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The Effect of the FRESH Program on Fruit and Vegetable Consumption in NYC

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by

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Abstract

In 2009, the New York City Economic Development Corporation (NYCEDC) launched its "Food Retail Expansion to Support Health" initiative. More commonly known as the FRESH program, this initiative is an ongoing attempt to increase access to healthy and affordable produce in underserved areas - also known as food deserts - in New York City. The program offers financial incentives to food retailers that lower the cost of owning, leasing, developing, and maintaining retail supermarket space.

This study examines whether the installation of these full-service supermarkets has had an effect on fruit and vegetable consumption of New Yorkers. Using data collected by the Department of Health and Mental Hygiene, a difference-in-difference regression with fixed effects was run. Results show that the FRESH program had a small, significant effect on net fruit and vegetable consumption for New Yorkers, but the effect was not equal for all demographic groups.

Introduction

In recent years, unhealthy diets have become a growing public health concern in the United States (ODPHP, 2015). An unhealthy diet, defined by the World Health Federation as one that is high in sugars, saturated and trans fats, low-fiber foods and low in fresh produce, legumes, and whole grains (World Heart Federation), is a risk factor for many preventable illnesses, including diabetes (Psaltopoulou et al., 2010), cancer (Baena Ruiz and Hernandez, 2014), obesity (Wright and Aronne, 2012) cardiovascular diseases (Berra et al., 2011) and more. The CDC estimates that up to 40 percent of deaths in the U.S. are preventable, some of which can be linked to poor dietary habits (CDC, 2014).

Unhealthy diets are especially prevalent in areas known as food deserts, or locations with poor access to fresh and nutritious foods. The official USDA definition of a food desert is that of an area in which 33 percent of the population lives further than one mile away from a supermarket, or 10 miles away for rural communities (USDA, 2019). Another common characteristic of food deserts is their high prevalence of low-income and minority populations (Beaulac et al., 2009).

Low-income neighborhoods are often less equipped with full-service supermarkets - which typically offer a greater variety of fresh and nutritional foods – and are instead overequipped with bodegas, smaller grocers, and fast-food chains (Moore and Diez Roux, 2006, Powell et al., 2007). These establishments are known to sell calorie-dense but nutrient-poor foods, which can potentially lead to adverse health outcomes. Conversely, the presence of neighborhood supermarkets has been previously associated with healthier diets, lower BMIs (Story et al., 2008), as well as increased intake of fruit and vegetables (Larson et al., 2009). Though a causation between proximity to a supermarket and better diet and health outcomes has yet to be established, it is suggested that lack of geographic access to supermarkets that offer a wider variety of

nutritionally dense foods is a key factor in constraining one's food choices, leading to diet-related health problems. The realm of public policy has largely adopted the belief that to combat food deserts, food environments must be changed on a structural level (Couzin-Frankel, 2012). It is thought that encouraging the development of full-service supermarkets and grocery stores in these underserved areas will lead to an improvement in the quality of one's diet, and therefore a decrease in the prevalence of preventable diet-related illnesses.

Among the most well-known of these initiatives is that of the Pennsylvania Fresh Food Financing Initiative (FFFI) (Reinvestment Fund, 2015). Launched in 2004, this public-private hybrid program sought to address the shortage of stores selling fresh, healthy foods in both rural and urban areas of Pennsylvania. By providing grants and loans to decrease the cost of developing and expanding new grocery stores, this initiative improved access to healthy, fresh foods to approximately 500,000 people in the state (Cummins et al., 2014). The FFFI eventually became the blueprint for a nation-wide program: The Healthy Food Financing Initiative, or the HFFI (USDA, 2020). A key prong of the White House Task Force on Childhood Obesity, this initiative provided up to $500 million in aid to dozens of food access expansion programs across the country. Similar programs have emerged in California, Washington D.C., Illinois, Louisiana, Maryland, Michigan, Nevada, Oklahoma, and New York (Kraus, 2019).

The purpose of this paper is to analyze the effect that one of these supermarket installation programs has had on fruit and vegetable consumption in New York City. The Food Retail Expansion to Support Health, also known as the FRESH Program, was part of a multi-pronged approach to improve the health of city residents, especially those living in chronically underserved, low-income neighborhoods that had high rates of diet-related diseases (NYCDCP, 2008). Officially launched in 2009, FRESH offers tax and zoning incentives that reduce the cost of developing and

owning supermarket retail space, thus encouraging retailers to operate full-service supermarkets in under-resourced areas (Chrisinger, 2016). Applicants must meet the following requirements to be eligible for funding: at least 30 percent of the store must be reserved for perishable food products - such as dairy, fresh produce, fresh meats, and frozen foods - and at least 500 square feet of their retail space must be reserved for fresh produce. Potential applicants must also be located within designated FRESH-eligible zones to be considered (NYCEDC, 2020). Initially, FRESH-eligible zones were located in Manhattan, the Bronx, Brooklyn, and Queens. The program has since expanded to include Staten Island. The program boasts an investment of $100 million into the NYC economy and the creation or retention of over 1,600 jobs. Though the program began in 2009, not all supermarkets were installed at this time. Rather, applicants in eligible zones began to apply for funding at the official start of the program. FRESH supermarkets were installed incrementally afterwards, with the first supermarket being installed in 2011, and are still being installed at the time of writing of this paper.

At the time of writing, there have been few rigorous analyses of the effectiveness of the FRESH program insofar as fruit and vegetable consumption of New Yorkers is concerned. There have also been few studies analyzing the effect of an entire supermarket installation program – as opposed to only one supermarket installed in one neighborhood – on dietary choices. The goals of this paper, then, can be seen as twofold. The first goal is to determine whether the FRESH program has indeed improved the dietary health of New Yorkers by increasing their intake of fresh produce. The second is to analyze the effectiveness of several supermarket installations under a policy program on dietary choices, as opposed to the single-supermarket studies typically found in the literature of this topic. These studies are explored in the Literature Review of this paper.

To perform this analysis, restricted data was obtained from the New York City Department of Health and Mental Hygiene's (DOHMH) "Community Health Survey" for the years 2008 to 2018. This survey, conducted annually by the DOHMH, randomly telephones New Yorkers living in all five boroughs to ask them a variety of health-related questions. Survey respondents average between approximately 8,000 to 10,000 per year.

As a first step to the analysis, a difference-in-difference Poisson regression with fixed effects is run to determine the effects of the FRESH program on city-wide fruit and vegetable consumption. Another regression is run to determine the effect of the program on fruit and vegetable consumption in only FRESH-treated neighborhoods. These two groups will be referred to as the "primary samples" of this study.

Later, stratifications are performed to further study the effect that the FRESH program had on distinct demographic groups. Stratifications for gender are performed as it is reasonable to assume that there can be gendered differences in eating habits, as previous studies have found (Kiefer et al., 2005). This gendered trend – namely that of women consuming more fresh produce than men - holds true in NYC (Li et al., 2016). Analyzing both genders separately can provide insight as to whether a program such as FRESH can influence this trend. Stratifications for race are also performed, as a key motivation behind FRESH was to improve access of fresh produce to low-income New Yorkers, many of whom are Black and Hispanic. A separate analysis of these groups is critical in determining whether the program was a success in this regard. Finally, two additional stratifications are performed to drop events that can be deemed as "unusual," the inclusion of which can distort the true effectiveness of the program. The first of these stratifications drops the years of the Financial Crisis, the socioeconomic damage of which directly influenced food insecurity and food prices across the country, from the analysis. The second stratification

drops two late-treated neighborhoods, which had supermarkets installed in 2018, from the analysis. This was to avoid including any temporary abnormalities in shopping habits that can arise from the novelty of a new place of shopping, but which do not represent a lasting or significant change in fruit and vegetable consumption.

Literature Review

Confirming a causal relationship between supermarket installation and a change of dietary habits has proved challenging. Therefore, the consensus on the impact of such intervention programs on one's diet has been mixed. Most previous studies on this topic utilize a difference-in-difference methodology to analyze the effect of one supermarket opening in an area classified as a food desert. In Philadelphia, a study found that the introduction of a single full-service supermarket in a food desert in the city altered neither residents' fruit and vegetable intake nor their BMI after 6 months, nor did many residents adopt the new supermarket as their regular place of shopping (Cummins et al., 2014). However, the study did find that residents' perceptions of food access in the neighborhood was more positive. A similar increase in perceived access to healthy foods was found in a study of a Pittsburgh food desert, as well as a net positive change in residents' neighborhood satisfaction in the intervention neighborhood (Dubowitz et al., 2015). Once again, however, no significant change was found in the consumption of fresh fruit, vegetables, and whole grains, nor was there a significant change in BMI in the intervention neighborhood. Though there was an improvement in some aspects of diet quality - the total consumption of calories, added sugars, and solid fats decreased - these net positive changes were not associated with usage of the new supermarket. A study in the same Pittsburgh food desert found that the treatment neighborhood's food environment did not change drastically because of a supermarket

intervention. With no significant net increase in the availability of healthy foods in the neighborhood, the analysis did not find strong evidence that the supermarket would help induce dietary changes in residents (Ghosh-Dastidar et al., 2017).

In New York, a study analyzing the impact of a FRESH-subsidized supermarket in a Bronx neighborhood on children's diets found neither a significant change in dietary habits nor a significant difference in the availability of healthy and unhealthy foods in their homes after the supermarket opening (Elbel et al., 2015). A similar study also taking place in the Bronx, this time focusing on the shopping and consumption habits of adults, found that while there was a decrease in the consumption of sugar sweetened beverages and carbohydrates associated with the new supermarket, no significant change was found in fruit and vegetable consumption nor the nutritional quality of net food consumed (Elbel et al., 2015).

Another study focused on analyzing the effect of a discount full-service supermarket in a North Carolina food desert found that the intervention neighborhood saw no noticeable change in the consumption of fruit, vegetables, and sugar-sweetened beverages. However, the authors did establish a significant, inverse relationship between distance to a primary grocery store and fruit and vegetable consumption, confirming the intuition that food availability and distance may play a role in one's dietary choices, especially with fresh produce consumption (Jilcott Pitts et al., 2018). But evidence supporting this intuition is mixed: another study concluded that distance to the nearest supermarket was not significantly associated with either fruit or vegetable consumption. However, this cross-sectional analysis had a relatively small sample, was not conducted in the context of a policy change or supermarket installation, and was conducted in England, which may have a different structural explanation for the emergence of food deserts (Pearson et al., 2005). Another study conducted outside of the U.S. found promising results: neighborhood residents of a

former food desert spent slightly more on fresh vegetables and less on meat and prepared foods than shoppers who did not reside in the neighborhood a year after the supermarket opening (Fuller et al., 2015). Still, this study took place in Canada, which may have a different food environment than the U.S., thus decreasing its applicability to American food deserts.

A Boston study found that among low-income residents, distance to a supermarket was not associated with fruit and vegetable consumption, even among those who did *not* live in areas identified as food deserts. Instead, the authors found a positive association between perceived supermarket availability and increased fruit and vegetable intake, suggesting that the perception of one's food environment may be important in determining one's dietary habits (Caspi et al., 2012). Another study that observed the phenomenon of food deserts in the "backwards" direction came to a similar conclusion. When the flooding and closing of a full-service supermarket in a rural town turned the community into a food desert overnight, residents had no choice but to shop at the neighborhood dollar store or travel outside the town for groceries. The analysis concluded that this closing did not alter the dietary habits of the community, but that the re-opening of the store did improve food access and social relations between community members (Campbell et al., 2020).

There have been other investigations into other positive health effects that a full-service supermarket can induce in a neighborhood besides healthier dietary habits. One such study found that an intervention neighborhood not only experienced a decrease in food insecurity, but also fewer diagnoses of high cholesterol and arthritis in community residents (Richardson et al., 2017).

Other papers have questioned the link between proximity and food access. Studies have found that residents of food deserts still purchase most of their food from full-service grocery stores despite not living close to one (Rahkovsky and Snyder, 2015, Drewnowski and Rehm, 2013).

This is echoed by other studies which have determined that most people do not actually shop at the supermarket that is closest to their homes (Dubowitz et al., 2014, Hillier et al., 2011). Others have pointed out that food desert residents still obtain most of their junk food from supermarkets (Vaughan et al., 2016). Findings such as these turn the fundamental intuition behind intervention policies - that lack of access to a full-service supermarket is a risk factor to a poor diet - on its head.

It is important to note that many studies examining the effectiveness of supermarket interventions in underserved neighborhoods are limited in their analyses by time and location. To date, there have been few studies that follow study subjects for more than a few (i.e., more than two to three) years. It is possible that more time is needed to adjust to a new grocery store to see a significant change in one's shopping and eating habits. Many of these studies apply a difference-in-difference methodology, but typically only study the effect of a single full-service supermarket opening in a particular neighborhood. This paper differs from previous literature in that the years of interest span a decade, from 2008 to 2018, in addition to analyzing the effectiveness of a program that has installed several supermarkets that operate in several neighborhoods.

Data and Variables

For the analysis, data were used from the New York City Department of Health and Mental Hygiene (DOHMH). Since 2002, the DOHMH has conducted an annual telephone survey known as the "Community Health Survey." The purpose of this survey is to understand the health behaviors of New Yorkers. Respondents are telephoned randomly across the five boroughs of New York City and are asked approximately 125 questions on a variety of health-related topics. All respondents must be at least 18 years of age to participate in the survey. Identities of respondents

are kept anonymous. As stated previously, observations range between approximately 8,000 and 10,000 respondents per year. This study uses data from 2008 – 2018 for the analysis.

A public-use version of the Community Health Survey exists online for all survey years at the time of writing, 2002 - 2018. Some survey variables, however, are restricted from public use and require a Data Use Agreement (DUA) to access. These variables typically reveal sensitive data about a respondent (such as their current neighborhood of residence, birthplace, and so on) and are restricted to protect their anonymity. Being that this analysis required neighborhood-specific data about respondents for the analysis, a DUA was signed with the NYC Department of Health to obtain those variables. Permission to proceed with this study was obtained by the Hunter College Institutional Review Board. The locations and opening dates of supermarkets supported by the FRESH program were obtained from a representative of the New York City Economic Development Corporation.

The key response variable of this paper is "Nutrition," defined by the CHS codebook as the total servings of fruit and vegetables the survey respondent consumed the day prior to the phone call, thus acting as a proxy for one's average intake of fresh produce. The key explanatory variable of interest is a dummy variable that is equal to one if the neighborhood in question had a new FRESH supermarket installed. The variable also accounts for the year in which the neighborhood saw the supermarket open. It is important to note that not all supermarkets were installed in 2009; rather, the program itself began in 2009. The very first supermarkets were installed in 2011, with supermarkets still being installed incrementally to this day. At the time of writing, 18 projects have completed construction and are open to the public. The evolution of FRESH supermarket openings can be found in **Table 7**.

Other explanatory variables in the regression include year, neighborhood, as well as one's age, sex, race, household size, employment status, imputed household income, whether one has a child, and whether one has a college degree. New York City neighborhoods in the Community Health Survey are organized into 34 categories, following the convention set forth by the United Hospital Fund, or UHF. All variables of interest of this paper were coded by the CHS in discrete terms.

From the survey, approximately 38% of respondents were White, 23% were Black, and 27% were Hispanic. 59% of respondents were female, as can be seen in **Table 1**. The majority of respondents (67%) ate between 1-3 servings of fruit and vegetables the day prior. 11% reported eating no servings the day prior. Unsurprisingly, fruit and vegetable intake drops dramatically after 6 servings, as can be seen in **Table 2.** Individual observations totaled at 101,255. Missing values in some demographic variables accounted for a slight loss in observations when the main regressions were run, as can be seen in the tables.

Methods

The effect of the FRESH program on fruit and vegetable consumption can be analyzed using a difference-in-difference (DiD) model with fixed effects. As previously mentioned, the FRESH program began in 2009, but not all supermarkets were installed at a single point in time. This, in addition to the non-linear nature of the Poisson model, complicates the standard DiD model in which there are two distinct time periods - "before" and "after" - and two distinct observational groups – one untreated in the before period, one treated in the after period. The standard DiD equation is as follows:

$$E [Y | T, G, X] = f (\beta_0 + \beta_1 T + \beta_2 G + \beta_3 TG + X\theta)$$

where T indicates the intervention or treatment period, G indicates the treatment group, and X indicates a set of control variables. The coefficient of β_3 represents the interaction term between the time and group of treatment - therefore representing the treatment or difference-in-difference effect, τ. That this term represents the treatment effect can be proven below. The equation

$$E [Y^0 | T = 1, G = 1, X] = f (\beta_0 + \beta_1 + \beta_2 + X\theta)$$

indicates that no treatment has taken place. Notice the absence of the interaction term. Conversely, the equation

$$E [Y^1 | T = 1, G = 1, X] = f (\beta_0 + \beta_1 + \beta_2 + \beta_3 + X\theta)$$

indicates that treatment has indeed occurred. Finding the difference between these two states reveals the treatment effect:

$$\tau = f (\beta_0 + \beta_1 + \beta_2 + X\theta + \epsilon) - f (\beta_0 + \beta_1 + \beta_2 + \beta_3 + X\theta) = \beta_3$$

The standard DiD model can be applied to the case of staggered entry of treatment groups with some modifications. The equation this analysis implements is as follows:

$$E [Nutrition_{it} | \alpha, \lambda, \delta, \gamma] = P [\beta_0 + \alpha_i + \lambda_t + \delta(FRESH_{it}) + \gamma(C_{it})]$$

where "Nutrition" indicates the total servings of fruit and vegetables eaten the day prior in neighborhoods *i* in years *t,* and "P" represents the function of the Poisson model. To account for the variation in the timing and location of treatment, a full set of year dummies (from 2008 to 2018) and a full set of neighborhood dummies (from UHF-1 to UHF-34) have been added to the equation.

These variables – α_i and λ_t, respectively - control for any changes that occur every year, in every neighborhood in the city, thus allowing for fixed time and location effects.

The policy treatment is represented by $\delta(FRESH_{it})$, where $FRESH_{it}$ is an interaction term between relevant neighborhood and year dummies, α_i and λ_t – the "β_3" of the standard DiD equation. The term $FRESH_{it}$ is equal to 1 for neighborhoods receiving treatment only during years t after the supermarket has been installed and is operating, and 0 otherwise. This dummy variable essentially signals the post-treatment period for every FRESH-treated neighborhood. The coefficient and statistical significance of δ of key interest in this analysis. The set of demographic control variables described in the Data and Variables section are represented by C in the term $\gamma(C_{it})$. The constant term is represented by β_0.

Two main regressions – or "primary samples" were run. In the first regression, all New York City neighborhoods were included, including ones that were *not* treated by a FRESH supermarket. This regression accounts for the FRESH program's impact on fruit and vegetable consumption on a city-wide level, as it is possible that a greater number of full-service supermarkets across the city can lead to spillover effects in fresh produce consumption even for neighborhoods that were not chosen for supermarket installation. It is also possible that one's primary place of food shopping is outside of the neighborhood in which they reside, thus further motivating the need for a regression that analyzes the impact of the FRESH program on all New York City neighborhoods.

In the second regression, only treated neighborhoods were included. This regression accounts for the impact of the FRESH program in underserved neighborhoods - in other words, neighborhoods that the policymakers of FRESH were most interested in. This regression acts as, in a sense, the "true" treated group. Still, it is important to note that even by the end of the study

period of this paper, some neighborhoods approved for FRESH installations did not yet see supermarket openings in their neighborhood at the time of writing, for reasons such as construction not having begun at all, or construction still being in progress. Additionally, other neighborhoods were still in the process of being reviewed for FRESH eligibility. The staggered nature of policy implementation makes separating such a "true" treatment group difficult. Therefore, this second primary regression only includes only neighborhoods that saw a FRESH supermarket opening in the area and excludes neighborhoods that were approved for treatment at some point in the future, but did not see a supermarket opening in the area. The implications of this construction are explored in the Discussion section of this paper.

In the framework of the Poisson model, the interpretation of coefficient β_3 can be interpreted as the percent change in fruit and vegetable consumption as a result of FRESH treatment, when $\beta_3 = 1$. Average marginal probability effects for policy treatment across all observations are also calculated. On a technical level, marginal effects calculate the derivative of predicted probabilities with respect to policy treatment for every observation in the regression. Then, the average of those derivatives is calculated. For interpretation of the estimation tables, the marginal interpretation of coefficients can be interpreted as the incremental additional daily servings of fruit and vegetables as a result of FRESH treatment, or when the interaction variable β_3 or $FRESH_{it} = 1$.

The analysis was later stratified further to observe the impact of the program, taking into account one's sex and race. As per previous studies, we can expect to see a difference between male and female eating habits, as women have been found to consume more fruit, vegetables, and generally healthier foods than men do (Kiefer et al., 2005). It is also important to analyze race, as one motivation behind the development of food access programs such as FRESH was to address

the diet-related health disparities that disproportionately affect Black and Hispanic residents living in poorer, underserved areas (NYC DOHMH, 2010). As the Department of Health has found that health disparities between races continue to exist even when accounting for neighborhood residency and income, we can expect to see a difference in health-related behaviors among Black, Hispanic, and White peoples. To ensure that any changes in neighborhood fruit and vegetable consumption are not obscured by White residents and falsely attributed to other demographics, the variable "White" is also included in this stratification. Like the previous one, this sub-analysis will provide a more accurate estimation of the program's effect on different New York City residents.

Two additional stratifications were run to take unusual events into account. One of these stratifications dropped what were deemed as "unusual years" – the worst years of the Financial Crisis, 2008-2009 - from the analysis. Both food insecurity (USDA, 2009) and household food spending (USDA, 2018) worsened significantly during these years as a result of the crisis. Due to the unique nature of these years, dropping them from the analysis can provide clearer evidence of the true effectiveness of the FRESH program, free from country-wide economic turmoil. Another stratification performed on an event deemed as "unusual" was that of dropping neighborhoods that saw their supermarkets installed in 2018, or "late" for the sample years available. The reasoning behind dropping late-treated neighborhoods is as follows: first, it can be hypothesized that less than a year (2018 supermarkets were opened during the summer months) is not sufficient time to see a meaningful change in fruit and vegetable consumption. It could also be hypothesized that a new supermarket can lead to a momentary shift in shopping habits due to the novelty of a new shopping environment, but that one's habits may return to normal after a few initial trips. Dropping late-treated neighborhoods can prevent any temporary increases of fresh produce consumption from artificially shifting the results.

Finally, all stratifications listed above were run once again with one modification: all non-treated neighborhoods were dropped from the analysis. This is to estimate the impact of FRESH with the above stratifications in mind, but specifically for the underserved neighborhoods that the program is primarily meant to target.

Results

Results from the primary sample can be viewed in **Table 3**, with all New York City neighborhoods in Column 1 and marginal effects in Column 2, and only FRESH-treated neighborhoods in Column 3 with marginal effects in Column 4. For both categories, the effect of FRESH supermarket installation on fruit and vegetable consumption is positive and significant at $p<0.01$, or the 1 percent level. The interpretation of the coefficients is as follows: all New York City neighborhoods saw a 3.1 percent increase in fruit and vegetable consumption, while only treated NYC neighborhoods saw a 4 percent increase in fruit and vegetable consumption. The marginal effects can be interpreted as follows: all residents in New York City neighborhoods ate .075 additional daily servings of fresh fruit and vegetables, while residents in treated neighborhoods ate an additional .088 daily servings.

When results are further stratified into sex, race, and unusual events, a more nuanced story emerges. We see that in **Table 4**, the effect of FRESH supermarket installations was only statistically significant for females, who ate 3.5 percent more servings because of intervention, but not for males. In **Table 5,** we observe the effects of one's race - Black, Hispanic, and White, respectively - along with the intervention. We can see that FRESH supermarkets were statistically significant at the for Black survey respondents at the $p<0.1$, or the 10 percent level. We see no statistically significant effect for Hispanics. We also see statistical significance at the $p<.05$, or the

5 percent level, for White respondents. Stratifications were also run to ensure that results were not skewed by unusual years and late-treated neighborhoods, which can be observed in **Table 6.** Fruit and vegetable consumption as a result of intervention remains positive and significant.

Finally, an attempt was made to run these stratifications on treated neighborhoods only. However, the results of these stratifications in treated neighborhoods were inconsistent and skewed. This is most likely due to a much smaller sample size in which significance can be detected.

Discussion

This study has a number of limitations. All survey data were self-reported, so it is possible that survey respondents did not accurately report their fruit and vegetable intake. The survey did not specifically ask respondents where they obtained their foodstuffs nor where their primary place of shopping is. That this information is missing is significant, as there is currently no consensus in the literature that residents of an intervention neighborhood change their primary place of shopping to the new supermarket. Had this data been included in the survey and a stronger connection been found between fruit and vegetable consumption and frequenting FRESH supermarkets, more evidence would exist in favor of supermarket intervention policies. Another limitation is that of uncertainty surrounding the movement of people who move in and out of FRESH-designated neighborhoods. For example, had a significant number of college-educated White women moved to these neighborhoods at the time of a FRESH supermarket opening, it is possible that the fruit and vegetable consumption of this demographic would have been higher than the average resident in the neighborhood. Such a change would have artificially inflated the consumption of the entire neighborhood as a result of a compositional change to the neighborhood, but not as a result of the FRESH program. Future studies would do well to attempt to capture such compositional changes.

Another limitation is that of potential bias in the primary samples. As stated previously, some to-be-treated neighborhoods that were approved for supermarket installations were not included in the second primary regression. Dropping such neighborhoods – which, at least by FRESH eligibility standards, are similar to those that actually received treatment - can potentially lead to bias in the estimation results. Future studies would also do well to categorize neighborhoods more finely for analysis.

Despite these limitations, this analysis contradicts many previous studies done on this topic. The analysis confirms that fruit and vegetable consumption among New York City residents, regardless of whether they resided in a treated or untreated neighborhood, increased following FRESH intervention. There are some explanations as to why this might be the case. As mentioned, the FRESH program requires that a certain amount of space must be reserved for perishable food products and fresh produce. This is a key element of the program that may have significant effects on one's dietary choices, as previous studies have found that people living in food deserts already do most of their food shopping for both healthy *and* unhealthy foods at full-service supermarkets (Vaughn et al., 2016). Full-service supermarkets, even if they are well-stocked with fresh produce, often stock unhealthy or "junk" foods as well as healthier options (Elbel et al., 2015). Previous authors have also discussed the dangers of an overrepresentation of unhealthy food options in a neighborhood "cancelling out" the potential positive effects of opening a full-service supermarket (Jilcott Pitts et al., 2018). Obligating owners to dedicate a portion of their stores towards healthier foodstuffs may be a strategy to replicate for future intervention programs. Additionally, the fact that the primary regressions for both all NYC neighborhoods and treated-only neighborhoods yielded similar outcomes is comforting insofar as fear of bias is concerned.

When stratified on gender, we see that the policy had a stronger effect on females than on males. This result confirms the earlier statement that females are typically more health-conscious and eat more fresh produce than males, and also suggests that gendered differences in dietary habits remain even when a new place of food shopping is introduced to one's food environment (Harvard Medical School, 2019). When stratified for one's race, we see that, as expected, treatment did not have an equal effect on White, Black, and Hispanic people. The policy had the strongest effect on White residents, a smaller but still significant effect on Black residents, but no effect for Hispanic ones. A similar result was found in an Oregon study, where a new supermarket opened in a racially and socio-economically mixed, gentrifying neighborhood that did not have one previously (Sullivan, 2014). The study found that White people were 3.5 times more likely to frequent the new supermarket weekly than non-White people. The supermarket in question was not a "standard" supermarket (the market specialized in organic and sustainably sourced foodstuffs), and therefore not representative of the kinds of supermarkets that were opened as a result of the FRESH program in NYC. However, the study argued that supermarket installations in food deserts may manifest into what Sullivan calls "food mirages." These are neighborhoods where full-service food markets are newly present, but where more vulnerable, low-income, or minority populations do not reap the benefits. Nevin Cohen of the CUNY Urban Food Institute has warned of the possibility of gentrification as a result of programs such as FRESH (Cohen, 2018). Since the FRESH program was partly founded with the goal of improving access to fresh, healthy produce to these communities, more attention must be paid towards ensuring these key demographics are served. While there is no clear explanation as to why the program was significant for Black people but not for Hispanics, Cohen argues that it is possible that policymakers underestimate the availability of nutritionally dense and culturally appropriate food sold by

retailers other than large chain supermarkets. Retailers such as smaller grocers and ethnic markets may be better suited to meet the needs of different demographics rather than conventional, "Anglicized" chain supermarkets. Indeed, previous studies have found that people's perceptions of food with cultural significance influences their shopping habits (Pearson et al., 2005, Zenk et al., 2013). One study found that Latino immigrant shoppers purchased fresh produce so long as it was of a familiar, specific type, and were less receptive to purchasing unfamiliar produce (Fish et al., 2013). Another study found that significantly more Hispanic shoppers shopped at specialty ethnic food stores than non-Hispanics, and that food selection was the most frequent reason given for shopping at such stores (Palmer et al., 2020). While the sample sizes for these studies were small, the findings suggest that one's cultural background plays a role in one's food shopping decisions and may explain why Hispanic residents did not appear to alter their fruit and vegetable consumption as a result of FRESH stores opening.

Conclusion

More research is needed to better understand the relationship between geographic access, shopping habits, diet, and health outcomes. More research is also needed to understand the relationship between one's race, gender, location, movement, and cultural background and supermarket intervention programs. Studies examining residents' supermarket choices and shopping behavior can better elucidate the effectiveness of FRESH-style intervention programs, and more studies must also examine which demographics are benefiting the most as a result of these interventions. Research such as this will allow for policymakers and stakeholders to architect optimal programs for their constituents.

Tables and Figures

Table 1: Summary Statistics of Key Demographics

	Obs	Mean	Std. Dev.	min	max
Female	101255	.587	.492	0	1
Male	101255	.412	.492	0	1
White	101255	.38	.485	0	1
Black	101255	.226	.418	0	1
Hispanic	101255	.272	.445	0	1

Table 2: Total Servings of Fruit and Vegetables Consumed Day Prior

Total Servings	Freq.	Percent	Cum.
0	11063	11.20	11.20
1	21388	21.66	32.86
2	26104	26.43	59.29
3	18727	18.96	78.25
4	10035	10.16	88.41
5	5944	6.02	94.43
6	2726	2.76	97.19
7	1080	1.09	98.29
8	750	0.76	99.05
9	227	0.23	99.28
10	365	0.37	99.65
11	50	0.05	99.70
12	85	0.09	99.78
13	29	0.03	99.81
14	26	0.03	99.84
15	39	0.04	99.88
16	8	0.01	99.89
17	4	0.00	99.89
18	3	0.00	99.89
19	3	0.00	99.90
20	28	0.03	99.92
21	3	0.00	99.93
22	2	0.00	99.93
23	7	0.01	99.94
24	2	0.00	99.94
25	12	0.01	99.95
27	1	0.00	99.95
28	1	0.00	99.95
30	12	0.01	99.96
32	3	0.00	99.97
33	2	0.00	99.97
34	1	0.00	99.97
35	2	0.00	99.97
40	6	0.01	99.98
43	1	0.00	99.98
44	1	0.00	99.98
45	3	0.00	99.98
47	2	0.00	99.99
48	1	0.00	99.99
50	11	0.01	100.00
51	1	0.00	100.00
52	1	0.00	100.00
Total	98759	100.00	

Table 3: The Estimated Effect of the FRESH Program on Fruit and Vegetable Servings Consumed, Treated and Untreated Neighborhoods

	All UHFs	M.E.	Fresh UHFs	M.E
FRESH Treatment	0.031***	0.075***	0.040***	0.088***
	(0.009)	(0.022)	(0.011)	(0.025)
Age: 25-44	0.046***		0.032**	
	(0.015)		(0.015)	
Age: 45-64	0.081***		0.075***	
	(0.015)		(0.022)	
Age: 65+	0.084***		0.068***	
	(0.017)		(0.025)	
College Graduate	0.171***		0.177***	
	(0.008)		(0.014)	
Female	0.139***		0.105***	
	(0.008)		(0.012)	
Black	-0.189***		-0.190***	
	(0.013)		(0.024)	
Hispanic	-0.225***		-0.221***	
	(0.015)		(0.024)	
Has Child	0.010		0.015	
	(0.007)		(0.010)	
Household Size	0.009***		0.007***	
	(0.003)		(0.002)	
Employment Status	-0.022***		-0.022***	
	(0.003)		(0.005)	
Household Income	0.043***		0.044***	
	(0.003)		(0.007)	
Constant	0.595***		0.522***	
	(0.021)		(0.036)	
Observations	94467	94467	39216	39216

Standard errors in parentheses
* p < 0.1, ** p < 0.05, *** p < 0.01
Dummies for individual years and UHF neighborhoods not shown

Table 4: The Estimated Effect of the FRESH Program on Fruit and Vegetable Servings Consumed for Males and Females

	Female	M.E	Male	M.E
FRESH Treatment	0.035**	0.089**	0.022	0.050
	(0.015)	(0.039)	(0.014)	(0.033)
Age: 25-44	0.087***		0.006	
	(0.022)		(0.022)	
Age: 45-64	0.127***		0.039**	
	(0.022)		(0.020)	
Age: 65+	0.133***		0.040*	
	(0.024)		(0.022)	
College Graduate	0.178***		0.163***	
	(0.012)		(0.011)	
Black	-0.201***		-0.175***	
	(0.015)		(0.018)	
Hispanic	-0.252***		-0.181***	
	(0.017)		(0.016)	
Has Child	0.019**		0.008	
	(0.009)		(0.014)	
Household Size	0.010***		0.006	
	(0.004)		(0.005)	
Employment Status	-0.021***		-0.022***	
	(0.005)		(0.005)	
Household Income	0.045***		0.040***	
	(0.003)		(0.005)	
Constant	0.674***		0.660***	
	(0.030)		(0.034)	
Observations	55462	55462	39005	39005

Standard errors in parentheses
* p < 0.1, ** p < 0.05, *** p < 0.01
Dummies for individual years and UHF neighborhoods not shown

Table 5: The Estimated Effect of the FRESH Program on Fruit and Vegetable Servings Consumed for Black, Hispanic, and White Residents

	Black	M.E	Hispanic	M.E	White	M.E
FRESH Treatment	0.037*	0.081*	0.004	0.008	0.035**	0.103**
	(0.020)	(0.043)	(0.017)	(0.033)	(0.015)	(0.044)
Age: 25-44	0.163***		-0.021		0.052**	
	(0.026)		(0.026)		(0.021)	
Age: 45-64	0.232***		-0.011		0.073***	
	(0.024)		(0.029)		(0.020)	
Age: 65+	0.215***		0.051		0.063**	
	(0.030)		(0.031)		(0.025)	
College	0.171***		0.252***		0.154***	
	(0.017)		(0.015)		(0.011)	
Female	0.124***		0.071***		0.189***	
	(0.018)		(0.012)		(0.008)	
Has Child	0.014		0.018		0.021*	
	(0.022)		(0.014)		(0.011)	
Household Size	0.003		0.008*		0.012***	
	(0.007)		(0.005)		(0.004)	
Employment Status	-0.014**		-0.029***		-0.019***	
	(0.007)		(0.006)		(0.005)	
Household Income	0.043***		0.030***		0.048***	
	(0.006)		(0.005)		(0.005)	
Constant	0.316***		0.432***		0.572***	
	(0.038)		(0.049)		(0.030)	
Observations	21486	21486	26216	26216	35418	35418

Standard errors in parentheses
$^{*}p < 0.1$, $^{**}p < 0.05$, $^{***}p < 0.01$
Dummies for individual years and UHF neighborhoods not shown

Table 6: The Estimated Effect of the FRESH Program on Fruit and Vegetable Servings Consumed for Unusual Events

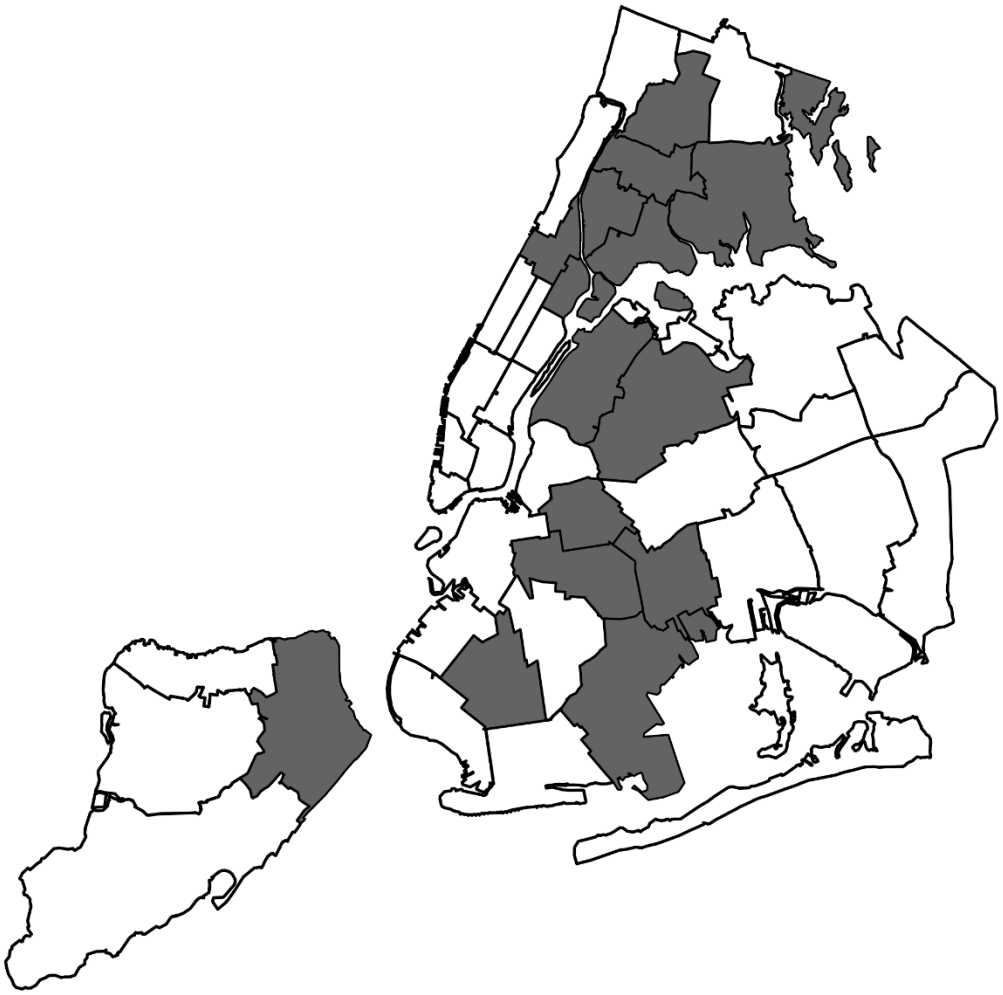
	No Recession	M.E	No Late UHFs	M.E
FRESH Treatment	0.027***	0.065***	0.033***	0.081***
	(0.009)	(0.021)	(0.010)	(0.024)
Age: 25-44	0.038**		0.047***	
	(0.015)		(0.016)	
Age: 45-64	0.070***		0.081***	
	(0.016)		(0.016)	
Age: 65+	0.070***		0.085***	
	(0.017)		(0.018)	
College	0.169***		0.167***	
	(0.008)		(0.008)	
Female	0.137***		0.141***	
	(0.008)		(0.009)	
Black	-0.188***		-0.182***	
	(0.013)		(0.011)	
Hispanic	-0.216***		-0.222***	
	(0.015)		(0.016)	
Has Child	0.018**		0.010	
	(0.009)		(0.008)	
Household Size	0.006**		0.009***	
	(0.003)		(0.003)	
Employment Status	-0.026***		-0.023***	
	(0.003)		(0.003)	
Household Income	0.044***		0.042***	
	(0.003)		(0.003)	
Constant	0.713***		0.595***	
	(0.022)		(0.022)	
Observations	78697	78697	87872	87872

Standard errors in parentheses
* p < 0.1, ** p < 0.05, *** p < 0.01
Dummies for individual years and UHF neighborhoods not shown

Table 7: FRESH Supermarkets Operating in NYC, 2008 – 2018

Year	# of FRESH Supermarkets Operating
2008	0
2009	0
2010	0
2011	1
2012	3
2013	4
2014	8
2015	10
2016	13
2017	14
2018	18

Figure 1: Map of FRESH-Treated NYC Neighborhoods, 2008 – 2018



Shaded regions indicate FRESH policy treatment

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