Mapping Hunger in the Concrete Jungle: Exploring Food Deserts, Food Swamps, and Demographic Disparities in New York City

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Introduction

The purpose of this project is to identify and analyze food deserts and food swamps in New York City. A food desert can be defined in many different ways; although many sources say the qualifications of a food desert involve a specific distance away from a fresh food store, given that I am working with a very densely populated city, I've defined a food desert as "neighborhoods with limited access to [fresh] food … or geographic areas where residents have few to no convenient options for securing healthy foods, especially fruit and vegetables (Annie E. Casey Foundation)." As I will explain in my data section, I identified food deserts as areas with a low density of fresh food stores. A food swamp is defined as an area that has a high concentration of fast food and little to no fresh food options.

In a sprawling city or rural areas, food deserts and swamps are often easier to pinpoint due to the lack of overlapping food environments (Walsh). However, in New York City, the intricate urban landscape makes these areas more complex and, at times, hidden. For instance, food deserts and swamps can exist side by side with neighborhoods abundant in fresh food options. The availability of healthy food directly impacts the lives and trajectories of individuals within a community. This project seeks to answer: **Where are food deserts and swamps located in New York City, and what demographic disparities arise as a result of these areas?** Based on research and what I see in New York City, I anticipate finding these areas on the outskirts of Brooklyn, parts of the Bronx, and much of Staten Island; I expect to see higher poverty rates and more people of color in these areas as well. By mapping these zones and analyzing their alignment with socioeconomic and racial demographics, the research aims to highlight structural inequalities and inform more targeted interventions.

Data

The data preparation, cleaning, and collection was fairly extensive for the project. To start off broadly, I uploaded the New York City census tract shapefile to QGIS. The only other shapefile I acquired was one that showed **diabetes** rates per Community District (there was no data on the census tract level), which I obtained from the NYC health data portal. Next, I collected census tract data. First, for race, I extracted the information on the Black population, as I wanted my primary focus to be their representation in these areas given their continued history of systemic marginalization. Once this data was uploaded into QGIS, I then calculated the **percent of Black people** in each census tract. Next, I collected poverty data and used the below 125% poverty level. While I could've used median income, I decided to use the **poverty level** because it provides a clearer indicator of individuals and families living in economic distress, which is directly tied to their access to essential resources like healthy food. Lastly, I collected population data.

After collecting the demographic data and joining it to the census tracts, I worked on finding datasets that contained food stores. I found one large dataset that contained food stores and their location through the New York State Department of Agriculture and Markets. However, this dataset contains all kinds of retail food stores, including bodegas and convenience stores.

Given that I want to look at fresh food stores (stores that sell fresh vegetables and fruit), I filtered out a good number of these stores using R Studio. It is important to note that there were over 24,000 food stores in this dataset and it did not contain any columns that identified what type of food store each location was. Therefore, while I did my best to filter out places that don't qualify as a fresh food store, there is a chance that some of the stores don't exactly fit the criteria; if I had more time I would've spent a lot more of it filtering through this dataset. Given that this dataset most likely has some food stores that do not fit the fresh fruit and vegetable criteria, in order to accurately measure the food swamps, I found a smaller dataset of recognized healthy food stores by the Borough's President's Office. I compare this with a dataset that I filtered out to contain the most common fast food places in New York City. Once I had all of these points geocoded and loaded into QGIS, I used the first big dataset to calculate **store density**, which I calculated as the number of fresh food stores per 1000 residents in each census tract. Lastly, after uploading all of the shapefiles, geocoded points, and census datasets, I had to set up a few thresholds for different variables, involving a lot of filtering for different maps. For example, many of the maps I will present have a low fresh food density component. After initially viewing the fresh food store density, I decided that anything less than 0.42 would be considered a low fresh food density area. Additionally, I made sure that areas with less than 100 people would not be counted as that is considered a non-residential area (parks, gardens, playgrounds). The preparation time for this project was lengthy but incredibly necessary and yielded some very eye-opening results.

Methodology

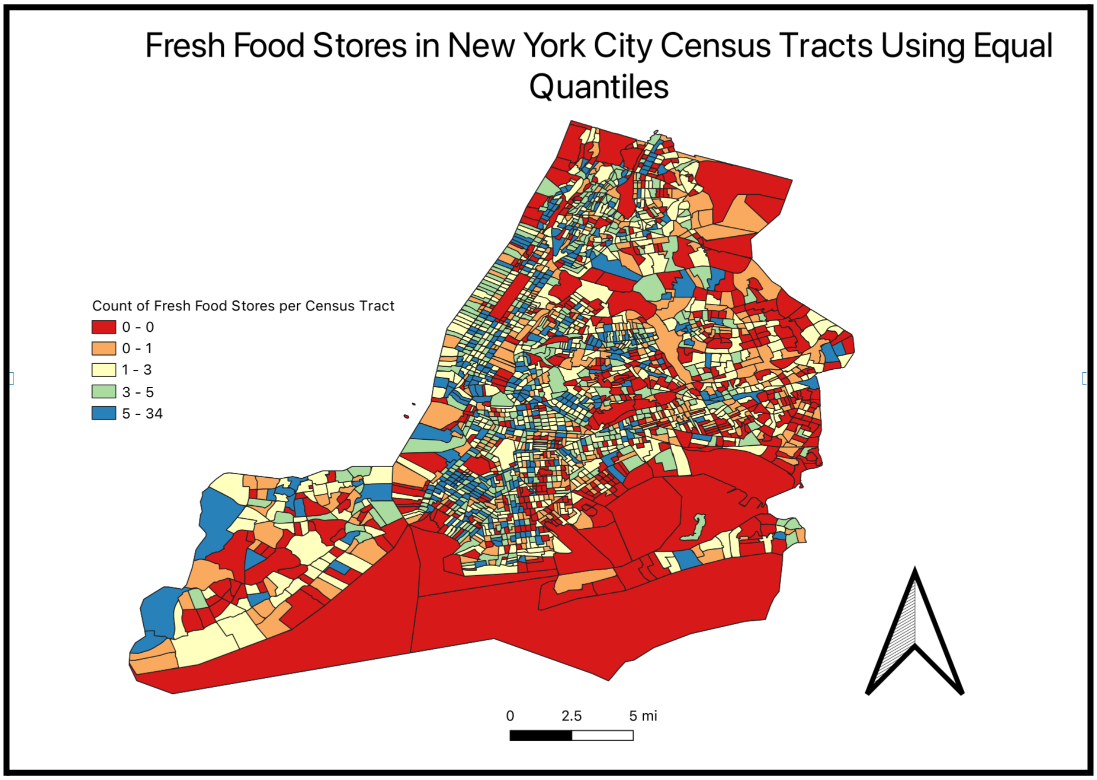
I employed quite a few different methods in order to pull out the insights in each of my maps. First I completed joins with all of my different demographic data to my census tract data, in order to make use of choropleth and other mapping tools.

For many of my maps, I used the Count Points in Polygon function to count the number of stores in each census tract; I employed this to count the number of fresh food stores in each census tract, to count the number of recognized healthy stores in each tract, and to count the number of fast food stores in each tract. Furthermore, I employed different joins with demographic data such as the population of Black people in each tract, the poverty percentage in each tract, as well as diabetes rates in different community districts. I joined all of this data to the census tract data so I could make meaningful choropleth maps. Lastly, I employed clustering with my Local Spatial Autocorrelation cluster map, which I performed using GeoDa. For every other map I used the filtering I described earlier and overlaid a few of my maps to reveal underlying patterns.

Results and Analysis

To start the analysis, it's important to understand the distribution of fresh food stores in New York City. **Figure 1** shows roughly how many fresh food stores are in each census tract using equal quantiles.

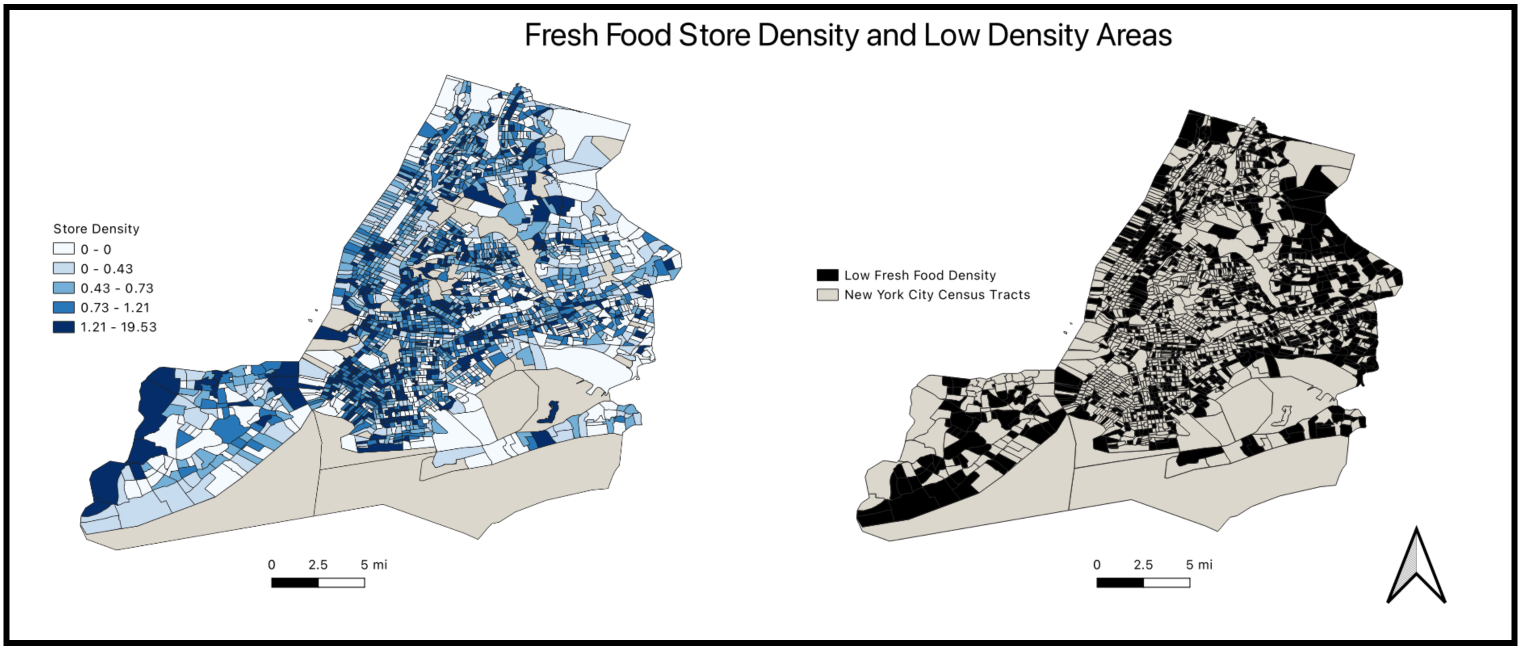
Figure 1. : Fresh Food Stores in New York City Census Tracts Using Equal Quantiles



This map reveals significant variation in fresh food store access across the city. Evidently,there are large areas, particularly around the edges of the city, shown in red that have no fresh food stores. In contrast, there are concentrated areas, particularly in Manhattan that have higher numbers of fresh food stores, as indicated by the blue and green coloring. This visualization helps identify potential food deserts.

In order to visualize where exactly the food deserts are located, I used store density, as mentioned before, calculated as the number of fresh food stores per 1000 residents in each census tract. **Figure 2** displays two maps side by side. The map on the left is showing the distribution of fresh food density using equal quantiles and the map on the right shows us the distribution of low fresh food density areas (characterized as areas with store densities less than 0.42). The map on the left shows the range of fresh food store density from 0 to 19.53 and, as seen in the legend for the left map, the white and lighter blue areas are between 0 and 0.42 for fresh food density; these areas are then mapped separately in the right map to show which areas are at or below 0.42 fresh food density. Lastly, as mentioned before, the areas with less than 100 people living there are taken out of these distributions.

Figure 2. : Fresh Food Store Density and Low Density Areas Using Equal Quantiles

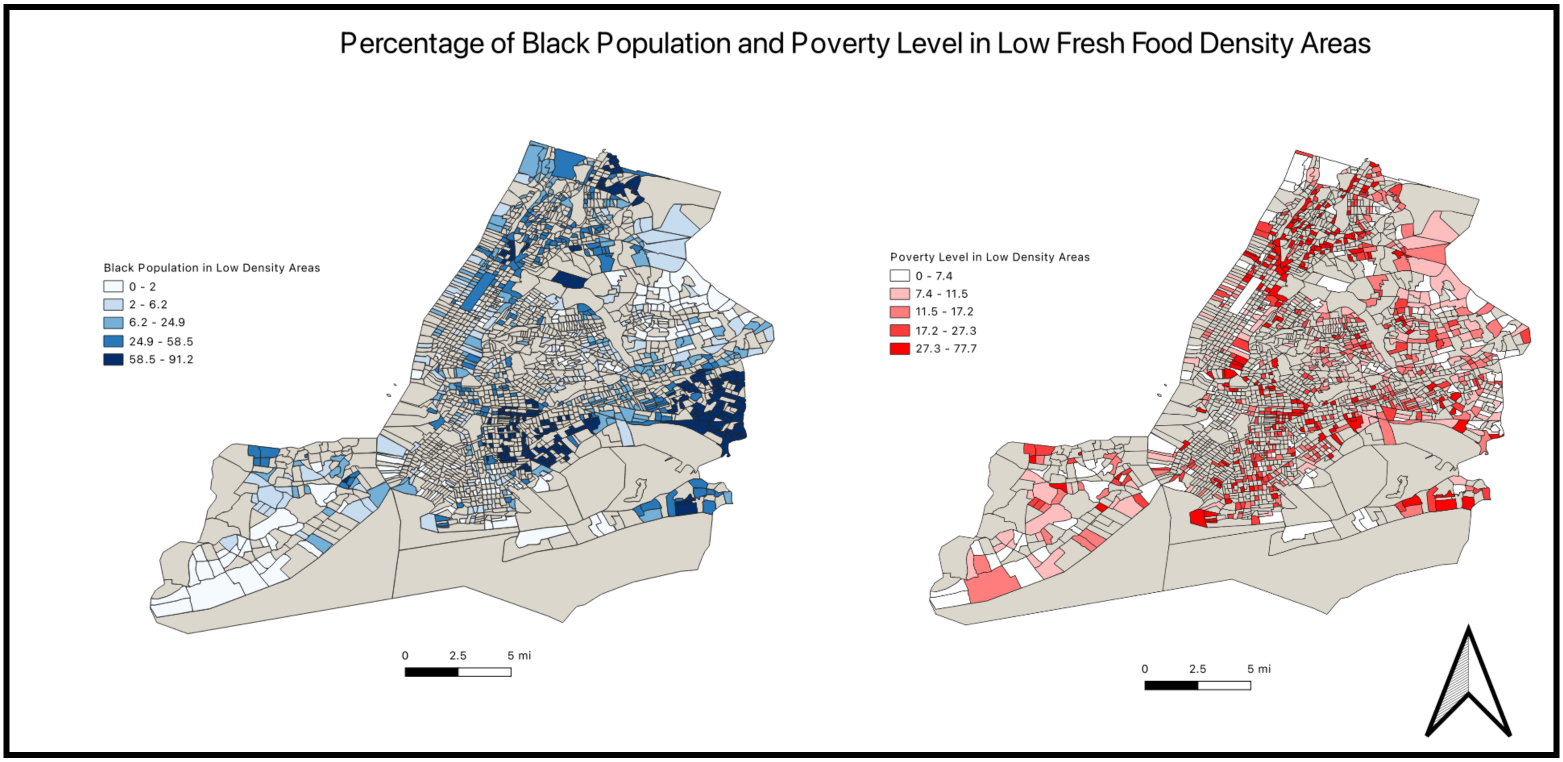


These maps reveal significant food deserts primarily in eastern Queens, southern sections of Brooklyn, large portions of Staten Island, and parts of the Bronx. These areas contrast sharply with the high concentration of fresh food stores in central Manhattan and downtown Brooklyn, highlighting substantial inequities in food access across New York City's boroughs. The distribution pattern suggests that outer boroughs and peripheral neighborhoods face greater challenges in accessing fresh food compared to more central, densely populated areas of the city.

Previous research has highlighted the intersection of race and socioeconomic status with food access disparities. Studies have shown that low-income and predominantly Black neighborhoods often face disproportionate barriers to accessing fresh food retailers (The Annie E. Casey Foundation) To better understand this relationship in New York City, **Figure 3** examines the spatial distribution of poverty rates and Black population across census tracts in relation to areas of low fresh food density.

These maps depict the percentage of Black population and poverty levels specifically within low fresh food density areas of New York City, with both variables displayed using equal quantiles. The left map shows the distribution of Black population, ranging from 0-2% (lightest) to 58.5-91.2% (darkest blue) across census tracts. The right map illustrates poverty levels, with percentages ranging from 0-7.4% (lightest) to 27.3-77.7% (darkest red) in census tracts identified as having low fresh food density. Both of these distributions are placed on the regular New York City census tracts, which are not considered to be low fresh food density areas; the low density areas in **Figure 2**'s right map are what is used for the following two maps in **Figure 3.**

Figure 3. : Demographics in Low Fresh Food Density Areas Using Equal Quantiles



These maps reveal a striking pattern in New York City's food deserts, particularly in how they intersect with race and poverty. The darkest blue areas, indicating high Black population percentages (58.5-91.2%), and the darkest red areas, showing high poverty levels (27.3-77.7%), frequently occur in low fresh food density areas, though not always in the same locations. Notably, many census tracts demonstrate an inverse relationship - areas with lower Black population percentages often show higher poverty rates, and vice versa. This pattern suggests that within food desert areas, residents tend to face at least one of these demographic challenges: either a high concentration of Black residents or significant poverty levels. This relationship is particularly evident in parts of eastern Brooklyn and the Bronx, where some tracts with lower poverty rates have higher Black populations, while nearby tracts might show the opposite pattern. This distribution indicates that limited access to fresh food in New York City disproportionately affects either predominantly Black communities or areas of high poverty, and sometimes both, highlighting a complex interplay between racial demographics, economic status, and food access.

Statistically, these results are also quite interesting. **Figure 4** and **Figure 5** below show different snapshots of the data within the maps we have seen so far. **Figure 4** shows the 5 census tracts with the lowest fresh food store density, not counting any census tracts with 0 fresh food store density, by borough. **Figure 5** compares the average poverty percentage and percentage of Black people per borough within the low fresh food store density areas and compares it to the borough's average poverty percentage and the percentage of Black people overall within the borough.

Figure 4: The 5 Census Tracts with the Lowest Fresh Food Store Density

TRACTCE	Population	Borough	Area (square meters)	Fresh Food Store Density
4400	17222	Staten Island	875,250	0.058
18700	9383	Staten Island	403,495	0.107
27900	8145	Bronx	276,332	0.123
16400	7371	Staten Island	177,384	0.136
40502	7320	Bronx	141,217	0.137

Within this table three of these tracts are in Staten Island and two in the Bronx, with densities ranging from 0.058 to 0.137 stores per square meter. Notably, Staten Island's tract 4400, despite having the largest population (17,222) and area (875,250 square meters) among the five, has the lowest store density. This suggests that even in relatively populous areas, store accessibility can be severely limited. The Bronx tracts, while smaller in both population and area, show slightly higher densities but are still significantly underserved. Importantly, this analysis only considers areas with at least some fresh food access, meaning there are additional census tracts in even more severe situations with no fresh food stores at all.

Figure 5: Poverty and Black Population Statistics per Borough

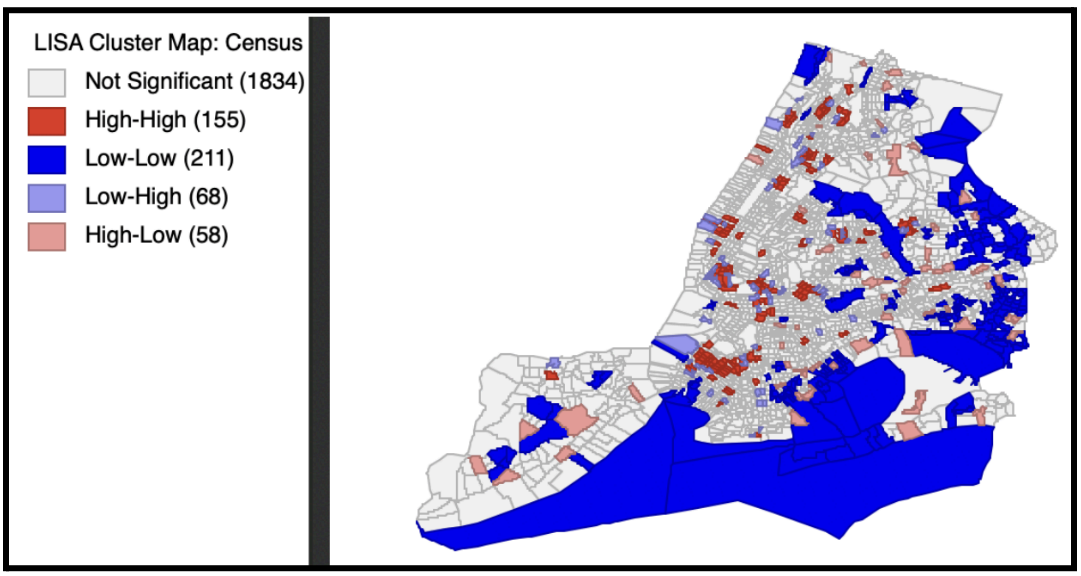
Borough	Borough's Average Poverty Percentage	Average Percentage of Poverty in Low Fresh Food Store Density Areas	Borough's Average Percentage of Black People	Average Percentage of Black People in Low Fresh Food Store Density Areas
Manhattan	23%	14.02%	15.5%	23.62%
Bronx	27.7%	25.82%	28%	34.97%
Brooklyn	19%	21.58%	26%	36.75%
Queens	13.1%	12.91%	16.2%	10.31%
Staten Island	13.2%	18.11%	10%	16.05%

This table reveals significant disparities in poverty and racial demographics across New York City's boroughs, particularly in areas with low fresh food store density. The Bronx shows the highest overall poverty rate (27.7%) and maintains a similarly high poverty rate (25.82%) in its low food density areas. Brooklyn and Staten Island demonstrate notably higher poverty rates in their low food density areas compared to their borough averages (21.58% vs 19% and 18.11% vs 13.2% respectively), suggesting a correlation between poverty and limited food access in these boroughs. Regarding racial demographics, Brooklyn shows the most striking disparity, with 36.75% Black population in low food density areas compared to its 26% borough average. The

Bronx follows a similar pattern (34.97% vs 28%). Manhattan's low food density areas have a significantly higher percentage of Black residents (23.62%) compared to its borough average (15.5%). Interestingly, Queens shows the opposite trend, with a lower percentage of Black residents in low food density areas (10.31%) than its borough average (16.2%). These statistics reinforce the earlier observation that areas with limited fresh food access tend to have either higher concentrations of Black residents or higher poverty rates, and in some boroughs like Brooklyn and the Bronx, both factors are significantly elevated in food desert areas.

Before moving on to the food swamp analysis, I want to include some statistical analysis I performed in GeoDa with the data we have seen so far. First, I performed a Local Spatial Autocorrelation Analysis (LISA) and created a cluster map as seen below in **Figure 6**.

Figure 6: LISA Cluster Map

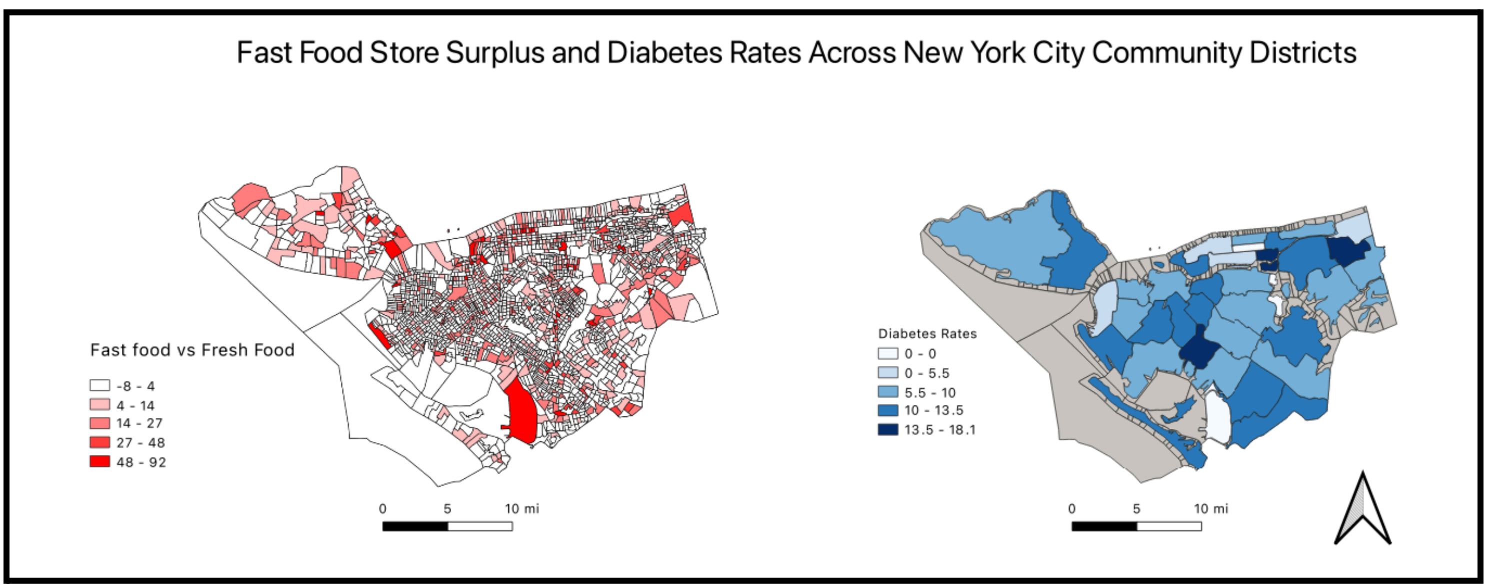


The LISA cluster analysis provides strong statistical evidence that supports our previous findings about food access disparities in New York City. The map displays these patterns through four categories: High-High (areas of high food access clustered together), Low-Low (areas of low food access clustered together), and Low-High/High-Low (areas that differ from their neighbors), with gray areas showing no significant clustering. The significant Low-Low clusters (shown in blue) align with areas we previously identified as having high poverty rates and/or large Black populations, particularly in eastern Brooklyn and parts of the Bronx. Meanwhile, the High-High clusters (in red) correspond to more affluent areas, especially in Manhattan, where we observed lower poverty rates and different demographic patterns. This spatial analysis statistically confirms that limited fresh food access is not randomly distributed but clusters in specific neighborhoods, reinforcing the relationship between race, poverty, and food accessibility in New York City's underserved communities. It is also worth noting that there are census tracts with very few fresh food stores bordering census tracts with a lot of fresh food stores, highlighting inequity and areas of gentrification.

Lastly, I ran a few different spatial regressions and OLS analysis to see how significant the results I saw in my maps are numerically.Statistical analysis reveals significant spatial patterns in fresh food store density across New York City. The spatial regression models demonstrate improved model fit ($R^2 = 0.074$) compared to traditional OLS regression ($R^2 = 0.014$). The models show that for every percentage point increase in Black population, there is a decrease in store density of approximately 0.003 stores ($p < 0.001$), while each percentage point increase in poverty is associated with an increase of about 0.005 stores ($p < 0.01$). The spatial coefficients (Rho = 0.306, Lambda = 0.305, both $p < 0.001$) indicate strong spatial clustering of fresh food access patterns, confirming our LISA analysis findings and demonstrating that food store distribution follows distinct geographic patterns rather than random distribution across the city.

Building upon my analysis of food deserts in New York City, I now turn to examining food swamps - areas characterized by a high density of fast food outlets relative to fresh food stores. Research has shown that food swamps may be stronger predictors of obesity and diet-related health outcomes than food deserts alone (NIH). To investigate this relationship in New York City, I analyzed the differential between fast food and fresh food store counts across community districts and compared these patterns to local diabetes rates. I counted the number of fast food stores in the different census tracts and subtracted the count of recognized healthy food stores from them; this is what is shown in the left map of **Figure 7**. The right map shows the diabetes rates in New York City per community district.

Figure 7. Fast Food Store Surplus and Diabetes Rates Using Equal Quantiles



Looking at the comparison between these two maps reveals concerning patterns in New York City's food environment and health outcomes. The left map shows several areas with significant fast food surpluses, with major food swamps (areas with 27-92 more fast food than fresh food stores) appearing in parts of southern Brooklyn, eastern Queens, and concentrated areas of the Bronx (shown in the darker red shades). The right map displays diabetes rates by community district, with the highest rates (13.5-18.1%, shown in darkest blue) concentrated in similar geographic areas, particularly in eastern parts of the city. There appears to be a spatial correlation between areas with high fast food surpluses and elevated diabetes rates, suggesting that food swamps may contribute to poor health outcomes in these communities. This pattern is particularly evident in areas that were previously identified as having limited access to fresh food, indicating that these neighborhoods face compounded challenges: not only do they lack fresh food options, but they also have an oversaturation of fast food establishments that may contribute to higher diabetes rates.

Discussion and Interpretation

The spatial analysis revealed significant disparities in food access across New York City, largely confirming my initial hypothesis. Based on the research, there are pronounced food deserts in eastern Queens, southern sections of Brooklyn, large portions of Staten Island, and parts of the Bronx. The LISA cluster analysis statistically confirmed these patterns weren't random, with significant Low-Low clusters aligning with areas of high poverty rates and large Black populations.

The relationship between demographics and food access proved more complex than initially hypothesized. While some areas showed both high poverty and large Black populations, many regions demonstrated an inverse relationship - areas with lower Black population percentages often showed higher poverty rates, and vice versa. This suggests that within food-insecure areas, residents typically face at least one of these demographic challenges.

The areas that had many more fast food than fresh food options were located mostly in southern Brooklyn, eastern Queens, and concentrated areas of the Bronx, highlighting the presence of food swamps. The spatial correlation between these food swamps and elevated diabetes rates (13.5-18.1%) in corresponding areas was particularly concerning and revealing about the effects of not having healthy options in a given area.

These findings highlight significant structural inequalities in New York City's food landscape. The concentration of food deserts and swamps in areas with higher poverty rates or larger Black populations suggests systemic barriers to food access that may perpetuate health disparities. The challenge of areas lacking fresh food options while being saturated with fast food establishments creates a particularly difficult environment for maintaining healthy dietary habits.

The correlation between food swamps and higher diabetes rates raises serious public health concerns, suggesting that the mere presence of fresh food stores isn't sufficient - the ratio of healthy to unhealthy food options may be equally important. This has significant implications for public health policy and urban planning, suggesting that initiatives should focus not only on increasing fresh food access but also on regulating the density of fast food establishments in vulnerable areas.

Lastly, several limitations should be considered when interpreting these results. The analysis of fresh food stores relied on filtering a larger dataset that lacked specific store-type identifiers, potentially resulting in some misclassification. The diabetes data was only available at the community district level, providing less granular insight than the census tract-level analysis used for other variables. Additionally, the study didn't account for public transportation access or walking distance to food stores, which could affect actual food accessibility differently than pure density measures suggest.

Conclusion

This analysis demonstrates clear spatial patterns in food access inequality across New York City, strongly supporting my initial hypothesis about the relationship between demographic factors and food access. The major food deserts identified in eastern Queens, southern Brooklyn, Staten Island, and parts of the Bronx, along with significant food swamps in southern Brooklyn, eastern Queens, and the Bronx, correlate strongly with both demographic and health outcome patterns.

The findings suggest a need for targeted interventions in these areas, particularly in communities facing both food desert and food swamp conditions. Based on these results, it is clear that New York City should focus on incentivizing fresh food retailers in identified food desert areas, implementing zoning regulations to limit fast food density in vulnerable communities, developing targeted programs to support healthy food access in areas with high poverty rates and Black populations, and creating initiatives specifically addressing the effects of food swamps and deserts in the most affected communities, particularly in the outer boroughs

This research contributes to our understanding of food access inequality in urban environments and provides a foundation for more targeted, effective interventions to improve food access and public health outcomes in New York City's underserved communities.

References

Annie E. Casey Foundation. (2022). Communities with Limited Food Access in the United States. Retrieved from https://www.aecf.org/blog/communities-with-limited-food-access-in-the-united-states

Anselin, L., Syabri, I., & Kho, Y. (2006). GeoDa: An Introduction to Spatial Data Analysis. Geographical Analysis, 38(1), 5-22.

City of New York. (2024). NYC OpenData. Retrieved from https://opendata.cityofnewyork.us/

Cooksey-Stowers, K., Schwartz, M. B., & Brownell, K. D. (2017). Food Swamps Predict Obesity Rates Better Than Food Deserts in the United States. International Journal of Environmental Research and Public Health, 14(11), 1366.

NYC Department of Health and Mental Hygiene. (2022). Diabetes in New York City. Retrieved from https://www.nyc.gov/assets/doh/downloads/pdf/epi/diabetes_chart_book.pdf

New York State Department of Agriculture and Markets. (2024). Retail Food Stores [Dataset]. Retrieved from https://data.ny.gov/Economic-Development/Retail-Food-Stores/9a8c-vfzj

NYC Department of Health and Mental Hygiene. (2024). Restaurant Inspection Results [Dataset]. Retrieved from https://data.cityofnewyork.us/Health/DOHMH-New-York-City-Restaurant-Inspection-Results/43nn-pn8j

QGIS Development Team. (2024). QGIS Geographic Information System. Open Source Geospatial Foundation Project. Retrieved from http://qgis.org

R Core Team. (2024). R: A language and environment for statistical computing. R Foundation for Statistical Computing, Vienna, Austria.

U.S. Census Bureau. (2022). American Community Survey 5-Year Estimates. Retrieved from https://data.census.gov

U.S. Census Bureau. (2020). TIGER/Line Shapefiles. Retrieved from https://catalog.data.gov/dataset/tiger-line-shapefile-2016-state-new-york-current-county-subdivision-state-based

Walsh, J. (2024). Most common fast food chains in New York. Stacker. Retrieved from https://stacker.com/new-york/most-common-fast-food-chains-new-york