# Rodents in the City: Exploring the Impact of Income on Sanitation and Restaurant Health Scores in New York

Seth Marcus

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***Dr. Ryan C. Sperry, Advisor***

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# Literature Review

## Introduction

Public health is a multidisciplinary field that focuses on promoting and protecting the health and well-being of communities and populations. It encompasses efforts to prevent diseases, prolong life, and improve the overall quality of life for individuals and societies (CDC Foundation 2023). Public health professionals work to identify health issues, assess risks, and develop strategies to address health challenges on a large scale (Satcher and Higginbotham 2008).

The scope of public health is broad and includes various areas such as disease prevention, health promotion, health education, environmental health, epidemiology, healthcare policy, and healthcare management (Detels and Tan 2012). Public health initiatives may involve vaccination programs, disease surveillance, sanitation and hygiene practices, health education campaigns, policy development, and advocacy for health equity (Centers for Disease Control and Prevention 2023 | Centers for Disease Control 2021).

Public health professionals collaborate with governments, non-governmental organizations, healthcare providers, and community stakeholders to implement evidence-based interventions and policies that protect and improve the health of populations (Rajabi, Aryankhesal, and Ebrahimi 2021). They work to identify health disparities and address the social determinants of health, which are the underlying factors influencing health outcomes, such as access to healthcare, education, housing, and economic opportunities (U.S. Department of Health and Human Services, n.d.)

Therefore it is important to study rodents and restaurants as they are major components of public health since they are directly linked to health risks and disease transmission. Rodents, such as rats, can carry and spread various infectious diseases such as salmonellosis (Himsworth

et al., 2013). Their presence in urban areas can lead to contaminated food, water, and living spaces, posing significant health hazards to the public. Restaurants also play a vital role in public health as they are responsible for food safety and hygiene. Improper handling, preparation, or storage of food can lead to foodborne illnesses, affecting a large number of people at once. Ensuring that restaurants comply with health and sanitation regulations is essential to prevent foodborne outbreaks and protect the health of patrons and the community. Public health authorities monitor and enforce proper rodent control and sanitation practices in restaurants to mitigate health risks. By addressing these issues, public health efforts aim to prevent the spread of diseases, maintain community health, and uphold high standards of public safety in both urban environments and food establishments.

Food poisoning is an important part of public health since every year, approximately 48 million Americans get sick from food poisoning with 128,000 of them being hospitalized, and 3,000 dying from foodborne illnesses, making food poisoning a real public health threat (Centers for Disease Control and Prevention, 2023). As Americans consume about a third of their calories from food not prepared at home (Lin & Guthrie, 2012), and spend a third of their food dollars on eating out services, restaurant food safety is increasingly important (U.S. Department of Agriculture, 2023). In New York City alone, its residents eat out nearly 1 billion times a year, or about every person once every 3 days (Lin & Guthrie, 2012, United States Census Bureau, n.d.). And even though most people who eat out do not get sick, Jones and Angulo (2006) discovered a correlation between the consumption of food prepared outside the home and an increase in the rise of sporadic food borne diseases.

The New York City Department of Health and Mental Hygiene (DOHMH) is charged with the responsibility of inspecting restaurants (including but not limited to bars, coffee shops, employee or university cafeterias, nightclubs, fixed site food stands, and bakeries). The manner in which the DOHMH does its inspections to measure the restaurant’s sanitary condition is by

using a scoring system where the lower the score the better the establishment is at adhering to food safety (Wong et al., 2015).

Restaurants are a major part of New York City with there being over 8,500 establishments in 2019 (Office of the New York State Comptroller, 2020). Given the frequency that New Yorkers eat out in addition to the health problems presented by eating out, it is of utmost importance that there are sanitary standards for the restaurants. Therefore there are federal guidelines that all jurisdictions have to implement in order to ensure a certain baseline health safety standard.

Before July 2010, these results were only posted online. However, this was not enough to notably make a difference for two main reasons. The first is that those who are the most vulnerable to foodborne illnesses, especially the elderly, are not likely to search online before entering a restaurant. The second reason is that only having the scores available online shifts information from ‘point-of-purchase’ (where the consumer may enter a restaurant), thereby limiting informed choice and a lacking transparency in the system’s key leverage point (Fleetwood, 2019). Therefore in July 2010 the DOHMH required restaurants to publicly display the letter grade in a visible window location that reflects the most recent health inspection conducted by the DOHMH. The letter grade is a function of the restaurant score. Scores in the range of 0-13 map to an A, scores in the range of 14-27 map to a B, and scores greater than or equal to 28 map to a C (NYC DOHMH, n.d.). The idea behind this policy change is that the consumer has easier access to inspection results, at the point of making a decision as to whether or not to eat at the location, encouraging restaurants to better comply with food safety rules and improve their sanitation thereby receiving a higher rating and thus hopefully attract more patronage. And this policy change appeared to have a significant impact since 88% of New York City respondents factored grades into their dining decisions (McKelvey et al., 2015), and

Salmonella cases decreased by 5.3% in New York City versus the rest of New York state from 2011 to 2015 (right after the adoption of the new policy) . The DOHMH collects this dataset to grade restaurants based on their health standards, which is intended for use by the average consumer to know, in part, the amount of rodent infestation and infestation occurrence in the specific establishment, knowledge which previous to this new program was unavailable to the average consumer.

Restaurants play an important role in the health of New Yorkers because of the frequency that they eat out and the health problems that come along with eating out. New York City therefore conducts inspections of restaurants in order to ensure that they maintain certain sanitary standards. In July 2010 New York City mandated that there be a public facing, easy to read letter grade to both inform diners about the sanitary condition of the restaurant and to incentive restaurants to perform better on these inspections, thereby improving the sanitary conditions of the establishment.

Rodents are a prominent feature of the urban setting. Rodents are also detrimental to society as they are a carrier of food borne diseases such as Salmonella. The more rats in an establishment, the higher the chance of contamination of food, leading to a higher rate of food-born illnesses related to rats. To help contain this threat, The New York City Department of Health and Mental Hygiene (DOHMH) does inspections of reported rodent sightings across the 5 boroughs.

New York City is piloting a containerization plan to cease the placing of garbage bags on curbs with a requirement for both businesses and residents to place their garbage bags into vermin proof containers. Some of the intended outcomes of the program include a more beautiful city, mechanized waste collection, improving the sanitation and public health of the city, as well as reducing the presence of vermin (New York City Department of Sanitation 2023). It is

therefore important to understand what factors currently impact the overall sanitation of New York City, how those factors how much, if any, impact they have on the sanitation, and create a baseline level of sanitation public health level in New York City before starting the program to then be able to do a pre/post test analysis later.

This analysis looks for a correlation between income, number of rodent sightings, and restaurant health score. It asks whether there exists a correlation between the mean income in a zip code and the number of reported rodent sightings in a zip code versus the mean restaurant health score for all restaurants in a zip code and in New York City. In terms of the correlation, this study did find evidence for a correlation between the number of reported rodent sightings and restaurant health scores in a zip code in New York City, albeit not a meaningful correlation. There are multiple limitations to this study including that zip codes are not an ideal measure for defining an area. Further analysis is required before being able to state a definitive answer.

This research is looking at what factors impact the overall public health in New York City. Since New York City residents eat out at such a high frequency, using restaurant health scores is a reasonable proxy for the overall sanitation and public health of the surrounding area. Therefore, the research question is are there factors outside of the New York City restaurant health grading rubric that impacts the restaurant health scores. Specifically, do restaurants in higher income neighborhoods have better restaurant scores due to higher expectations of the area. Additionally, do restaurants in neighborhoods with worse rodent issues have worse restaurant health scores as rats drive the sanitary conditions of an area. Looking at neighborhood health, income is something that comes up as impacting hygiene (strong correlation between income and health outcomes). The datasets that will be used are the New York City DOHMH datasets on reported rodent sightings, as well as their  restaurant inspection dataset. Additionally, this study will use income data provided by the United States Census Bureau.

The goal of public health is to create healthy communities where individuals can thrive and lead fulfilling and productive lives. By focusing on prevention, early detection, and intervention, public health efforts, such as New York City's restaurant grading and rodent sighting programs aim to reduce the burden of diseases and improve the overall well-being of New Yorkers. Public health plays a critical role in shaping health policies, guiding healthcare practices, and promoting health equity to achieve better health outcomes for everyone.

## Background

### *Rodents*

Rats have been reported as being prevalent in all areas, especially in densely populated urban areas such as New York City (Childs et al., 1998). In fact, New York City has been reported by Sullivan (2005) to be one of the cities with the largest rat populations in the United States. While several types of rats can be found in New York City, the most common rat found in New York City is the *Rattus norvegicus,* commonly known as the Norway rat, a burrowing species commonly found in subway and sewer systems (Clinton, 1969). These rats are known carriers of diseases, such as Salmonella enterica (Himsworth et al., 2013). These diseases are transmitted by foods, causing issues for those dining at establishments with rat infestations. One of the most notable diseases that rats can transmit is Salmonella, a bacteria that can spread through contaminated water (Walsh, 2014, *Salmonella Infection | Healthy Pets, Healthy People | CDC,* 2022). This is a major health concern since Salmonella represents one of the most common foodborne illnesses, with an average incidence rate of 12 cases per 100,000 a year in New York State (Walsh, 2014, *Salmonellosis - NYC*, 2015). Infection in humans is often through ingestion of foods contaminated with animal feces, such as rat droppings, or cross-contaminated by other sources. Salmonella isn't just a theoretical concern but rather a serious matter since there have been an estimated 100,000 annual antimicrobial-resistant infections caused by

Salmonella in the United States (Childs et al., 1998, Buckle & Smith, 2015). Therefore Salmonella is an issue that needs to be minimized in the restaurant setting, and given that rats are a significant transmitter of Salmonella it is important to know if there is a correlation between the number of rodents and restaurant health scores.

## *Restaurants*

One of the core functions of local health authorities is regular inspection of restaurants for food safety to promote public health, which is guided by the United States Food and Drug Administration (FDA) Food Code (U.S. Department of Health and Human Services, 2013). Even though the sanitation codes in all states are modeled after the FDA code, each state has its own implementation methods (Wong et al., 2015). In New York City, the DOHMH is charged with the responsibility of inspecting restaurants, bars, coffee shops, employee or university cafeterias, nightclubs, fixed site food stands, and bakeries (hereafter, restaurants). The manner in which the DOHMH does its inspections to measure the restaurant's compliance with the New York City Health code is by using a scoring system (where the lower the score the better the establishment is at adhering to food safety) which is updated regularly in order to maintain consistency with both the New York State Sanitary Code as well as the FDA Food Code (Wong et al., 2015). The DOHMH conducts approximately 24,000 restaurant inspections a year via unannounced visits to monitor compliance with both New York City and New York State food safety regulations (NYC DOHMH, 2012) and assigns a score based on how well it follows these standards. Official DOHMH inspectors check for "food handling, food temperature, personal hygiene, facility and equipment maintenance and vermin control. Each violation earns a certain number of points. At the end of the inspection, the inspector totals the points and this number is the restaurant's inspection score; the lower the score, the better" (NYC DOHMH, 2012).

## *Income*

The income of an area has a significant impact on the sanitation and public health conditions within that area, as supported by multiple studies. Research consistently demonstrates a correlation between higher household income and improved access to sanitation facilities such as in Ecuador where households in the top income quintile have a much higher likelihood of having access to private toilet facilities compared to those in the lowest quintile. The disparity is striking, with 43% of people in the lowest quintile reporting no access to any form of domestic sanitation, while this proportion drops to 16% in the highest quintile and reaches zero among the top percentile (Araujo et al. 2008). These findings highlight an income gradient where the wealthier households tend to enjoy better sanitation options.

In addition to access to sanitation, income levels also influence the overall health outcomes of households. Adams, Boateng, and Amoyaw emphasizes the role of rich households in producing better health outcomes, in part due to their ability to insure against health shocks and live in areas with improved sanitation (2016). The link between income and health is further supported by the observation that higher education levels, which are often associated with higher income, predict access to water quality and sanitation (Adams, Boateng, and Amoyaw 2016).

Disparities in access to sanitation stem from wider inequalities in income, power, and institutional capacity. Lower-income areas face challenges in accessing fresh water resources and implementing adequate sanitation infrastructure, resulting in inequitable access to water and sanitation services (Tiwari and Nayak 2013). These disparities highlight the need to address income inequality and strengthen institutional capacity to ensure that all communities, regardless of income level, have access to adequate sanitation facilities.

The income of an area plays a crucial role in determining the sanitation and public health conditions within that area. Higher household incomes are associated with improved access to

private toilet facilities and better overall sanitation options (Araujo et al. 2008). However, disparities persist, with lower-income areas experiencing greater challenges in accessing adequate sanitation services. Addressing income inequalities and strengthening institutional capacity are vital steps toward achieving equitable access to sanitation for all communities.

### *Education Data*

Education and literacy play a crucial role in determining the sanitation and public health conditions of an area. Various socio-economic and demographic factors, including education, have been identified as predictors of access to water quality and sanitation (Adams, Boateng, and Amoyaw 2016). Tiwari and Nayak's research in 2013 highlighted the significance of education and literacy rates in determining access to water and sanitation. Individuals with higher education levels are more likely to understand the consequences and costs associated with using unimproved drinking water sources and poor sanitation (Adams, Boateng, and Amoyaw 2016). This awareness can lead to a greater emphasis on adopting improved sanitation practices and seeking access to clean water sources. Therefore, promoting education and increasing literacy rates can contribute to improved sanitation and public health outcomes within communities.

## *Attitude Towards Sanitation*

Attitudes towards sanitation play a significant role in determining the cleanliness and hygiene of an area. Wang et al. (2018) found a correlation between residents' tolerance levels, poor sanitary conditions, and the presence of cockroaches. The study highlighted the importance of education in promoting proper sanitation practices, as a lack of awareness was linked to larger cockroach populations. Furthermore, Wang et al. revealed a positive association between kitchen and bathroom sanitation ratings and the absence of cockroaches, emphasizing the significance of maintaining a clean environment. Additionally, the study indicated that residents' tolerance of cockroaches was significantly associated with their presence, with individuals who expressed

greater concern about even a single cockroach having lower cockroach trap counts compared to those with higher tolerance levels. This suggests that positive attitudes towards sanitation, including a lower tolerance for pests, can contribute to improved sanitation outcomes. Further research by Abdulrasaq, Yakubu, and Adewale (2018) identified additional factors contributing to poor sanitation, such as poor attitudes and lack of concern for environmental issues, high levels of poverty, and misguided waste disposal practices. These findings underscore the importance of cultivating positive attitudes towards sanitation and environmental issues. Education and awareness programs can play a crucial role in fostering a culture of cleanliness and hygiene. By addressing these factors, communities can work towards improving their environmental sanitation and ultimately enhance public health outcomes.

## *Containerization*

Containerization involves storing waste in sealed, rodent-proof containers instead of plastic bags. Its purpose is to streamline waste collection, reduce the visibility of garbage in public areas, and relevant to this study, minimize the presence of vermin. Municipal containerization models, widely adopted in Europe, vary based on neighborhood density. Low-density areas typically use individual bins for each customer or waste generator, while higher-density neighborhoods utilize shared containers conveniently located near residential addresses. However, implementing containerization in New York City poses several challenges due to factors such as population density, weather conditions, curb space limitations, collection frequency, and the existing waste collection vehicle fleet (New York City Department of Sanitation 2023). Despite these challenges, viable solutions exist. It is crucial to implement an effective and practical solution, as the accumulation of massive trash piles has become a ubiquitous part of the New York City landscape. Navigating through 44 million pounds of daily trash (City of New York Department of Sanitation 2023) has become a norm for New Yorkers,

with bags left on curbs proliferating rat populations, creating unsightly trash mountains on sidewalks, and leaving behind soiled pathways even after collection. Implementing effective containerization solutions is imperative for addressing the sanitation challenges in New York City, as the accumulation of massive trash piles and the proliferation of rats have become pervasive issues.

# Methods

## Data

### *Restaurant*

This study uses the New York City DOHMH Restaurant Inspection Results dataset which contains every current violation citation from all program inspections conducted up to three years prior to the most recent inspection for restaurants in an active status. Each restaurant in New York City undergoes at least one unannounced inspection every year. The inspector assesses compliance with both city and state food safety regulations, assigning points for any violation of these rules during the inspection (New York City Department of Health and Mental Hygiene 2023). Given how much New Yorkers eat out, this is a competent proxy for the public health of an area. As of March 11, 2023 there were 208,225 inspections. Of these, 39,291 occurred in 2019 with all other inspections being removed from the dataset. The reason for this decision is that 2019 was the last full pre Covid-19 era year and this study wants to avoid any Covid-19 fallout from the study. Of the 39,291 inspections, 722 did not have a valid zip code and were removed from the sample leaving 38,569 inspections. Of the 38,569 inspections, 1,197 did not have a score associated with it. This can be for a variety of reasons, such as a data entry error or the score is still pending. These 1,197 inspections were removed from the sample leaving 37,399 inspections which is more than 95% of the total number of restaurant inspections that

occurred in 2019. These inspections were then grouped by their zip code with the average score of each restaurant taken by zip code, leaving a dataset with 206 observations having a zip code to average restaurant health score in that zip code association.

### *Rodent*

The New York City DOHMH maintains a dataset on rat inspections and intervention visits in New York City. This program is based on the idea that rodents rarely occupy a single property but rather they occupy entire blocks or larger areas. The DOHMH collects this dataset to inform community members of where there are likely to be more rodents so that they can take informed action based on this data to treat their rodent issues and thereby improve the public health of the area. The way a rodent inspection occurs is first a person has to observe a rodent, or rodent activity in a specific location. Then they have to file a complaint, whether online through the 311 portal or over the telephone. At this point the complaint is routed to the DOHMH who within approximately two weeks of receiving the complaint inspects the property, unless the property was recently inspected (in this case it is considered a duplicate complaint) (What Happens to Your 311 Rat Complaint?, 2021). When performing an inspection, an official DOHMH inspector searches for signs of rats or conditions that rats favor on the exterior of the property. Signs of rat activity include fresh gnaw marks, burrows (earthen or structural), tracks, fresh droppings, active rodent pathways, and live or dead rodents. Conditions that rodents favor include those that provide protection or shelter, such as clutter or overgrown vegetation and conditions that provide feed for rodents, such as exposed or uncontained garbage (What Happens to Your 311 Rat Complaint?, 2021, NYC DOHMH, n.d.). If the inspector does not find such signs or conditions, the property passes the inspection and as a result the 311 complaint is closed. If however the inspector does find signs of rats or conditions that rats favor during the inspection, then the property fails the inspection (What Happens to Your 311 Rat

Complaint?, 2021). The DOHMH does provide incentives for responsible parties to pass inspections, such as fines ranging from $300 to $2000 that the Office of Administrative Trials and Hearings (OATH) administers (What Happens to Your 311 Rat Complaint?, 2021). The purpose of collecting this dataset by the DOHMH is to provide community members with information about areas where rodent sightings are more likely. This empowers them to make informed decisions and take appropriate actions to address their rodent issues accordingly.

This study uses the New York City DOHMH Rodent Inspection dataset which contains information on both rat inspections and intervention visits in New York City. It is important to note about this dataset that if a location does not appear in the dataset does not indicate a lack of rodents, rather that it has not been inspected. Related to this is that an area with an increased number of active rodent sightings does not necessarily have a higher number of rodents, but rather that area has had more inspections. As of March 12, 2023 there were 2,327,279 reported rodent sightings in the dataset of which 248,357 occurred in 2019. Of these 248,357 reported rodent sightings, 1,673 had an invalid zip code and were removed from the sample, leaving 246,684 reported rodent sightings. Of these 246,684 reported rodent sightings, only 33,652 resulted in “Rat Activity.” This is not surprising as there are a variety of reasons for an inspection, including follow up, as well a tendency for people to enjoy complaining about anything to get attention. We therefore only included these reported rodent sightings that resulted in “Rat Activity” into our sample frame. These observations were then grouped by zip code resulting in 168 observations. It is worth noting that even though a zip code may not be included in this dataset, we can easily infer that it had zero reported rodent sightings resulting in “Rat Activity” for otherwise it would have been included in this dataset.

### *Income Data*

The income data from 2019 came from the United States Census Bureau and includes all zip codes for New York City where there is a non-zero population. Of the 223 New York City zip codes, 33 did not have a valid average income and were removed from the dataset leaving 190 observations. It is worth noting that there exist zip codes where there are restaurant(s) but have a zero population (such as JFK International Airport) as well as zip codes with a non-zero population but don't have any restaurants. This dataset was then merged with the restaurant dataset resulting in an average income per zip code to average restaurant inspection score by zip code association.

## Descriptive Statistics

The objective of this study is to determine whether or not there exists a correlation between average income per zip code and number of reported rodent sightings resulting in "Rat Activity" versus average restaurant health score by zip code in New York City. Given that the three metrics that will be used to measure these attributes are all continuous scales, we will use a scatter plot and a Pearson's r to test this question.

### *Income Dataset*

What is the distribution of mean incomes of zip codes in New York City? The mean income of zip codes in New York City is $135,672 with a standard deviation of $91,564 and a median of $103,872. Additionally the maximum average income in a zip code is $473,210 and the minimum average income in a zip code is $44,362. This distribution is illustrated below:

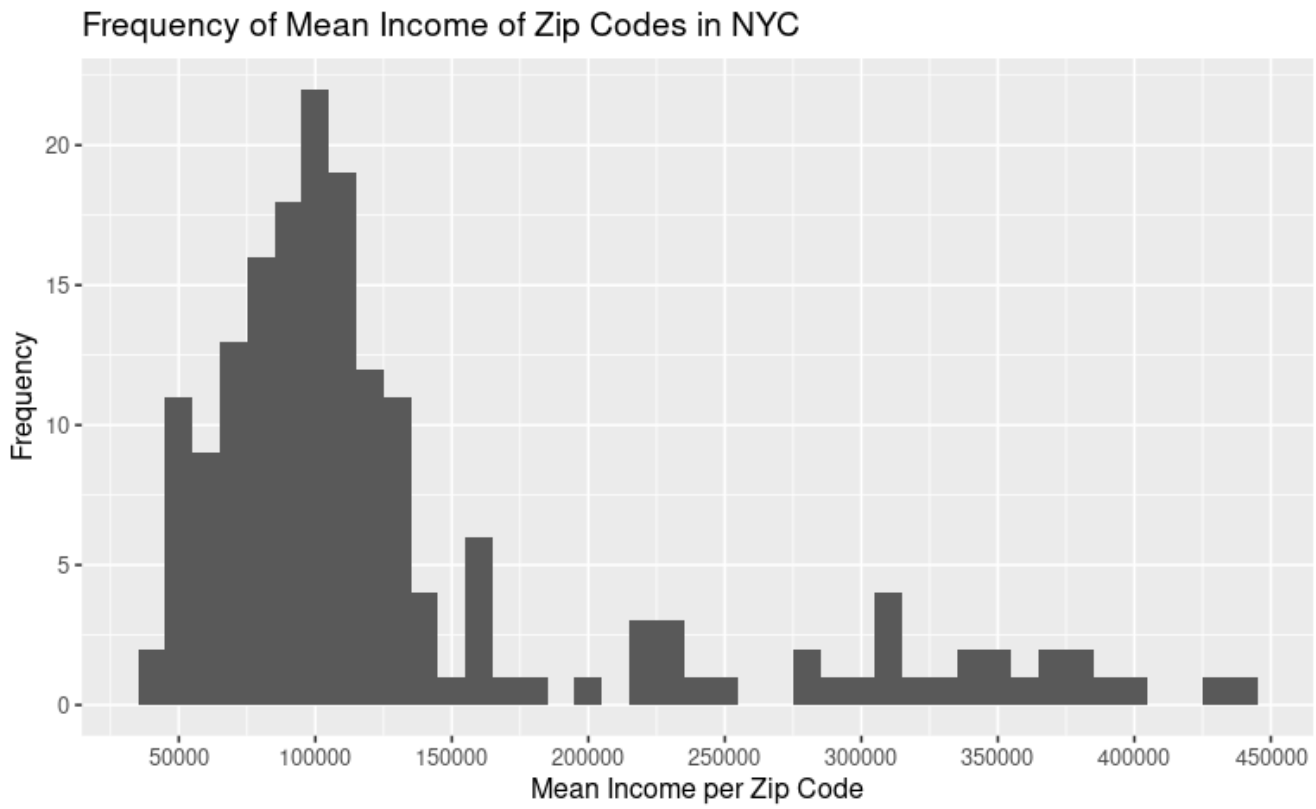


Figure 1: Frequency of Man Income of Zip Codes in New York City in 2019

We can see that the average income per zip code is right skewed, which matches our intuition; there are a handful of zip codes that require its residents to have exorbitant incomes with very few that allow for an income below the poverty line.

### *Restaurant Dataset*

What is the distribution of average restaurant health scores by zip code in New York City? The mean score is 19.24 points with a standard deviation of 3.67 points and a median of 19.4 points. Additionally, the lowest (best) average restaurant health score for a zip code was 7.5 points and the highest (worst) average restaurant health score for a zip code was 29.77 points. This distribution is illustrated below:

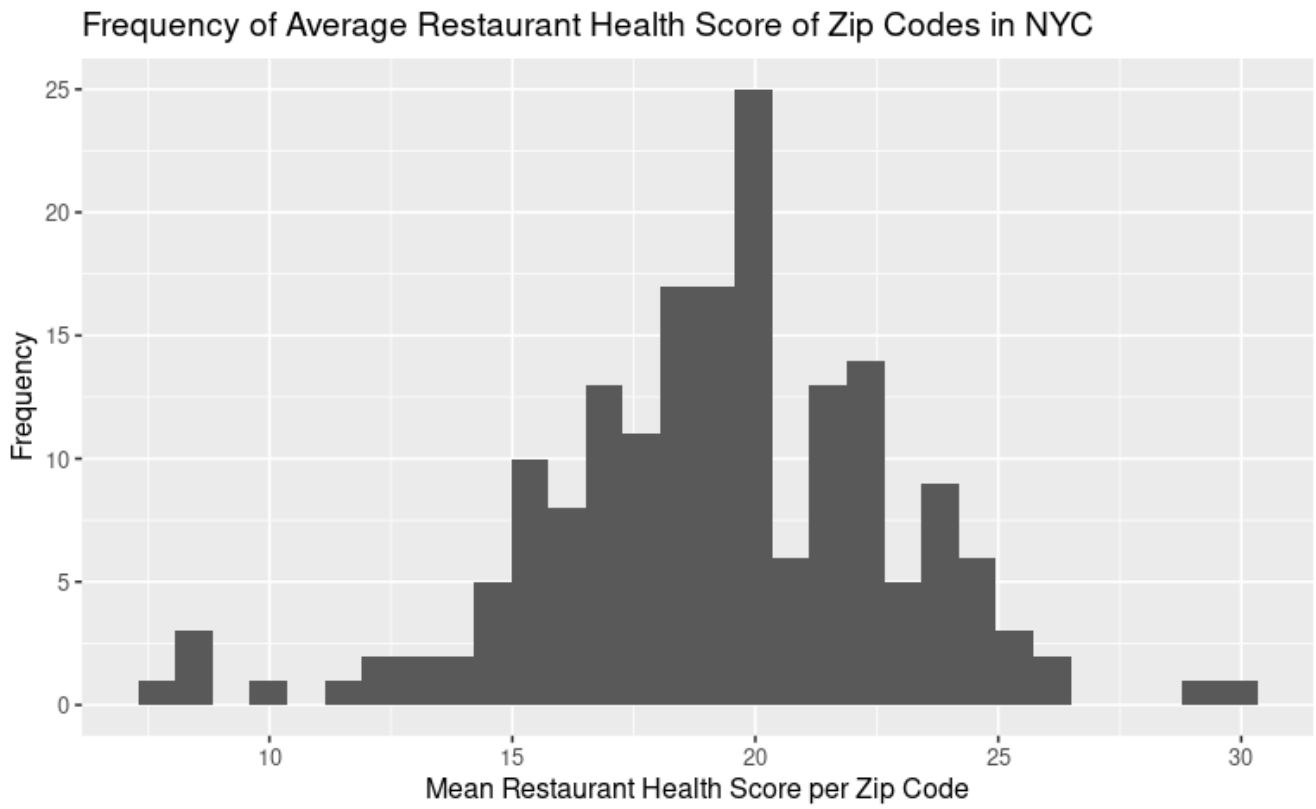


Figure 2: Frequency of Mean Restaurant Health Scores Of Zip Codes in New York City in 2019

We can see that the average restaurant health score is close to normally distributed which definitely surprises the author. We would have expected that there would have been more zip codes that have an average of A level (0-13 points) restaurants given how important restaurant health safety is.

### *Rodent Dataset*

What is the distribution of the total number of reported rodent sightings that resulted in "Rat Activity" by zip code in New York City? The mean number of reported rodent sightings was 187.90 with a median of 44.5 and a standard deviation of 322.53. Additionally the smallest number of reported rodent sightings in a zip code was 0 and the most was 2,104. This distribution with the log of the frequency per zip code plus 1 (to avoid log of zero errors) is illustrated below:

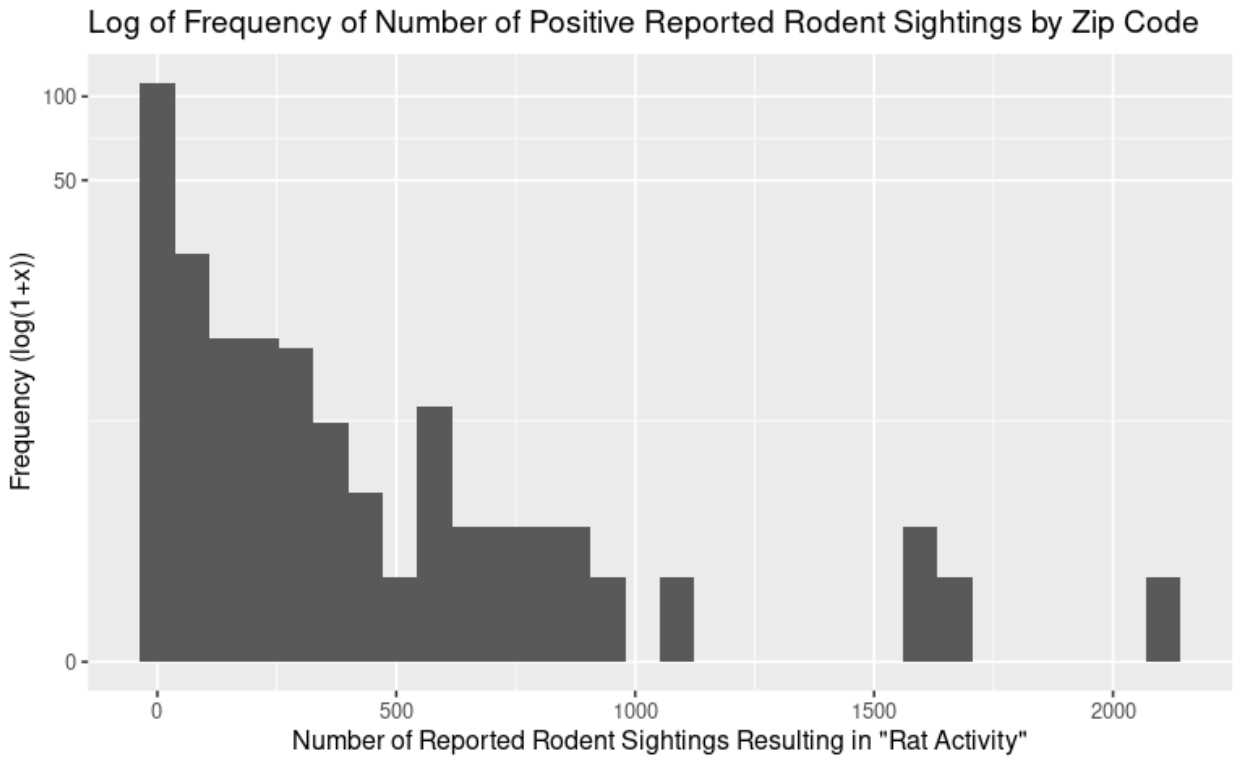


Figure 3: Log frequency of number of reported rodent sightings resulting in “Rat Activity” by zip code

Looking at this distribution, we can clearly see that the data is right skewed and contains a handful of far outliers. Tukey's fences, defined as $[Q_1\text{-}k(Q_3\text{-}Q_1), Q_3\text{+}(Q_3\text{-}Q_1)]$ and k=3, we removed 6 zip codes from this dataset, leaving 172 zip codes. After removing these outliers, the new rodent dataset is still right skewed, but much less so with a mean of 142.77 with a standard deviation of 203.87 and a median of 42.

# Results

## Descriptive Statistics

### *Income vs. Restaurant*

In this study, a linear regression analysis was conducted to explore the relationship between the average income by zip code and average restaurant health score in that zip code.

However, the results of the analysis indicated that the regression model was not statistically significant ($p > 0.05$), suggesting that the average income by zip code did not have a significant effect on the average restaurant health score in that zip code. Therefore, we fail to reject the null hypothesis, suggesting that there is no evidence of a linear relationship between the average income by zip code and the average restaurant health score in that zip code.

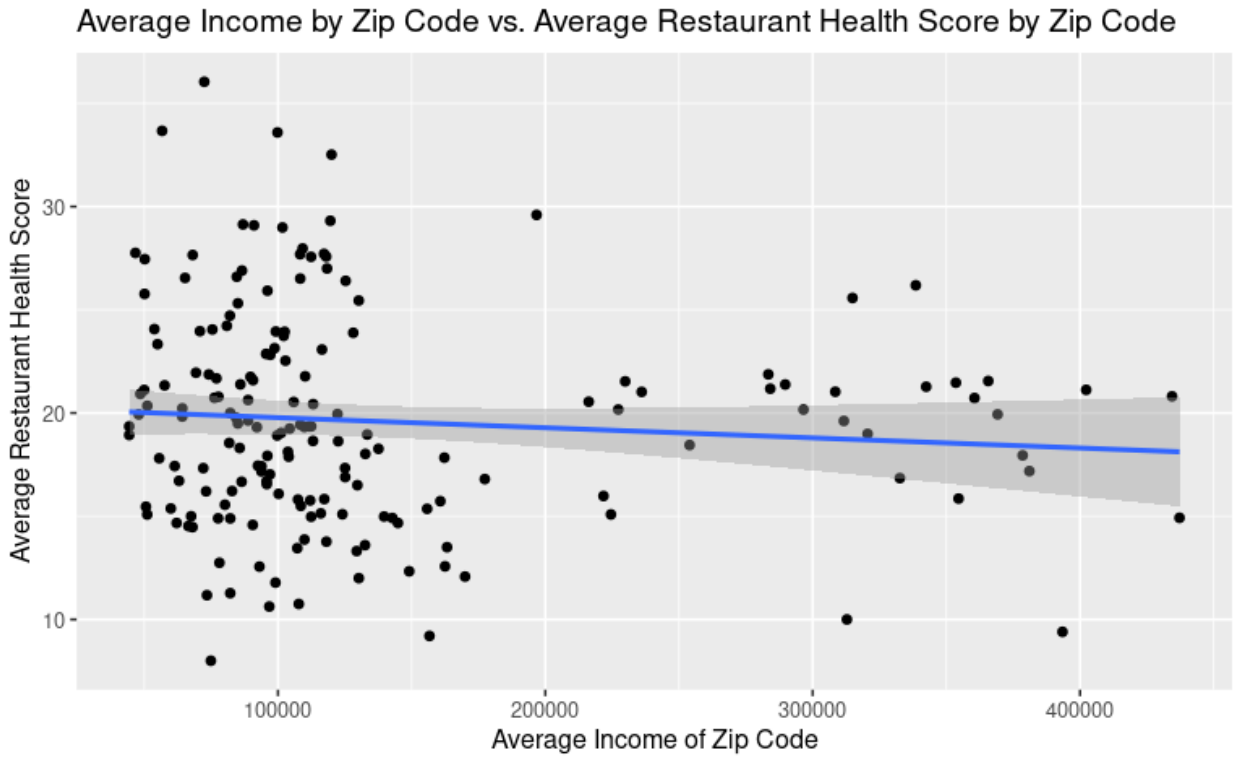


Figure 4: Linear relationship between average income by zip code and average health score by zip code

```
Call:
lm(formula = avg_income ~ `mean(score)`, data = final_merge)

Residuals:
   Min     1Q Median     3Q    Max
-91819 -53253 -29865    428 301123

Coefficients:
             Estimate Std. Error t value      Pr(>|t|)
(Intercept)     165354      27041   6.115 0.00000000613 ***
`mean(score)`    -1541       1334  -1.155          0.25
---
Signif. codes:  0 ‘***’ 0.001 ‘**’ 0.01 ‘*’ 0.05 ‘.’ 0.1 ‘ ’ 1

Residual standard error: 91470 on 175 degrees of freedom
Multiple R-squared:  0.007565,  Adjusted R-squared:  0.001894
F-statistic: 1.334 on 1 and 175 DF,  p-value: 0.2497
```

Figure 5: Result of linear regression between average income by zip code and average health score by zip code

The lack of statistical significance implies that the average income by zip code may not be good predictors of the average restaurant health score in that zip code or that other factors not included in the analysis might be influencing the relationship. It is important to note that the sample size, data quality, or other limitations of the study may have contributed to the non-significant findings.

## *Income vs. Rodent*

In this study, a linear regression analysis was conducted to explore the relationship between the average income by zip code and number of reported rodent sightings that resulted in “Rat Activity” in that zip code. However, the results of the analysis indicated that the regression model was not statistically significant ($p > 0.05$), suggesting that the average income by zip code did not have a significant effect on the number of reported rodent sightings that resulted in “Rat Activity” in that zip code. Therefore, we fail to reject the null hypothesis, suggesting that there is no evidence of a linear relationship between the average income by zip

code and the number of reported rodent sightings in that zip code.

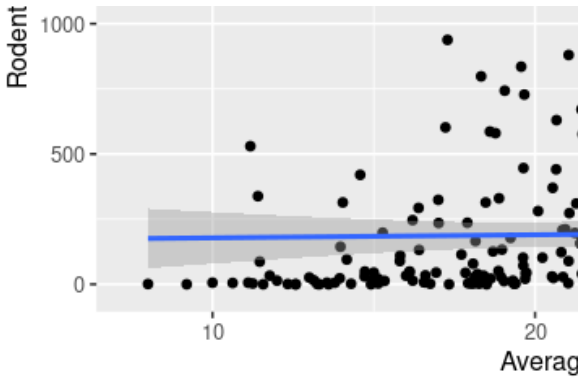


Figure 6: Linear relationship between average income by zip code and the number of reported rodent sightings by zip code

```
Call:
lm(formula = avg_income ~ rodent_cnt, data = final_merge)

Residuals:
   Min     1Q Median     3Q    Max
-94903 -53752 -32909    944 297765

Coefficients:
             Estimate Std. Error t value            Pr(>|t|)
(Intercept) 140788.20    7955.85  17.696 <0.0000000000000002 ***
rodent_cnt     -29.85      21.30  -1.402               0.163
---
Signif. codes:  0 ‘***’ 0.001 ‘**’ 0.01 ‘*’ 0.05 ‘.’ 0.1 ‘ ’ 1

Residual standard error: 91310 on 175 degrees of freedom
Multiple R-squared:  0.0111,    Adjusted R-squared:  0.00545
F-statistic: 1.964 on 1 and 175 DF,  p-value: 0.1628
```

Figure 7: Result of linear regression between average income by zip code and the number of reported rodent sightings by zip code

The lack of statistical significance implies that the average income by zip code may not be good predictors of the number of reported rodent sightings that resulted in “Rat Activity” in that zip code or that other factors not included in the analysis might be influencing the relationship. It is important to note that the sample size, data quality, or other limitations of the study may have contributed to the non-significant findings.

## *Restaurant vs. Rodent*

In this study, a linear regression analysis was conducted to explore the relationship between the average restaurant health score by zip code and number of reported rodent sightings that resulted in “Rat Activity” in that zip code. However, the results of the analysis indicated that the regression model was not statistically significant ($p > 0.05$), suggesting that the average restaurant health score by zip code did not have a significant effect on the number of reported rodent sightings that resulted in “Rat Activity” in that zip code. Therefore, we fail to reject the null hypothesis, suggesting that there is no evidence of a linear relationship between the average

restaurant health score by zip code and the number of reported rodent sightings that resulted in "Rat Activity" in that zip code.

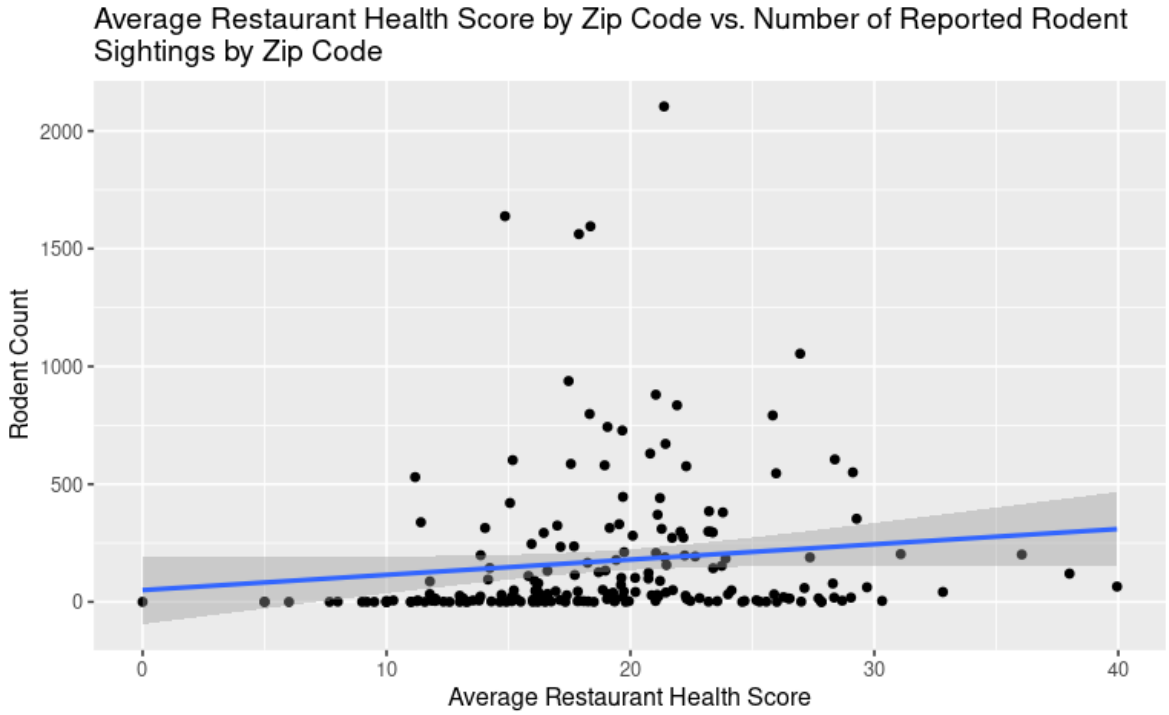


Figure 8: Linear relationship between average health score by zip code and the number of reported rodent sightings by zip code

```
Call:
lm(formula = `mean(score)` ~ rodent_cnt, data = final_merge)

Residuals:
     Min       1Q   Median       3Q      Max
-11.3820  -3.6942  -0.1359   2.4012  16.4245

Coefficients:
             Estimate Std. Error t value            Pr(>|t|)
(Intercept) 19.380863   0.450406  43.030 <0.0000000000000002 ***
rodent_cnt   0.001185   0.001206   0.983               0.327
---
Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1

Residual standard error: 5.169 on 175 degrees of freedom
Multiple R-squared:  0.005487,  Adjusted R-squared:  -0.0001958
F-statistic: 0.9655 on 1 and 175 DF,  p-value: 0.3271
```

Figure 9: Result of linear regression between average health score by zip code and the number of reported rodent sightings by zip code

The lack of statistical significance implies that the average restaurant health score by zip code may not be good predictors of the number of reported rodent sightings that resulted in “Rat Activity” in that zip code or that other factors not included in the analysis might be influencing the relationship. It is important to note that the sample size, data quality, or other limitations of the study may have contributed to the non-significant findings.

### *Income and Restaurant Scores vs. Rodent*

The objective of this study is to determine whether or not there exists a correlation between average income per zip code and number of reported rodent sightings resulting in “Rat Activity,” a proxy for the public health of a zip code, versus average restaurant health score by zip code in New York City. To assess this relationship, continuous scales will be utilized for the three metrics. Specifically, a scatter plot will be employed, along with the calculation of Pearson's correlation coefficient (r), to examine this research question.

```
Call:
lm(formula = `mean(score)` ~ avg + rodent_cnt, data = final_merge)

Residuals:
     Min       1Q   Median       3Q      Max
-11.6797  -3.7295  -0.3141   2.8732  16.1427

Coefficients:
               Estimate   Std. Error t value            Pr(>|t|)
(Intercept) 20.017204787  0.752002793  26.619 <0.0000000000000002 ***
avg         -0.000004520  0.000004278  -1.057               0.292
rodent_cnt   0.001049888  0.001212111   0.866               0.388
---
Signif. codes:  0 ‘***’ 0.001 ‘**’ 0.01 ‘*’ 0.05 ‘.’ 0.1 ‘ ’ 1

Residual standard error: 5.167 on 174 degrees of freedom
Multiple R-squared:  0.01183,   Adjusted R-squared:  0.0004679
F-statistic: 1.041 on 2 and 174 DF,  p-value: 0.3552
```

Figure 10: Results of linear regression of average income by zip code and number of positive reported rodent sightings in a zip code vs. average restaurant health score by Zip Code

This study did not find evidence for a correlation between the average income of a zip code and number of positive reported rodent sightings in a zip code versus the average restaurant health score in that zip code in New York City with a p-value of 0.3552, a probability above our 0.05 cutoff. In other words, given our assumption that there is no correlation between the average income of a zip code and number of positive reported rodent sightings in a zip code versus average restaurant health score in that zip code in New York City, we found no evidence to the contrary and therefore fail to reject our assumption. Therefore this study finds that knowing the average income of a zip code and number of positive reported rodent sightings does not provide insight into the average health score of restaurants in that zip code.

### *Income and Rodent vs. Restaurant Score*

In this study, a linear regression analysis was conducted to explore the relationship between the  average income by zip code and average restaurant health score by Zip Code vs. number of positive reported rodent sightings in a zip code. However, the results of the analysis indicated that the regression model was not statistically significant ($p > 0.05$), suggesting that the average restaurant health score by zip code and average income per zip code did not have a significant effect on the number of reported rodent sightings that resulted in “Rat Activity” in that zip code. Therefore, we fail to reject the null hypothesis, suggesting that there is no evidence of a linear relationship between the average restaurant health score by zip code and the average income of that zip code against the number of reported rodent sightings that resulted in “Rat Activity” in that zip code.

```
Call:
lm(formula = rodent_cnt ~ `mean(score)` + avg_income, data = final_merge)

Residuals:
    Min      1Q  Median      3Q     Max
-235.64 -173.22 -142.99   60.61 1900.86

Coefficients:
                Estimate  Std. Error t value Pr(>|t|)
(Intercept)   165.5537798  98.0465950   1.689   0.0931 .
`mean(score)`   3.6313533   4.4255787   0.821   0.4130
avg_income     -0.0003541   0.0002725  -1.299   0.1956
---
Signif. codes:  0 ‘***’ 0.001 ‘**’ 0.01 ‘*’ 0.05 ‘.’ 0.1 ‘ ’ 1

Residual standard error: 323.4 on 173 degrees of freedom
  (32 observations deleted due to missingness)
Multiple R-squared:  0.01354,   Adjusted R-squared:  0.002134
F-statistic: 1.187 on 2 and 173 DF,  p-value: 0.3076
```

Figure 11: Results of linear regression of average income by zip code and average restaurant health score by Zip Code vs. number of positive reported rodent sightings in a zip code.

The lack of statistical significance implies that the average restaurant health score by zip code and the average income of that zip code may not be good predictors of the number of reported rodent sightings that resulted in “Rat Activity” in that zip code or that other factors not included in the analysis might be influencing the relationship. It is important to note that the sample size, data quality, or other limitations of the study may have contributed to the non-significant findings.

## Discussion

This study was interested in looking at whether there exists a correlation between the income of an area and the sanitation of the area within New York City. The units used to measure these aspects of an area were the average income of the zip code, the number of reported rodent sightings in a zip code, as well as the average restaurant health score by zip code. The results of this study did not establish a significant correlation between the average income of

a zip code and the number of positive reported rodent sightings in that same zip code, compared to the average restaurant health score in New York City. Based on our assumption that there is no correlation between zip code income and rodent sightings versus restaurant health scores, we found no evidence ($p > 0.05$) to contradict this assumption. Therefore, we cannot reject the notion that knowing the average income and rodent sightings does not provide insights into the average health score of restaurants in a given zip code.

However, there are several limitations to the analysis. One of the limitations is with regards to the restaurant dataset. A limitation associated with this dataset is that the health score is based on a single metric that encompasses all aspects of health safety. Health safety from rodents is only one of a multitude of attributes that are considered when giving a restaurant a health score. Another limitation of this dataset is that the health score is given by a single individual and calculated based on a single visit. There are many variables and aspects that may or may not arise when the inspector is present that can greatly impact the health score.

One of the limitations is that the rodent dataset is based on self reported data. This is a limitation since even if a zip code doesn't have any reported rodent sightings, it does not necessarily mean that there are no rodents in that zip code. Similarly, zip codes with a higher number of reported sightings do not necessarily correlate with a higher rodent population, but rather just a larger number of reported sightings. Another limitation to this study is that it focused solely on reported rodent sightings, rather than looking for other causes that might lead to a worse health score.

Additionally, the economic status of an area can be indicative of a restaurant's cleanliness because wealthier areas tend to have higher expectations for cleanliness and hygiene. This is because people in these areas generally have higher disposable incomes and are more likely to dine out regularly. As a result, restaurants in these areas need to maintain high levels of cleanliness to meet the expectations of their customers and stay in business. However, this

analysis indicates that the economic status of an area is not a reliable indicator of a restaurant's cleanliness, at least in New York City. There are many clean and well-maintained restaurants in lower-income areas, and there may be dirty and unsanitary restaurants in wealthier areas as well. Ultimately, the cleanliness of a restaurant depends on the specific management and practices of that establishment.

This study only looked at New York City, one of the densest cities in the United States (Kolko 2021). Additionally, common alternative proxies for sanitation and public health, such as access to toilets, waste management, and the availability of clean water, wouldn't make sense to use in New York City since these attributes are consistent across the city as there is one system/organization responsible for these aspects across the city. Therefore, it is difficult to extrapolate from New York City to any other city. Future research may look at other cities with similarly available datasets, such as Baton Rouge and Chicago.

Future research should use a clustering algorithm, such as k-means, to create the geographic regions instead of using zip codes. Using a clustering algorithm to divide an area like New York City can offer several advantages over using predefined clusters, such as zip codes including having higher flexibility since k-means and other clustering algorithms can adapt to different data patterns and distribution characteristics. They do not rely on fixed geographic boundaries like zip codes, which may not accurately capture the underlying similarities or dissimilarities among neighborhoods. Additionally, pre-defined clusters like zip codes are often designed for administrative or logistical purposes, not necessarily based on data-driven similarities. Using k-means ensures a more unbiased grouping of areas, driven by the data's inherent structure rather than preconceived notions. Furthermore, k-means can incorporate multiple variables simultaneously, such as demographic, economic, or health-related data, to create more comprehensive and nuanced clusters. This multi-dimensional analysis can provide a more holistic understanding of the area under study. Finally, clustering algorithms can handle

large datasets and are scalable to accommodate diverse spatial extents like New York City. This makes them suitable for analyzing complex urban landscapes with extensive data points. While k-means clustering offers these benefits, it's important to consider the appropriateness of the algorithm for the specific research question or analysis goals. Other clustering methods or spatial analysis techniques may be more suitable, depending on the nature of the data and the objectives of the study.

Despite previous research suggesting a correlation between the sanitation levels of an area and its income, this study did not find evidence supporting this relationship. This raises questions for future research to explore why this finding does not hold true specifically in New York City. Is the lack of correlation related to income, or is it primarily influenced by the cleanliness of the neighborhood itself? Several theories could be considered, such as New York City's uniform waste management policy across the entire city. Furthermore, as one of the most culturally diverse cities globally, different cultural practices may impact the sanitation conditions of a neighborhood, regardless of its income level. Nevertheless, since this study did not find support for the presumed relationship, any policies aimed at improving sanitation in an area should not be contingent on income levels.

Future research should also look at if there is a meaningful difference in the rodent population in New York City after the implementation of the containerization program. It wasn’t always the case that New Yorkers could just leave their plastic bags of garbage on the curb as until the late 1960s (Bird 1967), and most Cities in the world do not allow trash bags unfettered access to the streets. Rats flourish and multiply by having access to food, which is usually available within a 100-foot radius of their nest (Johnson et al. 2016). In the context of New York City, this food source is conveniently presented in bags placed in front of every property two to three times a week, as nearly one-third of residential waste consists of food (City of New York Department of Sanitation 2017). A research study conducted by the New York City DOHMH

reveals that the primary factor influencing the presence of urban rats is the abundance of garbage, and the most impactful measure to control rat populations is reducing the availability of accessible trash (Johnson et al. 2016). Investigating the impact of the containerization program on the rodent population in New York City is an important avenue for future research, considering the historical context and the prevalence of food waste as a key factor in rat proliferation. Understanding the potential effects of reducing the availability of accessible trash can contribute to effective strategies for controlling rat populations in urban environments.

The objective of this analysis was to determine if a correlation exists between the average income of a zip code and the number of positive reported rodent sightings in that zip code, in comparison to the average restaurant health score in the same area in New York City. The average income of a zip code can serve as an indicator of the overall public health of the area, as higher earners may have better resources to maintain a healthier living environment. Additionally, rodent infestations pose various health, economic, and infrastructure issues. Identifying such areas can help pinpoint neighborhoods with cleaner and more sanitary restaurants, which is especially important considering the frequency with which New Yorkers eat outside their homes. New York City conducts restaurant health inspections to enforce a baseline of sanitary conditions, critical for the overall health of the city. To test the hypothesis on whether the average income of a zip code and the number of positive reported rodent sightings in that zip code are correlated with the average restaurant health score, a multiple linear regression was employed. The null hypothesis was rejected, indicating that a correlation was indeed found. This finding is not surprising, given the anecdotal evidence of higher levels of uncleanliness and rodent presence in lower-income areas.

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