

Impacts of Public Transportation Reliability on Food Accessibility & Health Outcomes

Anne Mercado, Taylor Gill

Applied Data Science

Center of Urban Science and Progress

Professor Stanislav Sobolevsky

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Abstract

The paper examines how the accessibility of public transportation, including performance and overall service quality, can affect food insecurity and its health related impacts in New York City households. In New York City, an estimated 1.2 million residents (14.6%) were food insecure and this makes up 50% of all the food insecure residents in New York state. (*Emergency Food in NYC*, n.d.) In a city that heavily relies on public transportation the paper then investigates its intersection between food source concentration and existing nutritional issues in the city and their correlation with each other. Using community detection and spatial comparative analysis, the study is able to find evidence on the relationship between public transportation quality and performance to food security. Through this analysis, this report aims to better understand how public transportation accessibility can impact both food insecurity and its health related issues and strives to get closer in alleviating the food insecurity in New York City.

Introduction

The U.S. Department of Agriculture (USDA) defines food insecurity as when people don't have sufficient food to eat to live an active healthy life. Despite being frequently referred to as "the land of plenty", food insecurity remains a crisis in America. It started in the late 1960 when hunger became an evident public issue in the country, even with a number of major federal assistance programs already in place. (Wunderlich & Norwood, 2006) Since then, the government has been trying to find ways to combat hunger. It was in February 1994 that USDA entered into an interagency agreement with the Census Bureau to develop, test, analyze food accessibility at the household level. (Baek et al., 2013) Since then, numerous studies have been published investigating the causes and impacts of food insecurity such as the study on food insecurity and its health outcomes by Gundersen and Ziliak (2015), predictors of food insecurity among older adults in the United States by Goldberg and Mawn (2014b), food insecurity and how it impacts and the special considerations to women by Ivers and Cullen (2011), effects of food insecurity to students (Cady 2014), and the effects of public transportation accessibility on food insecurity (Baek et al., 2013), which is where this research is building up on.

The positive impacts of public transportation accessibility on urban residents have been proven repeatedly in multiple studies. Especially for lower income residents, better access to public

transit in urban centers allow them to access necessary services including food resources. (Glaser, et al. 2008) By facilitating easier access to a diverse array of food sources, effective public transportation systems can help mitigate food insecurity. This is especially true in cities or neighborhoods where distances to affordable and nutritious food sources can be significant barriers for low-income households. (Safy 2019)

Problem Statement:

In New York City, when so many residents rely on public transportation, how does service quality impact the health outcomes associated with food accessibility? How does public transportation quality (service levels, reliability, travel times) impact food accessibility and health outcomes for NYC residents? When service is improved, do purchasing patterns and health outcomes improve?

Literature Review

Existing Research on Food Insecurity:

In 2022, USDA reported that 1 in 8 U.S. households struggled with food insecurity. (Nova, 2023) The rise in food insecurity affected approximately 17 million families, nearly 13% of U.S. households. In New York City, an estimated 1.2 million residents (14.6%) were food insecure. Among the boroughs, the Bronx has the highest rate of food insecurity at 19.7%. It is followed by Brooklyn with 15.5% then Manhattan at 13.6%, Queens at 12.1% and Staten Island at 10.1%. (*Emergency Food in NYC*, n.d.) According to the same report, New York City residents make up 50% of all the food insecure residents in New York state. In relation to this, Feeding America reported that 1 in 10 New Yorkers or 1,882,580 residents struggle with hunger, and of them 596,060 are children. As of April 2023, among the community districts with the most Emergency Food Assistance Program per capita, three are in the Bronx, two in Brooklyn and one is in Queens. On the other hand, among the fewest Emergency Food Assistance Program per capita, two are in Manhattan, two are in Queens, one in Staten Island and one in the Bronx. (*Emergency Food in NYC*, n.d.-b)

Public Transportation and Urban Accessibility:

Undeniably, public transportation is crucial to access not only food resources but all other amenities provided by an urban area. Safy (2019) was able to provide an in-depth analysis of how the quality of public transportation, specifically in New York City, impacts urban residents' access to necessary services, including food. Improved public transportation accessibility and performance can increase the number of businesses in a given area. It was one of the findings of the study, that better on-time performance correlates with an increase in the number of businesses. This, as a result, enhances service availability, including food markets along with other essential services, contributing to a more robust local economy and better service delivery. The same study highlights that low-income residents, who tend to be more dependent on public transportation, are disproportionately impacted by the quality of public transportation services. This was emphasized in a paper by Glaser, et al. (2008). According to the paper, for many poor urban residents, public transportation is not just a convenience but a necessity. It enables access to areas that offer essential services which includes grocery stores along with more affordable housing options and healthcare facilities.

Intersections of Transportation, Food Accessibility, and Health:

According to Cheung (2022), living in a disadvantaged neighborhood, which includes both transportation accessibility and food resource locations, affects health outcomes as it can determine the quality of accessible food and, in general, the living conditions of a person, which are critical determinants of health. Cheung (2022) also reiterates that limited access to grocery stores due to distance or poor transportation options and performance can lead to food insecurity, which is directly related to adverse health outcomes which includes malnutrition, cognitive decline and increased susceptibility to chronic diseases. These effects are much more evident in low-income communities. (Glaser, et al) 2008. Based on these documented analyses, it is not surprising that better public transportation systems can significantly decrease food insecurity by facilitating easier access to nutritious food, particularly in urban areas where distances can be a barrier to accessing suitable food options. This improved access is vital for maintaining good health and preventing diet-related illnesses. (Baek, 2014)

Methodology

Our study builds upon existing research by focusing on New York City's public transportation systems, comparing them to factors such as household income and food resource locations. This approach highlights how access to transit interacts with socioeconomic variables and examines its implications for food insecurity within respective communities. By conducting a comparative analysis with existing health studies, we investigate the potential health outcomes linked to food insecurity. Our research provides a comprehensive view of how urban accessibility influences both food availability and the health implications for city dwellers, enriching our understanding of urban food security and public health.

Analytical Methods:

- Community detection was used to determine communities in New York City based on Subway travel. On-time performance for New York City subways is determined by the time a train arrives at its final destination. On time performance percentage is calculated as scheduled trains less late, canceled, and terminated trains divided by scheduled trains. In order to apply this to the community level, we applied yearly on-time performance by line to each station, taking the average of all lines served. On time performance data is currently limited due to the fact that trains are only considered late if they are late at their final stop. As such, there is a strong likelihood that a neighborhood could experience frequent late trains that are never reported.
- Spatial comparative analysis between New York City subway availability, proximity and on-time performance to food resource location and concentration.
- Gini coefficient was used to analyze the concentration/distribution of food retail stores at the borough and zip code level.

Results

Data Presentation:

An analysis of on time performance in 2022 and 2023 showed that weekend performance improved on nearly all lines. For this reason, we focused on weekday trains.

line	Year	2022	2023	change
F	71.34%	70.17%	-1.64%	
A	69.06%	72.09%	4.38%	
C	68.82%	72.64%	5.54%	
D	72.62%	73.38%	1.05%	
N	76.33%	73.64%	-3.54%	
E	71.75%	74.31%	3.57%	
B	68.27%	75.91%	11.19%	
Z	74.79%	76.05%	1.68%	
Q	74.46%	78.35%	5.23%	
R	77.43%	79.63%	2.84%	
6	79.35%	79.69%	0.43%	
1	82.30%	82.34%	0.05%	
5	81.07%	82.52%	1.78%	
Systemwide	81.57%	82.88%	1.61%	
4	81.05%	83.20%	2.65%	
M	79.38%	85.93%	8.25%	
G	88.50%	86.26%	-2.53%	
3	84.76%	86.41%	1.94%	
JZ	84.84%	88.12%	3.88%	
7	90.59%	91.04%	0.50%	
L	91.12%	92.38%	1.38%	
S Rock	95.79%	96.66%	0.91%	
S Fkln	99.13%	99.11%	-0.02%	
S 42nd	99.34%	99.68%	0.35%	

Figure 1: On-time performance by Line



Figure 2: Community Detection, Max Communities = 6

community	aOTP	2022	2023	change	community
0	77.19%	76.61%	77.77%	1.16%	Purple
1	74.54%	73.83%	75.25%	1.42%	Green
2	77.40%	75.93%	78.87%	2.94%	Blue
3	76.97%	76.47%	77.47%	1.00%	Turquoise
4	84.29%	83.61%	84.98%	1.36%	Indigo
5	78.23%	77.29%	79.16%	1.87%	Yellow

Figure 3: On-time Performance by Community

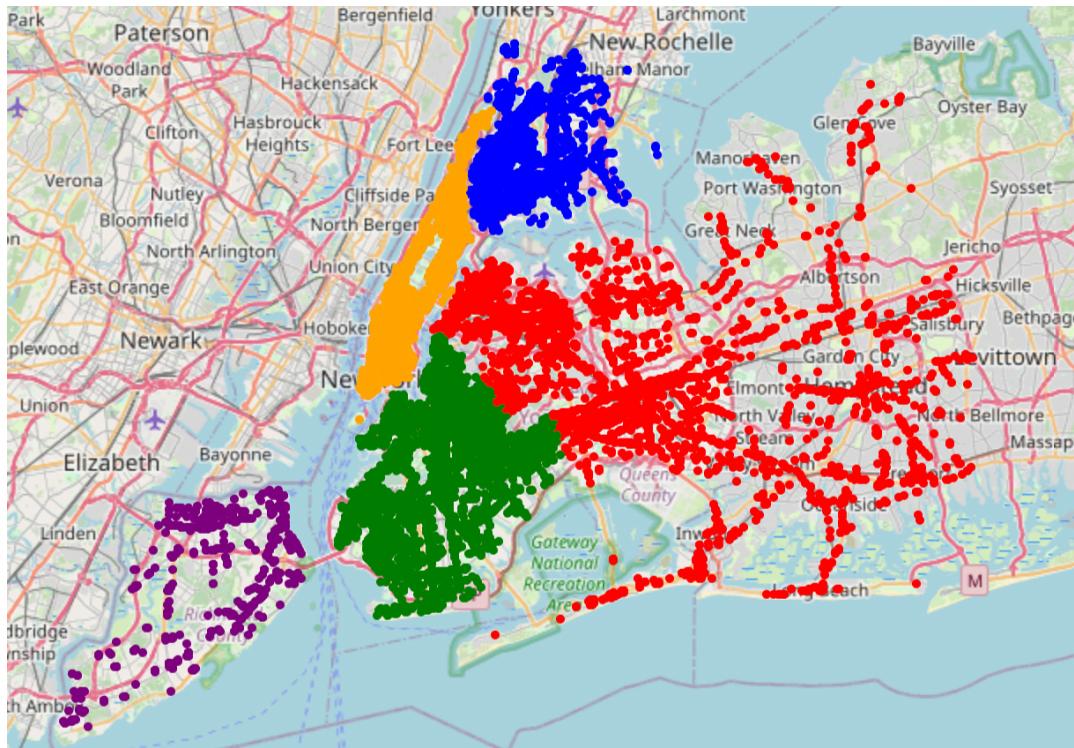


Figure 4: Food Retailer Concentration in New York City

Gini Coefficient (by Borough) = 0.29

Gini Coefficient (by Zip Code) = 0.49

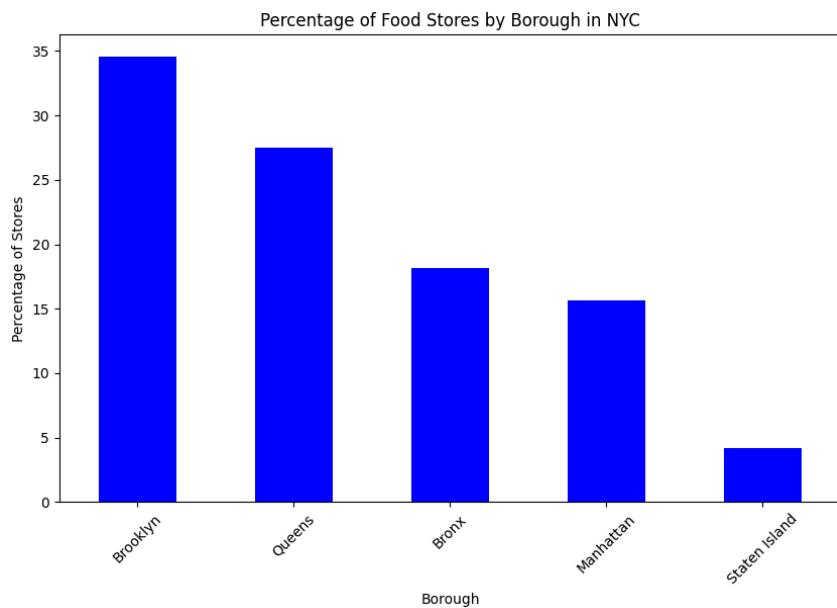


Figure 5: Percentage Breakdown of Food Retail Stores



Figure 6: Percentage Breakdown of Healthy Food Stores

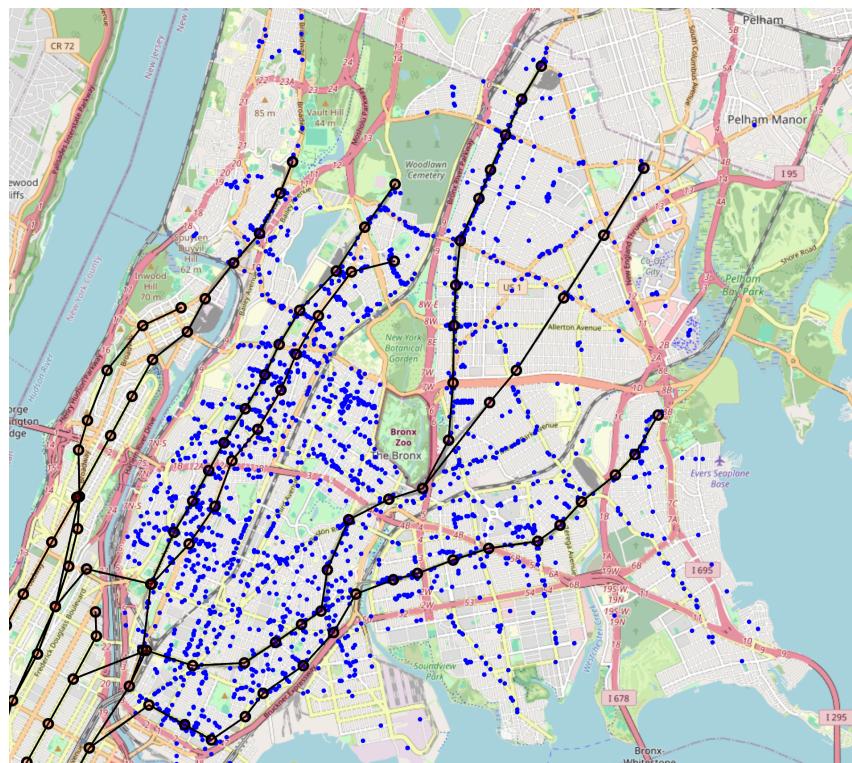


Figure 7: The Bronx Subway Lines and Retail Food Stores

Given the subway stations and retail food stores data, Staten Island has the longest average distance of stores to the subway stations with an average distance of 22 kilometers minimum of 25 meters and a maximum distance of 55 kilometers. This is followed by Queens having the second longest average distance of stores to the subway stations with an average distance of 17.3 kilometers with a minimum of 1..23 meters and maximum of 38.8 kilometers. It is followed by the Bronx with an average subway distance of 16.3 kilometers, minimum of 11 meters and maximum of 56.5 kilometers. The fourth is Brooklyn with an average subway distance of 12.4 kilometers with a minimum distance of 12 meters and maximum of 38.8 kilometers. At the bottom of the list is Manhattan with an average subway distance of 11.6 kilometers with a minimum distance of 1.7 meters and maximum distance of 49 kilometers.

Discussion

Interpretation of Results:

On-time Performance by Line

The line with the lowest on time performance was the F train, with only 70.2% of trains running on time in 2023, a reduction of 1.6% since the previous year. Despite serving many of the same stations, on time performance for the M train was 85.9% in 2023, increasing 8.3% compared to 2022. Analyzing node link data for all subway stations in New York City confirmed that the unshared portions of these lines are part of unique communities when at least six communities are being detected. Unsurprisingly, these communities tend to be similar to boroughs, with some added distinction based on train lines.

Concentration of Food Retail Stores by Borough and Zip Code

The Gini coefficient was used to determine the concentration of food retail stores across the city. Looking at it by borough, the Gini coefficient was 0.29. With 0 as perfect equality and 1 as perfect inequality, the value suggests a relatively low inequality in the distribution of stores. This means that the amount of stores are somewhat well distributed among the boroughs. At the zip code level, the coefficient almost doubles to 0.49. This suggests that at zip code level there is a significant variation in the distribution of food retail stores.

Average Distance of Food Retail Stores to Subway Stations

The results of the computation for the average distance of food retail stores to subway stations is a straightforward computation considering only the number of food retail stores within the borough and their distance to the subway stations based on their location. Given this premise, it makes sense that Staten Island would come on top of the list given that there is only one line in the island that is being considered. As for Queens, being second on the list, the ratio of the land area (282 square kilometers) and the available subway stations factor into the results. The Bronx comes in third and with only 1 kilometer difference from the average subway station distance in Queens. The Bronx though does not have the factor of having a massive land area as compared to Queens with 108 square kilometers. Brooklyn and Manhattan are comparable in terms of the average distance of retail food stores to subway stations.

Conclusion & Recommendations

Boroughs with the most health food stores were the Bronx and Brooklyn, with very few health food stores in Manhattan. Despite having access to many health food stores, the Bronx is the county with the highest rates of obesity and food insecurity. While quality food and proper nutrition play a major role in health outcomes, having health-food stores in the neighborhood is not correlated with better health outcomes. This may be attributed to what we label as “health-food”, but can also be linked to income levels, neighborhood walkability, and housing affordability. Communities with multiple options for public transportation were less impacted by delays on a single line, which should be taken into consideration when planning outages.

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Appendix:

Geography	Number	Percent
— Borough		
Bronx	332,000	32.4 (29.1, 35.8)
Brooklyn	479,000	24.6 (22.3, 27.0)
Manhattan	227,000	17.1 (14.7, 19.7)
Queens	435,000	24.6 (21.8, 27.7)
Staten Island	118,000	32.5 (26.5, 39.1)

*Appendix A: New York City Obesity in Adults Data as of April 2023
(Overweight Data for NYC – Environment & Health Data Portal, n.d.)*