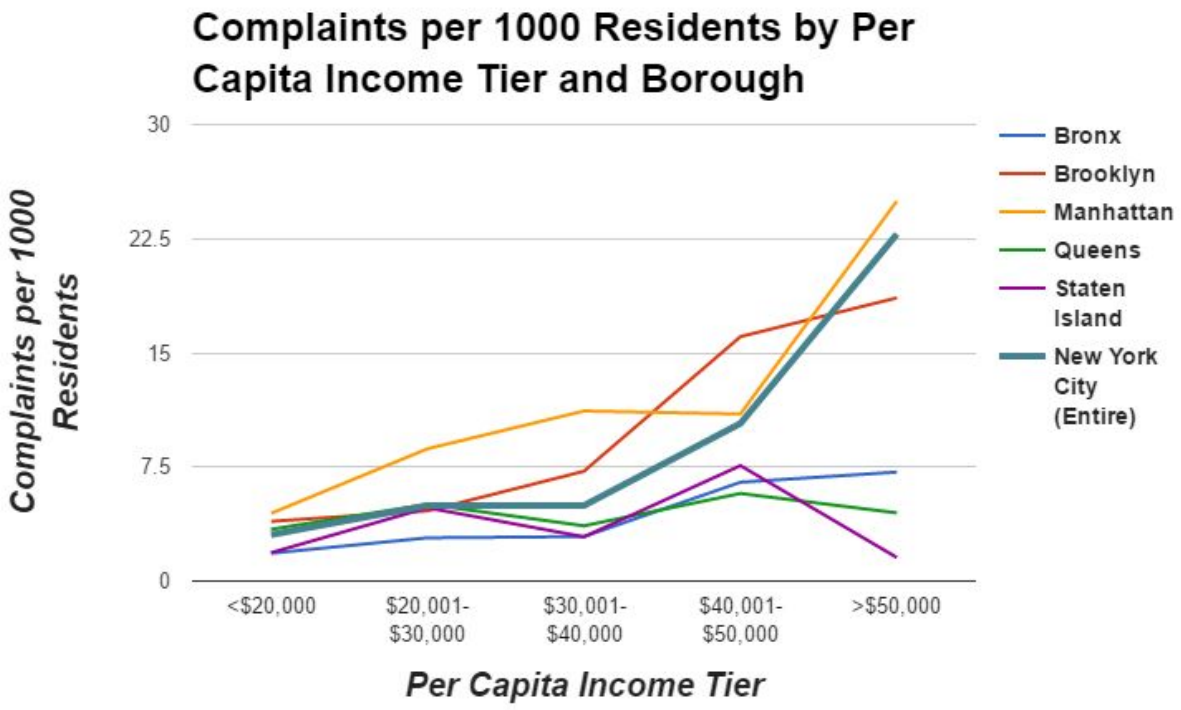
To address and ultimately reduce the number of construction related noise complaints in NYC, the DEP can work with those construction sites located inside zip codes, which are most sensitive to noise. Specifically, the DEP can conduct preventive construction site screenings to ensure that all noise mitigation policies are practiced.

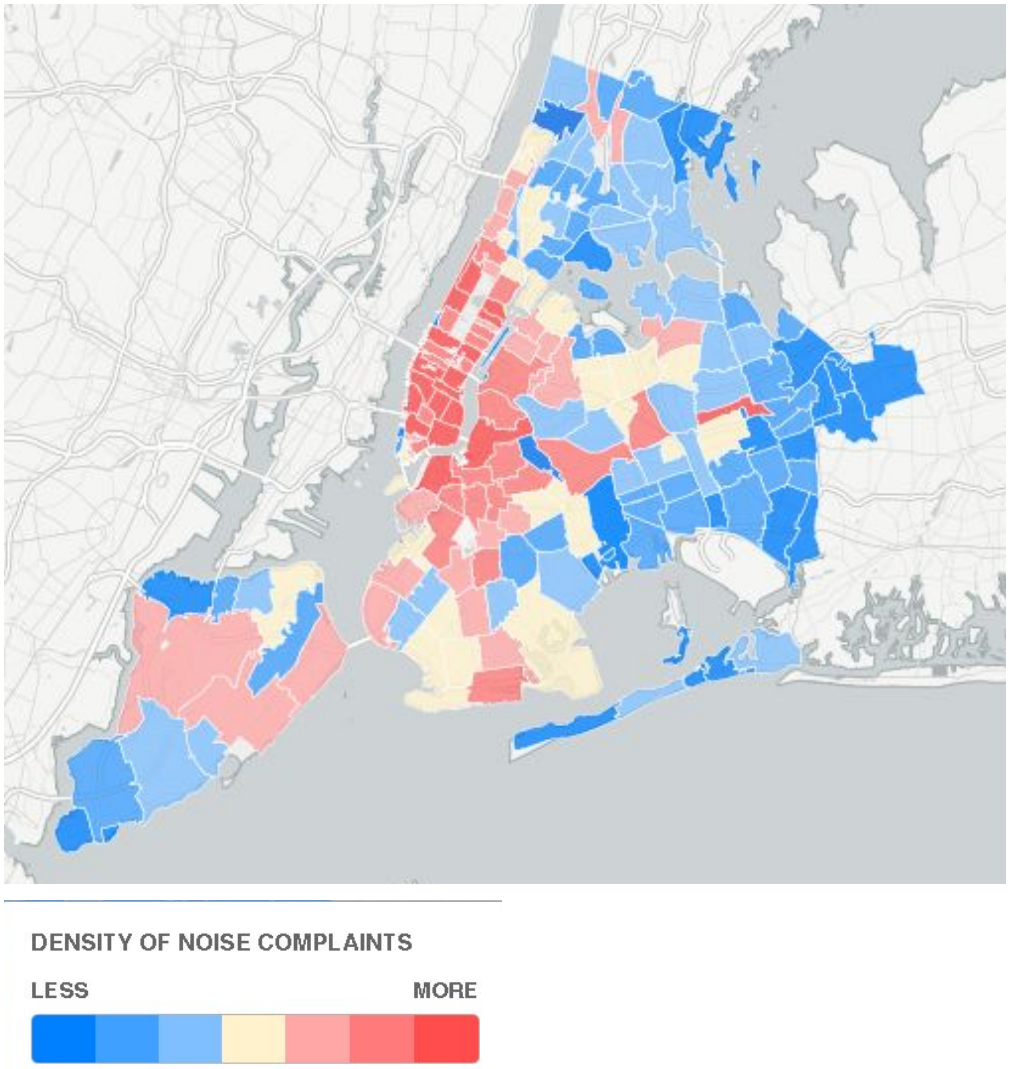
DEP can involve BIDs and local community organisations to augment their resources. DEP can increase compliance with the Noise Code by spreading awareness and leveraging the ranking matrix to have encourage self-improvement via healthy competition.

Datasets In Use

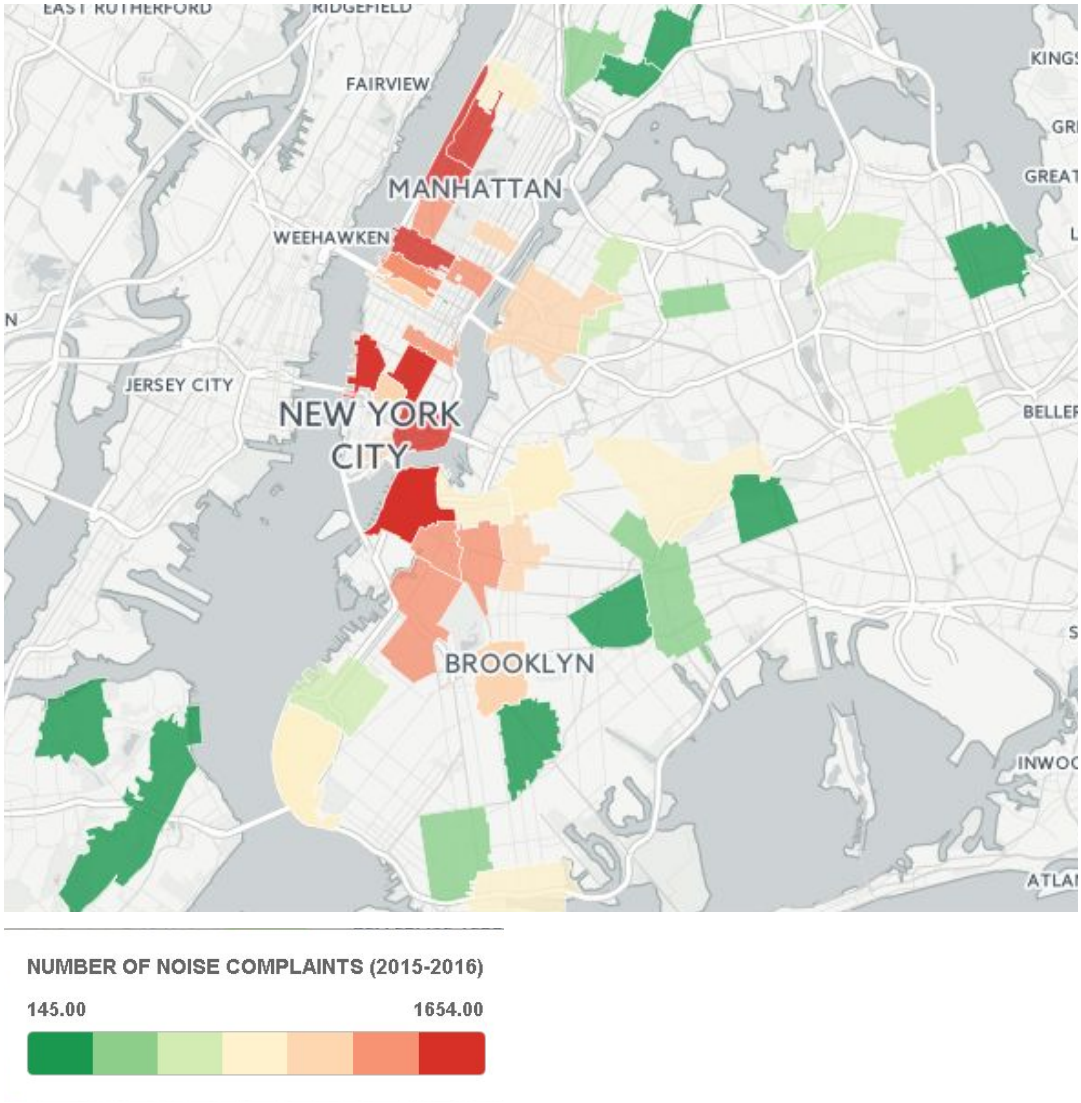
- US Census Data
- 311 Service Requests by DEP (filtered by “Noise”)
- NYC Open Data - Permit issuance
- National Oceanic and Atmospheric Administration’s Open Data
- NYC Open Data - Directory of business improvement districts

Graphs


Complaints per 1000 Residents by Per Capita Income Tier and Borough
Complaints per 1000 Residents
30
22.5
15
7.5
0
<$20,000
$20,001-$30,000
$30,001-$40,000
$40,001-$50,000
>$50,000
Per Capita Income Tier
Bronx
Brooklyn
Manhattan
Queens
Staten Island
New York City (Entire)



Noise Complaints by Zipcode (2015-2016)



Business improvement districts and noise complaints map (2015-2016)