The Association of Family and Neighborhood Characteristics with Utilization of the Seattle Fresh Bucks Program, Fruit and Vegetable Consumption, and Food Security

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Abstract

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This dissertation evaluates heterogeneities in associations between the Fresh Bucks program in Seattle, Washington and program outcomes by household and neighborhood characteristics. Fresh Bucks provides $40 per month to lower-income households in Seattle for purchases of fruits and vegetables to increase consumption and improve rates of food security. This dissertation first examines heterogeneities in Fresh Bucks benefit utilization and changes to fruit and vegetable consumption and food security by family composition following program enrollment. Next, I measure associations between Fresh Bucks benefit utilization and neighborhood characteristics. Finally, I examine associations between changes to fruit and vegetable consumption and food security and neighborhood characteristics following program enrollment. Findings from this work may provide context to decision-makers seeking to increase equitable access to nutrition benefit programs like Fresh Bucks.

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CHAPTER 1. INTRODUCTION

Food insecurity, or the lack of access to enough food for an active and healthy life, remains a concern in the United States. The United States (US) Department of Agriculture reports that in 2021, 10.2% of individuals living in the US were food insecure, with 3.8% having very low food security.[1] Individuals living in households with incomes below 185% of the Federal Poverty Level are more likely to experience food insecurity than their higher-income counterparts (28.6% vs. 10.5%)[1] and in Seattle up to 51% of low-income families with children experience food insecurity.[2]

Food insecurity is consistently associated with overall poor health[3,4] and high rates of chronic diseases.[5,6] Studies find that food insecure adults have higher rates of hypertension,[5] hyperlipidemia,[5] and diabetes.[6] Women and young adults who are food insecure have higher rates of mental health conditions, including depression and anxiety,[7–9] and children living in households with food insecurity were found to have 20% higher rates of lifetime asthma diagnosis and 28% higher rates of depressive symptoms.[10] Additionally, families experiencing food insecurity were found to have up to 20% higher health care expenditures per year, compared to food secure families.[11]

Disparities in fruit and vegetable consumption additionally exist. In 2019, less than 13% of adults in the United States, and 6.8% of low-income adults, ate the recommended servings of fruits and vegetables daily.[12] Older adults eat slightly more fruits and vegetables on average than their younger counterparts, but rates remain low across all age groups.[13] These disparities and low overall rates of consumption are likely due to healthy food, including fruits and vegetables, being more expensive on average than lower nutrient-density foods.[14] Low consumption of fruits and vegetables is additionally

associated with worse health outcomes, including higher rates of cardiovascular disease,[15] stroke,[15] and all-cause mortality.[16]

Fresh Bucks Program

This dissertation focuses on the Fresh Bucks program in Seattle, Washington, which provides $40 per month to lower-income households for purchases of fruits and vegetables. Households living within Seattle city limits and with incomes at or below 80% of the Area Median Income are eligible to enroll in Fresh Bucks; approximately 12,000 households are enrolled at a given time. Benefits are provided to households via an electronic benefit transfer (EBT) card and expire at the end of each month (i.e., benefits do not roll over). Households can use Fresh Bucks to purchase fresh, frozen, canned, or dried fruits and vegetables at farmers' markets and select smaller retailers. They can additionally purchase fresh fruits and vegetables at local branches of one national chain.

Fresh Bucks is implemented by the City of Seattle and funded by revenues from Seattle's sweetened beverage tax. Households can apply to the program via an online public application or with the help of a community-based organization (CBO). The City of Seattle has sought to reduce inequities in fruit and vegetable consumption and food security by focusing Fresh Bucks recruitment among populations that are frequently under-served by other nutrition benefit programs, including individuals who speak a primary language other than English, those eligible for the least amount of benefits from federal programs due to income requirements, and those who are not US citizens. Program administrators have collaborated with CBOs from over 12 cultural and

geographic communities throughout Seattle to reduce enrollment burden among prioritized populations.

In this dissertation I focus on three primary outcomes – utilization of Fresh Bucks benefits, fruit and vegetable consumption, and food security. The measure of utilization provides insight into groups who may have trouble engaging with Fresh Bucks and therefore utilize fewer of their benefits each month. Fruit and vegetable consumption and food security are critical outcomes for understanding potential health implications of the Fresh Bucks program.

This work occurred concurrently with a larger NIH-funded evaluation measuring Fresh Bucks program impacts and seeking to understand whether in the current implementation there is equitable access to the Fresh Bucks program across demographic groups. In this NIH-funded evaluation, we found differences in utilization of Fresh Bucks benefits by race/ethnicity and primary language spoken, with Chinese-speakers having the highest odds of redeeming most of their Fresh Bucks benefits.[17] We additionally found that a group of households randomly selected to enroll in the Fresh Bucks program for the first time had higher fruit and vegetable consumption and were more likely to be food secure after six months of enrollment, compared to a concurrent group randomly assigned to the program waitlist.[18] Future work under the NIH-funded evaluation will utilize qualitative interviews to understand equity in program implementation. It will additionally examine differences in health outcomes following Fresh Bucks enrollment for a group of enrolled participants compared to an unenrolled control group. Work from this dissertation and the broader evaluation seek to inform future implementation of the Fresh Bucks program and other nutrition benefit programs.

Conceptual Model

This dissertation utilizes the five domains of nutritious food access described in Freedman et al.[19] to understand potential associations between enrollment in Fresh Bucks, program utilization, and changes to fruit and vegetable consumption and food security (Figure 1.1). Per the Freedman model, the five domains of nutritious food access are economic, personal, social, spatial-temporal, and service delivery. While defined separately below, the domains work together to impact nutritious food access (represented by the larger purple arrows in Figure 1.1).

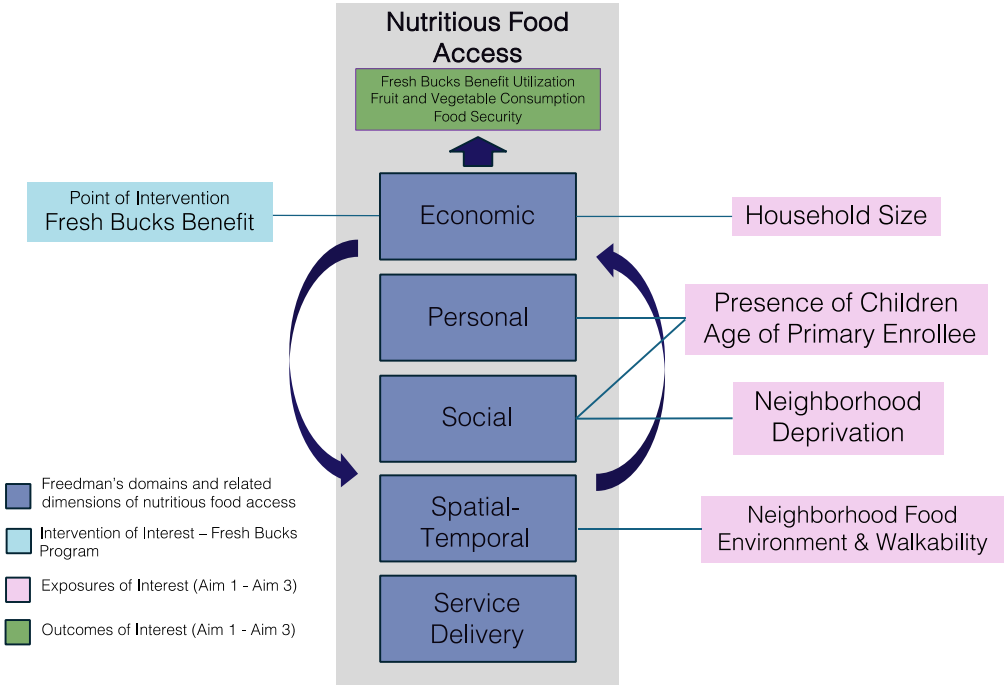

Figure 1.1. Conceptual Model of Fresh Bucks Program utilizing the Freedman, et al. model of Nutritious Food Access[19]

We conceptualize the Fresh Bucks program as intervening at the economic level, by providing financial assistance to households for the purchase of fruits and vegetables. This may allow households to simply purchase more food or allow them to redistribute

existing funds from fruits and vegetables to other key needs. However, the efficacy of the Fresh Bucks program may be moderated by one's household composition. Fresh Bucks provides the same amount of benefit regardless of household size, so larger families receive fewer dollars per household member than smaller households. Whether a household includes children and the age of the primary enrollee reflect the domains of social and personal factors. Households with children have higher monthly expenses and less time to prepare meals due to alternative demands on time and resources. Older enrollees may have more difficulty with food shopping and preparation due to mobility issues and may be more concerned with the perceived healthfulness of food, due to the higher potential for nutrition-related poor health outcomes (personal domain).[10,20] Additionally, older enrollees may be more likely to be concerned with stigmatization associated with receiving government aid, which in turn reduces their ability to access nutritious foods (social domain).[21]

We next consider the spatial-temporal domain, which Freedman, et al. describes as including both the ability to access a diversity of food retailers and travel time to retailers. We examine this domain via measures of Fresh Bucks participants' neighborhood characteristics, including access to Fresh Bucks retailers, density of retailers in the neighborhood, and neighborhood walkability. We additionally examine the social domain via a measure of neighborhood socioeconomic status, the Area Deprivation Index (ADI). This measure incorporates neighborhood education levels, employment, housing status, and other socio-economic characteristics to create a single measure of neighborhood socioeconomic status. These measures of socio-economic status are often driven by historical discrimination and lack of access to resources for marginalized groups.[22] We hypothesize that these socioeconomic

characteristics may be associated with a household's ability to utilize the Fresh Bucks program and gain access to nutritious foods. We additionally consider that the ADI, as a measure of neighborhood socioeconomic status, helps us understand a household's socio-economic status and therefore is also closely related to the economic domain.

Implications of Data Collection Timing (COVID-19)

The data for this study was collected during the COVID-19 pandemic, which may have impacted participants in a variety of ways. In the early months of the COVID-19 pandemic, the United States experienced significant job loss and economic turmoil due to stay-at-home orders and non-essential business closures to maintain public health. Millions of Americans became unemployed during this period and lost their regular source of income.[23] Several federal nutrition assistance programs and federal policies, including the Coronavirus Aid, Relief, and Economic Security (CARES) Act of March 2020 and the January 2021 COVID-19 relief package, sought to decrease the impact of the pandemic.[24,25] Locally in Seattle, several programs kept people fed during this tumultuous time, including food banks, senior meal programs, community meal programs, school-based programs for family meal pick-up, and emergency grocery vouchers.[26] These programs additionally expanded their scope of enrollment and offerings, with approximately 20,000 additional households in King Country receiving Basic Food benefits in March through May of 2020, as compared to February 2020.[27] Families who received emergency grocery vouchers were able to redeem additional funds, not tied to federal nutrition assistance program funding, for groceries during this period, and food banks expanded hours and locations to meet the growing demand. Schools implemented new programs to keep students fed who would normally eat free or reduced priced meals on campus. Between one- and two-thirds of families surveyed

in King County, WA, which includes Seattle, reported having received free food from a school or children's program between March and June of 2020.[28] Finally, the City of Seattle placed a moratorium on evictions for renters and implemented programs to defer payments on electricity and other public utilities.

This dissertation avoids many concerns about bias due to the COVID-19 pandemic by utilizing contemporaneous comparison groups in analyses of fruit and vegetable consumption and food security, in which all enrollees in the study were exposed to the COVID-19 pandemic. We contextualize our findings in the political and economic environment of the COVID-19 pandemic; however, it is important to note that in general the pandemic exacerbated existing inequities. Our baseline outcome measures occur in January 2020, prior to the start of the COVID-19 pandemic in the United States, and the follow up measure occurs in October 2021-January 2022, well after initial lockdowns had ended and unemployment rates had begun to recover. Therefore, the findings, utilizing a contemporaneous comparison group, help us to understand the associations between our exposures, program utilization, and fruit and vegetable consumption and food security beyond the timeline of the pandemic.

Dissertation Aims

This dissertation examines three aims related to the Fresh Bucks program. In Aim 1 I examine whether Fresh Bucks benefit utilization, fruit and vegetable consumption, and food security vary as a function of household characteristics. Aim 2 examines whether Fresh Bucks benefit utilization varies as a function of neighborhood characteristics. Finally, Aim 3 examines whether there are differential changes by neighborhood

characteristics to fruit and vegetable consumption and food security following a year of Fresh Bucks enrollment.

CHAPTER 2

Title:

Association between Household Characteristics and Fruit and Vegetable Consumption, Food Security and Utilization of a Nutrition Benefit Program

Authors:

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Abstract:

Background: Evidence suggests that nutrition benefit programs are effective at increasing purchasing of fruits and vegetables and rates of food security for enrollees, but little work has examined whether these changes are shared equitably across program enrollees.

Objective: We examine a nutrition benefit program in Seattle, Washington, Fresh Bucks, which provides monthly benefits to low-income families for purchases of fruits and vegetables at grocery stores, corner stores, and farmers markets. We seek to understand how program participation is differentially associated with changes to fruit and vegetable consumption and food security for varying household characteristics.

Methods: Using pre- and post- administrative program data, we examine whether utilization of program benefits, changes in fruit and vegetable consumption, and changes in food security vary by household characteristics (household size, presence of children in the household, and age of primary enrollee). We use longitudinal multinomial logistic regression models to examine differences in benefit utilization and logistic regression models to examine changes in fruit and vegetable consumption and food security. All models are adjusted for race and ethnicity, primary language spoken, household income, and program enrollment pathway.

Results: In adjusted analyses, we find high utilization of Fresh Bucks benefits overall, with the highest utilization by those over 60 years old and in households with more than 3 members. We additionally find program enrollment to be associated with increases in fruit and vegetable consumption and food security overall, with larger increases in food security for 1-2 person households and those without children, as compared to 3 or more person households and households with children, respectively.

Conclusions: These analyses help us understand characteristics of households most likely to benefit from the Fresh Bucks program and guide policy makers seeking to improve program uptake, fruit and vegetable consumption, and food security among participating households.

INTRODUCTION

Food insecurity, or the lack of consistent access to enough food for an active, healthy life,[29] impacted 10.2% of people living in the United States in 2021. Additionally, people in the United States generally do not consume adequate amounts of fruits and vegetables, with 87% of adults consuming less than the recommended amount of fruits, and 90% consuming less than the recommended amount of vegetables.[12] Together, food insecurity and low consumption of fruits and vegetables contribute to low dietary quality, which is associated with overall worse health and higher rates of chronic disease.[3–7] Individuals with lower incomes are disproportionately impacted by these health outcomes and associated risk factors.[5]

Several programs at the federal, state, and local levels seek to improve access to nutritious foods and decrease food insecurity. One such local program run by the city of Seattle, *Fresh Bucks*, provides low-income households with a $40 per month benefit that can be spent on fruits and vegetables. Enrollees in the program receive monthly allotted funds via an electronic benefit card, which is accepted at Seattle farmers' markets, a large grocery retailer chain in the Seattle area, and select small convenience stores. To enroll in the program, households must live in the city of Seattle, Washington and have an income below 80% of the Area Median Income (e.g. $72,400 for a household of 2). Potential enrollees can apply via a public enrollment system or via a community-based organization.

Previous work has demonstrated increased purchasing of fruits and vegetables following enrollment in nutrition benefit programs[30,31] and the United States Department of Agriculture has previously indicated increasing interest in funding these programs. A

recent analysis found that enrollment in the Fresh Bucks program leads to increased likelihood of eating fruits and vegetables three times per day and being food secure, compared to those who were randomly assigned to a waitlist.[18] However, few studies have measured whether programs like Fresh Bucks adequately serve all their intended participants equitably. Specifically, some individuals may require additional resources to participate in the program as intended. We anticipate that differences in outcomes following program enrollment by household characteristics, specifically household size, presence of children in the household, and age of primary enrollee, may be driven by multiple factors. Firstly, the benefit amount allotted per household by the Fresh Bucks program is the same for all households, regardless of size. Therefore, we hypothesize that enrollment in Fresh Bucks may be associated with larger increases in fruit and vegetable consumption and food security among smaller households, which split the monthly benefit between fewer household members.

Household characteristics may also drive differences in the prevalence of food security at baseline, which may lead to heterogeneities in changes to these outcomes following program enrollment. In 2021, 12.5% of households with children were food insecure, compared to 9.4% of households without children,[1] and older adults living alone are more likely to be food insecure than the average American.[1] These groups are therefore a priority for programs like Fresh Bucks, which seek to equitably improve access to nutritious foods. In this study, we assess whether household size, presence of children in the household, and age of primary enrollee are associated with 1) higher utilization of Fresh Bucks benefits, 2) differential changes in fruit and vegetable consumption, and 3) differential changes in food security, following enrollment in the Fresh Bucks program.

METHODS

Data and Study Sample

The sample includes households enrolled in the Seattle Fresh Bucks program from January 2020 to December 2023. We utilize two administrative data sources, which were collected by the Fresh Bucks program to monitor implementation and effectiveness. These data sources are linked via a unique household identifier, which was de-identified by the Fresh Bucks program prior to sharing with the study team. Appendix Table 1 displays a flowchart of study participant enrollment.

Fresh Bucks Utilization. First, to examine differences in Fresh Bucks utilization, we use a dataset generated as a byproduct of the program's electronic benefit cards. The Fresh Bucks program collected information on all Fresh Bucks transactions from October 2021 to December 2023, with each transaction including the unique household identifier, date of purchase, and dollar amount of Fresh Bucks' benefit utilized in the transaction. Observations for enrollees who moved out of Seattle or died were removed from analyses (n= 5,945 household-months). All other households participating in Fresh Bucks in a given month were included in analysis of Fresh Bucks utilization (n = 19,685 households; 388,906 household-months).

Fresh Bucks Application Questionnaire. To examine changes in fruit and vegetable consumption and food security in association with program participation, we use a second dataset consisting of two program enrollment questionnaires per household. This includes one administered pre-program enrollment, and one administered after having received the program for 24 months. The Fresh Bucks program application included a one-page questionnaire measuring fruit and vegetable consumption and food security status. Additional information on household characteristics, including income,

household size, presence of children in the household, age of primary enrollee, race and ethnicity of primary enrollee, and primary language spoken were collected. Households first completed this questionnaire in January 2020 (baseline, or pre-program enrollment measurement) for enrollment through December 2021. Households that sought to remain enrolled in Fresh Bucks in 2022 were required to re-apply to the program in January 2022 (follow-up measurement), using an application which included the same one-page questionnaire of fruit and vegetable consumption and food security status. We limited the analysis to program enrollees with both a baseline and follow-up completed questionnaire (n= 6,856), which was a subset of the enrollees included in the utilization analyses. All participants had the opportunity to apply for re-enrollment, however we find a generally similar distribution of measured demographic characteristics between the broader enrolled population and those that chose to re-apply (Table 1).

Outcome Measure Definitions

Utilization. For our primary outcome measure of benefit utilization, we summed the total amount spent per calendar month per household and divided it by $40 (the maximum benefit amount) to calculate the proportion of benefit utilized per month. Because the vast majority of households spent either less than $5 per month or approximately the full benefit, we then categorized utilization into a low (<25%), moderate (25-75%), or high (>75%) proportion of the benefit spent in the month.

Fruit and Vegetable Consumption. Our measurement of fruit and vegetable consumption comes from the two questionnaires (baseline and follow-up) described above. These questionnaires included a measure of fruit and vegetable consumption as

estimated times per day with a modified version of the Behavior Risk Factor Surveillance System (BRFSS) Fruit and Vegetable Module Questionnaire, excluding 100% fruit-juice consumption. This screener has been validated to perform similarly to a 24-hour recall, which is considered the gold-standard among dietary measures.[32] The screener, in its modified form, measures fruit and vegetable consumption with a 5-item brief dietary assessment tool, which includes frequency of consumption of fruits, green leafy or lettuce salads, fried potatoes, other potatoes, and other vegetables during the previous month. The questions are phrased as follows: "*During the past month, how often did you eat fruit?*" with the following response options: "*never*", "*1 time last month*", "*2-3 times last month*", "*1 time per week*", "*2 times per week", "3-4 times per week", "5-6 times per week", "1 time per day",* and "*2 or more times per day*". Combining the responses from these 5 items, we calculated a binary measure of having consumed fruits and vegetables at least three times per day daily in the previous month. While recommendations state that individuals should consume 5 servings per day of fruits and vegetables, we utilized a lower cut-off to account for the distribution of consumption present in the data.

Food Security. Included in the baseline and follow-up questionnaire was the 2-item Hunger Vital Sign food security screener, validated to perform well relative to the US Department of Agriculture 18-item Household Food Security Survey Module.[33] The 2 items include: *"In the past 12 months, I/we worried that food at home would run out before I/we got money to buy more"* and "*Within the past 12 months, the food I/we bought ran out, and I/we didn't have money to get more,*" with the following response options: "*often true", "sometimes true", "never true".* Those answering "often true" or "sometimes true" to at least one question are considered 'at risk' of food insecurity; we

reverse coded this variable for analysis to maintain consistency in the direction of interpretation for both the fruit and vegetable consumption and food security outcomes. Thus, households were categorized as food secure if they answered "*never"* to both questions.

Exposures

We utilized data collected in each household's baseline questionnaire to determine household size (1-2, 3-4, or 5+ household members), presence of children in the household (yes, no), and age category of the primary enrollee (18-39 years old, 40-59 years old, or ≥60 years old).

Covariates

All models were adjusted for race and ethnicity and primary language spoken, which we considered as potential confounders in the relationships of interest. Race and ethnicity were self-reported by the participant and collected in the following categories: Non-Hispanic (NH) Asian; NH American Indian or Alaska Native; NH Black/African American; Hispanic, Latino, or Spanish; NH Middle Eastern or North African; NH Native Hawaiian or Other Pacific Islander; NH White, and Mult-racial. Preferred language was self-reported with the following options: English, Amharic, Arabic, Chinese, Khmer, Korean, Lao, Oromo, Somali, Spanish, Tagalog, Tigrinya, Vietnamese, and Russian. To maintain adequate sample size in each comparison group we analyzed race and ethnicity data using the following categories: NH Asian, NH White, NH Black/African American, Hispanic or Latino, another race/ethnicity or multi-racial, and missing race/ethnicity. We similarly grouped primary language for analysis into the following categories: Chinese, English, Vietnamese, Spanish, Another Language, and Missing. We adjusted for two

precision variables that we expected were associated with the outcome. This included whether households enrolled via the public enrollment lottery or via a community-based organization (CBO), as those that enrolled via a CBO may receive more resources from the CBO (e.g. translation of materials or support accessing participating store locations) that result in greater program utilization. We additionally included a measurement of household income using the Department of Housing and Urban Development (HUD) household size-adjusted estimates of the area median family income for the Seattle metropolitan area. The benefit may represent a greater proportion of lower-income household's monthly food spending, and therefore more strongly impact lower-income household's monthly purchases. Households were categorized as <30%, 30-50%, 51-80%, or >80% of the area median family income.

Study Design and Analyses

Utilization analyses. For the analyses of benefit utilization, we used a panel-data multinomial logistic regression model with household-level random effects to estimate the odds of spending a low, moderate, or high proportion (<25%, 25-75%, and >75%) of the benefit in a given month as a function of household size and composition (i.e. presence of children and age of primary enrollee). A multinomial model was selected due to the outcome having a bimodal distribution, with most households spending either almost all or almost none of their benefit. Each household contributes multiple months of spending to the dataset (a minimum of two months and up to a maximum of 27). We account for repeated measures within a household by clustering the robust standard errors on the household identifier. The model takes the following general form:

$$\ln(p_j(x)/p_J(x)) = \beta_{0j} + \beta_{1j}\text{Family-Size} + \beta_{2j}\text{Child-in-Home} + \beta_{3j}\text{Age} + \beta_{4j}\boldsymbol{X_i}$$

where p_j is the probability of spending in the moderate or high proportion of the benefit category, p_J is the probability of spending in the low proportion category and $\boldsymbol{X}_i$ represents a vector of individual covariates. From this model we utilize, for example, $\beta_{1(j=high)}$ to estimate the natural log of the odds of spending in the high category, as compared to the low category, for large households versus small households. We additionally estimate the predicted probability of spending in each category.

The utilization models were mutually adjusted for each of our key exposure variables of interest: household size, presence of children in the household, and age of primary enrollee. They were additionally adjusted for race and ethnicity of the primary enrollee, primary language spoken, program enrollment pathway, and household income category.

Fruit and vegetable consumption and food security analyses. For the analyses of the binary measures of 1) consuming fruits and vegetables at least three times per day in the previous month and 2) food security, we utilized logistic regression models with an interaction term between the exposure of interest and a binary variable representing baseline versus follow-up questionnaire. The coefficient of interest is that of the interaction term. We included household-clustered standard errors to account for the repeated measures within a household and household-level random effects. The model for family size, for instance, takes the following general form:

$$\text{logit}(\Pr(Y_{it}=1|X_{it})) = \beta_0 + \beta_1 \text{Family-Size}_i + \beta_2 \text{Follow-up Questionnaire}_{it} + \beta_3 \text{Family-Size}_i \text{ x Follow-up Questionnaire}_{it} + \beta_4 \text{Child-in-Home}_i + \beta_5 \text{Age}_i + \beta_6 X_i + U_i$$

where Y represents either fruit and vegetable consumption or food security, *i* is an indicator for household identifier and *t* is time (baseline versus follow-up questionnaire)

and X_i represents a vector of individual covariates (race and ethnicity, primary language spoken, program enrollment pathway, and household income category). U_i represents household-level random effects. Using the outcome of food security as an example, β_3 is the difference in the change in the natural log of the odds of being food secure from pre- to post-program participation for those with 3-4 household members, as compared to those with 1-2 household members following at least a year of enrollment in Fresh Bucks. Prior work has demonstrated this method provides unbiased estimates of the difference between groups in program impacts using non-longitudinal pre- and post-program enrollment data.[34]

The models for fruit and vegetable consumption and food security included an indicator variable for baseline versus follow-up questionnaire, and were mutually adjusted for household size, presence of children in the household, and age of primary enrollee, but separate models were used for the interaction of each of these primary exposures with the indicator variable for the follow-up questionnaire (i.e. the main coefficient of interest).

All statistical analyses were performed in Stata, version 18 (StataCorp LLC). Statistical significance was set to an alpha of 0.05 with 2-sided hypothesis tests. Analyses were conducted between January 2024 and November 2024.

This study was reviewed by the University of Washington Institutional Review Board (IRB) which determined that as all data were collected as part of normal program operations and data received by the research team was de-identified, the activities conducted by the research team were nonhuman participant research. Therefore, informed consent was not required.

RESULTS

The sample for the utilization outcomes included 19,685 Fresh Bucks enrollees. Of these, a subset of enrollees (N=6,856) completed the baseline and follow-up questionnaires and comprised the questionnaire sample. The questionnaire sample had a similar distribution as the utilization sample for household size, presence of children in the household, and primary language spoken (Table 2.1). Across these two populations, 43-47% of the sample live in a single person household and 63-67% have no children in the household (Table 2.1). For primary language spoken, 49-52% of the sample primarily speaks English, while 16-22% speak Chinese and 9-12% speak Spanish (Table 2.1).

However, some differences between the study samples by data source were seen for race and ethnicity and age. Those who completed two rounds of the questionnaire were more likely to be Asian (39% versus 31%) and older (51% versus 39% reported being over 60 years old).

Utilization.

Overall, we find that Fresh Bucks program enrollees had more than three times the odds of spending a high proportion of their benefit, as compared to a low proportion of their benefit (Odds Ratio: 3.4; 95% Confidence Interval (CI): 3.2, 3.5; Table 2.2).

Household Size. We find that enrollees with 3-4 household members, compared to households with 1-2 members, had 30% higher odds of spending a high proportion (vs low proportion) of their benefit in a month (OR: 1.3; 95% CI: 1.1, 1.5; Table 2.2). Similar

results were seen for households with 5+ people, compared to households with 1-2 people (Table 2.2).

Children in the household. We find no statistically significant differences in proportion of the benefit spent by whether there was a child present in the household (Table 2.2).

Age of Primary Enrollee. We additionally find that enrollees who are over 60 years old have 3.5 times the odds of spending a high proportion (versus low proportion) of the benefit, compared to those who are 18-39 years old (95% CI: 3.1, 4.0; Table 2.2). Enrollees 40-59 years old, compared to those 18-39 years old, had 2.2 times the odds of spending in the high category, compared to the low category (95% CI: 2.0, 2.5; Table 2.2).

Predicted probabilities of spending in each category overall and by household size, presence of children in the household, and age are presented in Figure 2.1. The predicted probabilities suggest that over 50% of enrollees in Fresh Bucks spend in the highest category, regardless of household characteristic, with the highest predicted probability of spending in the high category being for those over 60 years old (63%; Figure 2.1d).

Fruit and Vegetable Consumption.

Table 2.3 shows the unadjusted prevalence of each outcome in the baseline and follow-up periods for each exposure group as well as the adjusted estimates for differential change over time in these outcomes by exposure category. Overall, the prevalence of eating fruits and vegetables at least three times per day increased from 18% to 22% during the study period, resulting in a 30% adjusted increase in the odds (OR: 1.3 95% CI: 1.2, 1.4).

Household size. The prevalence of eating fruits and vegetables at least three times per day increased from 19% to 24% for those in a 1-2 person household from pre- to post-Fresh Bucks enrollment and from 17% to 19% for those in a 3-4 person household (Table 2.2). Those in the largest households (5+ people) experienced an increase in prevalence of consuming fruits and vegetables at least three times per day from 14% to 16%. In adjusted difference in the change analyses, we find the change in the odds of consuming fruit and vegetables three times per day following enrollment in Fresh Bucks increased to a lesser extent for those in a 3-4 person household, compared to those in a 1-2 person household (OR: 0.9 (95% CI: 0.7, 1.1); Table 2.2), though this was not statistically significant. We find similar results for those in a 5+ person household, compared to 1-2 person households (OR: 0.8; 95% CI: 0.6, 1.1; Table 2.2).

Children in the household. Following enrollment in Fresh Bucks, the prevalence of consuming fruits and vegetables at least three times per day increased for those with a child in the household from 15% to 18%, while for those without a child in the household it increased from 19% to 24%. The adjusted difference in the change estimate for this outcome reveals a non-statistically significant lower odds of consuming fruits and vegetables at least three times per day following Fresh Bucks enrollment for those with a child in the household versus those without (OR: 0.9; 95% CI: 0.7, 1.1; Table 2.3).

Age of primary enrollee. For those over 60 years old, the prevalence of consuming fruits and vegetables at least three times per day grew from 21% prior to Fresh Bucks enrollment, to 25% following enrollment, compared to 18-39 year olds who increased from 13% to 17%, and to 40-59-year-olds who increased from 16% to 21%. The point estimate for the change in the odds of consuming fruit and vegetables three times per day following enrollment in Fresh Bucks was lower for those over 60 years old, as

compared to those 18-39 years old (OR: 0.8; 95% CI: 0.6, 1.0; Table 2.3), as was that for those 40-59 years old, compared to 18-39 years old (OR: 0.9; 95% CI: 0.7, 1.2; Table 2.3). Neither of these differences in the change reached statistical significance.

Food Security. Overall, we find that the prevalence of food security increased from 12% to 16% over the study period (Table 2.3), resulting in 1.3 times the odds of being food secure following enrollment in the program, as compared to pre-program (OR: 1.3; 95% CI: 1.2, 1.5).

Household Size. For those in a 1-2 person household, we find in unadjusted analyses that 11% were food secure prior to enrollment in the program, while 15% of 3-4 person households and 12% of 5+ person households were food secure at that time (Table 2.3). Following enrollment in the Fresh Bucks program, we find that 17% of 1-2 person households were food secure, while 15% of 3-4 person households and 14% of 5+ person households were food secure. After adjustment, difference in the change analyses show that, compared to 1-2 person households, 3-4 person households experienced 40% lower odds of becoming food secure (OR: 0.6; 95% CI: 0.5, 0.8) and 5+ person households experienced 30% lower odds of becoming food secure after enrollment in Fresh Bucks (OR: 0.7; 95% CI: 0.5, 0.98).

Children in the household. Similarly, households with a child present were found to have a 13% prevalence of food security prior to enrollment in Fresh Bucks and a prevalence of 14% following enrollment. Those without a child in the household went from a prevalence of 12% prior to enrollment to 17% following Fresh Bucks enrollment. For enrollees with a child in the household, the adjusted odds of being food secure following

Fresh Bucks enrollment increased to a lesser extent (OR: 0.8; 95% CI: 0.6, 0.9) than for those without a child in the household (Table 2.3).

Age of primary enrollee. For those over 60 years old, the prevalence of food security rose from 12% to 18% following Fresh Bucks enrollment, while for 18-39 year olds went from 13% to 15%, and 40-59 years olds from 12% to 14%. The point estimate for the odds of becoming food secure after enrollment in Fresh Bucks increased to a greater degree for those who are over 60 years old, as compared to those who are 18-39 years old (OR: 1.2; 95% CI: 0.9, 1.6) and for those 40-59 years old (OR: 1.1; 95% CI: 0.8, 1.4); however, these associations did not reach statistical significance

DISCUSSION

Using longitudinal, monthly data from Fresh Bucks, a $40-per-month nutrition benefit program serving 12,000 lower income families in the City of Seattle, we find that program utilization is high overall, with the highest users being enrollees with a larger household size and those over 60 years old. Using longitudinal pre- and post-enrollment program data from over 6,000 individuals, we find very low prevalence of food security at baseline, but overall improvements in fruit and vegetable consumption and food security following Fresh Bucks enrollment. We further find that enrollees living in larger households experienced increases in food security to a lesser degree than those in smaller households, as did those with a child compared to those without. We find no statistically significant changes in fruit and vegetable consumption as a function of household characteristics.

Our finding of very high utilization of Fresh Bucks benefits is consistent with previous work demonstrating high utilization of benefits in programs similar to Fresh Bucks.

Evidence from Moran and colleagues from a supermarket-based program in Maine found that 82% of benefits were used among families with children when provided with a 50% rebate on purchases of fruits and vegetables.[35] Furthermore an evaluation of a produce prescription program providing $100-120 per month to families enrolled in Medicaid found no overall differences in benefit utilization among those enrolled for 12 continuous months, by presence of children in the household but found higher utilization among larger families.[14] These findings are consistent with the present study, which includes households enrolled for an average of 19.8 months (median: 24 months), finding no differences in benefit utilization by presence of children in the household, but differences by household size.

Our findings that older age is associated with higher benefit use concurs with previous limited research. While no studies to our knowledge have compared benefit utilization between older adults and younger adults, one previous study examined older adults program utilization specifically.[36] They found that a healthy food incentive program among older adults in Durham, North Carolina led to increases in fruit and vegetable purchases only among those who were already familiar with technologies like coupons and EBT.[36] This study also highlighted that older adults may experience barriers to program participation such as poor mobility and access to transportation. Future qualitative research on the Fresh Bucks program should explore what facilitated high program benefits among older enrollees.

Our findings align with previous work focused on the Healthy Incentive Pilot (HIP) program in Hamden County, Massachusetts, which implemented a 30% rebate on purchases of targeted fruits and vegetables for 7,000 Supplemental Nutrition Assistance Program (SNAP) enrolled households. They compared purchasing to a control group of

over 40,000 SNAP enrolled households who received no rebate. Similar to our findings, the HIP study found no difference in fruit and vegetable consumption by age and presence of children in the household, despite finding overall differences in consumption among those that participated in the program, as compared to a control group.[37]

We find much lower rates of food security (12%) among the study population, compared to the broader United States (89%)[1] and King County, WA (89%; the county which includes Seattle, WA).[38] This is likely explained by the requirement for enrolled households to have incomes below 80% of the area median income. Nationally, rates of food security are 1.4 times higher for those with incomes greater than 185% of the federal poverty line, compared to those with incomes <100% of the federal poverty line.[1] Analyses of food security rates in Seattle additionally find the lowest rates of food security in south Seattle,[39] where the majority of Fresh Bucks enrollees live. Furthermore, approximately half of those enrolled in Fresh Bucks did so via a Community Based Organization (CBO). These CBOs may have sought to enroll patrons who were most at risk of food insecurity and therefore more likely to benefit from such a program.

We find that those with the highest likelihood of utilizing the full benefit amount (those over 60 years old and those in a larger household) do not experience differential increases in fruit and vegetable consumption, compared to those with lower benefit utilization. These findings echo previous work examining a produce prescription program among Medicaid recipients which found no dose response relationship between benefit utilization and fruit and vegetable intake.[40] This finding may be further understood via two mechanisms. First, the $40 benefit per month may not be sufficient

to purchase enough fruits and vegetables to impact our outcome of consuming 3 times per day for larger households and those with particularly low incomes. Secondly, the survey questions used do not capture consumption of the entire household. The previously discussed work by Moran et al., which provided a 50% discount on fruits and vegetables to low-income households at a single supermarket, found that households with children had 27% greater *purchasing* of fruits and vegetables per week after enrollment, compared to those who did not receive a discount, but found no changes to consumption by the primary enrollee.[35] The higher utilization for these households in our study could translate to increased consumption of fruits and vegetables for other family members, but we cannot measure this.

We interpret these findings cautiously, as this study does not include a control group, but we instead utilize a difference in the change framework to understand how a group's prevalence of fruit and vegetable consumption and food security changed differentially by household characteristic after being enrolled in Fresh Bucks for a year. While we used a smaller sample for the analysis of fruit and vegetable consumption and food security when compared to the benefit utilization analysis, we find this sample to be similar demographically to the larger sample. We additionally rely on self-reported consumption of fruits and vegetables and food security, which may be prone to self-report bias, however we mitigate this through use of validated tools for measurement. Other similar studies often rely on fruit and vegetable purchasing data alone to measure changes, while this study benefits from the use of self-reported consumption data. Our measurement of food security uses the Hunger Vital Sign, which is a screening tool used to identify households at risk of being food insecure and therefore may overestimate the actual prevalence of food insecurity.

These findings are likely generalizable to nutrition benefit programs in other mid- to large American cities but may not adequately represent the experiences of those living in rural or more suburban areas which may experience additional barriers to utilizing program benefits. Finally, this work benefits from the use of two large, linkable datasets of enrollees' purchasing, consumption and food security over a three year period. By following enrollees over time, we limit changes in the study population during the study period.

CONCLUSION

Nutrition benefit programs like Fresh Bucks are integral for addressing low nutritional quality and food security in the United States. This work aims to understand groups for whom nutrition benefit programs, like Fresh Bucks, may not adequately address inequities in fruit and vegetable consumption and food security. With the potential for increasing funding toward these types of programs, administrators should seek to improve access for currently underserved populations. Future research to understand the root cause of these barriers, and whether the results found here are replicated among other nutrition benefit programs, is needed for effective policy change.

Table 2.1. Study Participant Demographics

	Utilization Sample		Questionnaire Sample	
	N	%	N	%
Sample Size	19685		6856	
Age of Primary Enrollee				
18-29 years old	2418	12.3	512	7.5
30-39 years old	3618	18.4	1057	15.4
40-49 years old	3097	15.7	942	13.7
50-59 years old	2521	12.8	840	12.3
60-69 years old	3313	16.8	1345	19.6
70-79 years old	2886	14.7	1371	20
80 or older	1549	7.9	724	10.6
Prefer not to answer	283	1.4	64	0.9
Household Size				
1 person	8462	43.0	3191	46.5
2 people	4342	22.1	1564	22.8
3 people	2340	11.9	709	10.3
4 people	2045	10.4	624	9.1
5+ people	2496	12.7	767	11.2
Presence of Child in Household				
No	12394	63.0	4599	67.1
Yes	6964	35.4	2160	31.5
Prefer not to answer	327	1.7	96	1.4
Race/Ethnicity				
White	3118	15.8	1228	17.9
Asian	6056	30.8	2646	38.6
Black	4978	25.3	1459	21.3
Another Race/Ethnicity or Multi-Racial	2752	14	1297	18.9
Missing Race/Ethnicity	1949	9.9	225	3.3
Primary Language Spoken				
English	10310	52.4	3347	48.8
Chinese	3060	15.5	1525	22.2
Vietnamese	1259	6.4	537	7.8
Spanish	2284	11.6	609	8.9
Another Language	2654	13.5	795	11.6
Missing Language	118	0.6	42	0.6
Program Enrollment Method				
Community Based Organization	10226	51.9	2806	40.9
Public Enrollment	9459	48.1	4049	59.1

Table 2.2. Odds Ratio of Spending <25%, 25-75% or >75% of Benefit per Month for 19,685 enrolled households by Age Category, Household Size and Presence of Children in the Household

	Low Utilization (<25%)		Moderate Utilization (25-75%)		High Utilization (>75%)	
	Odds Ratio (95% CI)	p-value	Odds Ratio (95% CI)	p-value	Odds Ratio (95% CI)	p-value
Overall	Ref.		0.21 (0.20, 0.22)	<0.001	3.37 (3.24, 3.51)	<0.001
Household Size						
1-2 People	Ref.		Ref.		Ref.	
3-4 People			1.01 (0.90, 1.15)	0.828	1.30 (1.12, 1.50)	<0.001
5+ People			0.96 (0.82, 1.11)	0.562	1.28 (1.07, 1.52)	0.006
Presence of Child in Household						
No	Ref.		Ref.		Ref.	
Yes			1.25 (1.11, 1.41)	<0.001	1.09 (0.95, 1.25)	0.228
Missing Data on Children			0.88 (0.63, 1.21)	0.423	1.24 (0.85, 1.81)	0.259
Age of Primary Enrollee						
18-39 years old	Ref.		Ref.		Ref.	
40-59 years old			1.71 (1.55, 1.88)	<0.001	2.24 (2.01, 2.50)	<0.001
60+ years old			2.12 (1.90, 2.36)	<0.001	3.49 (3.09, 3.96)	<0.001
Missing Age			1.07 (0.75, 1.53)	0.717	2.02 (1.36, 3.02)	0.001

Notes: Confidence intervals are in parentheses. Estimates are mutually adjusted for household size, presence of children in the household and age of primary enrollee. Each model is additionally adjusted for race/ethnicity, primary language spoken, program enrollment pathway, and income category.

Table 2.3. Ratios of Changes in the Odds of Consuming Fruits and Vegetables ≥3 times per day and Being Food Secure following Fresh Bucks Enrollment by Household Size, Presence of Children in the Household and Age

	Consuming Fruits and Vegetables 3+ times per day				Food Security			
	Pre-Enrollment (%)	Post-Enrollment (%)	Unadjusted Difference (percentage points)	Difference in the Change (95% CI)	Pre-Enrollment (%)	Post-Enrollment (%)	Unadjusted Difference (percentage points)	Difference in the Change (95% CI)
Overall	17.7	22.1	4.4		12.2	16.2	4.0	
Household Size								
1-2 People	18.5	23.7	5.2	Ref.	11.4	16.9	5.5	Ref.
3-4 People	17.1	19.4	2.3	0.85 (0.67, 1.07)	15.2	15.1	-0.1	0.61*** (0.47, 0.79)
5+ People	13.9	16.1	2.2	0.81 (0.59, 1.12)	12.2	13.6	1.4	0.70** (0.50, 0.98)
Presence of Children in Household								
No	19.1	24.1	5	Ref.	12.2	17.3	5.1	Ref.
Yes	15.1	17.9	2.8	0.87 (0.71, 1.07)	12.8	14.4	1.6	0.75** (0.60, 0.94)
Missing Data for Children	12.6	16.1	3.5	1.27 (0.64, 2.50)	3.2	3.4	0.2	1.45 (0.64, 3.29)
Age of Primary Enrollee								
18-39 years old	12.5	16.8	4.3	Ref.	13	14.9	1.9	Ref.
40-59 years old	16.2	20.9	4.7	0.94 (0.71, 1.24)	11.8	14	2.2	1.08 (0.80, 1.44)
60+ years old	21.1	24.8	3.7	0.82 (0.64, 1.04)	12.3	18	5.7	1.21 (0.94, 1.56)
Missing Age	6.3	20	13.7	0.50 (0.19, 1.32)	1.6	5	3.4	0.42 (0.13, 1.29)

Notes: *** p<.01, ** p<.05, * p<0.1. Confidence intervals are in parentheses. Pre- and post-enrollment prevalences are unadjusted. Difference in the Change estimates are mutually adjusted for household size, presence of children in the household and age of primary enrollee. Each model is additionally adjusted for race/ethnicity, primary language spoken, program enrollment pathway, and income category.

Figure 2.1. Predicted Probabilities of Spending <25%, 25-75% or >75% of Benefit per Month by Age Category, Household Size and Presence of Children in the Household

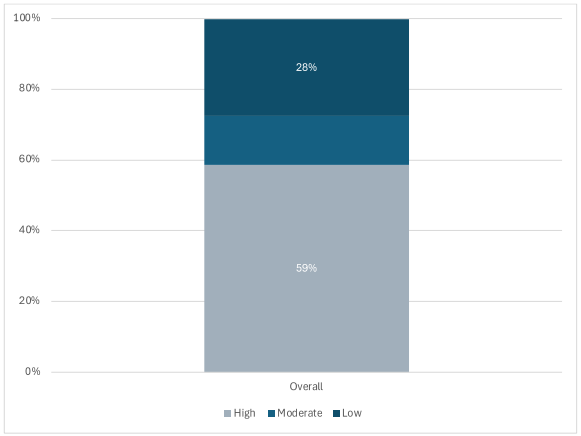

Figure 2.1a. Overall predicted probability of spending a low, moderate or high amount of benefit.

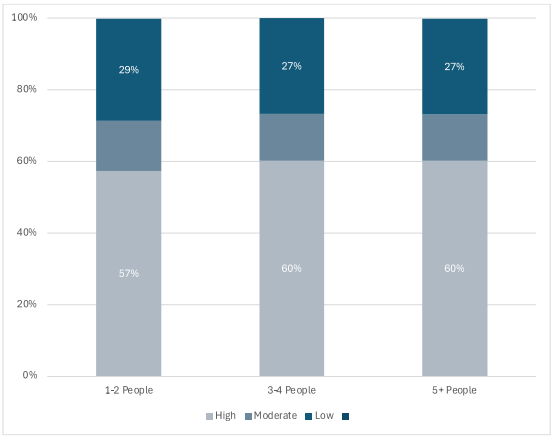

Figure 2.1b. Overall predicted probability of spending a low, moderate or high amount of benefit by household size.

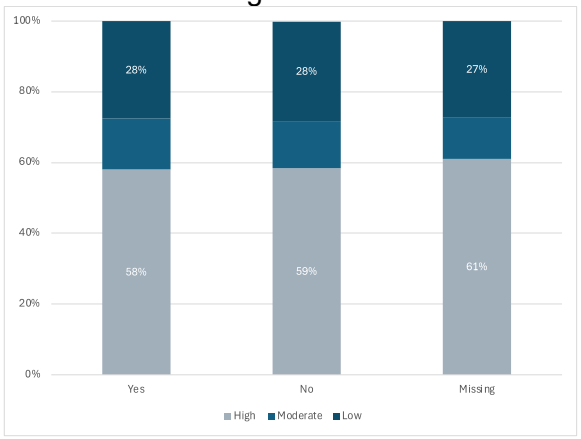

Figure 2.1c. Overall predicted probability of spending a low, moderate or high amount of benefit by presence of children in the household.

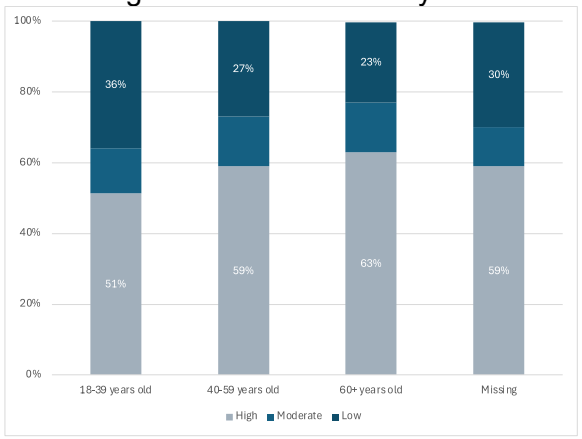

Figure 2.1d. Overall predicted probability of spending a low, moderate or high amount of benefit by age category of primary enrollee.

Notes: Models are mutually adjusted for household size, presence of children in the household and age of primary enrollee. Models are additionally adjusted for race/ethnicity, primary language spoken, primary language spoken, program enrollment pathway, and income category. Data is from October 2021-December 2023. [a]Missing category for presence of children in the household contains 288 households. [b]Missing category for age of primary enrollee contains 211 households.

CHAPTER 3

Title: Associations between Nutrition Benefit Program Utilization and Neighborhood Environment

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Abstract:

Background: Nutrition benefit programs seek to improve access to healthy diets by providing lower-income households with financial resources to purchase fruits and vegetables but may not adequately address disparities in food access. Neighborhood environments may exacerbate disparities in the ability to both afford a healthy diet and utilize program benefits.

Objective: We examined 18,732 households enrolled 1/1/2020-12/31/2023 for differences in utilization of a nutrition benefit program in Seattle, Washington by neighborhood environment. Enrolled households received $40/month for fruit and vegetable purchases.

Methods: We utilized a multinomial logistic regression model with household-level random effects and household-clustered robust standard errors to estimate the odds of spending <25%, 25-75%, or >75% of program benefits in a month as a function of neighborhood environment (distance to program-authorized retailer, density of food retailers, walkability, and neighborhood socioeconomic status). Models were mutually adjusted for neighborhood characteristics and additionally adjusted for household demographics.

Results: Compared to households living >1.5 miles away from a participating store, households who lived within 0.5 miles had 39% higher odds of spending >75%, versus spending <25%, of their monthly program benefits. We additionally found higher utilization of benefits for households with 1+ grocery store within a mile of their home, compared to households with no grocery store within a mile of their home. Finally, we found evidence suggesting lower utilization for households in more walkable neighborhoods and neighborhoods with more unhealthy retailers.

Conclusions: These findings may indicate that neighborhood environment should be considered when implementing nutrition benefit programs.

INTRODUCTION

Few people living in the United States consume adequate amounts of fruits and vegetables, though the cause of this low consumption is complex. One potential explanation is the cost of fruits and vegetables, which may be out of reach for many households. As the proportion of a household's monthly budget spent on food rises, they may reduce purchases (and thus consumption) of costlier foods. This may be particularly relevant for lower income households, as income elasticities indicate that purchases of fruits and vegetables decrease as income decreases.[12,41] Nationally, rates of food insecurity, or inability to afford enough food for an active and healthy life, are much higher for lower-income families than higher-incomes families.[1]

Many households with limited financial resources rely on federally funded nutrition assistance programs like the Supplemental Nutrition Assistance Program (SNAP) and the Special Supplemental Nutrition Program for Women, Infants, and Children (WIC). However, rates of food insecurity have remained high, suggesting that these programs are not sufficient to address the levels of food insecurity present in the United States.[1] In response, several cities have implemented complementary local programs to provide lower-income households with additional resources for the purchase of food, and to serve households with incomes that are just above eligibility criteria for SNAP or WIC. In Seattle, Washington, the Fresh Bucks program seeks to fill this gap by providing eligible households in Seattle with $40 per month that can be used for purchases of fruits and vegetables. Households earning less than 80% of the Area Median Income and living within Seattle city limits are eligible to enroll. Benefits are provided to households via an electronic benefit card and can be redeemed at authorized farmers markets, select

small retailers, and all locations of one large grocery retailer chain in the Seattle area. Approximately 12,000 households had active enrollment in Fresh Bucks in 2021.

Though Fresh Bucks and other similar programs seek to address the financial aspects of food security, additional barriers to food security may exist. In particular, barriers to food security are often conceptualized as a combination of lack of availability ("is there enough for everyone?"), accessibility ("is food physically accessible?"), affordability ("are households able to purchase food?"), acceptability ("are the available options palatable and culturally appropriate?"), and accommodation ("do the options meet the needs and preferences of consumers?").[42,43] This study seeks to examine accessibility of healthy foods in the context of a nutrition benefit program.

Previous work has demonstrated that lower-income neighborhoods tend to have worse access to food retailers offering healthy foods, especially full-service grocery stores, and often have worse quality fruits and vegetables available.[44–46] Additionally, convenience stores, which are over-represented in lower-income neighborhoods, often price fruits and vegetables higher than full-service grocery stores.[47–49] One study of Seattle neighborhoods found that lower-income neighborhoods had lower healthy food availability scores, indicating worse access to healthy foods, compared to higher-income neighborhoods.[50] These factors may impact enrolled households' ability to utilize Fresh Bucks program benefits and lead to disparities in program outcomes.

In earlier studies our team has found that compared to a group of randomly waitlisted households, enrollment in Fresh Bucks is effective at improving fruit and vegetable consumption and food security, though disparities by race and ethnicity for program outcomes remain.[18] We additionally find evidence of disparities in utilization by race and ethnicity in an analysis of all enrollees.[17]

In this paper we examined differences in the utilization of Fresh Bucks' benefits by neighborhood environment, consisting of food retailer access, walkability, and socioeconomic characteristics. Based on the findings from the food environment literature, we posit that households that live further away from any Fresh Bucks authorized retailers – and particularly those that live further away from their *preferred* Fresh Bucks authorized retailer - may experience greater barriers to utilization of Fresh Bucks program benefits. Additionally, lack of access to full-service grocery stores in one's neighborhood, and increased access to convenience stores and fast-food retailers, may further impact a household's ability to utilize program benefits. While all households in this study lived within Seattle city limits and therefore in primarily urban locations, previous research has demonstrated that walkability of one's neighborhood may impact access to healthy foods.[43] We therefore hypothesize that households living in less walkable neighborhoods will have lower utilization of benefits, compared to households in more walkable neighborhoods. Finally, neighborhood socioeconomic status may impact one's ability to utilize program benefits due to systemic disinvestment in communities and lack of access to full-service food retailers. We anticipate that households living in areas of greater socioeconomic disadvantage may have lower utilization of program benefits, despite experiencing greater need for resources and support.

METHODS

Data Sources and Study Sample

Fresh Bucks Program Transaction Data. We included all households who were enrolled in the Fresh Bucks program between January 2020 and December 2023. We examined transactions from October 2021 to December 2023, generated from the use of the

Fresh Bucks program electronic benefit cards. The Fresh Bucks program maintains a database of transactions to monitor program implementation, which were de-identified prior to being shared with the study team. Each transaction record includes the dollar amount of Fresh Bucks' benefit utilized in that transaction, date of transaction, and a unique household identifier. The transaction database was linked via de-identified customer identifier to a second administrative file containing household demographic characteristics, household census block, and a variable indicating the household's preferred food retailer.

Months in which a household was enrolled but did not utilize the benefit were assigned $0 (n=90,104 months) and households that were eventually disenrolled by program administrators for non-use of the benefit were included up until the month in which they were disenrolled. Households that did not have available census block data were removed from analyses (n=953 households). We removed 5,945 household-month observations for participants who moved out of Seattle (and therefore became ineligible for the program) or died. Our final sample includes 18,732 households, for a total of 346,907 household-months.

Distance to Nearest Fresh Bucks Retailer. To calculate neighborhood characteristics for each household, we used the centroid of the census block in which the participant reported living as the reference point. We calculated street network distances, i.e. shortest possible driving distance, using the Google Maps Directions API.

Food Retailers within 1 Mile. We used ArcGIS Pro to calculate 1-mile Euclidian (crow-fly) buffers around the centroid of each household's census block. One mile was selected as the appropriate buffer size because previous work has demonstrated that approximately 64% of household grocery shopping trips occur within 1 mile of home,[51]

and we sought to balance capturing as many potential trips as possible, while excluding potentially irrelevant retailers.

We acquired a list of food retailers within the City of Seattle, provided by Public Health-Seattle King County. Each food retailer was matched to a corresponding North American Industry Classification System (NAICS) code using, in this order of preference, 1) a DataAxel database of food retailers, 2) City of Seattle Active Business License database, or 3) manual categorization using publicly available information from Yelp and Google Images. Food retailers were then categorized into 4 categories: grocery stores or supermarkets, convenience stores, limited-service restaurants, or other ("other" category was not analyzed). NAICS codes for each category are listed in Appendix Table 1. Limited-service restaurants included fast-food restaurants, coffee shops, and snack bars. We conceptualized grocery stores as healthy food retailers because they are most likely to sell fruits, vegetables, and other nutritious foods. We conceptualized convenience stores and limited-service restaurants as unhealthy food retailers because they are more likely to primarily sell processed and less nutritious foods, which are often higher in fat, sugar and salt.[50,52] We then used the sf package in R to determine the count of each store type within the 1-mile buffer polygon.

Walkability. We examined walkability of each households' neighborhood using the Environmental Protection Agency's National Walkability Index (NWI).[53] This index is most granularly available at the census block group level, so we matched the NWI with each households' census block group to assign an NWI score from 1 to 20, with lower scores indicating less walkable neighborhoods.

Neighborhood Socioeconomic Status. We examined each neighborhood's relative socioeconomic status using the Washington-state-standardized 2022 Area Deprivation

Index (ADI) from the University of Wisconsin Center for Health Disparities Research.[54] This measure uses American Community Survey 5-year estimates at the census block group level to calculate a neighborhood's level of socio-economic deprivation, relative to other neighborhoods within Washington state. State-based estimates range from 1-10 with 1 representing the least disadvantaged census block groups and 10 representing the most disadvantaged.

Outcome Measure Definition

Our primary outcome measured the proportion of benefit utilized per month by participant households. To calculate this measure, we summed all transactions within a month by household and divided by the amount available per month to each household ($40). We found a bimodal distribution of this outcome variable, with the majority of households spending very little of their benefit (<$5/month) or approximately all their benefit. To account for this type of distribution of the outcome, we categorized the utilization outcome into the following categories: low (<25%), moderate (25-75%), or high (>75%) proportion of the benefit utilized in a month.

Exposures

The main exposures of interest were distance to nearest Fresh Bucks authorized retailer, density of neighborhood food retailers (grocery stores, convenience stores, and limited-service restaurants), walkability of neighborhood, and a measure of neighborhood socioeconomic status, the Area Deprivation Index. We additionally examined distance to nearest p*referred* Fresh Bucks retailer (described below), instead of distance to nearest Fresh Bucks retailer, in sensitivity analyses.

Distance to Nearest Fresh Bucks Retailer. We calculated the street network distance to the nearest Fresh Bucks authorized retailer of any type. To not impose an assumption of

linearity in this (and other) exposure measures, we created categories of the nearest Fresh Bucks store being <0.5, 0.5-1.0, 1.01-1.5 or >1.5 miles away.

Food Retailers within 1 Mile. We categorized households that have no access to grocery stores within 1 mile (0 stores) and divided the remaining households into tertiles based on the number of grocery stores within their 1-mile buffer (1-5, 6-8 or 9+ grocery stores). We then divided households into tertiles for both convenience stores (0-6, 7-11, 12+ stores) and limited-service restaurants (0-24, 25-45 and 46+ restaurants) within the 1-mile buffer.

Walkability. Almost all (99%) of NWI scores for the census block groups included in this analysis had a score between 10 and 20. To account for this distribution and to align with NWI suggested categorizations, we categorized each census block group as either "above average walkable" ($\leq$15.25), or "most walkable" (>15.25).

Area Deprivation Index. The ADI scores of the study population's census blocks ranged from 1-7, with 90% of households falling in an area with an ADI score ≤4. Previous ADI literature demonstrated higher prevalence of negative health outcomes among individuals living in the most disadvantaged 15% of neighborhoods in a sample, compared to individuals in the remaining 85%.[55,56] We therefore sought to categorize census block groups as either being in the most disadvantaged 15% or the more advantaged 85%. Due to data limitations we created categories of the most disadvantaged 10% (ADI score >4) and the more advantaged 90% (ADI score $\leq$4).

Sensitivity Analyses

Distance to Preferred Fresh Bucks Retailer. We examined distance to preferred Fresh Bucks retailer in sensitivity analyses. We removed households with a non-Fresh Bucks retailer as their preferred retailer (n=2,009) and households who did not indicate a

preferred retailer (n=5,463). We then calculated the street network distance to the nearest *preferred* Fresh Bucks authorized retailer. We categorized each household's preferred retailer as being <0.5, 0.5-1.0, 1.01-1.5 or >1.5 miles away.

Covariates

Participant covariates included race/ethnicity (non-Hispanic Asian, non-Hispanic White, non-Hispanic Black, Hispanic or Latino, another non-Hispanic race/ethnicity or multi-racial, and missing), primary language spoken (Chinese, English, Spanish, Vietnamese, another language, and missing) and age category of primary participant (18-40, 41-60, 61 years or older, and missing). Household-level covariates included household income (≤$10,000, $10001-25000, $25001-40500, $40501-63350, ≥$63351), household size (1,2, 3, 4, 5+), and presence of children in the household (yes/no).

Statistical Analyses

We estimated the odds of utilizing <25%, 25-75% or >75% of Fresh Bucks' benefits in a month as a function of neighborhood environment characteristics with a multinomial logistic regression. The multinomial logistic regression model allowed us to account for the bimodal distribution of utilization data by using a categorical outcome. Each model included household-level random effects and standard errors clustered on the household identifier to account for correlation over time within households. All models were mutually adjusted for all exposures of primary interest and further adjusted for all covariates listed above.

All analyses were completed between November 2024 and May 2025 using R 2021.09.0 (RStudio), ArcGIS Pro, and Stata 18.0 MP. Data for this project was collected as part of normal program evaluation activities by program administrators and was

therefore determined to be ‘not research’ by the University of Washington Institutional Review Board.

RESULTS

We included 18,732 households in the analysis and present demographic characteristics in Table 1. Most participants were NH Asian (32%) or NH Black (25%) and primarily spoke English (51%). Over 40% of the sample were greater than 60 years old and had an average household size of 2.4 people. Participants generally lived near a Fresh Bucks authorized retailer, with 70% living within 1 mile of the nearest Fresh Bucks retailer. Only 2% of participants had zero grocery stores within their 1 mile buffer (including both Fresh Bucks authorized and non-authorized stores). Participants additionally tended to live in highly walkable neighborhoods (mean NWI score=15.7) and neighborhoods with relatively low rates of area disadvantage (mean ADI score=3.0).

We found overall high use of Fresh Bucks’ benefits, with over half of participants utilizing >75% of their benefit in an average month (Table 2). In analyses examining distance to the nearest Fresh Bucks retailer, we found higher utilization to be associated with living closer to a Fresh Bucks authorized retailer. Compared to households that lived >1.5 miles away from the nearest Fresh Bucks store, households who lived <0.5 miles away had 39% higher odds, and households who lived 0.5-1 mile away had 19% higher odds, of spending in the highest category, compared to the lowest category (Odds Ratio (OR): 1.39, (95% Confidence Interval (95%CI): 1.19, 1.62); OR: 1.19, (95%CI: 1.02, 1.38), respectively; Table 2).

Compared to a neighborhood with no grocery stores, living in a neighborhood with a higher number of grocery stores, was associated with higher odds of utilizing >75% of

the benefit compared to <25% of the benefit (1-5 stores OR: 1.41 (95%CI: 1.04, 1.92); 6-8 stores OR: 1.66 (95% CI: 1.19, 2.30); 9+ stores OR: 1.47 (95%CI: 1.04, 2.08); Table 2). Households living within 1 mile of 46 or more limited-service restaurants (highest tertile), compared to those within a mile of less than 24 limited-service restaurants (lowest tertile), had 24% lower odds of spending >75% of the benefit, compared to <25% (OR: 0.76 (95%CI: 0.64, 0.90)). There was a trend toward lower utilization for households in areas with a greater number of convenience stores within 1 mile and for the middle tertile of limited-service restaurants, though these findings were not statistically significant (Table 2). We found that more walkable neighborhoods, as compared to less walkable, were associated with 11% lower odds of utilizing >75% of the benefit, compared to <25% of the benefit (OR: 0.89 (95%CI: 0.81, 0.98); Table 2). Finally, we found no difference in utilization by area deprivation index category (OR: 1.01 (95%CI: 0.87, 1.17); Table 2)

Sensitivity Analyses

In sensitivity analyses, we found similar results for the association between high utilization and distance to a household's preferred Fresh Bucks authorized retailer as were found for distance to *any* Fresh Bucks authorized retailer. Households living <0.5 miles from their preferred Fresh Bucks retailer had 23% higher odds of spending >75%, compared to <25%, as compared to households over 1.5 miles away from their nearest preferred retailer (OR: 1.23, (95%CI: 1.04, 1.44); Appendix Table 2). We found statistically significant 16% higher odds of spending >75% of the benefit, compared to <25% of the benefit, for households 1.01-1.5 miles away from their preferred retailer, compared to those >1.5 miles away from their preferred retailer. Households 0.5-1 mile

away showed a trend toward higher odds of spending >75%, compared to <25%, but it was not statistically significant (Appendix Table 2).

DISCUSSION

We examined a sample including all Fresh Bucks transactions from a two year period for over 18,000 households linked via household census block to six measures of neighborhood characteristics. We found higher utilization of program benefits for households living closer to a program-authorized retailer and households with a greater number of grocery stores within 1 mile of their home. Lower utilization was observed among households in neighborhoods with a greater number of unhealthy retailers and in more walkable neighborhoods. No differences were found by neighborhood socioeconomic status.

One recent study of SNAP-eligible households in Massachusetts who received a 30% rebate on fruits and vegetables as part of the Healthy Incentives Pilot, found that households living within 1 mile of a participating retailer spent 19% more than households who lived further away from participating retailers.[57] While this program differs from Fresh Bucks in implementation and allocation of benefits, these findings align with our results showing the highest odds of benefit utilization among households who live within 1 mile of a Fresh Bucks retailer.

To the best of our knowledge, no other work has previously examined heterogeneities in program implementation outcomes by neighborhood environment, though previous literature has examined the impact of neighborhood environment more broadly. Despite a focus in the last decade on ‘food deserts’ and their associations with poor dietary quality and worse overall health, more recent evidence suggests that the relationship may be more complicated.[58] For example, placement of new grocery stores in a

neighborhood with previously limited access was not found to be associated with increases to fruit and vegetable consumption or decreases in the prevalence of obesity, compared to nearby control neighborhoods that experienced no change to available food retailers.[59–61]

Our finding that a more walkable neighborhood was associated with lower utilization of benefits is not previously reported in the literature. However, the most walkable areas of Seattle are concentrated in the downtown and financial districts, which have a higher prevalence of convenience retailers, compared to grocery stores. The overlap between these measures may additionally help to understand our findings of lower utilization for those with a high number of limited-service restaurants within a mile, and the trend toward lower utilization for those with many convenience stores within a mile. Having an abundance of retailers providing mainly unhealthy options nearby, particularly within walking distance, may be a deterrent to visiting a Fresh Bucks authorized retailer to utilize benefits. Individuals living in these areas may additionally be less likely to own a personal vehicle due to the cost of parking in the city center and therefore experience additional barriers to utilizing program benefits. Furthermore, use of public transportation in Seattle fell by almost 50% during the COVID-19 pandemic in 2020 and began to improve slightly during 2021. This may have created additional barriers for households reliant on public transportation during the time period of this study.

Our finding that utilization does not appear to vary by ADI may indicate Fresh Bucks' benefits are utilized similarly across a variety of neighborhood socioeconomic contexts. However, there is little variation in this measure within Seattle, so these findings may not be generalizable to areas with higher levels of deprivation.

Our study has several limitations. First, to maintain participant anonymity, we could not obtain households' exact address for calculating neighborhood environment and instead used the centroid of the census block for each household. However, urban census blocks (as in Seattle) are relatively small, and often encompass a single city block, so provide a decent estimation of housing location. Like other work examining the retail food environment, we cannot categorize retailers with 100% certainty, which creates the potential for misclassification of the exposure measurement. We are also unable to measure the impact of COVID-19 pandemic related measures on store capacity, hours and perceived safety, which may have impacted groups differentially. We additionally acknowledge that because high utilization is highly prevalent outcome in this sample, the odds may overestimate the differences between groups. Finally, our study includes only participants enrolled in Fresh Bucks, so we are not able to measure program effectiveness, instead comparing differences in utilization between groups. Accordingly, the potential for unmeasured confounding due to other dimensions of food access, including price, quality, brand preferences, and commuting patterns,[62] remains.

CONCLUSION

We find overall high utilization of Fresh Bucks' benefits, with evidence of variation in utilization by neighborhood access to food retailers, but not by neighborhood socioeconomic status. These findings may help policymakers to tailor nutrition benefit programs to better serve households in a variety of neighborhood food access contexts, with the goal of improving equity in benefit utilization. Reduction in disparities in utilization may ultimately lead to reductions in disparities in fruit and vegetable consumption and food security. Future research should further explore potential drivers of the negative association between neighborhood walkability and benefit utilization and

examine whether utilization of benefits changes following improvements to a neighborhood's access to food retailers.

Table 3.1. Study Participant Demographics		
	N	**%**
Sample Size	18732	
Age of Primary Enrollee		
18-39 years old	5509	29.4
40-59 years old	5370	28.7
≥60 years old	7580	40.5
Prefer not to answer	273	1.5
Household Size (Mean (SD))	2.4	(1.7)
Child Present in Household (Yes)	6494	34.7
Race/Ethnicity		
Non-Hispanic (NH) Asian	5895	31.5
NH White	2925	15.6
NH Black	4673	24.9
Hispanic or Latino	2594	13.8
Another NH Race/Ethnicity or Multi-racial	1818	9.7
Missing Race/Ethnicity	827	4.4
Primary Language Spoken		
English	9635	51.4
Chinese	2954	15.8
Vietnamese	1231	6.6
Spanish	2172	11.6
Another Language	2628	14
Missing Language	112	0.6
Distance to Nearest Fresh Bucks Retailer		
<0.5 Mile	6214	33.2
0.5-1.0 Mile	6908	36.9
1.01-1.5 Miles	3271	17.5
>1.5 Miles	2339	12.5
Number of Grocery Stores within 1 Mile		
Zero	390	2.1
Lowest Non-Zero Tertile (1-5)	7286	38.9
Middle Non-Zero Tertile (6-8)	4945	26.4
Highest Non-Zero Tertile (9+)	6111	32.6
Number of Convenience Stores within 1 Mile		
Lowest Tertile (1-6)	5936	31.7
Middle Tertile (7-11)	6286	33.6
Highest Tertile (12+)	6510	34.8
Number of Limited-Service Restaurants within 1 Mile		
Lowest Tertile (0-24)	6276	33.5
Middle Tertile (25-45)	6559	35
Highest Tertile (46+)	5897	31.5
Walkability		
Above Average Walkable (Walk Score ≤15.25)	8664	46.3
Most Walkable (Walk Score >15.25)	10068	53.7
Area Deprivation Index (ADI)		
More Deprived (ADI Score >4)	1744	9.4
Less Deprived (ADI Score ≤3)	16819	90.6

Table 3.2. Odds Ratio of Utilizing <25%, 25-75% or >75% of Fresh Bucks Benefit per Month by Neighborhood Environment (n= 18,732 households)

	Low Utilization (<25%)		Moderate Utilization (25-75%)		High Utilization (>75%)	
Sample Size (Household-Months)	93,743		28,752		224,412	
	Odds Ratio (95% CI)	**p-value**	**Odds Ratio (95% CI)**	**p-value**	**Odds Ratio (95% CI)**	**p-value**
Overall	Ref.		0.21 (0.21, 0.22)	<0.001	3.52 (3.39, 3.67)	<0.001
Distance to Nearest Fresh Bucks Retailer						
>1.5 Miles	Ref.		Ref.		Ref.	
1.01-1.5 Miles			1.00 (0.86, 1.17)	0.973	1.14 (0.97, 1.34)	0.102
0.5 -1.0 Mile			1.21 (1.04, 1.39)	0.011	1.19 (1.02, 1.38)	0.027
<0.5 Mile			1.38 (1.19, 1.60)	<0.001	1.39 (1.19, 1.62)	<0.001
Number of Grocery Stores within 1 Mile						
Zero	Ref.		Ref.		Ref.	
Lowest Non-Zero Tertile (1-5)			1.00 (0.75, 1.32)	0.980	1.41 (1.04, 1.92)	0.027
Middle Non-Zero Tertile (6-8)			1.16 (0.86, 1.57)	0.333	1.66 (1.19, 2.30)	0.003
Highest Non-Zero Tertile (9+)			1.05 (0.76, 1.45)	0.752	1.47 (1.04, 2.08)	0.029
Number of Convenience Stores within 1 Mile						
Lowest Tertile (0-6)	Ref.		Ref.		Ref.	
Middle Tertile (7-11)			0.93 (0.82, 1.04)	0.208	0.93 (0.82, 1.05)	0.237
Highest Tertile (12+)			0.82 (0.69, 0.97)	0.022	0.87 (0.73, 1.03)	0.112
Number of Limited-Service Restaurants within 1 Mile						
Lowest Tertile (0-24)	Ref.		Ref.		Ref.	
Middle Tertile (25-45)			0.89 (0.79, 1.01)	0.061	0.91 (0.81, 1.03)	0.136
Highest Tertile (46+)			0.80 (0.68, 0.94)	0.007	0.76 (0.64, 0.90)	0.002
Walkability						
Above Average Walkable (Walk Score ≤15.25)	Ref.		Ref.		Ref.	
Most Walkable (Walk Score >15.25)			0.96 (0.87, 1.05)	0.378	0.89 (0.81, 0.98)	0.021
Area Deprivation Index						
More Deprived (ADI Score >4)	Ref.		Ref.		Ref.	
Less Deprived (ADI Score ≤4)			0.92 (0.79, 1.05)	0.221	1.01 (0.87, 1.17)	0.876

Notes: Confidence intervals are in parentheses. Estimates are mutually adjusted and adjusted for race/ethnicity, primary language spoken, age of primary participant, household income, household size and presence of children in the household.

CHAPTER 4

Title: Changes to Fruit and Vegetable Consumption and Food Security Differ by Store Access and Walkability Following Enrollment in a Nutrition Benefit Program
Authors: Jamie Wallace, M. Pia Chaparro, Nadine Chan, Melissa Knox, Barbara Baquero, Jessica Jones-Smith

ABSTRACT

Introduction: Nutrition benefit programs are effective at increasing fruit and vegetable consumption and food security. However, little work has examined whether those program impacts might be moderated by the neighborhood food environment, walkability, and neighborhood socioeconomic status. We assess if neighborhood characteristics moderate changes to fruit and vegetable consumption and food security following enrollment in Fresh Bucks, a program in Seattle, Washington that provides $40/month for produce purchases to low-income households.

Methods: We use mutually adjusted logistic regression models with household-level random effects and robust standard errors. We examine an interaction term between pre- versus post-program enrollment and exposure of interest (neighborhood food environment, walkability, socioeconomic status) to estimate the change in odds of consuming fruits and vegetables $\geq$3 times/day and of being food secure following at least a year of Fresh Bucks enrollment. We additionally adjust for race/ethnicity, primary language, household income, age, household size, and presence of children in the household. Households enrolled in Fresh Bucks beginning in January 2020, and who sought re-enrollment in Fresh Bucks in January 2022 (n=6,623) are included

Results: In unadjusted analyses we found a higher prevalence of consuming fruits and vegetables $\geq$3 times/day and being food secure in the post-program period compared to pre-program period across the broader sample. Households >1.5 miles away from a Fresh Bucks retailer and in neighborhoods with zero grocery stores within 1 mile had the largest increases in prevalence of consuming fruits and vegetables $\geq$3 times per day. Following program enrollment, we found lower changes in the odds of consuming fruits and vegetables $\geq$3 times/day among households located in areas with a greater number of unhealthy retailers within 1 mile of their home, compared to those with few unhealthy retailers. We additionally found larger changes in the odds of consuming fruits and vegetables $\geq$3 times/day and being food secure in the post-program period for households in more walkable neighborhoods, compared to relatively less walkable neighborhoods.

Conclusions: Households with limited access to healthy retailers may experience greater benefit from Fresh Bucks, helping to reduce disparities in food access. However, households with greater access to unhealthy retailers may experience fewer program-related benefits.

INTRODUCTION

The United States Dietary Guidelines for Americans recommends that adults consume at least 5 servings of fruits and vegetables per day, but most adults living in the United States do not meet these recommendations.[12] Limited fruit and vegetable consumption is linked to poor health outcomes, including cardiovascular disease and stroke.[15] Food security, or the lack of access to enough food for an active healthy life, is a contributing cause to low fruit and vegetable consumption[63,64] and is associated with higher prevalence of type 2 diabetes[6] and other chronic diseases.[5,8] Increasing access to fruits and vegetables and improving rates of food security has therefore been deemed a priority for policymakers.

Disparities in neighborhood characteristics affecting food access may contribute to these low rates of consumption and food security. Lower-income neighborhoods and neighborhoods with a higher proportion of Black, Indigenous, and People of Color have been found to have worse access to healthy foods, and often pay more for healthy foods at the available stores.[65] One study, based in Seattle, Washington, found lower Healthy Food Availability Scores for neighborhoods with lower-incomes, compared to higher-income neighborhoods.[50] This lack of access to healthy retailers may subsequently impact fruit and vegetable consumption.[66] Furthermore, lower-income households have much lower rates of food security than the broader population.[1]

A recent study found that living in a census tract with a greater number of supermarkets and full-service restaurants was associated with a healthier diet.[67]

Previous research has demonstrated a connection between walkability and overall nutrition outcomes which may suggest an association between walkability and fruit and

vegetable consumption and food security. Among individuals in urban Missouri, living in a highly walkable neighborhood was associated with 60% higher odds of reporting sufficient access to fruits and vegetables.[68] This association may be modified however by socioeconomic status, with evidence suggesting neighborhood walkability is associated with dietary consumption among high-income individuals, but not lower-income individuals.[69]

To address low rates of fruit and vegetable consumption and food security, state and local governments administer programs to improve access to healthy foods among their constituents. Limited research has examined whether these nutrition benefit programs are differentially associated with changes to fruit and vegetable consumption and food security by neighborhood characteristics.

We examine a nutrition benefit program in Seattle, Washington, Fresh Bucks, which provides lower-income families with $40 per month to be spent at a large grocery retailer, farmers markets, or select local stores on fruits and vegetables. Eligibility criteria for enrollment in Fresh Bucks includes residing within Seattle city limits and having household income less than 80% of the Area Median Income. The program served approximately 12,000 households between 2020 and 2022. We examined differences in changes in fruit and vegetable consumption and food security by neighborhood characteristics, including the food environment, neighborhood walkability, and neighborhood socioeconomic status following at least one year of enrollment in Fresh Bucks.

METHODS

Data and Study Sample

As part of usual program operations, the Fresh Bucks programmatic team administered two program enrollment questionnaires per household. Approximately 12,000 households first completed this questionnaire in January 2020 (pre-program enrollment measurement), for enrollment in Fresh Bucks through December 2021. In January 2022, households that wished to remain enrolled in Fresh Bucks (n=6,856) were required to re-apply to the program and complete the questionnaire again (post-program enrollment measurement). We limited the sample to households who completed both the pre-program and post-program enrollment questionnaires. Households with missing census block information were removed (n=233) for a final sample of 6,623 households.

The questionnaires described above included measurements of fruit and vegetable consumption and a screener for food security status. Administrative sections of the application collected information on household census block, and household demographics, including race/ethnicity of primary enrollee, primary language spoken, household income, age and household size. Households were additionally asked to report their preferred retailer for food shopping which could be either a Fresh Bucks-authorized retailer or a non-Fresh Bucks-authorized retailer.

Outcome Measure Definitions

Fruit and Vegetable Consumption. We assessed fruit and vegetable consumption using the pre- and post-enrollment questionnaires described above. Both questionnaires utilize a modified version of the Behavioral Risk Factor Surveillance System (BRFSS) Fruit and Vegetable Module Questionnaire (excluding 100% fruit juice). This questionnaire uses a five-item brief dietary assessment tool to measure frequency of consumption of fruits and vegetables in the previous month, specifically focusing on

fruit, green leafy or lettuce salad, fried potatoes, other potatoes, and other vegetables. Participants are asked, "*During the past month, how often did you eat [fruit]?*" and asked to respond with one of the following options: "*never*", "*1 time last month*", "*2-3 times last month*", "*1 time per week*", "*2 times per week", "3-4 times per week", "5-6 times per week", "1 time per day",* and "*2 or more times per day*". For each participant we summed the frequency of consumption across the five questions and then categorized each participant as consuming fruits and vegetables either <3 times per day or ≥3 times per day in the previous month. Recommendations suggest that individuals should consume fruits and vegetables at least five times per day, but three times per day was selected as the outcome definition for this analysis to account for the pre-program distribution of consumption present in the data. Previous work has shown the BRFSS tool to adequately measure fruit and vegetable consumption, validated against a 24-hour recall, which is the gold-standard for dietary research.[32]

Food Security. We additionally utilized a measure of food security, the 2-item Hunger Vital Sign food security screener, which was included in the pre- and post-enrollment questionnaires. This screener has been validated to identify households at risk for food insecurity in a manner consistent with the United States Department of Agriculture 18-item Household Food Security Survey Module.[33] This screener measures food security using the two following items: *"In the past 12 months, I/we worried that food at home would run out before I/we got money to buy more"* and "*Within the past 12 months, the food I/we bought ran out, and I/we didn't have money to get more,*" with the following response options: "*often true", "sometimes true", "never true".* Per the screener guidelines, we coded participants indicating "often true" or "sometimes true" to either question as 'at risk' for food insecurity. In our analyses we reverse coded this variable

so that it could be interpreted uniformly with the measure of fruit and vegetable consumption (i.e. we analyzed the prevalence of food security).

Exposures

We examined several measures of neighborhood environment, defining neighborhood as the area surrounding the centroid of the census block for each household.

Distance to Nearest Fresh Bucks Retailer. We first computed distance from the census block centroid to the nearest Fresh Bucks authorized retailer, via the street driving (i.e. network) distance using the Google Maps Distance API. In sensitivity analyses we similarly computed street driving distance to each household's self-reported preferred Fresh Bucks retailer. We categorized each household as being <0.5, 0.5-1, 1.01-1.5 or >1.5 miles away from either the nearest or nearest preferred Fresh Bucks retailer.

Density of Retailers in 1-Mile Buffer. We next estimated the density of food retailer by type within a one-mile Euclidian (i.e. straight-line) buffer around the centroid of the census block. Store types were determined based on a list of all Seattle retailers obtained from Public Health - Seattle & King County. We then matched those stores to relevant North American Industry Classification System (NAICS) codes using databases in the following order of priority: 1) DataAxel database of business retailers in Seattle and relevant NAICS categorization, 2) City of Seattle tax data, and 3) publicly available data for retailers from Yelp and Google Images (relevant NAICS codes for each category are presented in Appendix B, Table 1). We categorized each retailer within Seattle as a grocery store/supermarket, limited-service restaurant, convenience retailer, or other retailer type. We used ArcGIS Pro to create a one-mile Euclidian buffer around the centroid of each census block. We then calculated the number of grocery stores,

limited-service restaurants, and convenience retailers within the 1-mile buffer. For analysis we divided each retailer density variable into tertiles. For grocery stores we additionally included a category for having zero grocery stores within the 1-mile buffer, as we posit that this represents qualitatively different food access than having at least one grocery store within the 1-mile buffer. Households were categorized as having 0, 1-5, 6-8 or 9+ grocery stores and 0-6, 7-11 or 12+ convenience stores within their census block 1-mile buffer. Limited-service restaurants were much more prevalent within the data sample, so we categorized households as having 0-24, 25-45, and 46+ limited-service restaurants within their census block 1-mile buffer, again using tertiles of the distribution.

Walkability. We additionally assessed the walkability of the neighborhood surrounding each household. We used the United States Environmental Protection Agency's National Walkability Index (NWI), which is available at the census block group level. The NWI measures neighborhood walkability on a scale from 1-20, with higher scores indicating higher levels of walkability. Scores are then categorized as "least walkable" (1-5.75), "below average walkable" (5.76-10.5), "above average walkable" (10.51-15.25), and "most walkable" (15.26-20). Neighborhoods included in the sample were largely very walkable (less than 1.7% had a score of less than 10.51), so there was insufficient sample size to analyze less walkable neighborhoods separately. Thus, we categorized each household as being in a census block group with a score $\leq$15.25 or >15.25 to align with NWI categories of "above average walkable" and "most walkable".[53]

Socioeconomic Characteristics. Lastly, we examined neighborhood socioeconomic status using the University of Wisconsin's Area Deprivation Index (ADI) standardized to the state of Washington. The ADI is the most widely used measure of aggregate

neighborhood socioeconomic status and has been shown to predict prevalence of health outcomes in several populations.[55,56] A higher ADI score (maximum=10) corresponds to a census block with higher rates of socioeconomic deprivation, while a lower ADI score (minimum=1) corresponds to a lower level of deprivation. We calculated the ADI score for each household and categorized them as ≤4 and >4. This cutoff was selected as the group >4 represents the top 10% area deprivation scores present in the sample and previous research has found the top 10% of area deprivation scores to be associated with worse health outcomes.[55,56]

Covariates

Participants self-reported their race/ethnicity and primary language spoken, which we condensed into categories to ensure adequate sample size. For race/ethnicity the final categories were non-Hispanic Asian, non-Hispanic White, non-Hispanic Black, Hispanic or Latino, another race/ethnicity or multi-racial, and missing race/ethnicity. For primary language the final categories were Chinese, English, Spanish, Vietnamese, another language and missing language information. Participants additionally self-reported household income (≤$10,000, $10001-25000, $25001-40500, $40501-63350, ≥$63351), household size (1,2, 3, 4, 5+), and presence of children in the household (yes/no). All models were adjusted for these covariates.

Study Design and Analyses

We utilized separate logistic regression models with household-level random effects to examine the relationship between each exposure measure and the binary measures of fruit and vegetable consumption and food security. To assess change in the outcomes from pre-enrollment to 1-year post-enrollment, we included an interaction term between

the pre- vs post-enrollment variable and the exposure of interest. This is the primary coefficient of interest. We include cluster robust standard errors to account for repeated measures by households. All models are mutually adjusted for all exposures (as categorical variables) and the following sociodemographic characteristics: race/ethnicity, primary language, age, household income, household size, and presence of child in the household. The model takes the following general form (using the exposure of Distance to Nearest Fresh Bucks retailer as an example):

$$\text{logit}(\Pr(Y_{it}=1|X_{it})) = \beta_0 + \beta_1 \text{DistanceFBxRetailer}_i + \beta_2 \text{Follow-up Questionnaire}_{it} + \beta_3 \text{DistanceFBxRetailer}_i \text{ x Follow-up Questionnaire}_{it} + \beta_4 \text{CountGroceryStores} + \beta_5 \text{CountConvenienceStore}_i + \beta 6 \text{CountLimitedServiceRestaurant}_i + \beta_7 \text{NWI}_i + \beta_8 \text{ADI} + \beta_9 X_i + U_i$$

where Y represents a binary indicator for consuming fruits and vegetables $\geq$3 times per day or being food secure, i is an indicator for household identifier and t is time (pre- versus post-program enrollment questionnaire). X_i represents a vector of individual covariates (described above) and U_i represents household-level random effects. Using the outcome of food security as an example, β_3 is the difference in the change in the natural log of the odds of being food secure from pre- to post-program participation for households living <0.5 miles away from the nearest Fresh Bucks retailer, as compared to households living >1.5 miles away. This method has been found to estimate the difference between groups for pre- and post-program data in the absence of an untreated control group.[34] While this study includes one pre-enrollment period measurement and one post-enrollment period measurement for each household, we have no evidence to suggest that trends in fruit and vegetable consumption or food security differed by these exposures in the pre-program period (i.e. disparities

discussed above were not worsening or lessening differentially). Therefore, we determined that the parallel trends assumption was met.

All analyses were completed in ArcGIS Pro, R Version 2021.09.0 (RStudio), and Stata 18.0MP. Data were analyzed between November 2024 and May 2025. All data were de-identified prior to sharing with the study team and the study was determined to be not research by the UW IRB due to the data being collected for programmatic purposes and only a deidentified data set shared with the research team.

RESULTS

Our final sample included 6,623 households (Table 4.1); 39% of household primary participants were Non-Hispanic (NH) Asian, 21% were NH Black and 18% were NH white. Enrolled households primarily spoke English (48%) and Chinese (23%) and had relatively few household members (mean=2.2). Over half of primary participants reported being over 60 years old (51%).

Fruit and Vegetable Consumption. In unadjusted analyses we found the prevalence of consuming fruits and vegetables $\geq$3 times per day rose from 17.7% to 22.1% from the pre-program to post-program period for the overall sample (a 4.4 percentage point difference; Table 4.2). This increase in prevalence was seen across all exposure categories, though there was variation in the amount of increase by neighborhood characteristics (Table 4.2).

We found inconsistent results for the association between distance to the nearest Fresh Bucks retailer and changes to fruit and vegetable consumption in adjusted analyses. The change in the odds of consuming fruits and vegetables $\geq$ 3 times per day from pre-enrollment to 1-year post for households within 0.5-1 mile from the nearest Fresh Bucks

retailer was 32% lower, than households >1.5 miles away (Odds Ratio (OR): 0.68, 95% Confidence Interval (CI): 0.50, 0.91; Table 4.2). However, for households 1-1.5 miles away and <0.5 miles away of their nearest Fresh Bucks retailer, compared to households >1.5 miles away, we found no significant difference in the change in the odds of consuming fruits and vegetables ≥3 times per day.

For number of grocery stores within a 1-mile buffer, we found no statistically significant association between the number of grocery stores within the buffer and the change in the odds of consuming fruits and vegetables ≥3 times per day (Table 4.2).

The change in the odds of consuming fruit and vegetables ≥3 times per day from pre-enrollment to 1-year post enrollment was 44% lower for households with 12+ convenience stores nearby (OR: 0.66, 95%CI: 0.53, 0.82) and 22% lower for households with 7-11 convenience stores nearby (OR 0.78, 95% CI 0.63, 0.97), compared to households with 1-6 convenience stores nearby (Table 4.2).

Households living in a neighborhood with the 25-45 limited-service restaurants within 1 mile had 23% lower change in the odds of consuming fruits and vegetables ≥3 times per day, compared to households with <24 limited-service restaurants within 1 mile (OR: 0.78, 95%CI: 0.63, 0.97). We found point estimates in the same direction, indicating lower use, for households with ≥46 limited-service restaurants within 1 mile, compared to <24, but these findings were not statistically significant.

We additionally found significant differences in the change in the odds of consuming fruits and vegetables ≥3 times per day by neighborhood walkability. Households in more walkable neighborhoods were found to have 25% higher change in the odds of

consuming fruits and vegetables, compared to households in relatively less walkable neighborhoods (OR: 1.25, 95% CI: 1.05, 1.50; Table 4.3).

We found no differences in change in the odds of consuming fruits and vegetables ≥3 times per day as a function of area deprivation index category (OR: 0.97, 95% CI: 0.72, 1.30; Table 4.3).

Food Security. In unadjusted analyses of the overall sample, we found the prevalence of being food secure rose from 12.2% in the pre-program period to 16.2% in the post-program period (a 4 percentage point increase; Table 4.2). Higher prevalence of being food secure in the post-program period was seen consistently across all exposure categories (Table 4.2).

In adjusted analyses of food security, we found no differences in changes to the odds of being food secure as a function of distance to nearest Fresh Bucks store; count of grocery stores, convenience retailer or limited-service restaurant within 1 mile; or ADI score (Table 4.2 & 4.3). We found statistically significant changes to the odds of being food secure in the follow-up period for households living in a more walkable neighborhood, compared to those in a relatively less walkable neighborhood (OR: 1.27, 95% CI: 1.05, 1.55).

Sensitivity Analyses. In sensitivity analyses examining distance to nearest preferred Fresh Bucks retailer, point estimates were in the expected direction and demonstrated higher change in the odds of consuming fruits and vegetables ≥3 times per day and being food secure for households closer to a preferred retailer, but the estimates were not statistically significant (Appendix Table 3).

DISCUSSION

In this analysis examining over 6,000 households prior to and following enrollment in a nutrition benefit program in Seattle, we found varied evidence of an association between neighborhood food access characteristics (number of grocery stores, convenience stores, and limited-service restaurants within 1-mile) and differences in changes to fruit and vegetable consumption, but no association with differences in changes to food security. In this urban setting, neighborhood walkability had the largest association with changes to the odds of consuming fruits and vegetables and becoming food secure of the examined neighborhood characteristics. Neighborhood socioeconomic status was not found to be associated with differential changes to either outcome.

Our findings of null or negative associations between distance to nearest Fresh Bucks retailer and program outcomes are partially in alignment with a recent systematic review. This review reported that the majority of included studies (n=15) found no association between fruit and vegetable consumption and distance to nearest full-service retailer.[70] However, a more recent study found an association between average proximity to, and density of, healthy food retailers and participant's Alternative Healthy Eating Index (which measures overall diet, not just fruit and vegetable consumption) in a large, multi-ethnic cohort with over 10 years of follow-up. These findings may suggest distance to retailer is associated with overall dietary quality, not merely fruit and vegetable consumption.[71] This study additionally found that perception of availability of a healthier food environment within one mile was associated with higher dietary quality at baseline and follow-up, suggesting that factors influencing diet may additionally depend on quality of options, not merely distance.

In the present study, an alternative specification of distance to nearest Fresh Bucks retailer as a continuous variable indicated an association between households further from a Fresh Bucks retailer and larger changes in the odds of consuming fruits and vegetables ≥3 times per day, though this finding was not statistically significant. This may indicate a lack of robustness in findings related to distance to nearest retailer. Alternatively, pre- and post-program enrollment prevalences of consuming fruits and vegetables ≥3 times per day may help to understand these findings. Households living further away from a Fresh Bucks retailer experienced the largest change in prevalence from the pre- to post-program period, indicating that Fresh Bucks may be helping to reduce disparities associated with the neighborhood environment (Table 4.2).

Our findings of no association between the number of grocery stores within a 1-mile buffer and changes in odds of being food secure further agree with a cross-sectional study of the Food Acquisition and Purchase Survey (FoodAPS) which found no association between food security status and having a supermarket within 1 mile of one's house. This study instead found that use of one's own car to complete grocery shopping trips was associated with higher likelihood of being food secure, compared to individuals who used someone else's car.[72] This may suggest that car ownership is a modifier in the relationship we observe between grocery store access and food security status. Furthermore, one systematic review including quasi-experimental studies found limited increases in fruit and vegetable consumption for subgroups of people who began shopping at a retailer that was newly placed in their neighborhood, but found no changes for the broader population in the surrounding area (i.e. those that did not choose to shop at the new retailer).[73] This may indicate that household preferences play

a significant role in where to shop and how the neighborhood environment is associated with changes to fruit and vegetable consumption and food security.

We found greater changes in odds of consuming fruits and vegetables ≥3 times per day and being food secure, post vs. pre- program enrollment, for households in more walkable neighborhoods. Little work has examined the association between walkability and changes to fruit and vegetable consumption and food security following enrollment in a nutrition benefit program. One study in Chicago, Illinois found that retailers participating in a nutrition benefit program were located slightly closer to under-resourced neighborhoods and more walkable neighborhoods.[74] While this finding is based on a different program in a different city, it may help us understand why neighborhoods with greater walkability are associated with greater increases in fruit and vegetable consumption and food security, as these households may have overall easier access to program approved stores. Fresh Bucks participating households are lower-income and may experience lower access to cars and alternative transportation that increase the importance of the ability to walk to food retailers, particularly those that are program-authorized. Furthermore, this study takes place in the years following the height of the COVID-19 pandemic, which saw substantial decreases in use of public transportation[75] likely due to safety regulations and individuals' concerns about potential infection.

This study benefits from longitudinal data examining fruit and vegetable consumption and food security at baseline and follow-up, following enrollment in a nutrition benefit program. While we are unable to utilize participant exact home addresses, we had access to household's census block, which is a good estimation for address in an urban area like Seattle. We use street network distance to most accurately measure the

distance from the centroid of household's census block to program-authorized retailers, and validated measures for walkability, neighborhood socioeconomic characteristics, and fruit and vegetable consumption.

This study additionally has limitations. For our measurement of food security, we utilize a screener that measures risk of food insecurity, which may underestimate the prevalence of being food secure. However, we do not anticipate this underestimation to be different between groups. Walkability was measured at the census block group level and all census block groups in this study are within an urban metropolitan area with less variability in degree of walkability than the broader United States. This may impact our ability to measure differences between neighborhoods, though this would likely bias our results toward the null value as the neighborhoods would be more similar. We conceptualize grocery stores and supermarkets as 'healthy' retailers, and convenience retailers and limited-service restaurants as 'unhealthy' retailers, but this categorization may not be entirely accurate. Supermarkets and grocery stores offer a large variety of options, including highly processed or unhealthy options. Conversely, convenience retailers and limited-service restaurants may offer healthy options leading to misclassification of the exposure.[76] Finally, other aspects of neighborhood food access, including access to food banks or pantries may further impact how households access healthy foods.

CONCLUSION

We found increases in fruit and vegetable consumption and food security for the broader sample following enrollment in Fresh Bucks. Households living further away from a Fresh Bucks retailer or in a neighborhood with fewer grocery stores

demonstrated the largest increases in fruit and vegetable consumption and food security, indicating Fresh Bucks may help to lessen disparities associated with the neighborhood environment. Future work should examine the potential mechanisms by which nutrition benefit programs may lessen these disparities.

Table 4.1. Study Participant Demographics		
	N	**%**
Sample Size	6623	
Age of Primary Enrollee		
18-39 years old	1491	22.5
40-59 years old	1708	25.8
>60 years old	3362	50.8
Prefer not to answer	62	0.9
Household Size (Mean (SD))	2.2	(1.7)
Child Present in Household (Yes)	2069	31.2
Race/Ethnicity		
Non-Hispanic Asian	2585	39
Non-Hispanic White	1179	17.8
Non-Hispanic Black	1418	21.4
Hispanic or Latino	707	10.7
Another Race/Ethnicity or Multi-Racial	520	7.9
Missing Race/Ethnicity	214	3.2
Primary Language Spoken		
English	3197	48.3
Chinese	1499	22.6
Vietnamese	527	8
Spanish	578	8.7
Another Language	783	11.8
Missing Language	39	0.6
Distance to Nearest Fresh Bucks Retailer		
>1.5 Miles	2289	34.6
1.01-1.5 Miles	2423	36.6
0.5-1 Mile	1136	17.2
<0.5 Mile	775	11.7
Number of Grocery Stores within 1 Mile		
Zero	112	1.7
Lowest Non-Zero Tertile (1-5)	2494	37.7
Middle Non-Zero Tertile (6-8)	1799	27.2
Highest Non-Zero Tertile (9+)	2218	33.5
Number of Convenience Stores within 1 Mile		
Lowest Tertile (0-6)	2287	34.5
Middle Tertile (7-11)	2150	32.5
Highest Tertile (12+)	2186	33
Number of Limited-Service Restaurants within 1 Mile		
Lowest Tertile (0-24)	2294	34.6
Middle Tertile (25-45)	2093	31.6
Highest Tertile (46+)	2236	33.8
Walkability		
Above Average Walkable (Walk Score ≤15.25)	3027	45.7
Most Walkable (Walk Score >15.25)	3596	54.3
Area Deprivation Index		
Less Deprived (ADI Score ≤4)	5920	89.9
More Deprived (ADI Score >4)	663	10.1

Table 4.2. Ratio of Changes in the Odds of Consuming Fruits and Vegetables (F/V) 3+ times per day and Being Food Secure following Fresh Bucks Enrollment by Neighborhood Food Access (N=6,623)

	Consuming F/V 3+ times per day				Food Security			
	Pre-Enrollment (%)	Post-Enrollment (%)	Unadjusted Difference (percentage points)	Difference in the Change (95% CI)	Pre-Enrollment (%)	Post-Enrollment (%)	Unadjusted Difference (percentage points)	Difference in the Change (95% CI)
Overall	17.7	22.1	4.4		12.2	16.2	4.0	
Distance to Nearest Fresh Bucks Store								
>1.5 Miles	16.9	23.6	6.7	Ref.	13.7	17.2	3.5	Ref.
1.01-1.5 Miles	17.6	22.8	5.2	0.89 (0.64, 1.24)	14.2	18.1	3.9	0.88 (0.62, 1.27)
0.5-1 Mile	19.2	21.7	2.5	0.68 (0.50, 0.91)**	10.9	15.5	4.6	0.93 (0.67, 1.27)
<0.5 Miles	16.3	21.5	5.2	0.78 (0.58, 1.05)	12.0	15.8	3.8	0.92 (0.67, 1.27)
Number of Grocery Stores within 1 Mile								
Zero	15.2	24.1	8.9	Ref.	11.6	17.9	6.3	Ref.
Lowest Non-Zero Tertile (1-5)	16.5	23.3	6.8	0.85 (0.42, 1.75)	14.3	17.3	3.0	0.73 (0.35, 1.56)
Middle Non-Zero Tertile (6-8)	16.9	19.4	2.5	0.54 (0.26, 1.12)*	11.4	15.6	4.2	0.70 (0.33, 1.50)
Highest Non-Zero Tertile (9+)	19.7	22.6	2.9	0.57 (0.28, 1.17)	10.4	15.4	5.0	0.83 (0.39, 1.77)
Number of Convenience Stores within 1 Mile								
Lowest Tertile (0-6)	17.0	23.5	6.5	Ref.	13.6	16.1	2.5	Ref.
Middle Tertile (7-11)	17.5	20.9	3.4	0.78 (0.63, 0.97)**	12.5	17.9	5.4	0.97 (0.85, 1.38)
Highest Tertile (12+)	18.4	21.8	3.4	0.66 (0.53, 0.82)**	10.6	14.8	4.2	1.03 (0.81, 1.31)
Number of Limited-Service Restaurants within 1 Mile								
Lowest Tertile (0-24)	16.1	22.1	6.0	Ref.	13.3	16.4	3.1	Ref.
Middle Tertile (25-45)	17.8	20.8	3.0	0.68 (0.55, 0.85)**	12.3	15.4	3.2	0.97 (0.77, 1.24)
Highest Tertile (46+)	19.0	23.2	4.2	0.80 (0.64, 0.99)**	10.8	16.8	6.0	1.23 (0.97, 1.57)**

Note: Confidence intervals are in parentheses. Estimates are mutually adjusted and further adjusted for race/ethnicity, primary language spoken, income category, age, household size and presence of a child in the household. *** p<.01, ** p<.05, * p<0.1.

Table 4.3. Ratio of Changes in the Odds of Consuming Fruits and Vegetables (F/V) ≥3 times per day and Being Food Secure following Fresh Bucks Enrollment by Neighborhood Walkability and Socioeconomic Characteristics (N=6,623)

	Consuming F/V 3+ times per day				Food Security			
	Pre-Enrollment (%)	Post-Enrollment (%)	Unadjusted Difference (percentage points)	Difference in the Change (95% CI)	Pre-Enrollment (%)	Post-Enrollment (%)	Unadjusted Difference (percentage points)	Difference in the Change (95% CI)
Walkability								
Above Average Walkable (Walk Score ≤15.25)	17.3	21.3	4.0	Ref.	12.2	15.8	3.6	Ref.
Most Walkable (Walk Score >15.25)	18	22.7	4.7	1.25 (1.05, 1.50)**	12.1	16.6	4.5	1.28 (1.05, 1.55)**
Area Deprivation Index								
Less Deprived (ADI Score ≤4)	17.4	22.0	4.6	Ref.	12.2	16.4	4.2	Ref.
More Deprived (ADI Score >4)	20.2	22.5	2.3	0.97 (0.72, 1.30)	11.8	14.3	2.5	1.12 (0.79, 1.60)

Note: Confidence intervals are in parentheses. Estimates are mutually adjusted and further adjusted for race/ethnicity, primary language spoken, and income category, age, household size and for presence of a child in the household. *** p<.01, ** p<.05, * p<0.1.

CHAPTER 5. CONCLUSION

This dissertation sought to examine heterogeneities in utilization of Fresh Bucks benefits and changes to fruit and vegetable consumption and food security following program enrollment. Across the three aims we find high utilization of Fresh Bucks benefits and improvements to fruit and vegetable consumption and food security following two years of enrollment for all subgroups studied.

In Aim 1, I examine the association between household characteristics and program utilization, changes to the odds of consuming fruits and vegetables at least three times per day, and changes to the odds of being food secure, following two years of enrollment in Fresh Bucks. I find higher utilization of Fresh Bucks benefits among larger households (3-4 or 5+ household members) and older enrollees (>60 years old), but no difference by presence of children in the household. I additionally find no differences in changes to fruit and vegetable consumption by household characteristics but find that participating in Fresh Bucks for two years is associated with a lower change in food security for larger households (3-4 and 5+ people) and households with children, compared to smaller households and households with no children.

In Aim 2, I examine the association between neighborhood characteristics and program utilization. I find higher levels of utilization among households closer to Fresh Bucks approved retailers and those with a greater number of grocery stores within 1 mile of their home. I find lower levels of utilization among households with many unhealthy retailers (limited-service restaurants and convenience stores) within 1 mile of their home and households in highly walkable neighborhoods. I find no differences in program utilization by neighborhood socioeconomic status.

In Aim 3, I examine the association between neighborhood characteristics and changes to odds of consuming fruits and vegetables at least three times per day and being food secure. I find smaller changes to consumption of fruits and vegetables at least three times per day for households living closer to a Fresh Bucks retailer and households living within 1 mile of many unhealthy retailers. Examining neighborhood walkability, I find larger changes to consumption of fruits and vegetables at least three times per day and being food secure for households in more walkable neighborhoods. I find no differences by neighborhood socioeconomic status.

There are several exposures for which we do not see differential utilization of Fresh Bucks benefits or differential changes to fruit and vegetable consumption and food security, including presence of children in the household and household socioeconomic status. A plausible interpretation of these results is that Fresh Bucks does not further exacerbate existing disparities in food access across these characteristics. In other words, we find evidence that Fresh Bucks is implemented in a way that allows for equitable access to the program across these characteristics. Reducing, or at the very least not exacerbating, disparities in food access is an implicit goal of the Fresh Bucks program and other similar nutrition benefit programs. Future research should examine the mechanisms leading to this equitable implementation of the program.

While we did not explicitly test for an association between high utilization and changes to fruit and vegetable consumption and food security, we might hypothesize that households with characteristics associated with higher utilization of Fresh Bucks benefits would have larger changes to fruit and vegetable consumption and food security. However, we do not find that to consistently be the case. In the case of household size, these findings are expected, as the $40 per month available to

households results in a smaller amount per person for larger households than smaller households. For other subgroups, a potential explanation is that households reallocate funds that were previously used to purchase fruits and vegetables to other necessities, after enrollment in the Fresh Bucks program, meaning the program would impact households in a way we are unable to measure.

We may gain further insight into this discrepancy between utilization patterns and program outcomes by examining baseline levels of fruit and vegetable consumption and food security by each characteristic. As an example, we consider fruit and vegetable consumption by the number of grocery stores within 1 mile. As discussed in Chapter 4 (Table 4.2), in unadjusted analyses we see a higher prevalence of consuming fruits and vegetables at least three times per day at baseline among households with greater access to grocery stores. This disparity, however, is somewhat attenuated in the follow-up period, indicating that Fresh Bucks may be associated with larger changes to fruit and vegetable consumption among those with less access to grocery stores. One potential mechanism for this difference may be that households are motivated to use their Fresh Bucks benefits and so are willing to travel further or change their purchasing patterns.

Implications and Future Research

Findings from this dissertation will be disseminated back to Fresh Bucks administrators to potentially inform continued implementation of Fresh Bucks. Policy makers may consider the following in future implementations of the program. As described above, utilization among large families is quite high, but larger families experience smaller changes in the odds of being food secure after enrollment. This may indicate the need

for a larger benefit for larger families or a per-capita benefit structure. We additionally find that neighborhood socioeconomic status does not appear to be associated with program outcomes, but access to food retailers, particularly program-authorized retailers appears to be important. Policy makers may consider expanding the number of retailers eligible for Fresh Bucks benefit utilization. Beyond the program scope, the city may consider working to expand grocery store access across Seattle, as well as understanding characteristics of a grocery store that appeal to consumers (quality, price, etc.). We additionally see lower utilization of benefits among younger people (18-39 years old). Future research may seek to understand barriers to utilization for these younger populations.

The findings represented here are relevant to other cities that may look to implement nutrition benefit programs. While Seattle is distinct is some aspects (program funding source, political climate, cost of living), the findings here may be generalizable to many American cities with urban centers. Findings from this dissertation are difficult to compare to existing research as program structures and available outcome measures differ significantly. As cities and local governments continue to implement and expand nutrition benefit programs, policy makers may seek to align program structures and measured outcomes to allow for better comparability across multiple contexts.

APPENDIX A. Fresh Bucks Enrollment Survey

Fresh Bucks Impact Survey

Fresh Bucks is conducting a survey to understand the impact of Fresh Bucks in the community. Your answers will help us to improve the program. There are no right or wrong answers.
This survey is voluntary and will not affect your eligibility or program status.

Please return the completed survey in the enclosed, postage-paid envelope, or to:
Fresh Bucks, PO Box 94729, Seattle, WA 98124

During the past month, how often did you eat fruit? Include fresh, frozen, or canned fruit. Do not include juices.

☐ Never	☐ 1 time last month	☐ 2-3 times last month	☐ 1 time per week	☐ 2 times per week	☐ 3-4 times per week	☐ 5-6 times per week	☐ 1 time per day	☐ 2 or more times per day

During the past month, how often did you eat a green leafy or lettuce salad, with or without other vegetables?

☐ Never	☐ 1 time last month	☐ 2-3 times last month	☐ 1 time per week	☐ 2 times per week	☐ 3-4 times per week	☐ 5-6 times per week	☐ 1 time per day	☐ 2 or more times per day

During the past month, how often did you eat any kind of fried potatoes, including French fries, home fries, or hash brown potatoes?

☐ Never	☐ 1 time last month	☐ 2-3 times last month	☐ 1 time per week	☐ 2 times per week	☐ 3-4 times per week	☐ 5-6 times per week	☐ 1 time per day	☐ 2 or more times per day

During the past month, how often did you eat any other kind of potatoes, such as baked, boiled, mashed potatoes, sweet potatoes, or potato salad?

☐ Never	☐ 1 time last month	☐ 2-3 times last month	☐ 1 time per week	☐ 2 times per week	☐ 3-4 times per week	☐ 5-6 times per week	☐ 1 time per day	☐ 2 or more times per day

During the past month, not including what you just told us about green salads and potatoes, how often did you eat other vegetables?

☐ Never	☐ 1 time last month	☐ 2-3 times last month	☐ 1 time per week	☐ 2 times per week	☐ 3-4 times per week	☐ 5-6 times per week	☐ 1 time per day	☐ 2 or more times per day

Within the past 12 months, I/we worried that food at home would run out before I/we got money to buy more.

☐ Often true ☐ Sometimes true ☐ Never true

Within the past 12 months, the food I/we bought ran out, and I/we didn't have money to get more.

☐ Often true ☐ Sometimes true ☐ Never true

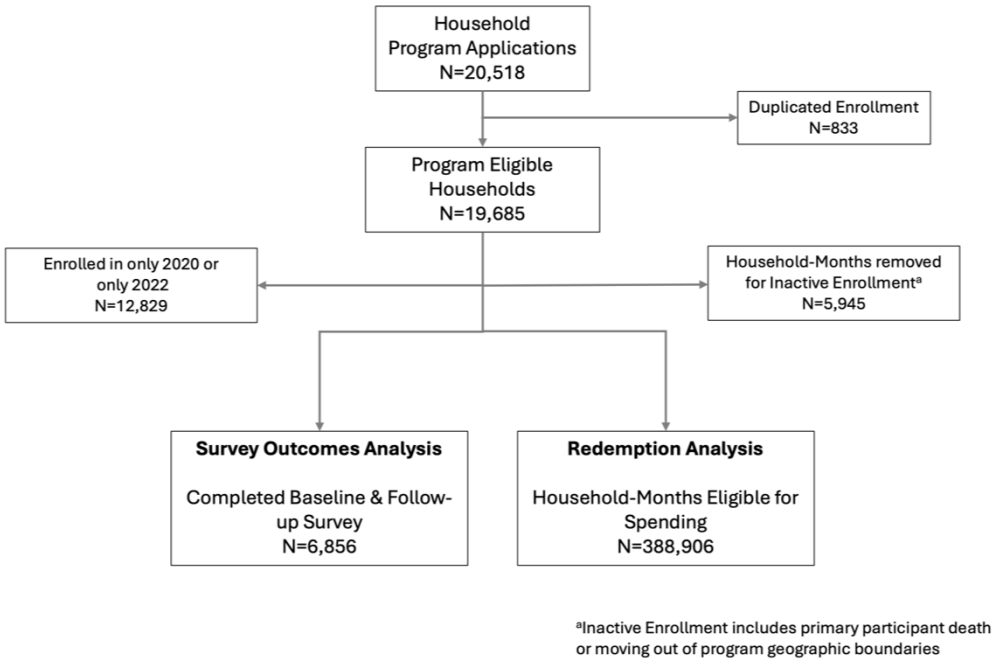
Within the past 12 months, I/we found it hard to buy healthy foods like fresh fruits and vegetables.

☐ Often true ☐ Sometimes true ☐ Never true

Personal information entered on this form is subject to the Washington Public Records Act, and may be subject to disclosure to a third-party requestor. At the City of Seattle, we are committed to protecting your privacy, and will ensure that any disclosures are done according to law.

APPENDIX B. Tables and Figures

Appendix Figure 1. Flow Diagram for Sample Inclusion – Chapter 2



Appendix Table 1. North American Industry Classification System (NAICS) Codes to Identify Retailer Type	
Retailer Category	**NAICS Codes**
Grocery Retailer	424410, 445110, 445210, 445220, 445230, 445240
Convenience Retailer	445120, 457110, 457100, 447110, 445310
Limited-Service Restaurant	311811, 722513, 722514, 722515

Appendix Table 2. Odds Ratio of Utilizing <25%, 25-75% or >75% of Fresh Bucks Benefit per Month by Neighborhood Environment with Distance to Preferred Retailer (n=11,203)

	Low Utilization (<25%)		Moderate Utilization (25-75%)		High Utilization (>75%)	
	Odds Ratio (95% CI)	**p-value**	**Odds Ratio (95% CI)**	**p-value**	**Odds Ratio (95% CI)**	**p-value**
Overall	Ref.		0.31 (0.29, 0.32)	<0.001	5.23 (4.99, 5.48)	<0.001
Distance to Nearest *Preferred* Fresh Bucks Retailer						
>1.5 Miles	Ref.		Ref.		Ref.	
1.01-1.5 Miles			1.20 (1.06, 1.37)	0.005	1.16 (1.02, 1.32)	0.029
0.5 -1.0 Miles			1.27 (1.11, 1.45)	0.001	1.09 (0.95, 1.25)	0.237
<0.5 Mile			1.45 (1.24, 1.68)	<0.001	1.23 (1.04, 1.44)	0.014
Number of Grocery Stores within 1 Mile						
Zero	Ref.		Ref.		Ref.	
Lowest Non-Zero Tertile (1-5)			0.84 (0.60, 1.18)	0.320	1.08 (0.75, 1.57)	0.676
Middle Non-Zero Tertile (6-8)			0.93 (0.64, 1.34)	0.687	1.15 (0.77, 1.72)	0.492
Highest Non-Zero Tertile (9+)			0.88 (0.59, 1.30)	0.509	1.04 (0.68, 1.59)	0.866
Number of Convenience Stores within 1 Mile						
Lowest Tertile (1-6)	Ref.		Ref.		Ref.	
Middle Tertile (7-11)			0.98 (0.85, 1.13)	0.761	0.93 (0.80, 1.08)	0.371
Highest Tertile (12+)			0.88 (0.72, 1.07)	0.198	0.85 (0.69, 1.04)	0.119
Number of Limited-Service Restaurants within 1 Mile						
Lowest Tertile (0-24)	Ref.		Ref.		Ref.	
Middle Tertile (25-45)			0.96 (0.83, 1.11)	0.555	1.01 (0.87, 1.18)	0.850
Highest Tertile (46+)			0.94 (0.77, 1.13)	0.492	1.04 (0.85, 1.28)	0.687
Walkability						
Less Walkable (Walk Score ≤15.25)	Ref.		Ref.		Ref.	
More Walkable (Walk Score >15.25)			0.97 (0.87, 1.08)	0.528	0.92 (0.82, 1.03)	0.142
Area Deprivation Index						
More Deprived (ADI Score >4)	Ref.		Ref.		Ref.	
Less Deprived (ADI Score ≤4)			1.22 (1.03, 1.44)	0.022	1.06 (0.89, 1.26)	0.538

Notes: Confidence intervals are in parentheses. Estimates are mutually adjusted and adjusted for race/ethnicity, primary language spoken, age of primary participant, household income, household size and presence of children in the household.

Appendix Table 3. Ratio of Changes in the Odds of Consuming Fruits and Vegetables (F/V) ≥3 times per day and being Food Secure following Fresh Bucks Enrollment by Neighborhood Food Access (N=5,793)

	Consuming F/V 3+ times per day				Food Security			
	Pre-Enrollment (%)	Post-Enrollment (%)	Unadjusted Difference (percentage points)	Difference in the Change (95% CI)	Pre-Enrollment (%)	Post-Enrollment (%)	Unadjusted Difference (percentage points)	Difference in the Change (95% CI)
Overall	17.7	22.1	4.4		12.2	16.2	4.0	
Distance to Nearest Preferred Fresh Bucks Store								
>1.5 Miles	20.2	22.2	2.0	Ref.	12.0	15.9	3.9	Ref.
1-1.5 Miles	16.0	23.2	7.2	1.17 (0.93, 1.49)	13.1	18.0	4.9	0.91 (0.70, 1.18)
0.5-1 Mile	17.8	21.3	3.5	1.15 (0.89, 1.49)	10.9	16.4	3.5	1.20 (0.90, 1.60)
<0.5 Miles	14.7	21.2	6.5	1.14 (0.84, 1.56)	10.1	16.0	5.9	1.36 (0.98, 1.88)
Number of Grocery Stores within 1 Mile								
Zero	15.2	24.1	8.9	Ref.	11.6	17.9	6.3	Ref.
Lowest Non-Zero Tertile (1-5)	16.4	23.3	6.9	0.86 (0.42, 1.76)	14.2	17.5	3.3	0.75 (0.35, 1.59)
Middle Non-Zero Tertile (6-8)	16.8	19.5	2.7	0.54 (0.26, 1.11)*	11.6	15.3	3.7	0.68 (0.32, 1.46)
Highest Non-Zero Tertile (9+)	19.9	22.6	2.7	0.57 (0.28, 1.17)	10.32	15.4	5.1	0.83 (0.39, 1.78)
Number of Convenience Stores within 1 Mile								
Lowest Tertile (1-6)	17.1	23.4	6.3	Ref.	14.0	16.3	2.3	Ref.
Middle Tertile (7-11)	17.2	20.7	3.5	0.78 (0.63, 0.97)**	12.5	17.5	5.0	1.10 (0.87, 1.39)
Highest Tertile (12+)	18.8	22.0	3.2	0.66 (0.53, 0.82)**	9.8	14.8	5.0	1.12 (0.88, 1.42)
Number of Limited-Service Restaurants within 1 Mile								
Lowest Tertile (0-21)	15.9	21.2	5.3	Ref.	13.0	15.8	2.8	Ref.
Middle Tertile (22-42)	18.2	21.7	3.5	0.77 (0.62, 0.95)**	12.6	16.2	3.6	1.10 (0.87, 1.39)
Highest Tertile (43+)	19.1	23.3	4.2	0.85 (0.69, 1.06)	10.8	16.6	5.8	1.29 (1.01, 1.64)**
Walkability								
Above Average Walkable (Walk Score ≤15.25)	17.3	21.3	4.0	Ref.	12.2	15.8	3.6	Ref.
Most Walkable (Walk Score >15.25)	18	22.7	4.7	1.25 (1.05, 1.50)**	12.1	16.6	4.5	1.27 (1.05, 1.55)**
Area Deprivation Index								
Less Deprived (ADI Score ≤4)	17.4	22.0	4.6	Ref.	12.2	16.4	4.2	Ref.
More Deprived (ADI Score >4)	20.2	22.5	2.3	0.97 (0.72, 1.30)	11.8	14.3	2.5	1.12 (0.79, 1.60)

Note: Confidence intervals are in parentheses. Estimates are mutually adjusted and further adjusted for race/ethnicity, primary language spoken, income category, age, household size and presence of a child in the household. *** p<.01, ** p<.05, * p<0.1.

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