

**SHIFTING FROM INDIVIDUAL TO COMMUNITY MEASURES: THE IMPACT
OF THE
HEALTHY CORNER STORES INITIATIVE ON OBESITY RATES IN
WASHINGTON, DC**

by
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Abstract

In recent years local health departments have worked to address the impacts of food insecurity through environment-based food intervention programs. Program evaluations on intervention effectiveness typically focus on the individual-level impacts of these programs through measurements like store inventory and consumer purchasing patterns. This research expands the scope of these evaluations by examining the impacts of Washington, DC's Healthy Corner Stores Initiative on ward-level obesity rates. A difference-in-differences estimator was used to capture changes in average adult obesity rates by ward before and after the program's implementation. Although customer survey data suggests that consumers are purchasing fresh produce through participating stores, this research shows that, on the community level, this program has not had a measurable impact on average adult obesity rates. This finding is at odds with past findings of environment-based food intervention programs, suggesting that evaluating these programs on the community level instead of the individual level can lead to contradictory conclusions.

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Introduction

Where an individual lives plays a role in the types of foods they have access to, and in turn, their health. In Washington, DC in 2018, for example, there were six neighborhoods that were food deserts, with no access to a grocery store or corner store, and 17 that were food swamps, with only access to corner stores, fast food restaurants, and liquor stores.¹ In areas like these, lack of access to affordable, nutritious foods can lead to negative health outcomes, including high obesity rates. The prevalence of food deserts and magnitude of community-level obesity rates are not equally distributed throughout Washington, DC – in the city’s eight wards, those areas with lower grocery store access also have higher average rates of obesity.

This problem is not unique to Washington, DC. Local health departments in cities throughout the United States have been working to address disparities in access to healthy foods, and the associated negative health externalities, by implementing food environment-based intervention programs.² In these programs, interventions are used to provide fresh produce to corner stores in areas with low grocery store access. The goal of these programs is to increase access to and purchasing of healthy foods, leading to better health outcomes. Past program evaluations of these interventions, including in Washington, DC, have focused on changes in store inventory and consumer purchasing

¹ Milloy, Courtland. 2020. *A D.C. nonprofit is bringing healthier options to neighborhood corner stores*. February 4. https://www.washingtonpost.com/local/a-dc-nonprofit-is-bringing-healthier-options-to-neighborhood-corner-stores/2020/02/04/0a7f92b2-475d-11ea-bc78-8a18f7afcee7_story.html .

² Dannefer, Rachel, Donya A. Williams, Sabrina Baronberg, and Lynn Silver. 2012. "Healthy Bodegas: Increasing and Promoting Healthy Foods at Corner Stores in New York City." *American Journal of Public Health* e27-e31.; Song, Hee-Jung, Joel Gittelsohn, Miyong Kim, Sonali Suratkar, Sangita Sharma, and Jean Anliker. 2009. "A corner store intervention in a low-income urban community is associated with increased availability and sales of some healthy foods." *Public Health Nutrition* 2060-2067.

patterns after program implementation.³ Through these evaluations, these programs are often found to be effective on the individual level. In Washington, DC, for example, 64% of customers surveyed in an intercept survey stated that the improved produce access at participating corner stores contributed to them eating more nutritious foods.⁴ What existing research does not capture, however, is if these programs also have an impact on community level health indicators, like average obesity rates.

This research expands the focus of these program evaluations by measuring the impact of Washington, DC's Healthy Corner Stores Initiative on the community level instead of the individual level. To do so, average obesity rates were collected on the ward level in the five years leading up to the program's implementation, and the first five years after it began. As not all eight of Washington, DC's wards have corner stores participating in the program, a difference-in-differences estimator was used to estimate changes in average obesity rates in response to the program while also controlling for differences in average obesity rates across wards before the program was implemented.

Although average obesity rates throughout the city did fall during the period of study, this research found that the presence of participating corner stores did not have a statistically significant impact on these changes. More specifically, obesity rates in wards with participating stores fell from 29.0% to 28.4%, while obesity rates in wards without participating stores fell from 11.9% to 11.8%. This finding was consistent when controlling for race, poverty, and education, as well as when including ward-based fixed effects.

³ Ibid.

⁴ Snelling, Anastasia, Erin Watts, Rachel Albershardt, Hugo Van Dyke, and Neil Kpamegan. 2017. *DC's Healthy Corner Store Program: An Evaluation 2014-2016*. Washington, DC: American University Department of Health Studies.

There are multiple areas of interest for future research based on these findings. For studies focusing specifically on Washington, DC and the Healthy Corner Stores Initiative, additional years of data could be included to understand if the program begins to be effective after it has been in place for a longer period of time. The scope of this study could be expanded by collecting survey data on consumer behaviors surrounding visiting corner stores to better understand the characteristics of those who do and do not shop at or purchase produce from participating stores. Studies similar to this one should also be conducted in other cities with environment-based food intervention programs like the Healthy Corner Stores Initiative. This will expand understanding of the overall effectiveness of these programs, including if they, like the Healthy Corner Stores Initiative, are showing impacts on the individual level but not the community level.

Literature Review and Theoretical Framework

Literature Review

Food Insecurity, Food Deserts, and Food Swamps

Food insecurity is when an individual's intake of food or overall eating pattern is disrupted because of a lack of resources.⁵ While food insecurity is found throughout the country, it is not evenly distributed on the national, state, or local level. Where an individual lives can impact if they are physically able to consistently access affordable, nutritious foods.⁶ This is commonly experienced in urban, rural, and low-income areas that do not have full supermarkets or grocery stores that can be reasonably accessed by

⁵ Office of Disease Prevention and Health Promotion. 2020. *Food Insecurity*. September. <https://www.healthypeople.gov/2020/topics-objectives/topic/social-determinants-health/interventions-resources/food-insecurity>

⁶ Office of Disease Prevention and Health Promotion, *Food Insecurity*.

foot, car, or public transit. Locations where residents can struggle with accessing healthy, reasonably priced food are food deserts.⁷ Similarly, areas with large numbers of food retailers selling unhealthy food options, like convenience stores and fast-food restaurants, are food swamps.⁸

Individuals living in socioeconomically disadvantaged communities typically have lower rates of fruit and vegetable consumption.⁹ In food deserts and food swamps people often rely on smaller stores, like convenience and corner stores, to purchase their food.¹⁰ While supermarkets typically have large amounts of healthy foods, including fresh produce, available at reasonable prices, convenience stores often sell high calorie foods and little fresh produce.¹¹ This lack of access can prevent people from consuming the recommended amounts of fruits and vegetables.¹² Past research has identified links between supermarket access, convenience store access, and obesity rates. In eastern Massachusetts, Lopez found that those with a supermarket in their community were 11% less likely to be obese than those without a supermarket.¹³ In New Orleans, after controlling for gender, race and ethnicity, poverty, age, education, physical activity, and television viewing, Bodor et al. found that supermarket access was negatively associated with obesity rates, while convenience store and fast food restaurant access was positively associated.¹⁴ In a study in the southern United States, Morland and Evenson found that an

⁷ Office of Disease Prevention and Health Promotion, *Food Insecurity*.

⁸ Snelling, et al., "DC's Healthy Corner Stores Program."

⁹ Hosler, Akiko S., Deepa T. Rajulu, Bonnie L. Frederick, and Adrienne E. Ronsani. 2008. "Assessing Retail Fruit and Vegetable Availability in Urban and Rural Underserved Communities." *Preventing Chronic Disease* 1-9.

¹⁰ Office of Disease Prevention and Health Promotion, *Food Insecurity*.

¹¹ Bodor, J. Nichola, Janet C. Rice, Thomas A. Farley, Chris M. Swalm, and Donald Rose. 2010. "The Association between Obesity and Urban Food Environments." *Journal of Urban Health* 771-781.

¹² Hosler, et al, "Assessing Retail Fruit and Vegetable Availability."

¹³ Lopez, Russ P. 2012. "Neighborhood Risk Factors for Obesity." *Obesity* 2111-2119.

¹⁴ Bodor, et al., "The Association Between Obesity."

area's obesity prevalence is reduced if that area has at least one supermarket, and that obesity prevalence is also lower in areas with at least one limited service restaurant or specialty food store. Alternatively, the authors found that obesity prevalence is higher in areas with at least one independently owned grocery store or convenience store with a gas station, or with more than one fast food restaurant.¹⁵

Food insecurity, food deserts, and food swamps are all present throughout Washington, DC. Between 2016 and 2017 almost 15% of households in the District did not have enough money to buy food in the past year.¹⁶ Many of those suffering in the District live in specific areas of the city. In 2018 the *Washington Post* identified six neighborhoods that were food deserts, and 17 that were food swamps.¹⁷ There have been ongoing efforts by the DC government and aid organizations to try and mitigate these food access issues. Local charities, including D.C. Central Kitchen, have also established programs reaching out to vulnerable, food insecure groups in the city.

Environment-Based Food Intervention Programs

Low income, urban communities are less likely to have access to supermarkets than higher income suburban communities. As store proximity affects shopping patterns, this can lead to higher rates of issues associated with lack of supermarket access, like obesity, in these urban locations.¹⁸ Recently, there has been a push to reshape these

¹⁵ Morland, Kimberly B., and Kelly R. Evenson. 2009. "Obesity prevalence and the local food environment." *Health Place* 491-495.

¹⁶ Rosso, Randy. 2018. *Food Hardship in America: A Look at National, Regional, State, and Metropolitan Statistical Area Data on Household Struggles With Hunger*. Washington, DC: Food Research & Action Center.

¹⁷ Milloy, Courtland. *A D.C. nonprofit is bringing healthier options to neighborhood corner stores*.

¹⁸ Bodor, et al., "The Association Between Obesity."

neighborhood food environments in an effort to improve food access and reduce obesity prevalence. New York City's Healthy Bodegas Initiative works with corner stores in high poverty areas of the city, offering ways to sell and promote healthy foods, and community support to ensure that residents purchase these healthier options. Dannefer et al. found that 78% of corner store owners participating in the Healthy Bodegas Initiative reported that the program helped them sell greater amounts of healthy foods, and that there was a six percentage point increase, from 6% to 12%, in those who bought at least one bottle of water, and an 11 percentage point increase, from 5% to 16%, in those who purchased healthier options.¹⁹ In Baltimore, the Baltimore Healthy Stores program worked with store owners to increase the stocking and sale of healthy foods. Song et al. found that stores participating in the program had increases in the sales of the healthy foods being tracked in the study, including low-sugar cereals, whole wheat bread, and 100% fruit juices during the study period, while non-intervention stores had a decrease in the sale of these products during the same time period.²⁰ Similar programs can be found in numerous other cities throughout the country, including Philadelphia, Los Angeles, San Francisco, and Washington, DC.²¹

A local Washington, DC nonprofit, D.C. Central Kitchen (DCCK), started the Healthy Corner Stores Initiative in 2011. The goal of the program is to increase the availability of healthy foods in DC food deserts. To do this, the program sells produce to corner stores in low-income areas at wholesale rates, so that these stores can sell fresh

¹⁹ Dannefer, et al., "Healthy Bodegas"

²⁰ Song, et al., . 2009. "A corner store intervention in a low-income urban community is associated with Increased availability and sales of some healthy foods."

²¹ Snelling, et al., "DC's Healthy Corner Stores Program."

fruits and vegetables at below-market prices to their community members.²² DCKK partnered with American University's Department of Health Studies to evaluate the program's effectiveness and impacts. Using customer intercept surveys from 2014-2016, Snelling et al. found that 64% of those surveyed said that the access to fruits and vegetables at the store contributed to them eating healthier, and 58% said that, of all the fruit and vegetables they consumed, some, most, or all came from a participating corner store.²³

When evaluating the effectiveness of these corner store-based food intervention programs, past evaluations have utilized customer intercept and store owner interviews to measure any changes in behavior associated with these interventions. The effectiveness of the Baltimore Healthy Store's intervention was measured using a Store Impact Questionnaire, records of weekly food sales, and unstructured customer interviews, and New York's Healthy Bodegas Initiative was measured with in-store purchasing observations and store owner and consumer surveys.²⁴ Similarly, the effectiveness of the DC Healthy Corner Stores Initiative was measured using intercept and in-depth customer surveys and the Healthy Corner Store Scorecard, which estimated the store's sustainability in the program based on the quantities and types of produce being sold and store owner perceptions and behaviors.²⁵

²² D.C. Central Kitchen. n.d. *Healthy Corners*. Accessed September 26, 2021. <https://dcentralkitchen.org/healthycorners/>.

²³ Snelling, et al., "DC's Healthy Corner Stores Program."

²⁴ Song, et al., "A corner store intervention;" Dannefer, et al., "Healthy Bodegas."

²⁵ Snelling, Anastasia, Robin McClave, Van Dyke, Ayanna Wells, and Lisa Joseph. 2020. *Healthy Corners: Balancing Store Performance & Customer Needs to Promote Fresh Produce Access & Consumption 2017-2020 Evaluation*. Washington, DC: American University Department of Health Studies.

Theoretical Framework

Measuring program effectiveness using customer and store owner surveys captures the impact of these programs on the specific stores and individuals that participate in them. These methods do not capture program impacts on the community level, however, as it is unlikely that everyone in a given area is interacting with the participating stores. Different indicator variables need to be used to shift these evaluations from measuring program effectiveness on the individual and store level to measuring it on the community level. This research will build on the existing evaluations of these programs by attempting to measure program effectiveness on the community level, instead of the individual level. As pervasive high level community obesity rates are one ongoing impact of lack of access to nutritious, affordable produce, this evaluation will use ward level obesity rates in Washington, DC to evaluate the Healthy Corner Store Initiative's effectiveness.

Data and Methods

Data

The Healthy Corner Stores Initiative started in 2011. To accurately capture obesity rates before and after the program's implementation, and the potential control variables associated with them, this analysis uses 10 years of data, from 2006 to 2015. Data on obesity rates, demographics, and socioeconomic characteristics were collected across all eight wards in Washington, DC. Ward level data was chosen because of the large differences in demographics, health, and standard of living across Washington, DC, including differences in obesity rates and in the presence of corner stores participating in the Healthy Corner Stores Initiative. These differences can be seen in

Table 1 and Figure 1 below.

One of the main data sources for this project was the District of Columbia Behavioral Risk Factor Surveillance System (DC BRFSS). DC BRFSS collects data on chronic disease and health indicators in the District of Columbia.²⁶ Some of this data, including obesity rates and demographics, is available on the ward level. DC BRFSS defines obese individuals as those with a Body Mass Index (BMI) of 30.0 or greater. There were several instances where the DC BRFSS report available for a given year did not include all of the needed information. When this occurred, additional sources or assumptions were made, including:

- In 2009, the percent of the population in each ward that was Black was not available, so the averages of this measurement from 2008 and 2010 were used,
- In 2010, the percent of the population in each ward that was Black was not available through DC BRFSS, so it was gathered from the Urban Institute²⁷.

Table 1 uses data from DC BRFSS to show average obesity rates and the percentage of each ward that is Black over time. There is large variation in both these variables across wards, and a strong positive correlation between them as well. Ward 3, for example, has the lowest average obesity rate and the lowest percentage of the population that is Black, while Wards 7 and 8 have the highest average obesity rates and the highest percentages of the population that are Black.

Additional data on poverty level and education level was gathered by the Census Bureau American Community Survey (ACS) and compiled by DC Health Matters, a data portal sponsored by the DC Health Matters Collaborative.²⁸ A given ward's poverty level

²⁶ DC Health. n.d. *Behavioral Risk Factor Surveillance System*. Accessed December 6, 2021. <https://dchealth.dc.gov/service/behavioral-risk-factor-surveillance-system>.

²⁷ Urban Institute. n.d. *Greater DC Data Explorer*. Accessed December 6, 2021. <https://greaterdc.urban.org/data-explorer?geography=wd12&indicator=PctBlackNonHispanic&topic=population&year=2010>.

²⁸ DC Health Matters. n.d. *DC Health Matters Collaborative*. Accessed December 6, 2021.

is measured by the number of people living below the Federal Poverty Level, and, in this analysis, its education level is measured by the percentage of people aged 25 or older who possess a bachelor's degree or higher. In order to access this data on the ward level, instead of only in the District overall, 5-year estimates of the ACS were used. Although the ACS does also release 1-year data estimates, 5-year estimates were used because 1-year estimates are not available for smaller population levels, and because 5-year datasets are more accurate for very small populations, like individual wards within Washington, DC.²⁹ The collected data was coded so that the year at the beginning of the year range was used in the analysis (e.g., the year 2011 was assigned to the 2011-2015 dataset). DC Health Matters did not have data on these issues available for 2006-2010, so 2005-2009 data was gathered from the DC Office of Planning and the Justice Policy Institute and used as a proxy.³⁰

Table 1 shows ACS data on the percentage of people in each ward living below the poverty line, and the percentage in each ward that are 25 or older and have a bachelor's degree or higher. As with the data gathered from DC BRFSS, there is large variation across wards for both these variables. Ward 3 is again at one end of the spectrum, with the lowest percentage of people experiencing poverty and the highest

<https://www.dchealthmatters.org/tiles/index/display?alias=aboutus>; United States Census Bureau. n.d. *American Community Survey (ACS)*. Accessed December 6, 2021.

<https://www.census.gov/programs-surveys/acs>.

²⁹ US Census Bureau. 2021. *When to Use 1-year or 5-year Estimates*. December 7. Accessed December 8, 2021. <https://www.census.gov/programs-surveys/acs/guidance/estimates.html>.

³⁰ DC Office of Planning. n.d. *Census and Demographic Data*. Accessed December 6, 2021.

<https://planning.dc.gov/page/census-and-demographic-data>; Ashton, Paul. n.d. "The Education of D.C." *Justice Policy Institute*. Accessed December 6, 2021.

https://web.archive.org/web/20150928084658/https://www.justicepolicy.org/uploads/justice-policy/documents/education_of_dc_-_final.pdf.

percentage of people with a bachelor’s degree or higher, while Wards 7 and 8 have the highest rates of poverty and lowest rates of bachelor’s degree attainment.

Table 1: Ward Averages, 2006-2015 (Std. Dev. in Parentheses)

Variable	Sample	Ward							
		1	2	3	4	5	6	7	8
Obesity Rate	24% (10%)	19% (3%)	13% (3%)	11% (2%)	25% (3%)	30% (3%)	22% (4%)	35% (3%)	40% (3%)
Pct. Black	53% (32%)	34% (3%)	14% (7%)	6% (1%)	60% (3%)	77% (3%)	41% (4%)	94% (2%)	94% (1%)
Pct. Below Poverty Level	21% (10%)	16% (1%)	23% (7%)	9% (2%)	10% (1%)	29% (6%)	14% (2%)	31% (2%)	34% (3%)
Pct. 25+ with Bachelor’s or Higher	49% (25%)	29% (6%)	81% (4%)	85% (3%)	49% (7%)	44% (10%)	51% (16%)	16% (2%)	15% (2%)
Sample Size	80	10	10	10	10	10	10	10	10

Author’s calculations, from DC BRFSS and ACS.

Locations for the corner stores participating in the Healthy Corner Stores Initiative were collected from OpenData DC.³¹ The addresses for these locations were used to identify which ward they were located in, using the What's My Ward? Tool through the DC Office of Planning.³² There are 71 participating corner stores across 6 wards in the District: 7 in Ward 1, 6 in Ward 4, 20 in Ward 5, 6 in Ward 6, 15 in Ward 7, and 17 in Ward 8. No corner stores in Wards 2 or 3 participate in the Initiative. The distribution of these stores can also be seen in Figure 1. For the purposes of this analysis, it is assumed that Wards 1, 4, 5, 6, 7, and 8 have participating corner stores throughout the scope of study, and that Wards 2 and 3 never have participating corner stores. This assumption is supported by multiple sources capturing the locations of participating stores at different points in time.

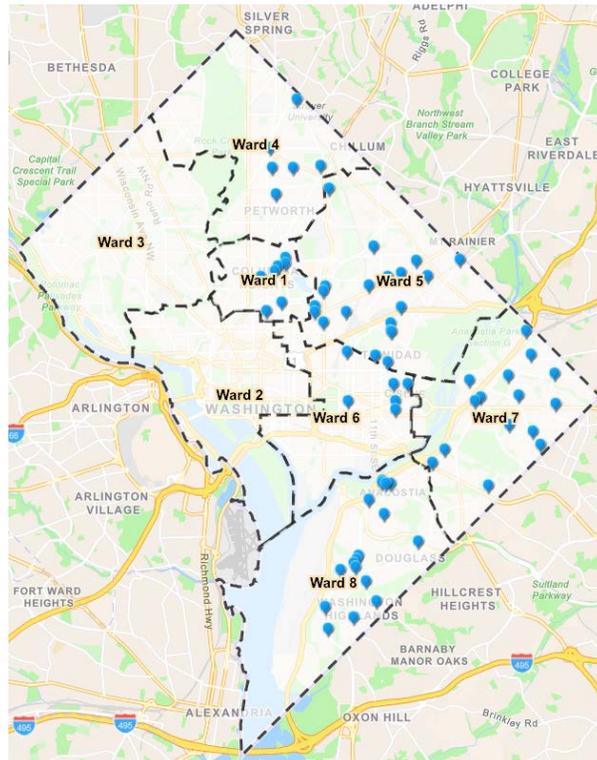


Figure 1: Healthy Corner Store Locations

³¹ Open Data DC. 2021. *Healthy Corner Stores*. September 14. Accessed December 6, 2021. <https://opendata.dc.gov/datasets/DCGIS::healthy-corner-stores/about>.

³² DC Office of Planning. *Census and Demographic Data*.

Methods

The dependent variable in this project was adult obesity rates, on the ward level, in Washington, DC. Traditional measures of food insecurity would not change after the interventions from the Healthy Corner Stores Initiative, because they typically measure grocery store access, which this intervention does not impact. Instead, adult obesity rates were used as a proxy to measure one of the main goals of environment-based food intervention programs like this one: reduction in obesity rates due to improved access of nutritious foods. The main independent variable of interest in this model was the presence of participating corner stores on the ward level. It was hypothesized that presence of these stores is associated with a decrease in average adult obesity rates in that ward. Additional demographic and socioeconomic variables, including race, education, and income level, were used to control for differences in populations across wards. The data cleaning, compilations, and analysis for this research we conducted using the R programming language and RStudio version 1.2.1335.

A series of regressions were estimated using a difference-in-differences estimator to understand the impacts of the presence of stores participating in the Healthy Corner Stores Initiative on adult obesity rates in Washington, DC. This method was chosen because there are differences in obesity rates across the District, and because not every ward in the city has any stores participating in the initiative. Additionally, obesity rates

vary drastically before the program’s implementation. The difference-in-differences estimator controls for these differences, which allows the estimated regressions to better capture the impacts of the program specifically. As can be seen in Figure 2, obesity rates across these two groups match the parallel trends assumption in the years leading up to the implementation of the Healthy Corner Stores Initiative.^{33,34}

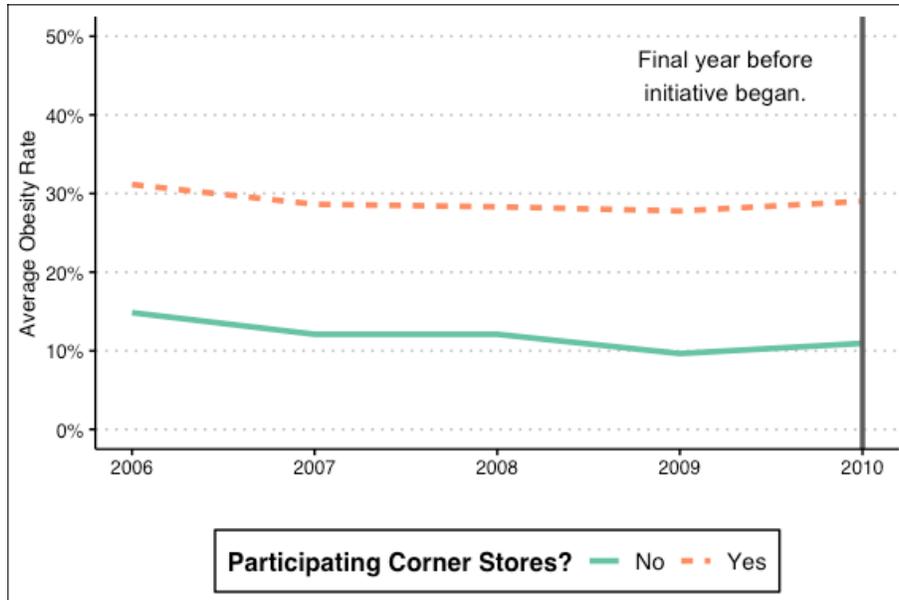


Figure 2: Average Obesity Rates in Wards With and Without Participating Stores

Results

Preliminary Analysis

The treatment effect of this study, presence of a corner store participating in the Healthy Corner Stores Initiative, is in six of the eight wards in Washington, DC starting in 2011. Table 2 shows a preliminary analysis of this program’s impact, comparing

³³ The parallel trends assumption, which is one of the key assumptions that must be met in order to use a difference-in-differences estimator, states that before a treatment is administered trends between the control and treatment groups are parallel over time. The sample used in the analysis met the requirements for consistent treatment history and the treatment not being determined by the eventual outcome as well.

³⁴ Zeldow, Bret, and Laura Hatfield. n.d. *Difference-in-Differences*. Accessed December 6, 2021. [https://diff.healthpolicydatascience.org/#assumptions.](https://diff.healthpolicydatascience.org/#assumptions;); Columbia Public Health. n.d. *Difference-in-Difference Estimation*. Accessed December 6, 2021. <https://www.publichealth.columbia.edu/research/population-health-methods/difference-difference-estimation>.

average obesity rates in wards with and without participating corner stores in the five years before and after the program’s implementation. Wards 2 and 3, the two wards with no participating stores, had lower average obesity rates throughout the time period being studied. In these 10 years the average obesity rates in these two wards had minimal changes, falling from 11.9% to 11.8%. The average obesity rate in those wards with participating corner stores did fall slightly after the treatment was implemented, by 0.6%. Even with this decline, average obesity rates in wards with participating corner stores continued to be almost 20 percentage points higher than rates in other wards. Average obesity rates declined slightly throughout the city in the post-treatment period when compared to before the treatment period, and they did decline by 0.5 percentage points more in Wards with participating corner stores.

Table 2: Average Obesity Rates Before and After Treatment

Participation Status	Average Obesity Rate	
	Pre-Treatment (2006-2010)	Post-Treatment (2011-2015)
Participating Wards	29.0%	28.4%
Not Participating Wards	11.9%	11.8%

Regression Analysis: Control Variables

To determine if this reduction in average obesity rates in wards receiving the treatment effect had a statistically significant relationship with the presence of stores participating in the Healthy Corner Stores Initiative, a series of regressions were estimated. Both a difference-in-differences estimator of the treatment effect and various control variables were used. The results of these regression estimates are in shown in Table 3 below.

Table 3: Estimation Results with Control Variables

	Obesity Rate (1)	Obesity Rate (2)	Obesity Rate (3)	Obesity Rate (4)	Obesity Rate (5)
Presence of Participating Stores	.01 (0.04)	0.01 (0.01)	0.01 (0.01)	0.01 (0.03)	0.01 (0.02)
Pct. Black		0.29*** (0.01)	0.28*** (0.02)		
Poverty Rate			0.02 (0.06)	0.68*** (0.09)	0.23*** (0.06)
Pct. College Educated					-0.30*** (0.03)
Intercept	.24*** (0.01)	0.09*** (0.01)	0.09*** (0.01)	0.10*** (0.02)	0.34*** (0.02)
Observations	80	80	80	80	80
R-squared	0.00	0.86	0.86	0.42	0.80

*Standard errors are in parenthesis
*** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$*

Of all of the regressions estimated, none found that the presence of corner stores participating in the Healthy Corner Stores Initiative was statistically significantly associated with a reduction in ward level obesity rates. In addition to this lack of statistical significance throughout all of the models that were estimated, Model 1, which only included the treatment effect being studied, had an R-squared of 0, meaning that the presence of the treatment explained zero percent of the variation in ward level obesity rates throughout the city. Models 2 and 3 have the greatest R-squared values. This indicates that much of the variation in average ward level obesity rates can be explained by the demographics in that ward. While there are numerous demographic and socioeconomic variations across wards in the District of Columbia that could have an impact on obesity rates, it was challenging to control for multiple variables simultaneously because of the substantial multicollinearity found within the different potential combinations of control variables.

Regression Analysis: Ward-Level Fixed Effects

To avoid multicollinearity issues across control variables while also controlling for uncaptured variation across wards, a regression with locational fixed effects was also used. As demonstrated in Table 4, even when controlling for unobserved differences across wards, there is still no statistically significant relationship between ward level obesity rates and the treatment effect. The high R-squared value in this model suggests that locational fixed effects can explain much of the variation in obesity rates across Washington, DC, while further reaffirming that the presence of the treatment effect does not have a statistically significant impact.

Table 4: Estimation Results with Fixed Effects

	Obesity Rate
Presence of Participating Stores	0.01 (0.01)
Ward 2	-0.07*** (0.01)
Ward 3	-0.08*** (0.01)
Ward 4	0.06*** (0.01)
Ward 5	0.11*** (0.01)
Ward 6	0.03* (0.01)
Ward 7	0.16*** (0.01)
Ward 8	0.21*** (0.01)
Intercept	0.19***

	(0.01)
Observations	80
R-squared	0.92

*Standard errors are in parenthesis
 *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$*

Regression Analysis: Overweight vs. Obese

The same regression analyses were conducted using the percentage of each ward that was overweight, rather than obese, to try and capture a different potential impact of the program.³⁵ The impact of the Healthy Corner Stores Initiative in this version of the study was the same: the treatment effect, presence of corner stores participating in the initiative, did not have a statistically significant impact on the community level. This was true both when controlling for various demographic factors and when controlling for locational fixed effects.

Discussion

The regressions estimated in this analysis indicate that the treatment effect being studied, the presence of corner stores participating in the Healthy Corner Stores Initiative, did not have a statistically significant impact on ward level obesity rates in Washington, DC in the first years after the program was implemented. This supports and expands upon the findings of the preliminary analysis, which showed only minor changes in the average obesity rates for wards with stores participating in the program. Difference-in-differences estimators, like the one used throughout this analysis, can typically be used to identify causal relationships.³⁶ While the findings of this study were consistent across the different regressions that were estimated, the small sample size, of only 80 observations,

³⁵ DC BRFSS defines “overweight” as those with a BMI between 25.0 and 29.9.

³⁶ Columbia Public Health. *Difference-in-Difference Estimation*.

should be considered when interpreting these results and making causality-related conclusions.

As demonstrated in past studies measuring the sales of fresh produce at participating corner stores, individuals in the District are purchasing fruits and vegetables from participating corner stores. The findings in this analysis, however, show that the individual-level impacts of the Healthy Corner Stores Initiative are not translating to community-level impacts on obesity rates. One of the major goals of these environment-based food intervention programs is to improve access to healthy food to improve community health, reducing the prevalence of obesity in the process. The results of this study, combined with the results of past evaluations of Washington, DC's Healthy Corner Stores Initiative, indicate that this initiative has been successful in improving access to healthy foods for the individuals shopping at participating corner stores, but that it has not been effective at reducing obesity prevalence.

Conclusion

This research expanded previous analyses of environment-based food intervention programs by evaluating the impacts of the Healthy Corner Stores Initiative on the community level, instead of the individual level. Although obesity rates in Washington, DC did fall by a small amount during the time period studied, the Healthy Corner Stores Initiative was not found to have a statistically significant impact on ward level obesity rates. This lack of impact is the opposite of what previous studies have said about this program – previous studies have shown that individuals in DC who shop at participating corner stores are utilizing the program's benefits by purchasing fresh produce. This

research suggests that the individual impacts of those purchases are not translating to community level impacts, including reducing obesity rates.

There were several limitations to this study, primarily revolving around issues of data availability and sample size. Ward-level data was chosen to ensure that all variables studied could be analyzed at the same level of disaggregation. Although some data was available at the zip code level, not all data was available at that level of granularity. Using data aggregated to this level prevents controlling for differences and measuring changes in subgroups within the eight wards studied and leads to a smaller overall sample size available for analysis. It also relies on the assumption that individuals purchase groceries in the same ward that they live in; the design of this study does not account for Ward 2 residents shopping in Ward 5, for example. Additionally, while numerous factors are associated with community-level obesity rates, the strong multicollinearity issues throughout the variables examined and the small overall sample size prevented multiple issues from being controlled for simultaneously. While this study focused on Washington, DC, other evaluations of programs in different cities would likely face similar issues regarding data availability, sample size, and key assumptions.

Based on the findings from this analysis, there are numerous avenues for future research. Within Washington, DC, once more Census data is released, additional years should be included in the study.³⁷ This would capture any changes in obesity rates if the program is effective on the community level over a slower period of time than captured in this study. Expanded surveys could be used to collect data on the consumer behaviors of those who live in wards with participating corner stores, to differentiate between the

³⁷ The publication of the 2016-2020 ACS 5-year estimates have been delayed until March 2022.

behaviors and purchasing patterns of those who do and do not purchase produce at corner stores. Data like this could help identify avenues to expand the program's impact from the individual level to the community level. Additionally, as Washington, DC is not the only city to have implemented an environment-based food intervention program like this, similar studies should be conducted in other cities with these programs as well, to understand if these programs also have a similar lack of impact on the community level. As each of these programs has a slightly different focus and implementation strategy, it is possible that best practices for establishing and carrying out initiatives will also be identified when evaluating their effectiveness.

One of the main findings of this analysis is that there is a contradiction between the individual and community level impacts of Washington, DC's Healthy Corner Stores initiative. Although sales data and survey results suggest that people are purchasing produce from participating stores, this analysis shows that those purchases are not translating to community-level reductions in obesity. These results should not be used to justify the removal of this program, however, as the purchasing data shows that individuals are utilizing the purchasing opportunities found in participating stores. Instead, the focus should now be on identifying who within these communities is benefiting from these programs and working to understand how those benefits can be expanded to the broader population.

These findings also demonstrate how disparities in Washington, DC are pervasive, even after the implementation of a program like the Healthy Corner Stores Initiative. This highlights how ongoing disparities cannot be addressed or remedied through one policy or program alone. This research's focus on food insecurity and the

health issues associated with it also contributes to the broader discussions regarding social determinants of health and their real impacts within communities. Without additional policies and initiatives to improve the factors leading to poor social determinants of health, disparities will continue to lead to poorer health outcomes for certain populations and communities than for others.

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