Impact of a grocer-led fruit and vegetable promoting intervention in a rural Minnesota ethnic community

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ABSTRACT

This thesis evaluates a four-part intervention program in four rural Minnesota ethnic grocery stores. Stearns County, Minnesota has hosted approximately 1,200 primary refugees from 2011 to 2020, with nearly 92% having sought refuge from Somalia. The project team worked with Somali grocery store owners in the city of St. Cloud located in Stearns County to better supply their stores with fresh fruit and vegetables (FV). The in-store intervention methods included (1) training produce handlers, (2) implementing in-store demonstrative and educational material for customer viewing, (3) providing funding for refrigerated cases, and (4) subsidizing fresh produce procurement. From a series of pre-intervention and post-intervention surveys, this analysis included a full sample of 173 responses and 42 unique households with paired baseline and endline survey observations. We analyze models using the full and paired samples, alongside models using subsamples of food insecure households and post-intervention responses. Across all empirical models, we find consistent results in the magnitude and probability increase of weekly fruit, greens, and other vegetable consumption in the post-intervention period or with increased Somali store patronage. With 73% of individuals in the post-intervention period reporting increased patronage at the Somali stores, indicating higher exposure to fresh produce, we assume shoppers experienced a greater incentive to frequent the grocery stores. Higher patronage in the post-intervention period is also associated with an increase in the probability of FV consumption through a 24-hour consumption recall, at a statistically significant level. However, the probability of FV consumption shares a negative relationship with unplanned FV purchases.

I. Introduction

Grocery stores are vital in supplying fresh fruit and vegetables (FV) to rural populations. With very little access to supermarkets in rural areas, rural grocery store owners act as essential stakeholders in discussions and work involving rural food access. Grocery store owners hold a decisive position in rural areas as they have control of the main food items available to their community. Likewise, ethnic grocery stores can act as community hubs and a source of culturally accommodating food items to their respective ethnic communities (Khojasteh and Raja 2017). This thesis evaluates a set of in-store interventions implemented in 2020 through 2021, in collaboration with Somali grocery stores in Central Minnesota. We aim to explore the role of rural grocery store owners as influencers of their customers' consumption choices through direct intervention methods in the participating study stores.

The primary customer base of the Somali grocery stores (SGS) are Somali immigrants and refugees residing in a Central Minnesota city, St. Cloud, that is surrounded by rural land. Acculturation, or the process of cultural change when individuals of different cultures mingle (often a change in behaviors and habits of the non-dominant cultural group to the dominant culture), is a shared experience for immigrant communities (Berry 2008). Likewise, this sense of change applies to refugees. After migrating out of their home country due to reasons such as civil unrest and war, many refugees carry prolonged stress and trauma that cause additional burdens to their new lifestyle. Included in the process of acculturation, individuals are compelled to accommodate their diets to the new food environments they live in. However, these new changes may not always encourage healthier dietary choices. Newly arrived immigrants to the U.S. report healthier diets compared to U.S.-born individuals, but their diets begin to worsen with more time residing in the U.S. (Argeseanu Cunningham, Ruben, and Venkat Narayan 2008). As the

American diet tends to include less FV, higher fats and sugars, larger portions, and other unfavorable consumption habits, immigrants who reside in the U.S. for longer periods begin to pick up on these habits (Popovic-Lipovac and Strasser 2015). These results are unsurprising with the abundance of ready-to-eat options and widespread availability of fast food in the U.S., creating one of the reasons for misallocated access to healthy food (Zorbas et al. 2018). The discussion on healthy food accessibility within immigrant communities includes the physical availability of FV and individual level of familiarity with the U.S. food environment. Environmental and behavioral factors are therefore necessary considerations for population health and consumption choices.

Over 111,000 refugees have been relocated to Minnesota since 1979 with the largest ethnic group (22%) having migrated from Somalia (MN Department of Health 2020). With the largest influx of Somali refugees in the early 1990s, Somali immigrants have grown accustomed to Minnesota culture by creating spaces for themselves through entrepreneurial endeavors, building community spaces, as elected officials, and in other fields of work. In 2019, there was an estimated total population of nearly 70,000 Somali residents in Minnesota (Census Bureau 2019). Additionally, most Somali households in Minnesota are comprised of family households with children under the age of 18 years old. In 2019, the median income for Minnesota Somali households was estimated to be $26,464 a year, with nearly 39% of the total population having lived in poverty.

Furthermore, as an examination of health outcomes among Somali immigrants, a study using data from a Minnesota primary care network showed that Somali immigrant patients were found to suffer greater cardiovascular health issues due to high rates of diabetes, prediabetes, and obesity compared to non-Somali patients (Njeru et al. 2016). Anemia and malnutrition are also

common health conditions experienced by Somali refugees, especially among Somali refugee children (Centers for Disease Control and Prevention 2021). With the community at risk of these varying health issues, developing a healthy food environment for the immigrant population is critical. Furthermore, it is worth finding the responsiveness of Somali immigrants to food assistance programs such as the Supplemental Nutrition Assistance Program (SNAP) and the Special Supplemental Nutrition Program for Women, Infants, and Children (WIC). Researchers find that in a small study sample of older Somali women in San Diego, California, all respondents reported SNAP recipiency and higher preferences to shop at SGS due to the certainty that these stores supplied *halal* food items (Greenwald and Zajfen 2017). Another study of a Somali immigrant community in Lewiston, Maine found that about 77% of their sample were SNAP and WIC recipients but 55% of these households exhausted their monthly benefits within 15 to 20 days (Dharod et al. 2011). Through these papers, we find that Somali immigrants across the nation are highly responsive to making use of federal food assistance programs and heavily rely on local SGS in their food environments.

Lack of FV consumption due to factors such as healthy food availability and store accessibility is largely a low-income population issue (Larson, Story, and Nelson 2009). The income divide in healthy food access disproportionately affects immigrants, ethnic minorities, and rural residents. Healthy food access is particularly important due to the multitude of health-related risks caused by poor dietary habits, often measured by a lack of FV consumption. Well studied in various social and health science journals, there have been successful evidence-based approaches to increase FV intake. In studying these various methods, it is worth noting that there are also large differences in the structure, culture, and environment of rural communities (Lenardson, Hansen, and Hartley 2015). Lenardson and colleagues discuss that the success of a

FV incentive program in rural areas would largely depend on the amount of effort researchers place in adapting to their targeted community's cultural and habitual patterns. In this study, researchers work with a University of Minnesota (UMN) Extension educator from the study area who is familiar with and works closely with the Somali community in St. Cloud.

The study evaluated in this thesis was performed in St. Cloud, Minnesota, located in Stearns County which is about a one-hour drive north of the Twin Cities. In Minnesota, Somali refugees are often relocated to Hennepin County (Minneapolis Metro), Ramsey County (St. Paul Metro), or Stearns County (St. Cloud). St. Cloud is the 12th largest city in Minnesota and hosts approximately 20% of the Somali refugees relocated to Minnesota from 2011 to 2020 (MN Department of Health 2020). St. Cloud is particularly notable as a relocation hub for Somali refugees as Stearns County is largely rural by land composition compared to other relocation hubs in the state (Hennepin and Ramsey County) which are metro areas.

In the study, researchers implement a four-part intervention model with an experimental group of four ethnic grocery stores: (1) Midnimo Grocery and Halal Meat, (2) Iftin Grocery Store, (3) Green Market, and (4) Qalinle Family Grocery Store. In an attempt to increase the FV intake of their patrons (Somali immigrants), researchers (1) provided training to produce handlers to properly store fresh FV, (2) implemented in-store educational posters for specific FV and produce preparation demonstration videos, (3) granted store owners funding for refrigeration, and (4) subsidized a portion of the FV supply in-store. Past studies show that similar FV-promoting interventions presented mixed results, especially when conducted in rural areas (Ayala et al. 2013; Gittelsohn et al. 2013; Pitts et al. 2018). This study approached a FV promotion intervention through empowering community leaders, who are, in this context, grocery store owners. This intervention model essentially allows for leaders of the community

(grocery store owners) to directly provide a positive health influence on their community (Somali residents). The study establishes this thesis, which addresses two questions:

1. How significant is the role of rural ethnic grocery store owners to influence their customers' healthy consumption habits? With increased exposure to fresh produce in-store, what fruit and vegetable consumption effects are seen among consumers?
2. What differential effects are seen in fruit and vegetable consumption? How do level of income, SNAP recipiency, and WIC or free or reduced lunch assistance affect or differentiate individual fruit and vegetable intake?

To answer these questions, the research team fielded two surveys to Somali households in St. Cloud before and after the intervention period. The full survey data sample includes 173 responses including both baseline and endline surveys. A total of 42 households who completed both pre- and post-intervention surveys were matched. We specified four models in our analysis to seek robust results. The multivariate analyses robustly revealed increases in post-intervention weekly consumption for all FV categories: fruit, green leafy vegetables, other vegetables, and total vegetables. Additionally, with increased SGS patronage in the post-intervention, the probability of increased weekly FV consumption in the endline survey increased only for vegetable consumption and the probability of FV consumption from a 24-hour recall during a randomly selected day of the post-intervention period increased for both fruit and vegetable consumption.

Determining the levers of change in the food system is essential in creating policy for equitable food access and encouraging healthy consumption habits. The successes of rural and ethnic grocery stores are vital to feeding a population with poor access to supermarkets and larger grocery stores. This paper contributes to the past FV-promoting literature by evaluating a community-driven process. The niche characteristics of groups with similar socioeconomic standing and cultural background should be well considered in work that involves community concerns influenced by social or environmental factors (Zorbas et al. 2018). In analyzing a FV intervention study that attempted to encourage healthier consumption habits within an ethnic minority population, considering these cultural needs is especially important for this study's target population. While social and environmental surroundings can gravely affect individual food consumption choices, a healthy food environment with an adequate level of FV availability can, in turn, create a positive influence on individual consumption choices.

II. Literature review

In this study, researchers attempted a direct consumer approach to increase FV consumption and essentially implement a community-driven FV intervention model. While the study's FV incentive model is more community-led, on the federal level, the U.S. Department of Agriculture (USDA) has started three different healthy eating initiatives through the past three Farm Bills (John et al. 2021). First is the Healthy Incentives Pilot (HIP) in the 2008 Farm Bill, second is Food Insecurity Nutrition Incentives (FINI) in the 2014 Farm Bill, and the most recent is the Gus Schumacher Nutrition Incentives Program (GusNIP) through the 2018 Farm Bill. The funding for these programs targets Supplemental Nutrition Assistance Program (SNAP) participants and is allocated to state-level food assistance programs or non-profit organizations. Often, these projects come in the form of matching funds of SNAP dollars to expenditure on FV purchases. As an example, an individual who spends a dollar in SNAP benefits is returned a dollar by the match programs to spend on fruits and vegetables (FV); this dollar-for-dollar return is referred to as a 100% match rate. Nutrition experts argue that the best way to execute these programs would be to implement 100% match rates and eliminate match caps for FV purchases, a more effective electronic method that could be instantly used by the participants, and expand food options, populations, and participating retailers (John et al. 2021). Expanding food options would be especially important for rural residents as frozen and canned FV are more suitable in shelf life compared to fresh produce.

In this study, researchers provided the participating SGS owners and produce handlers training and funding for necessary store structure changes to properly supply fresh produce in-store. Customers were then exposed to increased fresh FV supply, alongside posters displaying the health benefits of and video demonstration to prepare certain FV items from home. A study

published in 2013 followed a very similar intervention style, but with a group of Latino grocery stores in North Carolina and a 2-month long intervention period (Ayala et al. 2013). Their intervention consisted of training sessions for the store employees and managers, a marketing campaign that included promotions for healthy food through preparation instructions and recipes, audio messages, and funding for equipment needed to adapt to needed structural changes in the store. Using baseline and endline surveys, they tracked changes in FV consumption. Through a mixed effects model and a sample (n=179) of customers across their four stores, they did see an increase in FV consumption among their participants. However, they found self-efficacy, or the individual's belief in their ability to successfully execute a task, for purchasing FV decreased with the intervention (Ayala et al. 2013). In other words, they had less belief in themselves that they were able to purchase FV after the intervention.

A community-based FV intervention study published in 2013 followed different intervention methods for the Navajo nation focused more on the effects of their intervention on body mass index (BMI) scores and questions specific to intervention material; health food knowledge, self-efficacy scores, intention scores, healthy food purchases, healthy food cooking habits, perception of healthy food, and nutrition label reading scores (Gittelsohn et al. 2013). They found that with more exposure to the intervention material and healthy food from the intervention, BMI scores significantly decreased, self-reported healthy food intentions increased, healthy cooking habits increased, and healthy food purchases increased.

Another study in North Carolina used similar intervention methods from the North Carolina Healthy Food Small Retailer Program (HFSRP), a state-funded healthy food supply assistance program for small food retailers implemented in 2016 (Pitts et al. 2018). HFSRP targets food desert areas in North Carolina, identified by USDA measures, by providing food

retailers with 3000 square feet of space or less in food deserts with funding to purchase and install changes in store structure to be better equipped for supplying nutrient-dense food items including as fruits, vegetables, and other healthy food items in stores. Using a difference-in-difference analysis, researchers compare the 1-year baseline and endline results of HRSP participating corner stores and non-participating control stores between 2017 and 2018. They measure changes in consumption habits using the Healthy Eating Index from in-store "bag checks" and the Veggie Meter™ to measure skin carotenoids. Although they found that the program led to an increased supply of FV in the study stores compared to the control stores, there were no significant findings or differences in self-reported FV intake, sugary beverage consumption, skin carotenoids, or BMI scores among customers. However, researchers conclude that as the HRSP was a newer program, the analysis would require more time to implement additional needs such as marketing and educational material (Pitts et al. 2018). In the Somali store study, changes from the intervention were measured within a similar time frame as this study but the Somali store owners received more direct guidance and training from researchers through the intervention.

Despite sharing similar intervention methods, the same successes or shortcomings of these previous studies cannot be fully reflected in the outcomes of the Somali store study evaluated in this thesis. The methods used for the study SGS and the processes in which researchers worked with store owners were specifically catered to the Somali immigrant community, although some were successful and others less. One productive method was the usage of the Somali language or Somali presenters in the produce handler training, FV promotion posters, and FV preparation demonstration videos. However, other methods employed, such as the recommended serving styles or ways to prepare certain FV items, may not

have been as successful for the Somali community since they were less culturally accommodating. It is through these studies and trials that researchers can determine the intervention methods that work best for certain communities.

Literature relevant to FV access for immigrants relocated in rural areas involves is contributed by studies published in public health, medical, economic, geographic, psychology, and sociology journals. Relevant topics to this study include health concerns in marginalized communities, personal health benefits of nutritional diet, ethnic and immigrant studies, low-income communities, and studies in rural America. The first section of this literature review covers the personal health benefits of FV consumption. Several studies have shown that there are associations between healthy eating to avoid the risk of numerous health issues (USDA and HHS 2020). This finding alone is the main driver of this study—healthier diets lead to healthier individuals which leads to a healthier community. The second section covers the barriers to FV access in low-income communities, including one section on ethnic and racial minority groups, which include immigrant communities, and a section for rural populations. Many social science and health researchers have emphasized the importance of focusing healthy eating studies on low-income communities. Two major characteristics of low-income and in-poverty households in the U.S. are racial minorities and rural residents (USDA Economic Research Service 2021). Lastly, I discuss the current and past research on immigration to America, followed by a review of Somali immigration and the refugee community in the United States and Minnesota, in two separate sections. Essentially posing as a review of the refugee and immigrant population, and more precisely of Somali immigrants in the U.S., this discussion provides background information on the study sample.

1. Personal health benefits of fruit and vegetable consumption

Under the context of diets and nutrient-dense foods recommended by federal dietary guidelines, consumption of FV is essential to the human diet. In the *2020-2025 Dietary Guidelines for Americans* created by the USDA and the Department of Health and Human Services (HHS), about 90% of the U.S. population failed to meet the recommended intake of vegetables while 80% of the population failed to meet the recommended intake of fruits (USDA and HHS 2020). Consuming more fruits and vegetables, or in a more general sense a healthy diet, can help prevent major health conditions and chronic diseases. Several health conditions directly associated with poor diets are often leading causes of death or underlying health issues that can cause deadly diseases, such as overweight and obesity, heart diseases, diabetes, cancer, and bone health. Heart disease is the primary cause of death in the country (USDA and HHS 2020). By a racial comparison, the USDA reports that there are more Black adults than White adults with hypertension, at 54% and 46%, respectively. The overweight or obesity rate among adults in the U.S. is about 74% while approximately 90% of diabetic adults are overweight or obese.

Before discussing the effects of a balanced diet on personal health, understanding the chemical components of FV that can provide health benefits to avoid life-threatening health conditions is imperative. There are numerous nutrients and bioactive compounds that derive from FV (Liu 2013). More specifically, FV contains various phytochemicals, plant-based compounds, that are associated with health benefits. Some well-known phytochemicals well-studied in the topics of FV consumption are phenolics and carotenoids. Phenolics are known to be vital players in plant growth but are also known to lower the risk of varying chronic diseases—namely, cancer, heart disease, and diabetes (Liu 2013). Blueberries and blackberries

are fruits that contain the highest phenolic content while spinach contains the highest phenolic content among vegetables. However, apples and potatoes contribute the highest phenolics in the American diet for their respective food groups. Carotenoids, however, are beneficial for the human body by having antioxidant and provitamin characteristics (Liu 2013). Alongside these benefits, carotenoids have been used in numerous studies as biomarkers of FV consumption (Neuhouser et al. 2007; Pitts et al. 2014). Liu and colleagues claim in their review that through multiple studies of FV content and its health benefits, increased FV intake and an overall healthier diet are essential in reducing the risk of cardiovascular diseases and have been estimated to prevent one-third of all cancer deaths in the U.S. To incorporate a healthier diet, individuals can do so by increasing any form of FV consumption to between 9 to 13 weekly servings and decreasing sugar, salt, and fat intake (World Health Organization 2019; Liu 2013). This understanding of FV as a key contributor to a healthy diet extends the benefits of FV to preventing additional health risks such as obesity and cognitive health.

Obesity is one of the most acknowledged risks of an unhealthy diet. Of the many health conditions obesity has been linked with, it is also known to be linked to cognitive issues at an early age, throughout adolescence, and into adulthood (USDA and HHS 2020; Wang et al. 2016). Wang and colleagues found that obesity measured by BMI in earlier childhood is associated with struggles in attention, mathematics, reading, mental rotation, and executive functions. Obese adolescents are also found to struggle with attention and executive functions. However, as individuals reach older age, the association between BMI and cognitive function becomes weaker to measure. The authors claim that exercise can, however, improve cognitive performance in addition to physical performance as a form of combating obesity.

The Centers for Disease Control and Prevention (CDC) addresses the prevalence of obesity in the U.S. by implementing the nationwide High Obesity Program (HOP) (CDC 2018). The program funds public land-grant and research universities in high obesity prevalence counties to work on lowering obesity rates in their area through extension and outreach programs. Some studies have found that in more urban areas, there is significantly less obesity, yet rural areas have higher obesity rates and lower FV consumption (Cohen et al. 2018). Cohen and colleagues conclude that this, in turn, leads researchers to question the effectiveness of FV intervention models as a solution to lowering obesity rates in rural America. Additionally, obesity is often the outcome of several underlying factors such as environmental, genetic, and behavioral effects (Bray et al. 2018). The most effective method to lose weight is to have a negative energy intake, therefore losing more calories than the amount an individual is consuming. While it is not the sole solution, modifying personal diets can be essential to weight loss. For one, the Mediterranean-style diet, which consists of increased whole foods including FV, showed more weight loss compared to a low-fat diet and significance in waist circumference reduction (Bray et al. 2018). While the effectiveness of solely increasing FV consumption to lose weight is questionable due to the many factors that are needed to create negative energy intake, the nutritional benefits of consuming FV act as effective substitutes for other food items that are lower in nutritional value.

In a study of an immigrant population sample, researchers have found that increased FV consumption or healthier diets have also been associated with improved mental health (Emerson and Carbert 2019). Conducted in Canada, researchers examine the associations between FV consumption as a preventative measure for mental health issues. Using the Canada Community Health Survey from 2011 to 2014, they use a multiple linear regression model to find the

associations between FV consumption and anxiety and/or mood disorders and distressed levels measured by the 6-item Kessler Psychological Distress Scale and a self-reported measure of individual mental health. Including both visibly ethnic-minority immigrants (43% of the sample) and white immigrants, they find that higher consumption of FV is associated with a decrease in the odds of experiencing anxiety and/or mood disorders, higher distress levels, and higher odds of self-reported good mental health (Emerson and Carbert 2019).

Mental health is an especially important focus for refugees; unfamiliarity with any sudden environmental changes would begin as a stressful experience (Lincoln et al. 2016; Ellis et al. 2022). A 2013 study done in Italy found that nearly 74% of their medical patient sample of first-generation immigrants reported serious post-migration living difficulties and nearly 61% have experienced a potentially traumatic event (Aragona et al. 2013). Relative to this paper, the stress that Somali refugees may face as a majority Muslim population for one, would include finding culturally appropriate food items such as *halal* meats, cultural spices, and mosques as a space for spiritual worship, all of which are integral parts of the Somali culture. Searching for these needs requires constant mental awareness of their surroundings and while experiencing this in a majority white environment, factors such as discrimination may surface. Increased levels of discrimination have been shown to predict higher levels of mental health concerns such as depression, anxiety, and PTSD (Lincoln et al. 2016). For a community that could have easier access to FV, the associations between mental health and FV consumption are integral for the Somali community in St. Cloud and could be worth further examining. As a low-income and rural population, the need for ease in FV access is only even more important for the community.

2. Assistance and barriers to FV consumption in low-income communities

Nutritional intervention programs and studies should implement methods that have shown significant results in increasing healthy food consumption specifically for individuals of low socioeconomic status. These methods have been discussed thoroughly in years of literature and systematic reviews. In 2018, Zorbas and colleagues conduct a systemic review of healthy food intervention studies published since 2008 to find the facilitators and barriers to consuming healthier diets (Zorbas et al. 2018). They classify relevant factors at the individual level, social level, food environment, and lived environment. Through examining various papers, they find nutritional knowledge and skill with food to be significant facilitators to increasing FV consumption, provided they are given accessible nutritional facts and proper cooking instructions. Furthermore, poor nutritional literacy, which is a necessary skill in understanding nutrition labels, was an especially reoccurring issue among individuals of low socioeconomic standing. On a social level, there have been significant influences on unhealthy eating from marketing and media, social stigma, and cultural norms. Cultural cooking habits can act as both facilitators and barriers to healthy food consumption. Supermarkets are vital to healthy food consumption but can also be the main source of unhealthy food items—nonetheless, they are vital in food insecure, often low-income, communities as they provide a large array of food options. Lastly, for the lived surroundings and environment, individuals with lower socioeconomic standing struggle to consume healthier food due to convenience or time, transportation, seasonality, and the geography of their residence (Zorbas et al. 2018).

Researchers in another study found that their sample population of urban and mostly immigrant Black men on average reported low levels of FV consumption (Wolf et al. 2008). In the study, researchers also identified the barriers and supportive factors of increasing FV

consumption for their sample group. Their sample of immigrant Black men reported they knew of the health benefits associated with FV, but many struggled to name a specific benefit. Additionally, increased knowledge of federally recommended daily FV intake and fewer perceived barriers to preparing and ease of consuming FV were associated with higher FV consumption (Wolf et al. 2008). In addition to these pre-existing environmental and personal challenges to consume more FV for socially disadvantaged populations, the act of changing consumption habits comes with great difficulty. For one, the food environment one spends their early years adapting to will largely affect consumption choices in adulthood (Yeh et al. 2008). There are barriers to changing consumption habits that are simply fundamental to the self and more difficult to change. Nonetheless, this paper focuses less on behavioral changes, techniques, and psychological methods to consuming FV and more on studying the direct response in consumption by changes in the environment and increased exposure to FV. Catering specifically for our study group of Somali refugees in a rural Minnesota county, we find relevance in studying the barriers to healthy food in rural America and among immigrant communities of America. This section covers these two characteristics of our study population as (a.) rural residents and (b.) immigrant refugees to the U.S.

a. Rural America

Accessible and affordable groceries are only one of the many lacking necessities in rural communities and are mainly due to the structure of rural-urban land and resource allocation in the U.S. Rural residents nationwide have less access to resources while experiencing higher levels of poverty compared to urban residents (CDC 2017; USDA ERS 2021). Even in comparing poverty persistence, rural residents suffer the longest amount of time in poverty (Kyzyma 2018). The CDC has also found that when comparing percentages of preventable

deaths, rural areas reported higher percentages compared to urban areas. Many of these preventable deaths came from heart disease, cancer, unintentional injuries, respiratory diseases, and stroke (CDC 2017). One study finds that urban residents consume more FV compared to their rural counterparts and that one of the biggest barriers to accessing fruits and vegetables among rural residents is transportation (Hendrickson, Smith, and Eikenberry 2006; Dunn et al. 2012). One of the leading causes of the prevalence of poverty in rural areas largely involves poor access to healthy food options that are not pre-made or fast food. Larger grocery stores or supermarkets serve as a hub for healthy and fresh produce as they offer the widest range of products compared to smaller grocery stores (Larson, Story, and Nelson 2009). Many rural areas lack access to supermarkets and a wider array of FV options, which leaves rural residents with very few options to implement healthier diets.

The 2020 Census urban-rural classifications indicate that St. Cloud, Minnesota is an urban area (Census Bureau 2022). However, St. Cloud is located in Stearns County, which composes of largely rural land. Stearns County is central to Minnesota's agriculture economy, especially dairy products, and is also the self-proclaimed capital of organic farming in Minnesota (Stearns County Minnesota). The large population scale in St. Cloud may be due to the St. Cloud State University (SCSU) student population. The attendance at SCSU as of Fall 2020 was recorded at over 11,000 students, which would account for about 16% of the city's population (St. Cloud State University 2020). The local economy in St. Cloud, however, is notably growing and is one of Minnesota's fastest-growing labor forces (Senf 2019).

One major health issue in rural America is simply access to healthcare providers and medical resources. Alongside this major health disparity, obesity is a major issue for many rural communities across the country. Rural U.S. counties report higher obesity rates on average

compared to urban U.S. counties (CDC, 2018). Some of the reasons for this is due to the fundamental structure of the rural landscape. To tackle obesity in rural areas, the CDC recommends that the work should be focused on gathering spaces such as schools, places of work, and Cooperative Extension Services, adding bicycle paths, paved sidewalks, and recreation facilities. Rural counties lack the infrastructure urban cities have that encourages healthier lifestyles. However, rural communities in the U.S. are community-driven by nature. Therefore, implementing a community-based FV intervention program can be effective in promoting healthier consumption choices.

Studies that discuss rural food access and include FV incentive programs have reported several successful cases while others have shown to be less successful. In a 2007 study, researchers use a cancer prevention program to measure changes in FV consumption and found that household food inventory count alone cannot be a successful measure of FV intake, especially for rural and ethnically diverse women (Neuhouser et al. 2007). Neuhouser and colleagues found poor to modest correlations between the household FV inventory of women in rural Washington and their serum carotenoid biomarkers. Meanwhile, other methods that work directly with grocery stores by providing training to owners, customer discounts, and lifestyle programming to promote healthy diets have shown positive results in consuming or purchasing more healthy food and less unhealthy food options (Fergus, Seals, and Holston 2021).

Encouraging the consumption of FV among rural populations alone is already difficult but addressing the intersectional barriers to food access for a population of both rural residents and racial minorities uncovers greater issues. While also rural residents and immigrants, Somali immigrants in the U.S. are racially Black and fall into sample populations of studies on Black communities. One FV intervention study done in rural Texas by Dunn and colleagues attempted

to find the effects of distance and cost on FV consumption while comparing the results of Black and White participants. They find that while the Black residents lived closer to the grocery stores, they consumed less FV compared to their White counterparts (Dunn et al. 2012). However, distance still plays a very important role in their purchasing decisions. For an additional mile Black individuals live from the closest store, the probability that they consume 2 servings of fruit decreases by 3 percentage points, and for 3 servings of vegetables decreases by 1.8 percentage points. Relevant to the Somali community as an immigrant population, Torres-Aguilar and colleagues also conduct a survey study of immigrant and WIC-participating Latina women in the rural Midwest from 2008 to 2009. They observed the dietary patterns of these women by predicting the consumption of "protective" (i.e., consumption of FV and whole grains) and "potentially harmful" (i.e., fast food and sugary beverages) foods by environmental and lifestyle factors. For these Latina women, they find there are positive associations between "promotive" environmental factors, which include food resource and information availability, and protective consumption habits, or the consumption of healthy food including FV (Torres-Aguilar et al. 2016).

b. Racial or ethnic minorities, immigrants, and refugees

Similar to studying FV incentives in rural communities, various ethnic and racial communities have intervention methods that work better for some groups and others less. A breadth of the studies performed on U.S. immigrant populations has focused on comparing immigrant groups of different ethnicities. In 2007, Allen and colleagues examine the differences in preventative health behaviors between Asian and Latino adolescents grouped by generational groups of immigration and compared to their white adolescent counterparts. The data used in this study was from the 2001 California Health Interview Survey. Considering healthy eating as

preventative health behavior, the questions formed in this study targeted fruit and vegetable consumption alongside the frequency of drinking soda and milk. The results show that while both first-generation Asian and Latino immigrant groups consume more FV, stability or improvement in FV consumption was only found among the following generation of Asian immigrants (the children of the first immigrants would be the second-generation, the children of the second generation would be the third generation, etc.). Meanwhile, the FV consumption of Latino immigrants of the following generations decreased so much that by the third generation of immigrants, they eventually consumed less than their white counterparts (Allen et al. 2007).

Multiple studies have found that dietary acculturation, more specifically in the context of changing one's diet when immigrating to a Western country, results in unhealthier diets that are often low in FV consumption (Zorbas et al. 2018; Popovic-Lipovac and Strasser 2015). A study done by Gustavsen and colleagues using survey data from 1999 to 2012 compared the consumption patterns of U.S.-born and foreign-born racial groups in the U.S. This study uses a generalized linear model to find the probability of consumption for each food group, including FV, and the associations of time spent in the U.S. to consumption patterns. Holding income constant, they find that U.S.-born Black Americans consume the least vegetables among all other groups (U.S.-born and immigrant Hispanic, Black, Asian, and White). However, Black immigrants had higher consumption of FV compared to their U.S.-born counterparts—but still lower vegetable consumption compared to the total U.S. vegetable consumption. However, despite the higher consumption of fruits among Black immigrants, there was a significant finding that with more years in the U.S., the percentage of Black immigrants consuming fruit decreased by 6 percentage points (Gustavsen et al. 2021). Another study from 2014 supports this finding in that for their sample of African immigrants there were higher odds of poor self-reported health

for those who reported moderate dietary change upon arrival to the U.S. (Okafor, Carter-Pokras, and Zhan 2014). They discuss that African immigrants who experienced this reported poor self-reported health may be consuming more fast food and less FV (Okafor, Carter-Pokras, and Zhan 2014).

The study of FV consumption by immigrant children is also quite widespread in public health and social science literature. Unlike the past results found for adults consuming less FV with more years in the U.S., children are found to eat healthier with more years of their parent residence in the U.S. (Chaparro et al. 2015). In a 2011 study done in Los Angeles County of WIC-enrolled 30- to 60-month-old children of U.S. immigrants, Chaparro and colleagues compare the FV consumption of the preschool-aged children depending on their parent's length of stay (10 years and more or less than 10 years) in the U.S. and place of birth. They find that children of foreign-born Hispanic parents who lived in the U.S. for more than 10 years consumed more FV than the children of newer immigrants. More specifically, children of foreign-born Hispanic parents with more than 10 years in the U.S. consumed more fruit by 0.27 servings and more vegetables by 0.20 servings (Chaparro et al. 2015). Another study by Morello and colleagues from 2007 found associations between Hispanic parents' BMI and acculturation to the BMI and FV intake of their children. The researchers found that while both parents' BMI and level of acculturation (i.e., time spent living in the U.S.) are significantly associated with the children's fruit consumption, the parent's level of acculturation was not a significant predictor of the children's vegetable consumption (Morello et al. 2012).

Parents who consume adequate amounts of FV, oftentimes those who have access to information on the benefits of healthful diets, have a positive effect on the FV consumption of their children (Zhylyevskyy et al. 2013). In a 2013 study of Black youth by Zhylyevskyy and

colleagues, researchers attempted to find endogenous effects of FV consumption among Black youth by the FV consumption of their parents, friends, and relative prices. They find statistically significant positive effects in both fruit and vegetable consumption for Black youth by the FV consumption of their parents. However, there were only statistically significant positive fruit consumption effects for the parents by the fruit consumption of the youth but not vegetables (Zhylyevskyy et al. 2013). Therefore, there are significant endogenous consumption effects in the Black household—if the parent consumes more FV the child is likely to also consume more FV, but if the child consumes more FV the parents will only carry the effect of consuming more fruits.

Intervention programs for healthier diets have been implemented in multiple ways for different ethnic and immigrant groups. One approach to a community-led FV intervention program is through faith-based methods. Hughes and Obayashi conduct an intervention program within the South Korean immigrant church community in California. In their study, they intercept South Koreans at their community churches. The participants were provided with (1) binders that included faith-based health messages and exercises for healthy eating, (2) coaching on FV consumption and preparation, and (3) FV-related church activities such as cooking classes. This method showed positive results for the community as they find that there was a larger scale increase among the intervention group compared to the control group (Hughes and Obayashi 2017). Using the place of worship as a community gathering space has also been shown to be central for other ethnic and racial groups. In a focus group, Black participants stated that churches and primary care clinics were also possible spaces to effectively promote healthy habits through healthy food consumption and beyond (Yeh et al. 2008). Similar to FV incentive work in rural communities, when working to ameliorate the lack of FV consumption in certain

ethnic communities, it is just as necessary to provide a heavy focus on the community's cultural diets and needs.

3. United States immigration patterns, refugee intake, and socioeconomic outcomes

The 2021 American Community Survey 1-Year Estimates reported the foreign-born population to be over 45 million residents, at approximately 13.6% of the total U.S. population (Census Bureau 2021). The foreign-born population and percentage of foreign-born (i.e., immigrants) population in the U.S. has been continuously rising in the past 50 years (Census Bureau 2021). The states with the highest proportion of immigrants in the U.S. are California, New York, New Jersey, Florida, Texas, and Hawaii. Most immigrants from Latin America and Asia reside in the Western and Southern parts of the country. Meanwhile, Black immigrants from Africa have experienced the largest growth in the U.S. not specified to a certain region in the country (Tamir 2022).

Foreign-born residents of certain ethnic groups experience differences in the socioeconomic outcome as residents of the U.S. In 2016, the U.S. Bureau of Labor Statistics (BLS) found that foreign-born workers earn 83% of the earnings that native workers gain, using a comparison of median weekly earnings. Compared by race and ethnicity, the foreign-born population with the lowest proportion of earnings to their native counterparts were foreign-born Hispanic workers at 83.5% of U.S.-born Hispanic earnings (BLS 2017). Meanwhile, foreign-born Black workers earned about the same in earnings compared to their native counterparts, and foreign-born White and Asian workers earned more than their native counterparts. There are also significant health disparities between different ethnic and racial groups in the U.S. In 2021, Black and Hispanic communities have the highest percentage of food insecure households, which reflects similar patterns in the U.S. for the past 20 years (Odoms-Young and Bruce 2018;

USDA ERS 2021). The COVID-19 pandemic has been shown to disproportionately affect ethnic minority groups and immigrants while uncovering additional personal health conditions prevalent in these communities that act as risk factors for COVID-19 (Greenaway et al. 2021). Black Americans, Latinos, and South Asians have reported higher rates of varying chronic health conditions (diabetes, hypertension, and cardiovascular diseases) that are major risk factors for COVID-19. While these conditions are not only risk factors for COVID-19, sufficient consumption of FV can act as a preventative behavior to avoid these chronic health conditions.

Reasons for immigration may largely explain these differences in earnings by a racial group of immigrants. While the majority of certain ethnic groups from one part of the world may come to the U.S. to flee political and economic unrest in their home countries, other ethnic groups might immigrate to the U.S. as professionals or high-skilled workers seeking to advance in their careers or education. This difference in class status and socioeconomic standing before immigrating creates a large gap in the earnings of immigrant populations. However, the assimilation of immigrants might better explain why there are minimal earning gaps for immigrant and native workers. Otherwise known as convergence, U.S. immigrants assimilate into American culture and workforce with more years of actively participating in the labor force (Abramitzky and Boustan 2017). Therefore, as immigrants spend more time working in the U.S., they develop a better understanding of workforce culture to eventually become more familiarized. This familiarity is learned to close the earnings gap with their native counterparts. Nonetheless, immigration patterns in the U.S. can shift very frequently depending on any occurring international events or shifts in immigration policy.

While foreign immigration continues to rise in the U.S., the past five years have shown a decrease in U.S. refugee intake (Refugee Processing Center 2022). During the Trump

administration, the refugee admission ceiling significantly decreased from 110,000 refugees in his first year (2017) to 45,000 refugees in his second year (2018). The number of total refugees admitted to the U.S. gradually decreased throughout his presidency. The lowest number of refugee admissions since the start of U.S. refugee admissions was in 2021, at the very end of his term, with 11,411 refugees total admitted into the country. By the Biden administration in 2022, the ceiling immediately increased to opening entry for 125,000 refugees to the U.S., yet numbers still lagged with 25,465 refugees admitted to the U.S. in 2022. Using this same data, the total Somali refugee intake showed similar patterns—6,130 Somali refugees were admitted to the U.S. in 2017 and immediately dropped to 315 refugees by the next year in 2018. The number of Somali refugee admissions has remained relatively low in the U.S. and have been not increased since 2018.

4. Somali immigration in the U.S.

In the 1980s, political and economic conflict arose in Somalia, inciting civil war in parts of the country and displacing over 100,000 Somalis of refugee status (Abdi 2012). The civil war in Somalia prompted the wave of Somali immigration to the U.S., starting in the 1990s. Somalis account for the largest African refugee population across the country and are mainly resettled in Minnesota and Ohio. Before this wave of refugee immigrants, the first major wave of Somali immigration in the U.S. occurred in 1960 with a small group of Somali students seeking higher education. These students either went back to Somalia or were forced to stay in the U.S. due to the conflict back home and began families, continuing to the further generations of Somali immigrants in the U.S. Nonetheless, no matter by refugee status or educational migration, Somali immigrants have been around in the U.S. for many years. As a population that has been so

prominent in the U.S. for a long time, their consumption habits are bound to have acculturated to the U.S. food system.

The resettlement of Somalis in the U.S. took place in two major cities— Minneapolis, Minnesota and Columbus, Ohio (Abdi 2012). As Somalis refugees moved to these cities, they resided in selected public housing properties. In Minneapolis, specifically, the Somali population has built a strong community in the Cedar-Riverside apartments, close to Downtown Minneapolis, which were designated as public housing properties. In the Cedar-Riverside area, members of the Somali community have opened businesses and gathering spaces over the years. The area became well-known to the Somali immigrant population to access *halal* meats, cultural clothing, and mosques for congregated prayer. With the Muslim-majority population of Somalis, *halal* meat is integral to their diet. This pattern of the refugee population building businesses and resources for their community members repeated as Somali refugees resettled in St. Cloud, Minnesota, and other parts of the country. These behaviors reflect the benefits of refugee populations residing in proximity as it encourages and eases the recreation of a familiar space to communities back home.

The latest 2019 ACS 1-Year Estimates of the Somali population in the U.S., estimated about 182,951 Somali residents nationwide and 69,702 Somali residents in Minnesota (Census Bureau 2019). Therefore, about 38% of the total Somali population in the U.S. reside in Minnesota. Further estimates from 2015 ACS 5-year Estimates using Census Designated Places to compare the Somali population sizes within Minnesota counties and cities find that there is a higher proportion of non-U.S. citizen Somali immigrants in St. Cloud compared to other cities in Minnesota, mainly Minneapolis and St. Paul. Specifically, the ratio of non-U.S. citizen Somali residents to U.S. citizen Somali residents is 3.4 to 1 in St. Cloud, 0.8 to 1 in Minneapolis, and 0.5

to 1 in St. Paul (Census Bureau 2015). Non-citizenship status may indicate more recent refugee status compared to the first wave or later generations of Somali immigrants in the U.S. This could show that St. Cloud resides on a larger scale of first-generation or recent refugee Somalis compared to a larger scale of the later generations of Somali immigrants residing in the Twin Cities.

Somali residents in Minnesota are particularly at risk of a multitude of underlying health issues. For one, refugees come to the U.S. with experiences of trauma, stress, and torture (Robertson et al. 2006). In a 2006 published study specifically focused on a group of Somali and Oromo refugee women, Robertson and colleagues find that there is generally high exposure to torture and levels of trauma among their sample of refugee women. Higher levels of trauma were shown to have a moderate to strong correlation with more social, psychological, and physical difficulty. The Somali immigrants in the Midwest are also at particularly high risk for cardiovascular diseases. Another study that was performed in four primary care provider networks in Minnesota found that when comparing Somali to non-Somali patients, there was a significantly higher prevalence of diabetes mellitus, prediabetes, and obesity among the Somali patients compared to their non-Somali counterparts (Njeru et al. 2016).

Furthermore, struggles with immigrant and refugee mental health extends to be associated with social interactions in the West namely, with discrimination. In a study conducted in four different North American cities, researchers find that discrimination does have a significant effect on worsening the mental health of Somali youth (Ellis et al. 2022). Using a longitudinal survey, they find that discrimination played a major role in predicting higher levels of anxiety and depression. Overall, immigrant youth will generally experience a downward trend with symptoms of mental health issues as they spend more years in their country of immigration

(U.S. or Canada). Most relevant to our study, malnutrition is a significant concern for Somali refugee children. In a study comparing the nutritional status of refugee children and low-income children in Washington, researchers find that there is a significantly higher prevalence of wasting nutritional status (i.e., low proportion of weight to height) for refugee children and more specifically, the highest wasting nutrition prevalence among Somali children (Dawson-Hahn et al. 2016). Additionally, of all refugee children ages 0 to 10 years old, Somali children reported the highest prevalence of wasting nutritional status and the lowest prevalence of obesity compared to the other refugee children from Iraq and Burma.

The prevalence of socioeconomic and health issues among Somali immigrants, in their multiple forms of immigration to the U.S., indicates a need for health and economic aid in the community. The successes of the Somali immigrant community in Minnesota as entrepreneurs and businesses contribute greatly to the Minnesota economy. The previously mentioned cultural resources such as Somali shopping malls, restaurants, and grocery stores have reached the demand of the greater Muslim population in Minnesota. Slowly, St. Cloud has shown similar business starts with clothing stores and restaurants in addition to the grocery stores that contributed to the study evaluated in this thesis. Comparing these results from rural and urban ethnic business starts of the same immigrant population would be beneficial research in understanding the differences in needs and available resources of these two areas.

III. Study Design

1. Theoretical Framework

This thesis is an evaluation of the Somali store intervention study, which aimed to increase the FV supply at grocery stores frequented by the targeted study population, allowing them greater access to healthy food. Through a theoretical lens, holding all else equal, when the marginal cost curve of a good shifts downwards, quantity supplied increases. In this scenario, by providing grocery store owners with procurement subsidies for fresh produce to supply in store, the stores experienced a downward shift in their marginal cost curve for fresh FV. In other words, they were provided lower costs to supply fresh produce. The decreased marginal cost implies increased quantity supplied as the change is essentially a shift to the right of the supply curve. In other words, a larger supply of fruits and vegetables is feasible due to lower marginal cost. A decrease in cost would lower equilibrium prices that allow for more consumers to purchase. However, in addition to shifting the supply, researchers helped store owners provide educational material through FV promoting and suggested preparation guides. Through these intervention materials, the assumption is that customers were more informed of the health benefits of FV consumption. This is representative of increased knowledge and information that enhances the desirability of FV, which would imply an outward shift of the demand curve. If they noticed the videos or posters, additional knowledge of FV consumption as "healthy" would lead customers to value FV more and increase demand. We assume that increased purchases would mean increased consumption.

This framework is a sustainable approach in improving FV consumption for consumers and maintaining FV supply economically feasible for store owners. A simultaneous increase in the supply and demand curves leaves out the drastic price changes that could harm either the

consumers or store owners if the shifts had occurred alone. If supply increases alone, the market price is expected to decrease which would be unfortunate for the store owners. If demand increases alone, willingness to pay would increase which could lead to higher prices and be less accessible for the shoppers who do not experience the effects of the intervention methods. This would also be counterproductive to the goals of the intervention to promote FV consumption to all shoppers at large. This shift in both supply and demand creates a sustainable change in the equilibrium quantity and price through marginal cost and willingness to pay.

Assuming customers make rational decisions, their consumption choices will depend on individual preferences and budget constraints. Fruits and vegetables are considered normal goods, meaning the quantity demanded will increase with higher income, all else equal. We expect that individuals with more income will report higher FV consumption. In relationship with participation in nutrition assistance programs, we expect FV consumption to increase for individuals residing in SNAP, WIC, and free or reduced school lunch (FRSL) recipient households. While direct consumption effects would only be seen in children living in FRSL participating households, there has been evidence found in that the consumption choices of children can influence positive consumption effects of their parents, however only in the consumption of fruit (Zhylyevskyy et al. 2013).

We run regression models in our empirical models to measure FV consumption by post-intervention survey effects and increased SGS patronage in the post-intervention period alongside control variables including household income, SNAP, WIC, and FRSL recipient household binary indicators. The relationship between household income and FV consumption variables will determine how individuals reporting varying levels of income respond to the

intervention methods. In our empirical analysis, we consider four different ordinary least squares and linear probability models to evaluate the impact of the intervention on FV consumption.

2. Study Setting

The Somali community in St. Cloud has multiple community-led forces that allow its members to feel a sense of familiarity with their home country. These initiatives have been done through small business ventures and community gathering spaces such as mosques. As of December 2022, there were 15 Somali-owned grocery stores and four Somali restaurants in St. Cloud. This prevalence of Somali businesses is seen statewide; in 2008, there were over 550 estimated Somali-owned businesses in Minnesota (Samatar 2008). Ethnic grocery stores allow the community to find food that fits their tastes and preferences (Khojasteh and Raja 2017). In the Somali community, a population that is majority Muslim, for example, there is strong demand for meat that is slaughtered in an Islamically guided technique that labels the meat as *zabiha,* more commonly known as *halal* meat (Greenwald and Zajfen 2017). Somali residents in Minnesota frequent the grocery stores that participated in this study to purchase *halal* meat, which is a staple grocery item for their households.

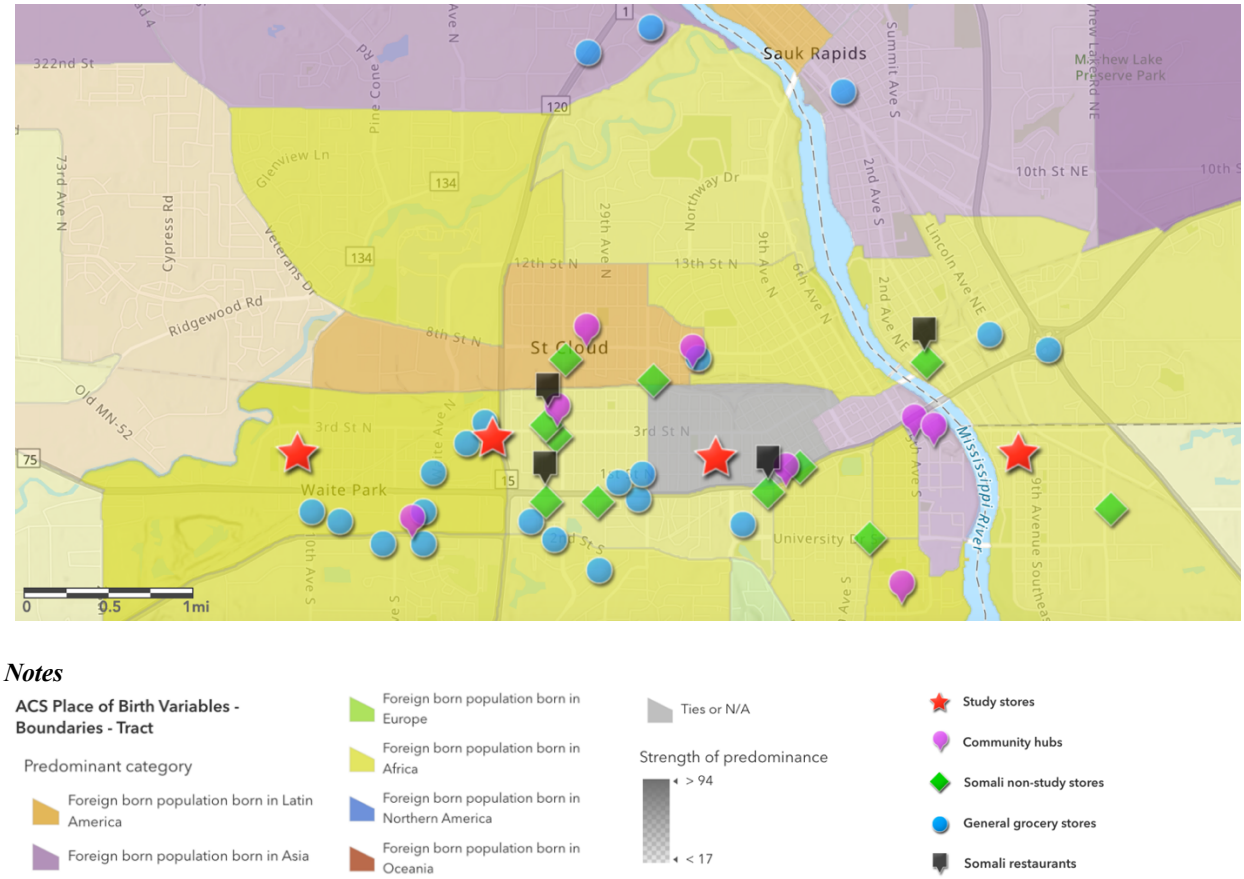
One of the main obstacles for these Somali grocery stores is missing information to adequately cater fresh fruits and vegetables to their customer base. As they are more familiar with supplying cultural food items, there are low supplies of fresh produce in stores. One of the goals of this study was to connect the store owners to access more affordable bulk FV items. As a niche type of grocery store, there will always be demand for the goods offered at the Somali grocery stores that other grocery stores or supermarkets nearby do not offer. This unique trait of their business is to the owners' benefit as there is persistent demand. Implementing fresh FV in these highly frequented stores by the Somali residents allows the community more exposure and

access to healthy and fresh produce. Thus, the ease in access and availability of produce items could lead to increased store patronage.

Figure 1 represents the spread of the SGS in the study area, alongside community hubs, other Somali grocery stores, Somali restaurants, and chain supermarkets/supercenters in the area (i.e., Walmart, Target, Aldi's, etc.). This map was created in ArcGIS, by importing geographic coordinates of each location over a pre-existing layer from Esri ArcGIS online of foreign-born population birthplace using Census tract data from the American Community Survey 5-Year Estimates from 2017 to 2021. The majority of the African foreign-born population surround the downtown area. Although the data does not represent Somali residents or refugees exclusively, nearly 92% of Stearns County's refugee intake from 2011 to 2020 was from Somalia (MN Department of Health 2020). Therefore, it is a fair assumption that a large percentage of the African foreign-born population were Somali refugees or immigrants.

The SGS that participated in the study are represented by the star points, community hubs and interview locations are the round pinpoints, other non-study SGS are the rotated square points, other grocery stores (supermarkets and other ethnic grocery stores) are the circular points, and Somali restaurants are the black squared pinpoints on the map. The other grocery stores presented by the circle points are locations where fresh FV would be accessible to the study population, as these points represent larger supermarkets such as Walmart, Aldi, and Target that supply FV in larger variety and greater affordability. This map is provided to serve as a reference for the study area and the spread of grocery stores, food environments, and community resources.

Figure 1: Geography of the study area

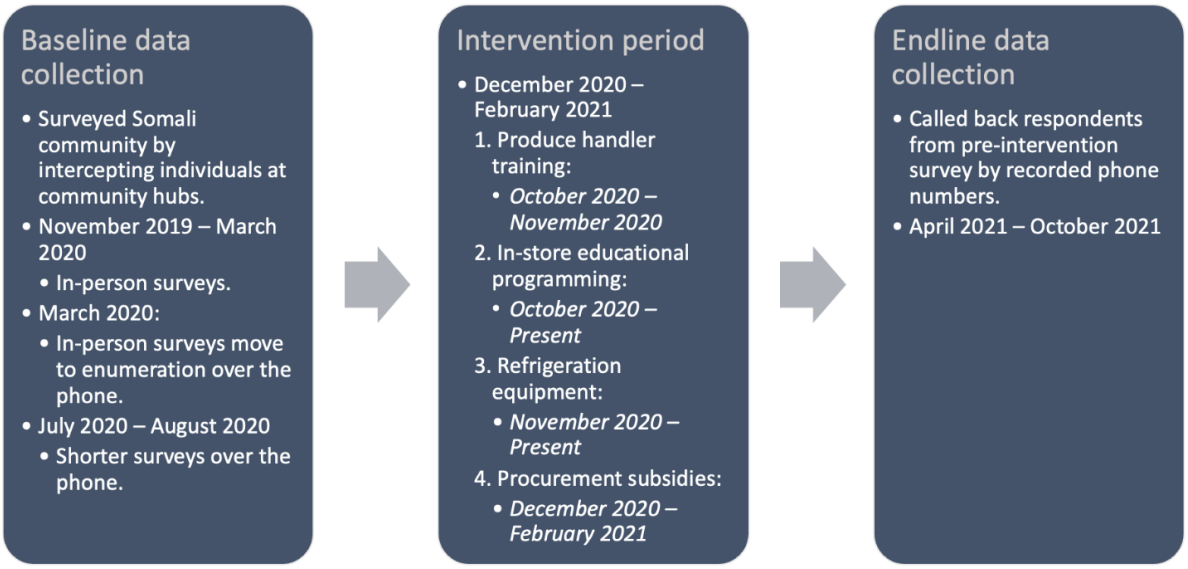


As represented by the map, Somali grocery stores, community hubs, and restaurants are concentrated in the downtown St. Cloud area. As previously mentioned, this downtown area is surrounded by Census tracts that reside higher proportions of foreign-born Africans. The spread also presents high prevalence of foreign-born individuals from Latin America and Asia closer to the center of the downtown area. These resources for the Somali community are conveniently placed in a center location to the city, near larger supermarkets. Individuals could shop at the Somali grocery stores and stop by a chain grocery store to purchase fruit, vegetable, dairy, pantry food items, and other non-cultural grocery items for the household at a lower price and with more options. However, there is even more convenience in making a single stop during a

shopping trip that satisfies all household grocery needs. The structure of a single centralized location to access grocery stores and the need to visit multiple stores to purchase all household needs can be difficult for individuals without easy access to a vehicle or other forms of transportation.

Figure 2 presents a timeline of the study, including surveys and implementation of intervention material. After members of the community were surveyed for baseline measurements, the interventions began taking place at the SGS. As previously mentioned, the intervention consisted of four elements; (1) fresh produce management training for produce handlers at each store, (2) FV prepping/educational training videos and health informational posters were displayed in-store for customer viewing, (3) funding for new refrigeration equipment was provided to the stores, and (4) FV procurement subsidies were allocated to store owners. Intervention materials were implemented immediately after baseline surveys were completed in August 2020. Training the store staff on produce storing, presentation, and handling began in October 2020. In the same month, in-store informational posters and FV preparation demonstration videos were displayed and remains displayed in-store as of Fall 2022. Once refrigeration equipment was assembled in November 2020, procurement subsidies were distributed to the stores in December 2020 through February 2021, for a total of three months.

Figure 2: Study timeline



3. Intervention Methods

Out of the four intervention methods applied in-store, the researchers began with providing fresh produce handling training to store employees. Grocers were asked to complete an online produce handling training created by the UMN Extension. The training was presented as a series of video presentation in the Somali language. The content included topics such as the economic benefits of selling fresh fruits and vegetables for the grocery store. Simultaneously, researchers also began implementing in-store educational material for customer viewing. Televisions were placed on the walls of the stores that displayed a slideshow including slides (referred to as "posters" in the survey) that informed shoppers of the health benefits and recommended serving style of the FV sold in-store. Alongside these posters, the slideshow also displayed demonstration videos that showed different ways to prepare certain FV items. For example, the poster for cabbage listed "Fry with herbs and a little oil or add to your vegetable soup" and "High in vitamins C and K, which are good for immunity and heart health." The posters were followed by a demonstration video to cut cabbage into large chunks or thin slices.

Appendix A1-A4 provides a visual representation of the posters and videos in detail, as well as additional details on the survey questions and sample characteristics results related to posters and demonstration videos.

Researchers had also observed that many of the stores lacked the infrastructure to properly supply fresh produce, mainly proper refrigeration. Due to this observation, store owners were granted funding for refrigeration equipment. The amount in funds for refrigeration and equipment size depended on store size. In addition to poor store structure to supply fresh FV, researchers learned that store owners were unaware of methods to properly and economically source fresh FV to supply in-store. Researchers then discussed more affordable and sustainable FV sourcing practices with the store owners, by referring them to wholesale distributors or connecting them with local producers to source their fresh produce. Additionally, store owners were then granted FV procurement subsidies. Each month from December 2020 to February 2021, store owners were provided $100 in FV procurement subsidies and were asked to match the amount upon receiving each payment. In these months, researchers observed each store to ensure satisfactory FV supply and even found that stores continued to stock the refrigerators with fresh FV in the following months after the last round of subsidies.

IV. Empirical approach

1. Survey Overview

The data used in this analysis was obtained from a series of surveys distributed to a convenience sample of Somali residents in St. Cloud, MN during the time before and after the intervention period of this study. The survey included screening questions to ensure that the sample group was solely Somali adults and primary grocery shoppers in their households. Two types of surveys were fielded: a pre-intervention (baseline) survey and a post-intervention (endline) survey. Baseline survey responses were enumerated in person by surveyors who were appointed to intercept potential study participants around the community and by phone.

Beginning in mid-November 2019, the pre-intervention surveys were conducted in person, until a halt in enumeration due to the global COVID-19 pandemic in mid-March 2020. Before the delay from the pandemic, Somali residents were intercepted at community hubs, including ESL (English Second Language) classes, mosques, and employment services non-profits. Pre-intervention surveys resumed from mid-July 2020 to August 2020, as the research team adjusted the survey distribution process to accommodate the pandemic-related restrictions. This modified pre-intervention survey included fewer questions so that surveyors could complete them through phone interviews with respondents within a reasonable time. In total, the pre-intervention survey process acquired 184 valid responses for analysis. From the pre-intervention surveys, the surveyors asked for individual phone numbers to contact after the intervention period. After the intervention period, post-intervention surveys were conducted by phone from April 2021 to October 2021. The post-intervention survey process collected a total of 124 valid responses. The post-intervention survey included additional questions that measured changes in shopping frequency, unplanned FV purchases from the SGS, and responsiveness to perceived

changes in each participating grocery store. Detailed prompts and questions for each variable included in this paper are listed in *Appendix B*.

The survey questions and responses were offered to respondents in both English and/or Somali. Surveyors screened for self-identified Somalis, individuals who "usually" shop for their household, adults over the age of 18 years old, and willingness to share phone numbers to be contacted for the endline surveys. While not all individuals were matched by phone number as intended, all valid responses were included in the analysis. Individuals were incentivized to participate by being offered $20 in prepaid debit cards upon completion of the survey. The initial dataset included a total of 308 observations including all baseline and endline surveys. The final cleaned dataset in this analysis includes only observations with non-missing values for *all* explanatory and dependent variables. The cleaned dataset of available dependent and explanatory variables resulted in a total of 173 total observations and 42 total pairs.

2. Evaluation Instruments

The first round of baseline or pre-intervention surveys included detailed questions that measured socioeconomic status, levels of FV consumption, grocery store purchasing habits and spending, grocery store patronage (non-Somali and Somali grocery stores), perception (affordability, quality, easiness to find, and variety) of available produce and goods at nearby stores (non-Somali and Somali grocery stores), and a recall of food items consumed per meal (breakfast, lunch, dinner, and snacks) that day. The measures of socioeconomic household standing included income, household size, number of vehicles owned by the family, current rent or mortgage, number of years lived in the study area, household benefits recipiency, and a measure of household food security using the 10-item USDA Adult Food Security Survey Module. Individual-level questions included self-perceived health, educational attainment, age,

gender, and discrimination scale. The shorter pre-intervention survey asked the respondents all the same questions without the lengthier questions about food items consumed during that day for breakfast, lunch, dinner, and snacks. Further details to examine the distinction between the pre-pandemic baseline survey and the inter-pandemic baseline surveys is provided in *Appendix C1-C2.*

The post-intervention survey included additional consumption measures such as specific FV items purchased in store by amount and consumption of certain food groups (including vitamin A-rich fruits, greens, and other vegetables) within 24 hours of responding to the survey. The post-intervention survey also listed questions more specific to the four participating SGS: (1) Midnimo Grocery and Halal Meat, (2) Iftin Grocery Store, (3) Green Market, and (4) Qalinle Family Grocery Store. Individuals were asked if they shopped more at SGS in the past year, the total number of visits for each specific store in the past three months after December 2020, unplanned FV purchases during their visit to SGS, noticed changes at each store, level of awareness towards the intervention material, and willingness to purchase new FV after awareness of intervention material.

Measurement of FV consumption is asked in the survey by weekly servings and binary 24-hour consumption recall of selected food items, including fruit, leafy greens, and other vegetables. The weekly consumption measure is based on the National Health Interview Survey (NHIS) Dietary Questionnaire which was initially developed by the National Cancer Institute (NCI) (NHIS 2015). The 2020-2025 Dietary Guidelines for Americans suggest fruit consumption by a daily measure and specific vegetable types by a weekly measure. In the data cleaning process, observations with missing weekly FV consumption responses were filled with a converted daily FV servings value. For any observation with a non-zero and non-missing

response to daily FV consumption and a missing weekly FV consumption response, the weekly consumption variable was converted to a value of 7 servings, to indicate consumption of at least one FV serving per day. For this reason, the cleaned dataset includes fewer missing responses for the weekly measure for both fruit and vegetables.

In addition to the weekly consumption variable as a measure of FV consumption, a binary measure of vitamin A-rich FV consumption in the past 24 hours of the post-intervention survey was also included in this analysis. The measure for FV consumption by a 24-hour recall was unlike the more commonly used 24-hour Dietary Recall developed by the NCI that includes open-ended questions on all consumption within 24 hours or the Automated Self-Administered 24-Hour (ASA24®) Dietary Assessment Tool (NCI). The "24-hour recall" prompt used in this survey was not open-ended. Individuals were asked whether they consumed certain food items including, but not limited to, meats, milk products, cereals, sweets, vitamin A-rich fruits, green or leafy vegetables, and other vitamin A-rich vegetables within one day of taking the survey. Affirmative responses "yes" were coded as 1 while negative responses "no" were coded as 0.

Further explained in the *Empirical Framework* section, in summary, our analysis includes four models: (*Model 1*) a full sample model, (*Model 2*) a food insecure sample model, (*Model 3*) a paired baseline and endline survey sample model, and (*Model 4*) a post-intervention sample model. The full sample and food insecure sample models use the continuous weekly FV servings variable as the dependent consumption measure while the paired sample model uses a binary indicator of increased weekly FV servings in the post-intervention period as the dependent consumption measure. Unlike the other three models, the post-intervention sample model uses the binary 24-hour recall of vitamin A-rich FV consumption variable as the dependent consumption measure. While the weekly consumption variable allows for a more comprehensive

measure of FV consumption by self-reported consumption within a longer time period, the vitamin A-rich measure presents a binary daily FV consumption approach at a random point in time of the post-intervention period. There are benefits and drawbacks of both measures that will be further discussed in the *Limitations* section.

To measure the effects of self-reported FV consumption from the intervention, the independent variables used are a post-intervention survey indicator, an increased SGS shopping frequency measure within a year of the post-intervention survey, and a binary variable to indicate any unplanned FV purchases during visits to the SGS. The post-intervention indicator variable is a binary variable coded as 1 if the observation is a post-intervention observation and 0, otherwise. This variable is only used in models that include both baseline and endline observations (i.e., full sample model and food insecure sample model). In the post-intervention survey, individuals were asked if they had shopped more at the SGS within the past year. This variable is used to measure changes in-store with the intervention methods. Individuals who responded "More" were coded as 1 while "Same" or "Less" were coded as 0. Additionally, individuals were asked whether they had any unplanned FV purchases at the SGS in the past year of their post-intervention survey response. If they did report any unplanned purchases, the variable would be coded as 1, and if not, coded as 0.

The analysis also includes income, SNAP and WIC and/or FRSL recipient household variables as controls to measure the intervention effects on FV consumption. Income questions in the survey were offered in both raw value format and by a selection of an income range. For missing raw income values, the income variable used in this model used the median value of the categorical income range response. The income variable used in this analysis is the raw value of self-reported household income. Individuals were also asked to indicate the benefits they

received in the past 12 months out of a list that included SNAP, WIC, free or reduced school lunch, an account (i.e., tab) with the Somali grocery stores, free grocery from friends or family, and food pantries. Those who indicated they received SNAP benefits were coded as 1, and 0 if not. Individuals who reported having received WIC and/or FRSL (WICFRSL) were coded as 1 and 0 otherwise.

Aside from the previously mentioned variables, the models also include control variables for household size, age, years of residence in the study area, and household food security. Household size was asked in the survey in a measure from "1" to "10+," indicating a maximum of 10 individuals in a household. Those who responded "10+" were coded as 10 and other responses were left as responded. The variable for age was divided by generation category. According to an article from the Pew Research Center, Generation Z was born between 1997-2012, Millennials were born between 1981-1996, Generation X was born between 1965-1980, Boomers were born between 1946-1964, and individuals in the Silent generation were born between 1928-1945 (Dimock 2019). Years of residence in St. Cloud were asked to individuals to respond by a number of years or the year they moved to St. Cloud. After merging these two measures and cleaning the data for inaccuracies, binary variables were created for less than five years, between five to 10 years, and more than 11 years of residence in St. Cloud. Lastly, the food security questions in the survey were based on the USDA ERS 10-item module where a total score of 0 indicates food security, 1-2 indicates marginal food security, 3-6 indicates low food security, and 7-10 indicates very low food security (USDA Economic Research Service 2012).

Including the evaluated explanatory variables in the analysis, the full sample (n = 173) model measures the continuous variable of self-reported weekly FV consumption by the post-

intervention indicator, income, SNAP recipiency, and WICFRSL recipiency as the observed explanatory variables. The food insecure sample (n = 60) model follows the same model as the full sample model, but only includes a sample of very low food security, low food security, and marginal food security households from the full sample using the USDA household measure of food security. The paired responses are observations from the full sample available in the longitudinal form: baseline and endline survey pairs (indicating data availability in pre- and post-intervention periods) were merged by phone number. This sample with 42 observations was reduced from the full sample of 173 observations, therefore representing 84 observations of the total from the full sample. The sample uses the same weekly consumption measure but uses a binary indicator for an increase in post-intervention weekly FV consumption from the individual's pre-intervention weekly FV consumption response. The post-intervention sample model includes only post-intervention responses and uses the separate 24-hour recall vitamin A-rich FV consumption measure. The explanatory variables in the paired and post-intervention sample include the same income, SNAP recipiency, and WICFRSL recipiency variables but also measure the effects of increased patronage at the SGS and any unplanned FV purchases by consumption, as they are questions only asked in the post-intervention survey.

3. Sample characteristics

a. Dependent FV consumption variables

Below, *Table 1* presents the descriptive statistics for the dependent variable used in *Models 1-3*, i.e., the changes in weekly FV consumption as self-reported by the respondents. In comparing weekly consumption solely by summary statistics, the averages and medians for weekly servings of fruit, green leafy vegetables, other vegetables, and total vegetables are highest for the endline results in the paired sample. For one, the paired sample reports an average

weekly serving of fruit at about 7.3 servings in the baseline survey while the reported consumption of fruit increased to about 12.5 servings on average in the endline survey. Additionally, for all categories of FV, at least 70% of the sample increased in weekly FV consumption. Overall, the lowest FV consumption is seen with the food insecure sample, which include marginal, low, and very low food secure households. This sample reports averages as low as 6.5 to 7 servings of FV compared to the 7.8 to 8.5 range in the full sample. This is consistent with the issues in food insecurity, reflecting less consumption of healthy food and poor access to affordable FV among food insecure households.

Next, *Table 2* provides the summary statistics of the dependent variable used in *Model 4.* Here, we analyze the consumption of FV in the post-intervention *alone* without any inclusion of pre-intervention consumption measures. Respondents were asked whether they consumed either vitamin A-rich fruits, green leafy vegetables, or other vegetables in the past 24 hours of their survey response. The summary results show that the majority of the respondents did consume each FV type in the past 24 hours with the least at 84% for green leafy vegetables and the highest percentage being 88% for fruits.

TABLE 1. Descriptive Statistics: Dependent consumption variables [Model 1, 2, 3]

	(1) Full sample n = 173, $n_{baseline}$ = 129, $n_{endline}$ = 44				**(2) Sample of food insecure households** n = 60, $n_{baseline}$= 50, $n_{endline}$= 10				**(3) Paired sample** n = 42			
Weekly consumption (servings)	**Baseline Mean**	**Baseline Median**	**Endline Mean**	**Endline Median**	**Baseline Mean**	**Baseline Median**	**Endline Mean**	**Endline Median**	**Baseline Mean**	**Baseline Median**	**Endline Mean**	**Endline Median**
Fruit	7.08	7	12.48	11	6.93	7	12.67	10	7.31	7	12.50	11.00
Green and leafy vegetables	6.48	7	13.73	12	6.54	7	17.00	13.5	6.61	7	13.69	12.00
Other vegetables (not potatoes or beans)	6.48	7	11.57	11	6.96	7	16.17	15	7.23	7	12.00	11.50
Total vegetables (greens + other veg.)	12.97	14	25.30	23	13.50	12	33.17	24	13.83	14	25.69	23.50
Increased weekly consumption (servings) in post-intervention period									**Frequency**		**Percentage**	
Fruit									32		76.19%	
Green and leafy vegetables									30		71.43%	
Other vegetables (not potatoes or beans)									30		71.43%	
Total vegetables (greens + other veg.)									32		76.19%	

TABLE 2. Descriptive Statistics: Dependent consumption variables [Model 4]

Post-intervention consumption variables	POST dataset n = 52	
	Frequency	Percentage
Vitamin A rich fruits consumption in the past 24 hours	46	88.46%
Vitamin A rich green leafy veg. consumption in past 24 hours	44	84.62%
Vitamin A rich veg. and tubers consumption in past 24 hours	45	86.54%

b. Explanatory and control variables

To provide a better understanding of the samples used in the regression models, *Table 3* and *Table 4* show the summary statistics for *Models 1-4* alongside a *(4)* supplemental column of unpaired baseline sample characteristics. *Table 3* also includes summary data of *(5)* the Minnesota Somali population, extracted from the 2019 American Community Survey (ACS) 1-Year Estimates, that are comparable to the sample characteristics. The most significant underlying results of the study sample was that the majority (at least 95%) of our sample were regular shoppers at their local Somali grocery store(s). In terms of food security and SNAP recipiency we see that the proportion of SNAP recipient households was smaller in our sample compared to the general Somali population in Minnesota.

Census estimates from 2019 were used because the first surveys in this study were fielded in the later months of 2019. Consistent with the general Somali population in Minnesota, the sex breakdown of the full study sample was majority female. By age, the majority of the Minnesota Somali population were children under the age of 18 years old. While our study sample was screened for adults over the age of 18, the majority age generation was millennials at

approximately 58% of the full sample (n = 173). This is also reflective of the adult Minnesota Somali population from the ACS Estimates, with 61.25% of the adult population falling within the Millennial generation category, who are between the ages of 25 to 44 years old. While not perfectly comparable, years of residence show that the majority of individuals in the full sample are more recent residents to the St. Cloud area, having lived in the city for less than ten years. Similarly, the ACS data shows that the majority of respondents in their sample are recent immigrants to the U.S. (not specifically to St. Cloud).

A notable difference in our sample to the general Minnesota Somali population is the proportion of SNAP recipients in each sample. Our full study sample reported a smaller proportion of SNAP recipients compared to the full Minnesota Somali population at an average of nearly 44% compared to 54% in the ACS sample. However, the food insecure sample reported about the same percentage of SNAP recipient households as the ACS sample at about 55%. In the post-intervention model, the percentage of WICFRSL recipient households decreased, which is seen in both programs; there was a decrease in WIC recipiency but a larger decrease in FRSL recipiency. This may be due to the shift to online learning where FRSL programs were placed on hold.

The unpaired baseline sample characteristics were provided to find any potential inconsistencies in the characteristics of individuals who participated in the pre-intervention enumeration but were excluded (unable to be reached) in the post-intervention survey. This sample included baseline responses from the full sample (n = 173) that did not have a paired post-intervention response, therefore excluding individuals in the paired sample. Comparing the characteristics of the unpaired sample in baseline to the paired sample in baseline, there were not

TABLE 3. Descriptive Statistics: Binary explanatory and control variables [Model 1, 2, 3 + Baseline unpaired sample]*

Control variables	*(1)* Full sample n = 173		*(2)* Sample of food insecure households n = 60		*(3)* Paired baseline sample n = 42		*(4)* Unpaired baseline sample ** n = 82		*(5)* Somali population in MN n = 69,702 ***	
	Freq.	%	Freq.	%	Freq.	%	Freq.	%	Variables	%
***Post-intervention **	44	25.43%	6	10.00%	N/A	N/A	N/A	N/A		
Gender	*(n = 167)*		*(n = 58)*				*(n = 77)*		***Gender***	
Female	104	62.28	34	58.62%	27	64.29%	46	59.74%	*Female*	56.1%
Male	63	37.72	24	41.38%	15	35.71%	31	40.26%	*Male*	43.9%
Somali grocery store	*(n = 129)*		*(n = 54)*							
Somali store shopper	123	95.35	52	96.30%	40	95.24%	78	95.12%	***Age***	
Age and generation									*18 to 24 years*	11.94%
Gen Z	5	2.89%	2	3.33%	1	2.38%	3	3.66%	*25 to 34 years*	37.57%
Millennial	101	58.38	33	55.00%	24	57.14%	51	62.20%	*35 to 44 years*	23.68%
Gen X	43	24.86	13	21.67%	11	26.19%	17	20.73%	*45 to 54 years*	10.57%
Boomer	21	12.14	10	16.67%	5	11.90%	10	12.20%	*55 to 64 years*	8.61%
Silent	4	2.61%	3	5.88%	1	2.38%	2	2.74%	*More than 65*	7.63%
Years of residence in St. Cloud										
0 to 5 years	81	46.82	28	46.67%	20	47.62%	39	47.56%	***Nativity***	
Between 6 to 10 years	55	31.79	21	35.00%	13	30.95%	26	31.71%	*U.S. Native*	42.48%
11 years and more	37	21.39	11	18.33%	9	21.43%	17	20.73%	*Foreign-born*	57.52%
									FB U.S. entry	
									2010 or later	34.30%
									2000-2009	47.90%
									Before 2000	17.80%

Notes

Age, years of residence, benefits, and food security measures are according to the pre-intervention survey findings (for paired sample).

Gender and Somali grocery store patronage question are not included in the model; Somali store patronage is only presented in the pre-intervention survey.

** Supplemental column—not used to represent any of the models.

*** U.S. Census Bureau (2019). American Community Survey 1-Year Estimates Selected Population Profile. Retrieved from [https://data.census.gov/].

TABLE 3 (continued). Descriptive Statistics: Binary explanatory* and control variables [Model 1, 2, 3 + Baseline unpaired sample]

Control variables	*(1)* Full sample n = 173		*(2)* Sample of food insecure households n = 60		*(3)* Paired baseline sample n = 42		*(4)* Unpaired baseline sample ** n = 82		*(5)* Somali population in MN n = 69,702 ***	
	Freq.	%	Freq.	%	Freq.	%	Freq.	%	Variables	%
Benefits									***Poverty & Benefits***	
** SNAP*	76	43.93%	33	55.00%	18	42.86%	39	47.56%	*SNAP*	54.40%
** WIC + Free or reduced lunch*	97	56.07%	40	66.67%	26	61.90%	57	69.51%	*Poverty rate*	38.60%
WIC	44	25.43%	16	26.67%	12	28.57%	24	29.27%		
Free or reduced lunch	82	47.40%	34	56.67%	23	54.76%	45	54.88%	***Vehicles at home***	
Account with Somali grocery store	37	21.39%	11	18.33%	3	7.14%	6	7.32%	*At least one*	79.90%
Other food assistance in cash or	17	9.83%	9	15.00%	3	7.14%	6	7.32%		
Free groceries from friends or	1	0.58%	1	1.67%	0	0%	1	1.22%		
Food security										
Food secure	147	84.97%	34	56.67%	36	85.71%	69	84.15%		
High food security	113	65.32%	0	0%	27	64.29%	46	56.10%		
Marginal food security	34	19.65%	34	56.67%	9	21.43%	23	28.05%		
Low food security	19	10.98%	19	31.67%	6	14.29%	8	9.76%		
Very low food security	7	4.05%	7	11.67%	0	0%	5	6.10%		

Notes

Age, years of residence, benefits, and food security measures are according to the pre-intervention survey findings (for paired sample).

Gender and Somali grocery store patronage question are not included in the model; Somali store patronage is only presented in the pre-intervention survey.

** Supplemental column—not used to represent any of the models.

*** U.S. Census Bureau (2019). American Community Survey 1-Year Estimates Selected Population Profile. Retrieved from [https://data.census.gov/].

TABLE 4. Descriptive Statistics: Binary explanatory and control variables [Model 4]*

Post- intervention control variables	POST dataset n = 52	
	Frequency	Percentage
Shop more often at SGS compared to 1 year	38	73.08%
Purchase FV unplanned	37	71.15%
Gender		
Female	33	66.00%
Male	17	34.00%
Age and generation		
Gen Z	2	3.85%
Millennial	27	51.92%
Gen X	16	30.77%
Boomer	6	11.54%
Silent	1	2.17%
Years of residence in St. Cloud		
0 to 5 years	21	40.38%
Between 6 to 10 years	18	34.62%
11 years and more	13	25.00%
Benefits		
** SNAP*	21	40.38%
** WIC + Free or reduced lunch*	15	28.85%
WIC	10	19.23%
Free or reduced lunch	14	26.92%
Account with Somali grocery store	32	61.54%
Other food assistance in cash or kind	8	15.38%
Free groceries from friends or families	0	0%
Food shelves, pantries, churches, or shelters	2	3.85%
Food security		
Food secure	45	86.54%
High food security	41	78.85%
Marginal food security	4	7.69%
Low food security	4	7.69%
Very low food security	3	5.77%

many notable differences in distribution of gender, age, or years of residence in St. Cloud. In terms of benefits recipiency, however, the unpaired baseline sample reported higher percentage of SNAP and WICFRSL recipient households compared to the paired baseline sample. This

indicates that more vulnerable households dropped out of the paired sample analysis and the post-intervention effects of these households were left unmeasured in the full and food insecure sample models. Including the post-intervention sample presented in *Table 4*, there is a large drop in the percentage of WICFRSL recipients while the percentage of SNAP recipient households decreased by less than 3%. For WICFRSL recipients, the drop was mainly seen in FRSL recipiency (most likely due to the shift to online learning from the COVID-19 pandemic). However, there is also a near 10% drop in WIC recipient households in the post-intervention.

Comparing the unpaired and paired baseline samples once again, while the overall proportion of food secure households in both samples were similar at about 85% representing food secure households, there were major differences in the breakdown for each food security level. The baseline sample that did not have paired post-intervention responses reported *higher* proportion of very low and marginal food security households, but *lower* proportion of high and low food security households compared to the baseline sample with paired post-intervention responses.

The next tables show the extended explanatory and control variables of all the models, with only continuous variables reported by averages and medians. *Table 5* shows the summary statistics of continuous explanatory and control variables used in *Models 1-3* by other socioeconomic factors that help define the sample populations and were relevant to the analysis. This table also includes the same supplemental columns as *Table 3* that observe the *(4)* unpaired baseline sample characteristics and *(5)* ACS estimate data for the Somali population in Minnesota. Although the ACS data estimates are sparser in this table, between the three study samples, there were very few differences in average and median household incomes. However, the average household income for the larger Somali population in Minnesota was much higher at

TABLE 5. Descriptive Statistics: Continuous explanatory and control variables [Model 1, 2, 3]*

Control variables	*(1)* Full sample n = 173		*(2)* Sample of food insecure households n = 60		*(3)* Paired baseline sample n = 42		*(4)* Unpaired baseline sample n = 86 **		*(5)* Somali population in MN n = 69,702 ***	
	Mean	**Median**	**Mean**	**Median**	**Mean**	**Median**	**Mean**	**Median**	**Mean**	**Median**
** Household Income (in $)*	34,306.47	27,499.50	34,091.50	27,499.50	37,049.83	27,249.75	37,424.19	30,000.00	42,081.00	26,464.00
Benefits (amount in $)	*(n = 72)*		*(n = 31)*		*(n = 14)*		*(n = 37)*			
	440.03	350.00	318.42	200.00	589.29	525.00	431.76	400.00	N/A	N/A
Age	40.10	35	41.07	36	40.71	35.5	38.40	34.5	N/A	N/A
Years in St. Cloud	6.83	6	6.08	5	6.52	5.00	6.72	6.00	N/A	N/A
	(n = 171)									
Children in household	2.30	2	2.33	1.5	2.22	2.00	2.51	2.00	N/A	N/A
Household size	4.66	4	4.82	4	4.60	4.00	4.89	5.00	(Owner-occupied unit) 5.77 (Renter occupied unit) 3.63	N/A
Automobiles, vans, or other vehicles at home	1.54	2	1.55	2	1.52	1.00	1.59	2.00	N/A	N/A

Notes

Paired sample variables are according to the pre-intervention survey findings.

** Supplemental column—not used to represent any of the models.

*** U.S. Census Bureau (2019). American Community Survey 1-Year Estimates Selected Population Profile. Retrieved from [https://data.census.gov/].

TABLE 6. Descriptive Statistics: Continuous explanatory* and control variables [Model 4]

Explanatory variables	POST dataset n = 52	
	Mean	Median
** Household Income*	27,988.28	27,499.50
Benefits (amount in $)	*(n=19)*	
	660.47	509
Age	41.96	37.5
Years in St. Cloud	7.79	6
Household size	4.40	4
Automobiles, vans, or other vehicles at home	1.46	1

$42,081 with a smaller median of $26,464 whereas the average income for the full sample was $34,306 and the median was $27,499.50. This could be an indication that the distribution was positively skewed. The ACS sample captured households with much larger income brackets compared to the rest of the population, to a degree less drastic than our sample. Additionally, the survey from this study measured self-reported income which may lack accuracy.

Comparing the baseline sample of unpaired observations to paired observations, there were once again no major differences in the sample characteristics. The average or median household income, age, years of residence in St. Cloud, number of children in the household, and household size were similar for the baseline results in both the paired and unpaired samples. Although not included in the regression models, the baseline population with paired post-intervention observations reported higher average and median benefits recipiency in amount of dollars compared to the unpaired baseline sample.

Lastly, *Table 6* shows the descriptive statistics for the explanatory and control variables used in *Model 4*. Notably, the average household income was lower in this sample (n = 52) while the amount received in benefits was higher with an average of $660 and median of $509

compared to overall average benefits of $440 in the full sample (n = 173) with a median of $350. This increase in benefits and decrease in household income may be due to increased government financial assistance from to the COVID-19 pandemic that all had households received. While SNAP and WIC benefits recipiency did not increase in the post-intervention model, there was a large increase in individuals who created an account with the Somali grocery stores. Nearly 62% made an account in this model compared to approximately 21% in the full sample dataset. This could imply that with increased FV supply in stores, customers frequented the SGS more often and began creating accounts with the grocery stores. However, these observations require further analysis on potential consumption smoothing during the economic shock from the global pandemic.

The following sections discuss the regression results of observed explanatory variables by each model's respective consumption measure. Regression results for additional control variables are included in *Appendix E1-E4.*

4. Model Specification

We use FV consumption variables to measure the outcomes of this study, expecting increased FV intake in the post-intervention (POST) period. We specify four different models to analyze the results of this study and include specific samples in each model. Two of the models (*Models 1 & 2*) are ordinary least squares (OLS) models with the same dependent and explanatory variables but are estimated for different samples. The other two models (*Models 3 & 4*) are linear probability models (LPM) that are specified using variables available only in POST. The models are summarized as follows:

Model 1 OLS Model regresses weekly consumption of FV using a full sample (n=173, including baseline and endline) on a POST indicator, income, SNAP recipiency, and WIC or free or reduced lunch recipiency alongside other control variables.

Model 2 OLS Model regresses weekly consumption of FV using a marginally food secure and food insecure sample (n = 60, including baseline and endline) on a POST indicator, income, SNAP recipiency, and WIC or free or reduced lunch recipiency alongside other control variables.

Model 3 LPM model estimates the probability of an increase in weekly FV consumption using a paired sample of baseline and endline surveys successfully matched by phone numbers (n = 42) by binary indicators for increased patronage at SGS in the post-intervention period, any unplanned FV purchases during their visit, income, SNAP recipiency, and WIC or free or reduced lunch recipiency alongside other control variables.

Model 4 LPM model estimates the probability of consuming vitamin A-rich FV in the past 24 hours of the survey using the endline sample only (n = 52) by binary indicators for increased patronage at SGS in the post-intervention period, any unplanned FV purchases during their visit, income, SNAP recipiency, and WIC or free or reduced lunch recipiency alongside other control variables.

a. MODEL 1: Weekly FV consumption using the full sample

This model measures weekly FV consumption by a post-intervention consumption indicator, income, and benefits measures as explanatory variables using ordinary least squares (OLS). We use the stacked dataset to form the largest sample with 173 observations. A larger sample size increases precision. As a stacked dataset, this sample includes both pre-intervention and post-intervention observations. The model is then as follows:

$$(1)\ Y_{i\gamma} = \beta_0 + POST_i\beta_{POST} + INCOME_i\beta_{INCOME} + SNAP_i\beta_{SNAP} + WICFRSL_i\beta_{WICFRSL} + INC_i \times SNAP_i\ \beta_{INC\times SNAP} + INC_i \times WICFRSL_i\ \beta_{INC\times WICFRSL} + \delta_i\beta_\delta + \varepsilon_{i\gamma}$$

We measure the consumption of FV by $Y_{i\gamma}$ where Y is the weekly servings of type γ (types of FV) for individual i where γ includes fruit, green leafy vegetables, other vegetables, or total vegetables. The measure of weekly total vegetable servings is measured as the sum of weekly servings of green leafy and other vegetables. The $POST_i$ variable is a binary indicator of a post-intervention survey where 1 equals a post-intervention survey response and 0 equals a pre-intervention survey response. The variable $INCOME_i$ is representative of income in thousands of U.S. dollars for individual i. The explanatory variables for benefits or government assistance are $SNAP$ and $WICFRSL$, which are binary indicators for SNAP recipiency and WICFRSL. The benefits variable $SNAP$ equals 1 when individual i received SNAP benefits in the past year and 0 if they did not and $WICFRSL$ equals 1 when individual i received WIC or FRSL in the past year and 0, otherwise.

We include SNAP and merge WIC and FRSL recipiency variables because our sample is generally low-income and reports high SNAP recipiency, which will be discussed further in the *Results* section. As benefits are heavily tied to reported income, we include these nutritional assistance programs as individual variables but also as interaction terms with income. Adding the benefits and interaction terms allows us to correct any specification errors in the income effects.

The control variables included in this model, δ_i, are household size, a very low food security indicator, a low food security indicator, a marginal food security indicator, Generation Z

and Millennial generation indicator, Generation X, less than five years of residence in St. Cloud, and between six to ten years of residence in the St. Cloud.

b. MODEL 2: Weekly FV consumption using food insecure sample

In this model, we analyze the FV consumption effects for a sample of unstable food security (marginal, low, and very low food security). As many refugee populations are vulnerable populations, we find it relevant to examine an especially vulnerable population of the refugee community—those who are food insecure. Furthermore, creating an exclusive analysis of a food insecure sample is imperative to this study as we are measuring changes in FV consumption for a community food system that lacks access to fresh FV. This sample eliminates the fully food secure population where their food security score equals zero (i.e., no affirmative responses to food security module prompts) from the full sample. In total, this sample is reduced to 60 observations, including all pre-intervention and post-intervention observations. The 10-item U.S. Adult Food Security Survey Module and coding procedure are provided in *Appendix D*. Based on classifications provided by the USDA, a marginal food secure individual would be coded as food secure. However, we include the marginal food secure population in this food insecure sample as they are also at potential and close to the risk of becoming food insecure. The model is then as follows:

$$(2)\ Y_{i\gamma} = \beta_0 + POST_i\beta_{POST} + INCOME_i\beta_{INCOME} + SNAP_i\beta_{SNAP} + WICFRSL_i\beta_{WICFRSL} + INC_i \times SNAP_i\ \beta_{INC\times SNAP} + INC_i \times WICFRSL_i\ \beta_{INC\times WICFRSL} + \delta_i\beta_\delta + \varepsilon_{i\gamma}$$

In this model, we use the same dependent and explanatory variables as *Model 1*. There are no changes in coding consumption Y, $POST$, $INCOME$, $SNAP$, and $WICFRSL$, either. This

time with a sample of food insecure individuals, we measure the servings of fruit, green leafy vegetables, other vegetables, and total vegetables (indexed by γ) by the post-intervention survey indicator and the same control variables as *Model 1* except for the marginal food security measures. We set marginal food security as the reference category and include low and very low food security binary variables in the model. Once again, we use an OLS statistical method for this analysis and the same coding procedure for all variables.

c. MODEL 3: Increased weekly FV consumption using paired sample

This model uses a sample of individuals who were successfully paired from both pre-intervention and post-intervention surveys. In code, they were paired by phone number, which was collected in the pre-intervention period. Individuals were called back for the post-intervention survey by their recorded phone numbers. This sample is otherwise referred to as the paired sample. Using the same weekly FV consumption measure as *Model 1*, the dependent variable in this model, $incY_{i\gamma}$, is a binary variable that equals 1 when the individual exhibits an increase in FV consumption after the intervention period. By code, this would be an increase in the post-intervention survey response to the pre-intervention survey response. We implement a linear probability model following a similar equation as follows:

$$(3)\ incY_{i\gamma} = \beta_0 + \mu_i\beta_\mu + \tau_i\beta_\tau + INCOME_i\beta_{INCOME} + SNAP_i\beta_{SNAP} + WICFRSL_i\beta_{WICFRSL} + INC_i \times SNAP_i\ \beta_{INC\times SNAP} + INC_i \times WICFRSL_i\ \beta_{INC\times WICFRSL} + \delta_i\beta_\delta + \varepsilon_{i\gamma}$$

This model excludes the $POST$ survey indicator since all observations were derived from the POST survey. Therefore, the explanatory variables in this model vary from previous models. In this model, we use a binary measure, μ_i, of increased Somali grocery store patronage in the

past year for individual i and a binary indicator, τ_i, of unplanned FV purchases for individual i during their visit (survey details included in *Appendix C1-C2)*. These measures allow for analysis of the consumers' responses to the intervention material. Since these variables are post-intervention questions, there are valid responses for all observations in this sample. There is accuracy in analyzing the results from a full sample that responded to these questions. However, this is at the cost of a smaller sample size of 42 observations compared to the previous 173 observations from *Model 1*. In addition to the two previously mentioned measures, income and benefit recipiency measures from the pre-intervention period were included in the equation alongside the same interaction terms and control variables.

It is worth noting, however, while the direct intervention-related explanatory variables in this model are strictly post-intervention responses, we use the pre-intervention measure for the income and benefits explanatory variables. Additionally, the household size and very low food security variables are excluded from this model due to insufficient observations. Control variables for other food security levels, age generation, and years in St. Cloud are also pre-intervention measures and remain the same in this model. All observed and control variables are coded in the same way as the variables in *Model 1*.

d. MODEL 4: FV consumption in the past 24 hours by post-intervention sample

The previous models used the same dependent variable, although coded differently in *Model 3.* This last model is different in using a separate survey question as the dependent variable. In addition to μ and τ that were included as additional questions in the post-intervention survey, individuals were also asked additional questions to analyze the consumption effects of

the intervention period. These questions were similar yet with minor differences. The model is as follows:

$$(4)\ VitaminA\ Y_{i\gamma} = \beta_0 + \mu_i\beta_\mu + \tau_i\beta_\tau + INCOME_i\beta_{INCOME} + SNAP_i\beta_{SNAP} + WICFRSL_i\beta_{WICFRSL} + INC_i \times SNAP_i\ \beta_{INC\times SNAP} + INC_i \times WICFRSL_i\ \beta_{INC\times WICFRSL} + \delta_i\beta_\delta + \varepsilon_{i\gamma}$$

This equation uses a linear probability model to estimate the probability of consuming $VitaminA\ Y_{i\gamma}$, or vitamin A-rich FV consumption within the past 24 hours of completing the survey for individual i. In other words, this model uses a 24-hour FV consumption recall as the dependent variable (survey details included in *Appendix C1-C2)*. The FV types, or γ, in this model are fruit, vegetables (including tubers), and green leafy vegetables. Since the dependent measure is not continuous, we cannot compile a sum of green leafy and other vegetable consumption to measure the individual's total vegetable consumption in the past 24 hours. Instead, in this model, γ is only vitamin A-rich fruit, vitamin A-rich vegetables, and vitamin A-rich green leafy vegetables.

This prompt in the survey also included other FV options, listed as "other fruits" which include wild fruits, and "other vegetables" which include tomatoes, onions, eggplants, and wild vegetables. Although these are also valid measures of FV, the above FV measures are specified to vitamin A-rich FV that allows for easier distinction in health benefits. This model also includes the continuous income variable in thousands of dollars, as well as SNAP and WICFRSL binary variables alongside the same interaction terms. The control variables used in this model are the same as in *Model 3* in excluding the household size variable due to insufficient responses

but include the very low food security variable. These observed and control variables are now measured by post-intervention results and not pre-intervention numbers as in *Model 3*.

This sample includes post-intervention survey results, regardless of having a paired pre-intervention response or not. In total, this sample compiles a final sample size of 52 observations. This was done to capture outcomes of the same measures in *Model 3* with a slightly larger sample, although using a different dependent variable measure.

V. Results

1. Model 1: Full sample

Using the SAS 9.4 package to run the following statistical analyses, we find statistically significant impacts of the intervention methods on changes in FV intake by the post-intervention period. There are consistently significant coefficients on the POST indicator for all FV types γ. The results show that individuals consume more servings of all four FV types γ after the intervention period, all at the same significance level. At the 1% significance level and on average, individuals reported 4.6 more weekly servings of fruit in the post-intervention period compared to weekly fruit servings before the intervention period, holding all else equal. At the same significance level, individuals reported 5.9 more weekly servings of green leafy vegetables, 5.0 more weekly servings of other vegetables, and 10.8 more weekly servings of both types of vegetables after the intervention period compared to vegetable intake before the intervention.

It is worth noting that these increases in consumption are much larger in magnitude compared to consumption changes reported in other intervention studies. One FV intervention study from Minneapolis, MN analyzed the effects of a FV intervention program performed with a sample of Somali women with children, using a combined FV measure for daily consumption by servings (Hearst et al. 2014). Researchers found a median of 0.3 combined daily FV servings in the pre-intervention and 2 daily FV servings in the post-intervention, at a statistically significant difference (Hearst et al. 2014). Interpreting these results as a change in consumption, there was an 11.9 FV servings increase from the pre-intervention to post-intervention, which is a much smaller change compared to our findings, considering this measure includes both fruit and vegetable consumption. One major limitation of the consumption measure in this study could be the imperfect nature of self-reported consumption. These results alongside limitations will be further discussed in the *Discussion* section of this paper.

The income variable is statistically significant for fruit, green leafy vegetables, and total vegetables. However, the results are contrary to our hypothesis in that there is a negative relationship between FV consumption with increased income. For an additional $1000 in household income, individual fruit consumption would decrease by 0.6 weekly servings at the 1% statistical significance level. At the 5% statistical significance level, an additional $1000 in household income would lead to a 0.4 decrease in weekly greens servings. Lastly, at the 10% statistical significance level, an additional $1000 in household income would lead to a 0.6 decrease in individual total vegetable consumption. There is a positive relationship, however, between SNAP recipiency and vegetable consumption. At the 5% statistical significance level, if a household received SNAP, an individual living in this household would experience an increase of 3.5 servings of greens, 3.1 servings of other vegetables, and 6.6 servings of total vegetables weekly over the study period, on average. Lastly, none of FV types γ showed statistical significance in changes to consumption by WICFRSL recipiency.

Since the model includes interaction terms between income and benefits recipiency, it is necessary to consider the interactions of SNAP and WICFRSL by income and the effect of income alone. The interaction terms between income and the benefits showed varying statistical significance levels, but only for vegetable consumption. A noteworthy pattern in the relationship between the interaction terms and weekly vegetable consumption is the positive relationship by the $Income \times WICFRSL$ interaction term and a negative relationship by the $Income \times SNAP$ interaction term. As previously mentioned, we expect an individual who resides in a non-SNAP recipient household with $1000 more in household income to consume 0.4 fewer servings of greens and 0.6 fewer servings of total vegetables. However, if the individual resided in a SNAP recipient household, for an additional $1000 in income, they would experience a larger decrease

in weekly servings of greens and total vegetables by 1.04 servings of greens and by 1.99 servings of total vegetables.

TABLE 7. Model 1 OLS Regression Results

OLS	Weekly consumption (servings)			
Explanatory variables	**Fruit**	**Green Leafy Veg.**	**Other Veg.**	**Total Veg.**
$Post\ intervention$	4.57***	5.92***	4.89***	10.81***
	(1.47)	(1.40)	(1.22)	(2.46)
$Income$	-0.56***	-0.44**	-0.11	-0.55*
	(0.21)	(0.19)	(0.13)	(0.28)
$SNAP\ recipiency$	1.34	3.51**	3.09**	6.60**
	(1.64)	(1.70)	(1.44)	(2.74)
$WIC\ and\ free\ or\ reduced\ school\ lunch\ recipiency\ (WICFRSL)$	-1.41	-2.97	-0.50	-3.47
	(1.93)	(1.83)	(1.53)	(2.99)
$Income \times SNAP$	-0.15	-0.60*	-0.84***	-1.44**
	(0.37)	(0.31)	(0.32)	(0.56)
$Income \times WICFRSL$	0.35	0.51*	0.22	0.73*
	(0.31)	(0.26)	(0.22)	(0.39)

Notes
*** p-value ≤ 0.01
** p-value ≤ 0.05
* p-value ≤ 0.1

Reversely, for an individual who resided in a WICFRSL recipient household, an additional $1000 in income would increase their consumption of greens by 0.07 weekly servings, and consumption of total vegetables would increase by 0.18 weekly servings, both at the 10% statistical significance level. This difference in consumption effects by benefits associated with household income may be due to higher incentives and initiatives in the WIC and school lunch programs to consume more FV compared to SNAP. The WIC programs provide additional cash benefits to participants for fruit and vegetable purchases, adjusted annually for inflation (USDA Food and Nutrition Service 2023). Meanwhile, school lunch programs across the nation

beginning 2014 to 2015 have stocked more fruits and vegetables in school through farm-to-school programs, adding more variety to fruits and vegetables, implementing vegetarian meal options, and more (USDA Food and Nutrition Service 2019). However, WIC and school lunches only target women and children. This may be indicative of a gap in nutritional benefit programs in encouraging healthy consumption, putting the general population of SNAP recipients (which is not exclusive to women and children) at a disadvantage. However, it might also be due to other reasons less dependent on the structure of each program, which will once again be further covered in the *Discussion* section.

2. Model 2: Marginal food security and insecure sample

In this model, we examine the outcomes of weekly FV consumption in a sample of individuals who lived in marginal food secure and food insecure households (n = 60). We find consistent results with *Model 1* in the effects of the intervention using the post-intervention variable. The post-intervention variable is once again statistically significant for all FV types γ. At the 1% statistical significance level, an individual would experience a consumption increase of 9.0 weekly fruit servings, 10.2 weekly greens servings, and 18.8 total vegetable servings in the post-intervention period compared to pre-intervention weekly servings. At the 5% statistical significance level, other vegetable consumption is expected to increase by 8.6 servings per week in the post-intervention period.

TABLE 8. Model 2 OLS Regression Results

OLS	Weekly consumption (servings)			
Explanatory variables	**Fruit**	**Green Leafy Veg.**	**Other Veg.**	**Total Veg.**
$Post\ intervention$	9.00***	10.20**	8.59**	18.79***
	(2.35)	(3.16)	(4.08)	(6.54)
$Income$	-0.09	-0.27	0.06	-0.21
	(0.22)	(0.24)	(0.34)	(0.49)
$SNAP\ recipiency$	-1.42	0.34	2.37	2.71
	(1.56)	(1.81)	(1.81)	(3.31)
$WIC\ and\ free\ or\ reduced\ school\ lunch\ recipiency\ (WICFRSL)$	1.51	-2.56	-2.09	-4.64
	(1.71)	(1.92)	(1.89)	(3.22)
$Income \times SNAP$	0.14	-0.18	-0.66*	-0.84
	(0.32)	(0.31)	(0.36)	(0.59)
$Income \times WICFRSL$	0.05	0.34	0.26	0.60
	(0.33)	(0.32)	(0.35)	(0.53)

Notes
*** p-value ≤ 0.01
** p-value ≤ 0.05
* p-value ≤ 0.1

The notable difference between the post-intervention estimates in the food insecure sample is a considerably higher degree of the consumption estimates compared to the increases in servings by the post-intervention indicator in the full sample. This could assume that individuals from food insecure households experience larger positive effects from the in-store intervention compared to a full sample that measures the changes in consumption for food secure individuals. However, it is worth considering the sample characteristics to determine inconsistencies in the model. Only 10% of this food insecure household sample are post-intervention results and these individuals report very high weekly servings for all γ. Further conceptualization and analysis of these results will be covered in the upcoming *Discussion* section.

Although we follow close to the same model and variables as *Model 1*, there are less statistically significant results in the income and benefits explanatory variables. The only statistically significant income or benefits outcomes is the interaction term between household income and SNAP recipiency. Following a similar effect to the full sample, an individual living in a household that received SNAP benefits with a $1000 increase in household income is estimated to experience a decrease in weekly consumption of other vegetables by 0.7 servings at the 10% statistical significance level, although the income variable is not statistically significant.

3. Model 3: Paired sample

In the paired sample, we use a linear probability model to analyze the probability that an individual would increase their weekly FV intake by the same income and benefits explanatory variables. Instead of the post-intervention binary measure, this model uses binary variables that indicate increased SGS patronage compared to a year before the post-intervention survey and any unplanned FV purchases during their visit. While the increased SGS shopping frequency measure shares similar interpretations and effects as the previously used POST variable, the two measures are not interchangeable effects. For this model, there are fewer statistically significant results. For vegetable consumption alone (i.e., all γ except γ_{Fruit}), there is a statistically significant increase for individuals who reported increased SGS shopping frequency in the past year. Otherwise, no other variables are statistically significant to measure the probability of increased FV consumption in the post-intervention period.

At the 1% statistical significance level, the probability that an individual consumes more servings of other vegetables that are not green leafy vegetables every week in the post-intervention period increases by 0.6 percentage points if they also reported increased SGS shopping frequency in the past year. Similarly, at the 5% statistical significance level, an

individual who reported increased SGS shopping frequency in the post-intervention period would experience a 0.6 and 0.5 percentage point increase in weekly consumption of green or leafy vegetables and all vegetables, respectively. Otherwise, see similar estimates for the income and benefits interaction terms but not at a statistically significant level.

TABLE 9. Model 3 LPM Regression Results

LPM	Weekly consumption (servings)			
Explanatory variables	**Fruit**	**Green Leafy Veg.**	**Other Veg.**	**Total Veg.**
$Increased\ SGS\ shopping\ frequency$	0.36	0.57**	0.60***	0.48**
	(0.22)	(0.21)	(0.18)	(0.18)
$Unplanned\ purchases$	-0.19	-0.02	-0.07	0.07
	(0.21)	(0.20)	(0.17)	(0.17)
$Income$	-0.01	-0.01	0.03	0.03
	(0.04)	(0.04)	(0.03)	(0.03)
$SNAP\ recipiency$	-0.02	0.03	0.10	0.17
	(0.31)	(0.29)	(0.25)	(0.25)
$WIC\ and\ free\ or\ reduced\ school\ lunch\ recipiency\ (WICFRSL)$	-0.15	-0.03	0.03	0.05
	(0.31)	(0.03)	(0.25)	(0.26)
$Income \times SNAP$	-0.02	-0.09	-0.07	-0.09
	(0.11)	(0.10)	(0.09)	(0.09)
$Income \times WICFRSL$	0.02	0.02	0.00	-0.01
	(0.05)	(0.05)	(0.04)	(0.04)

Notes
*** p-value ≤ 0.01
** p-value ≤ 0.05
* p-value ≤ 0.1

4. Model 4: Post-intervention sample

This last model uses a sample of only post-intervention observations with a sample total of 52 observations. This model examines the results of post-intervention survey results based on self-reported consumption of vitamin A-rich fruits, green leafy vegetables, and other vegetables

including tubers in the past 24 hours by increased SGS patronage in the past year and any unplanned FV purchases during their visit to the store, alongside the same benefits and income explanatory variables. This model is very similar to *Model 3* in its LPM form and by explanatory variables but differs in the dependent variable. Instead of measuring a continuous dependent variable for weekly consumption or a binary indicator for an increase in the weekly consumption, we implement a linear probably model using the previously mentioned dependent variable of any FV consumption by category (γ) in the past 24 hours by increased patronage and unplanned purchases. In this model, we do not incorporate the results for total vegetables.

TABLE 10. Model 4 LPM Regression Results

LPM	**Consumption of Vitamin A-rich FV in the past 24 hours**		
Explanatory variables	**Fruit**	**Green Leafy Veg.**	**Other Veg.**
$Increased\ SGS\ shopping\ frequency$	0.63***	0.53***	0.45**
	(0.11)	(0.17)	(0.17)
$Unplanned\ purchases$	-0.37***	-0.29*	-0.24
	(0.11)	(0.17)	(0.17)
$Income$	0.10*	0.00	0.04
	(0.05)	(0.07)	(0.07)
$SNAP\ recipiency$	-0.18	-0.40*	-0.26
	(1.14)	(0.20)	(0.20)
$WIC\ and\ free\ or\ reduced\ school\ lunch\ recipiency\ (WICFRSL)$	0.04	-0.15	-0.09
	(1.14)	(0.20)	(0.20)
$Income \times SNAP$	0.07	0.11*	0.09
	(0.04)	(0.06)	(0.06)
$Income \times WICFRSL$	-0.11**	-0.02	-0.05
	(0.05)	(0.07)	(0.07)

Notes
*** p-value ≤ 0.01
** p-value ≤ 0.05
* p-value ≤ 0.1

The results show that for all three γ FV categories in this model, at a statistically significant level, self-reported SGS increased patronage in the past year would lead to an increase in the probability of consuming FV in the past 24 hours of the survey. Here, there are more statistically significant results for the consumption of fruit, γ_{Fruit}, compared to the results seen in *Model 3*. At the 1% statistical significance level, the probability that an individual who consumed vitamin A-rich fruit in the past 24 hours increases by 0.6 percentage points if they reported increased SGS shopping frequency in the past year increases, holding all else equal. At the same statistical significance level, if the individual reported increased shopping frequency in the past year, the probability that they consume green leafy vitamin A-rich vegetables in the past 24 hours increases by 0.5 percentage points. At a 5% statistical significance level, increased shopping frequency increases the probability of an individual having consumed other vitamin A-rich vegetables in the past 24 hours by 0.5 percentage points. However, an individual who reported an unplanned purchase at the SGS in the past year is 0.4 percentage points less likely to have consumed fruit in the past 24 hours. The same negative relationship is present in the probability of consuming vitamin A-rich green leafy vegetables in the past 24 hours, reporting a 0.3 percentage point decrease by the unplanned purchases binary variable at the 10% significance level.

Other than the direct intervention-related explanatory variables, there are also several statistically significant results in the income and benefits recipiency explanatory variables. Unlike results from *Model 1,* an individual living in a non-SNAP and non-WICFRSL recipient household with a $1000 increase in income would experience a 0.1 percentage point increase in the probability of having consumed vitamin A-rich fruits in the past 24 hours of the survey. Additionally, if the individual resides in a WICFRSL recipient household, the probability that

they would consume vitamin A-rich fruit in the past 24 hours with increased income decreases by 0.01 percentage points. Similarly, in showing opposite results to *Model 1*, at the 10% statistical significance level, the probability of an individual having consumed green leafy vegetables in the past 24 hours is expected to decrease by 0.4 percentage points with SNAP recipiency. The probability of a SNAP recipient consuming greens is expected to decrease by 0.29 percentage points if they experience a $1000 increase in income. The causes of these changes are uncertain, but an explainable reason may be the shift in the economy from the global COVID-19 pandemic that occurred in the distribution of the post-intervention survey.

VI. Discussion

The majority (73%) of individuals in the full sample reported increased patronage at Somali grocery stores in the post-intervention period. This statistic alone could imply that changes in store structure and availability of more fresh produce encourage members of the community to shop more at the Somali stores. With these results, we can assume that the study population became more exposed to fresh produce at the study stores during the post-intervention period.

Through the results of our analysis, we find evidence that the intervention methods used in this study were effective in increasing FV consumption among the sample of Somali SGS shoppers. Firstly, in observing *Model 1* (full sample) and *Model 2* (food insecure sample), we see that the number of weekly servings for all γ increased with the post-intervention response. For fruit, the full sample model showed 4.6 weekly servings increase in the post-intervention, while the food insecure sample model reported 9.0 weekly servings increase in the post-intervention period. The higher magnitude increases in expected consumption of fruit for individuals living in food insecure households compared to the full sample is consistently observed with green leafy vegetables, other vegetables, and total vegetables, as well. In a supplemental model that excludes all control variables, the model reported very similar results by degrees in change, direction, and statistical significance to the original model.

Although this analysis is not designed for a difference-in-difference interpretation, the larger impacts of the intervention estimated for food-insecure household sample remains a notable finding. A further difference-in-difference analysis could find proper evidence of the food insecure sample having experienced larger consumption effects compared to the food-secure population in the full sample. However, these large differences may also be due to the

lack of post-intervention responses in each sample. For the full sample, 25.4% were post-intervention responses and in the food insecure sample, 10% were post-intervention responses. In a closer look at the food insecure sample that has only 6 post-intervention responses, the average endline weekly fruit and other vegetable consumption were 12.67 servings and 33.17 servings on average, respectively (*Table 3*, *Table 1*). The average fruit and total vegetable consumption in the pre-intervention for the sample of food insecure households, at a much larger sample size of 54 observations, was 6.30 and 11.31 servings on average, respectively. This large increase in consumption with only a small group of post-intervention observations does not serve as a good enough representation of the changes in FV consumption for the entire community of Somali residents in St. Cloud. This may also be indicative of social desirability bias, a major fallacy in self-reported survey data, where individuals report information that is more desirable for the outcomes of the survey.

Further discussing the large increase in consumption from the intervention but observing the full sample, the average fruit and total vegetable consumption in the pre-intervention period was 7.08 weekly servings of fruit and 12.97 weekly servings of total vegetables. The large increase in consumption remains visible when comparing average consumption in the post-intervention, 12.48 weekly servings of fruit and 25.30 weekly servings of total vegetables. This sample of post-intervention responses, while larger in size than the food insecure household sample, is still quite small at 44 observations. The issue may also be due to the small sample size, which once again, cannot represent the entire Somali population in St. Cloud and any changes in their FV consumption habits from the store intervention. While this analysis supports our hypothesis in resulting increased consumption, the magnitude of the increases may be overstated.

As shown in *Table 3* and *Table 5* in the *Sample Characteristics* section, we analyze a supplemental "unpaired" sample, which includes individuals in baseline who did not have a paired post-intervention observation. There are little but also notable differences in the baseline samples between the paired and unpaired samples. While the unpaired baseline sample reported a higher percentage of SNAP recipients, WICFRSL recipients, and very low food secure households, they also reported lower amounts in benefits compared to the paired baseline sample. Additionally, both baseline samples earned about the same in income, but the unpaired baseline sample did report slightly higher average and median household income. This may indicate that the unpaired baseline observations were more vulnerable in that they were food insecure but earned just enough income to not qualify for food assistance programs or receive enough benefits. Unfortunately, the unpaired baseline observations were excluded from post-intervention measures as their changes in consumption were left unmeasured. While this is a small sample of between 5-10 observations, the exclusion of these individuals in the post-intervention may explain the large magnitude increase in consumption from the intervention, as seen in the full sample model.

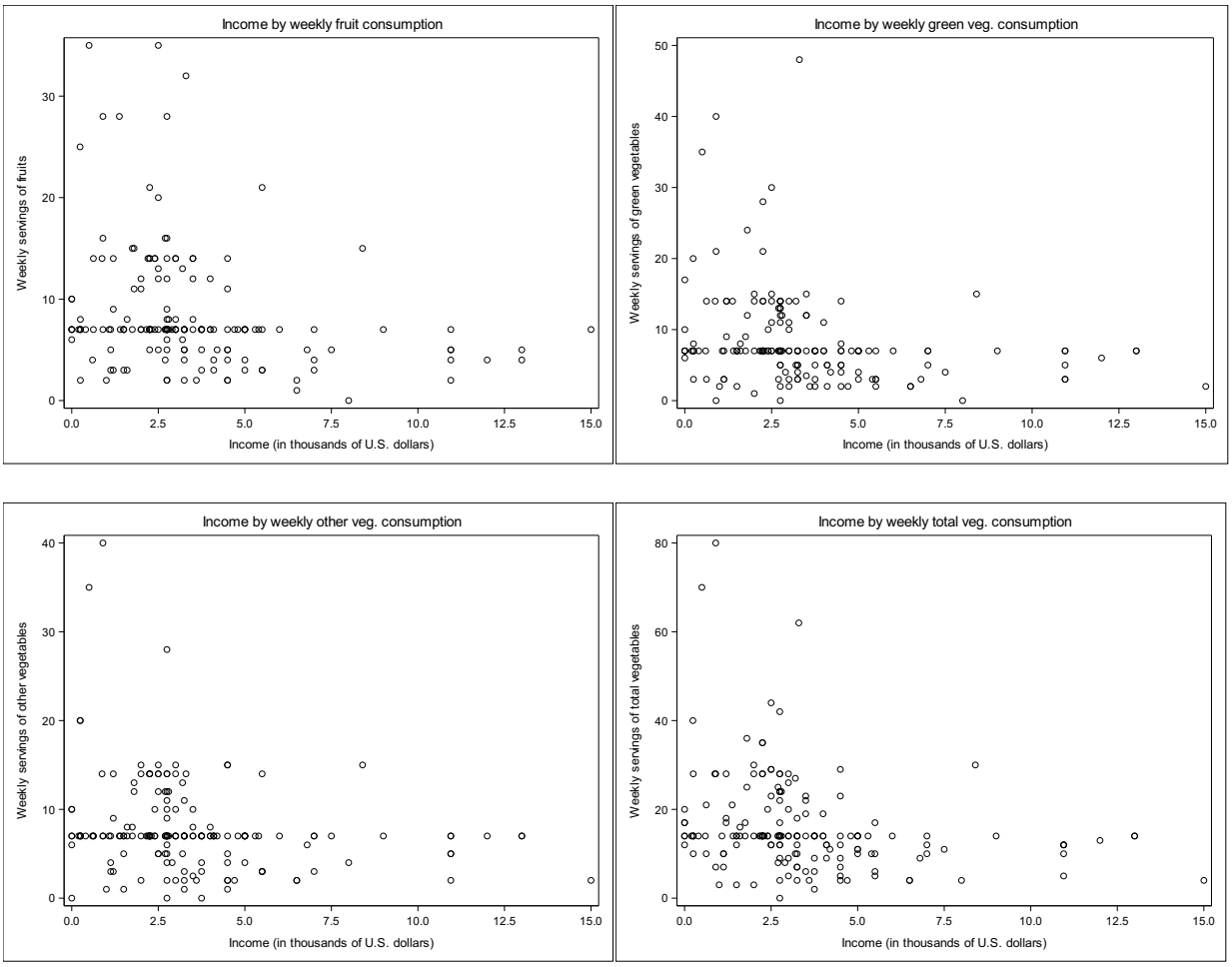
Additionally, *Appendix F* shows the average consumption in the pre-intervention period for the unpaired sample compared to the baseline consumption averages in the full and paired samples. The baseline averages in the unpaired sample were slightly smaller at 6.98 average weekly servings of fruit and 12.45 average weekly servings of total vegetables. Compared to the other samples, the average weekly intake of fruit in baseline was 7.08 servings (full sample) and 7.31 baseline servings (paired sample). For vegetables, the full sample average was 12.97 baseline servings, and the paired sample average was 13.83 baseline servings. Individuals who participated in both surveys reported higher consumption, overall, especially those in the paired

sample. This supports the idea that the unpaired baseline observations were more vulnerable in that they also consumed less FV before the intervention.

In *Model 1* (full sample), we find the most statistical significance in the income, SNAP, and WICFRSL explanatory variables. We find a negative relationship for all γ weekly servings by income in thousands of dollars. This indicates that individuals in the reference group with lower incomes increased their FV consumption while those with higher incomes did not. However, the negative relationship with income is only statistically significant for fruit, green leafy vegetables, and total vegetables in *Model 1* and not, as previously mentioned, the other models. However, *Model 4* shows a statistically significant opposite effect in servings of fruit, aligning more with our hypothesis that income and FV consumption share a positive relationship.

The unexpected negative relationship in FV consumption by income as seen in *Model 1* can be further examined through scatterplots of income by self-reported weekly servings of each FV type, displayed below in *Figure 3*. According to our prediction and the general nationwide trend; with increased income, Americans consume more fruits and vegetables. *Figure 3* presents the opposite relationship in that individuals who lived in lower income households consume more FV while those in higher-income households consume less FV. The scatterplots, however, also allow for further analysis of the distribution of individuals in their income and consumption placements. In fact, the majority of individuals consumed approximately less than 15 weekly servings of fruit, greens, and other vegetables while there are a few individuals with lower income that report very high consumption.

Figure 3: Scatterplot of income by weekly consumption of fruit, greens, other vegetables, and total vegetables in the full sample (n = 173)



With a large group of individuals having consumed 7 weekly servings of fruit, greens, and other vegetables and 14 weekly servings of total vegetables, it could also be argued that the conversion of daily to weekly consumption may have led to an inaccurate representation of the income by consumption distribution. However, *Appendix G* presents the scatterplots of a recoded weekly consumption variable sample to test the distribution by a recoded measure of weekly consumption. Instead of the original weekly measure that converts any value of daily consumption to 7 (to indicate one serving per day) for missing weekly consumption observations, this recoded weekly consumption variable uses the reported daily measure

multiplied by 7. In these scatterplots, there are similar results in the distribution although less spread. Nonetheless, the regression results in this model for the consumption variables by income remain negative at a statistically significant level.

The reasoning behind the odd shape seen in the scatterplot may be due to the characteristic breakdown of the sample in the pre-intervention and post-intervention, as previously discussed. Once again, however, there are very slight changes in household income between the unpaired and paired baseline sample groups. Additionally, the unpaired sample model outputs the same negative effects on income by consumption as the full sample model. The reasoning behind the unpredicted spread in income by weekly consumption is unclear. Some reasons could, once again, be due to social desirability bias once again or self-reported income *and* FV intake. Nonetheless, an ambiguous measure of FV consumption as a reason for the distribution serves as a major shortcoming of this study, which will be further discussed in the *Conclusion* section.

The effects of income on FV consumption could be further explained by the interaction variables between income and benefits. The $Income \times SNAP$ interaction term displays a negative relationship with vegetable consumption despite a positive relationship between SNAP recipiency and FV intake. However, the $Income \times WICFRSL$ interaction term shows a positive relationship with vegetable consumption and shows negative relationships for all γ by WICFRSL recipiency alone, yet there is statistical significance for WICFRSL recipiency alone. This alludes to the possibility that with increased income, recipients of any nutritional assistance programs experience a reverse effect on FV consumption. Higher income earning SNAP participants are expected to decrease their consumption of vegetables while higher income WICFRSL participants are expected to increase in consumption of vegetables.

As previously mentioned, this difference in the interaction terms between SNAP and WICFRSL by income could be due to the heavy focus WIC and free or reduced school lunch programs place on healthier food options and FV consumption for their participants. As previously mentioned, WIC recipients receive additional supplementary funding specifically allocated to fruit and vegetable purchases. Meanwhile, FRSL programs nationwide began including more fresh fruits and vegetables in the meals served in schools. SNAP, however, places less of a focus on healthy FV consumption, although there are multiple FV incentive pilot programs led by research entities and nonprofit organizations nationwide. While healthy food initiatives pilot programs through SNAP are funded by the Farm Bill, there has yet to be a federal FV or healthy consumption initiative within the program itself. Any household food items that are not live animals, hot food items, alcohol, or vitamins are allowed under SNAP with no specified portions allocated to certain food types (USDA Food and Nutrition Service 2021). As many participants are low-income, households opt for food items that are easier to access, prepare, and more filling. Often, this convenience may come in the form of heavy carbohydrates or high in fat food items which are easier meal options compared to preparing and cooking fresh vegetables.

In summary, our sample reports that *higher*-income WICFRSL recipients are expected to consume more vegetables while *lower*-income SNAP recipients are expected to consume more vegetables, although SNAP recipiency *alone* increases vegetable consumption. Another explanation for increased consumption of vegetables among higher income WICFRSL households could be due to an information gap from not only the FV promotion within each program but also the social nature of mothers being more informed of feeding their children healthier diets. Aside from the fundamental structures of SNAP, WIC, and FRSL programs,

mothers with younger children are more likely to purchase healthier foods. Younger children require healthier diets which would easily incentivize mothers to purchase fruits and vegetables among other healthy food items. With higher income, increased assistance from the WIC program, and more experience in preparing fresh FV items as mothers, they are more willing to purchase FV from the stores.

The paired sample in *Model 3* does not show any significant results for the income or benefits explanatory variable. However, *Model 4* does show some statistical significance in income and benefits effects. With increased income in the post-intervention sample, an individual is expected to experience a 0.10 percentage point increase in the probability of having consumed fruit in the past 24 hours. This is the opposite result of the previous models (*Model 1* and *Model 2*), where income shared a negative relationship with the continuous weekly consumption measure. We also see that there is statistical significance in the probability of consuming green leafy vegetables in the past 24 hours by SNAP recipiency and the interaction term for income and SNAP. This relationship is also the opposite of the results of *Model 1* and *Model 2.*

This shift in the direction of income and SNAP recipiency effects in *Model 4* could be reflective of differences in the consumption measure from a weekly FV consumption frequency measure in *Model 1* and *Model 2* to a form of 24-hour FV consumption recall measure in *Model 4*. The 24-hour recall measure for consumption may be a more accurate measure in this study due to the disproportionate large degree increases in weekly consumption. However, a major drawback of the 24-recall measure is its availability only in the post-intervention survey. Without the same, or even comparable, measure in the pre-intervention survey, we cannot form a proper comparison in pre-intervention and post-intervention consumption using this variable.

Another reason for this difference in the post-intervention could be changes in income and SNAP recipiency due to additional nutritional and financial assistance backed by the COVID-19 pandemic. Households received financial assistance from the pandemic in the form of stimulus checks. This change in household income and increased financial assistance could have shifted the effects of income and benefits recipiency on FV consumption levels.

Model 3 also does not show any statistically significant results in the unplanned FV purchases binary indicator. However, there are statistically significant results for the unplanned FV purchases variable in the post-intervention sample, *Model 4*. We see that for an individual who reported an unplanned FV purchase during their recent visits to the SGS, the probability that they have consumed vitamin-A-rich fruit and green leafy vegetables in the past 24 hours of the survey decreases by 0.4 and 0.3 percentage points, respectively by each γ, at statistically significant levels. The reasoning for this negative relationship is difficult to decipher. This may be due to hesitancy or uncertainty in consuming the FV that was purchased without prior intention because it could have been a produce item that individuals were unfamiliar with preparing or consuming. However, this claim cannot be proven by this model and is merely an assumption.

Lastly, all *Model 3* γ vegetable categories are statistically significant to at most a 5% statistical significance level for increased SGS shopping frequency. Individuals in the paired sample who reported higher SGS patronage in the past year were more likely to have increased weekly servings of vegetables (greens, other, and total) in the post-intervention period. Likewise, in *Model 4*, consumption of FV in the past 24 hours of the survey had a positive relationship with the same increased patronage variable. In *Model 4*, we see that increased shopping frequency in the past year, or since the start of the intervention period in December 2020, the probability of γ

vitamin-A-rich fruit, green leafy vegetable, and other vegetable intake in the past 24 hours of the survey is statistically significant, to at most the 5% significance level.

The results in the *POST* variable used in *Model 1* and *Model 2*, as well as the μ variable or the increased patronage binary variable in *Model 3* and *Model 4* are the most suitable measures of the intervention method's effectiveness. Consistently, these results are positive and statistically significant in all models for most of the γ types of FV. Through *Model 3* and *Model 4*, we find increased probability in consumption with increased shopping frequency at the SGS, which leads to higher exposure to fresh produce, and encourages consumers to purchase more FV. Yet, in *Model 1* and *Model 2,* there is increased weekly intake of FV but to an abnormal magnitude increase. In the models with controls, generally, the reference group consists of Somali immigrants of the Boomer generation who have lived in St. Cloud for more than 10 years with household food security status and size depending on each model.

VII. Conclusion

1. Limitations

The FV consumption measure was a major shortcoming in this analysis. A comparison of the FV consumption measure as used in this paper to the cup measurement used to measure recommended FV intake in the *Dietary Guidelines for Americans 2020-2025* created by the USDA and HHS would be misleading. Surveyors in this study were not specific in utilizing any form of measurement mechanisms such as by cup, fist, handful, or other measurements commonly used in other academic surveys to measure FV intake.

In the *Results* section, we discuss social desirability bias with self-reported FV intake. The measure of self-reported intake is inherently flawed due to multiple reasons, some of which may also be due to external factors. In this study, in particular, these external factors may have affected the disproportionately large degree increase in consumption, with very high self-reported FV consumption even in the baseline survey. The surveyors and respondents may not have been on the same level of understanding of what is considered "consumption" of FV. In addition to the small sample and unclear measures of consumption that taint the measures as inaccurate, individuals in the community may have felt a desire to support store owners indirectly through overreporting consumption in the post-intervention survey. The method employed in this section of the survey to measure weekly amounts of FV consumption is a form of food frequency questionnaire (Shim, Oh, and Kim 2014). While it is a reputable and valid form of surveying FV intake, it may have been flawed due to inaccurate measurements (in the survey question and/or the execution of asking the question) and the social desirability bias.

The measure of FV consumption in the past 24 hours of the survey used in *Model 3* and *Model 4* is an example of a 24-hour dietary recall questionnaire that lists several food items and

asks individuals if they have consumed said items in the past 24 hours of the survey (Shim, Oh, and Kim 2014). These models (*Model 3* and *Model 4*) yield fewer problematic results with the increased patronage variable compared to the frequency questionnaire or weekly consumption results. The 24-hour recall questionnaire measure may be more accurate in quantifying changes in consumption by the post-intervention period through a binary measure. While using this measure does not discount the potential for social desirability bias, it may output more accurate results that do not report disproportionate increases in weekly consumption. However, a major drawback to this measure in this analysis is the availability of the responses *only* in the post-intervention survey. A more accurate measure of consumption using this variable would be a comparison of FV consumption in both baseline and endline surveys, which would mean the availability of data in both surveys. Additionally, in the *Discussion* section, we discuss an unobserved vulnerable portion of the sample. A more accurate representation of the full sample in both baseline and endline surveys would be beneficial.

Another shortcoming of the study was the survey timeline and correspondence with the seasonality of certain fresh FV items. The pre-intervention survey was primarily conducted during the wintertime (November 2019 to March 2020) and the post-intervention survey was primarily conducted throughout the summertime (April 2021 to October 2021). Considering the seasonality of fresh FV is important for the nature of this study since store owners supplied more fresh produce in-store. From an economic standpoint, the seasonality of fresh FV sourced both locally and non-locally has significant effects on the store owner's ability to set prices and supply enough produce in-store. The difference in seasons that each survey was conducted in leads to inaccuracy of the data due to a lack of control in supply and price changes. For future

studies that focus more heavily on fresh produce, the timeline of baseline and endline surveys should match in terms of seasonality to control for supply changes and price fluctuations.

2. Implications

Considering the limitations of this study to assume equivalence in the measure of "cups" used in the *Dietary Guidelines for Americans 2020-2025* to servings of each FV item in our survey measure of "weekly servings," the descriptive statistics in our paired sample show that individuals in the pre-intervention survey failed to meet these recommendations with average weekly fruit consumption at 7.3 servings and total vegetable consumption at 13.8 servings.[1] In the post-intervention averages, the number of servings reaches 12.5 servings of fruit and 25.7 servings of total vegetables. The post-intervention average fruit consumption nearly meets the recommended number of servings while the average vegetable consumption exceeds the recommended amount.

Our analysis also shows the importance of incentivizing healthy foods such as fruits and vegetables within nutritional assistance programs, especially SNAP. There are effective results in FV consumption for WIC and free or reduced lunch program participants, yet these programs are geared towards a selected vulnerable population of women and children. Where SNAP acts as a nutritional assistance program that targets a larger population of food-insecure and low-income Americans, we find there is a gap in fruit and vegetable consumption between SNAP recipients and other nutritional assistance programs such as WIC or free or reduced school lunches.

[1] The *Dietary Guidelines for Americans 2020-2025* suggests 2 daily servings of fruit, or 14 servings of fruit per week for the average American. Daily serving recommendations for any type of vegetable is 2.5 servings per day. For specific types of vegetables, the weekly recommended serving amount of dark green vegetables is 1.5 servings per week; 5.5 weekly servings of red and orange vegetables; 1.5 weekly servings of beans, peas, and lentils; 5 weekly servings of starchy vegetables; and 4 weekly servings of other vegetables. In summary, the recommended weekly serving is 14 servings of fruit and 21 servings of total vegetables.

Although this study did not target a population of SNAP recipients in particular, this distinction is necessary for future policy and healthy food initiative programs.

This study overall also shows that research and community-led efforts in rural and ethnic populations require a substantial amount of cultural understanding and recognition of the target population's needs. By working with professionals local to the study area who are familiar with the study population, a level of trust was established between researchers and community members. For this reason, we find it imperative that researchers and professionals build these connections before inserting work into vulnerable populations and working closely with community leaders like the grocery store owners of this study.

Overall, this analysis provides evidence of the effective outcomes of the intervention methods used in the study. This study implemented an intervention method that included exposure to fresh produce and educational material for the customers while providing rural ethnic grocery store owners the access to resources and guidance they needed to successfully supply their community with fresh produce. As a result, these methods were effective in increasing the consumption of fruits and vegetables among their customer base. However, the external validity of this analysis is limited. While effective, the main shortcoming of this analysis is the lack of comparison of the employed methods to other intervention methods of the same population sample. Evaluating differences in the results of other intervention methods would be necessary for determining the effectiveness of the methods employed in this study.

Nonetheless, the researchers and store owners established a sustainable and successful long-term approach to increasing the community's FV consumption while ensuring economic success for the grocery stores. The results of this analysis can support the success of these methods and encourages a similar approach for future FV promotion programs. As leaders with a

key role in overseeing the consumption choices of their community, grocery store owners can, in fact, act as levers of change in their community. Provided the necessary resources and professional guidance when needed, they can yield successful results in healthy consumption effects which can be reflected in their community.

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———; American Community Survey, 2021 American Community Survey 1-Year Estimates, Table S0502; generated by Nurfadila Khairunnisa; using data.census.gov; https://data.census.gov/table?q=foreign+born+2021&tid=ACSST1Y2021.S0502.

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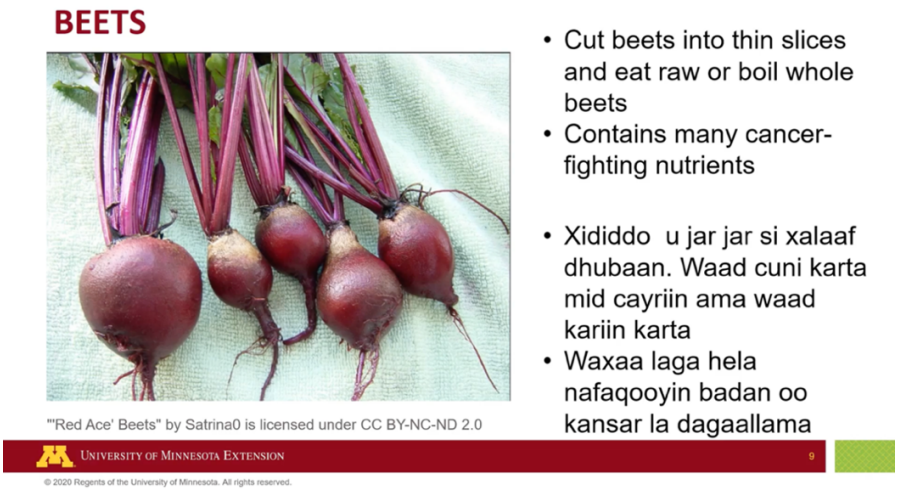
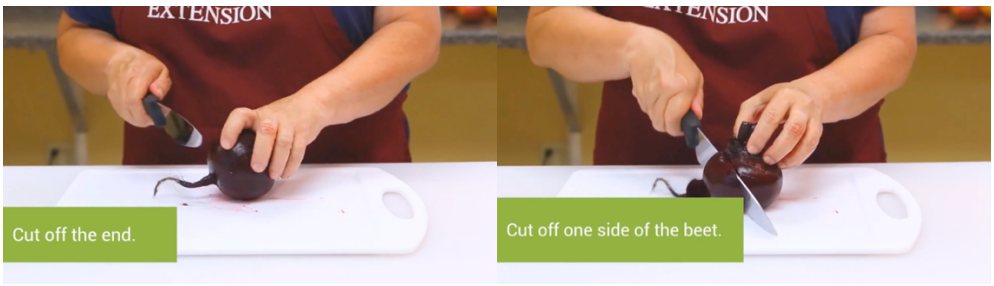
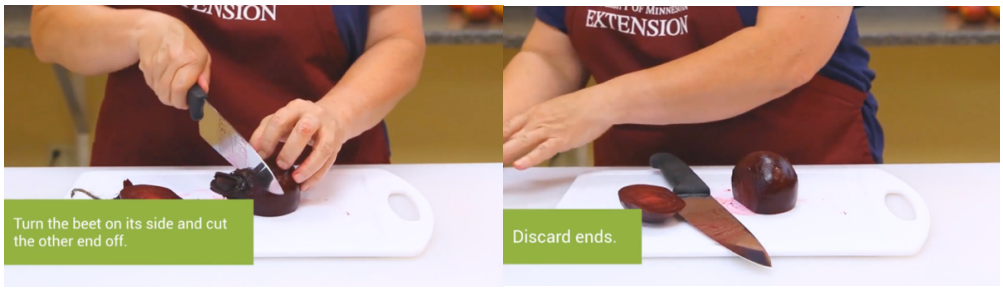
IX. Appendices

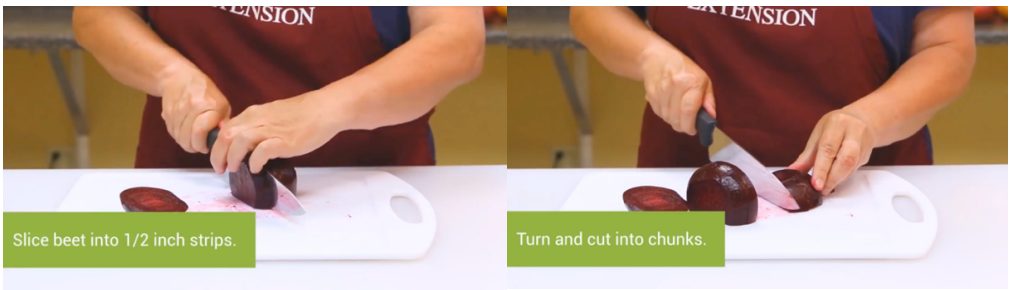
Appendix A1: Posters and video example

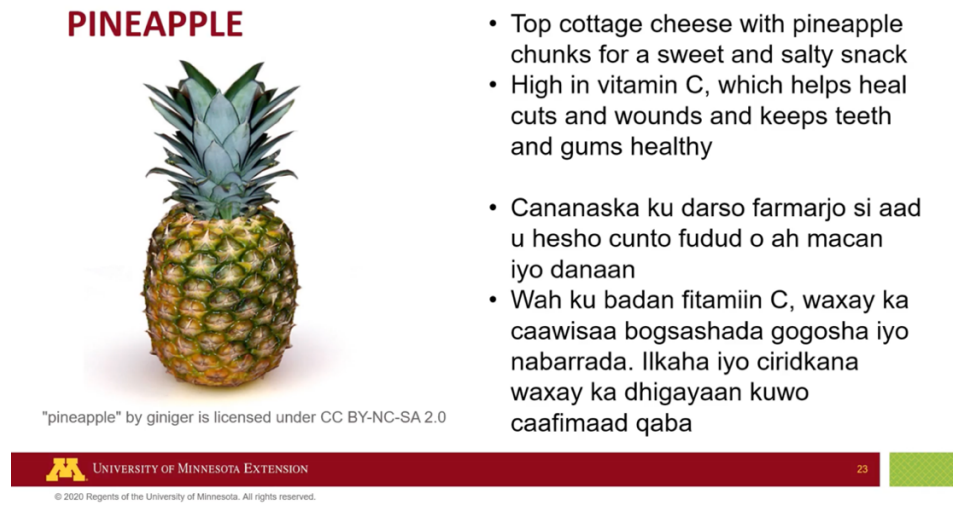


Description
In-store poster display of beets (above)
and demonstration video screenshots of beets (below)









Description
In-store poster display of pineapple (above)
and demonstration video screenshots of pineapple (below)

Appendix A2: Intervention material awareness questions in post-intervention survey

Measure or variable	***Survey question or variable description***	***Possible outcomes***
Awareness of fruit	Which of the following fruits or vegetables did you notice in posters or demonstrations at the grocery stores recently? Select all that apply: Melon, Grapes, Orange, Strawberry, Avocado, Pineapple, Kiwi, Plum	Any real number between 0 and 8
Purchased fruit	Which of the following foods did you buy for the first time EVER because you saw it or watched a video about it at the Somali grocery store? Select all that apply: Melon, Grapes, Orange, Strawberry, Avocado, Pineapple, Kiwi, Plum	Any real number between 0 and 8
Awareness of greens	Which of the following fruits or vegetables did you notice in posters or demonstrations at the grocery stores recently? Select all that apply: Cabbage	Any real number 0 or 1
Purchased greens	Which of the following foods did you buy for the first time EVER because you saw it or watched a video about it at the Somali grocery store? Select all that apply: Cabbage	Any real number 0 or 1
Awareness of other vegetables	Which of the following fruits or vegetables did you notice in posters or demonstrations at the grocery stores recently? Select all that apply: Winter squash, Beet, Broccoli, Carrot, Summer squash, Cucumber, Bell pepper, Garlic, Jicama, Sweet corn, Mushrooms	Any real number between 0 and 11
Purchased other vegetables	Which of the following foods did you buy for the first time EVER because you saw it or watched a video about it at the Somali grocery store? Select all that apply: Winter squash, Beet, Broccoli, Carrot, Summer squash, Cucumber, Bell pepper, Garlic, Jicama, Sweet corn, Mushrooms	Any real number between 0 and 11

Appendix A3: Descriptive statistic results of noticed posters

Explanatory variable		Full sample (n = 173)		Paired sample (n = 42)		Food "insecure" sample (n = 60)	
		Freq.	%	Freq.	%	Freq.	%
Post-intervention		44	25.43%	42	100%	6	10%
Noticed posters							
Fruit	*Melon*	29	16.76%	27	64.29%	1	1.67%
	Grapes	30	17.34%	27	64.29%	1	1.67%
	Orange	28	16.18%	27	64.29%	1	1.67%
	Strawberry	15	8.67%	14	33.33%	1	1.67%
	Avocado	15	8.67%	14	33.33%	1	1.67%
	Pineapple	21	12.14%	20	47.62%	0	0%
	Kiwi	6	3.47%	5	11.90%	1	1.67%
	Plum	4	2.31%	4	9.52%	1	1.67%
Green leafy	*Cabbage*	24	13.87%	22	52.38%	1	1.67%
Other veg.	*Winter squash*	17	9.83%	16	38.10%	1	1.67%
	Beet	6	3.47%	5	11.90%	1	1.67%
	Broccoli	16	9.25%	13	30.95%	1	1.67%
	Carrot	31	17.92%	29	69.05%	1	1.67%
	Summer	15	8.67%	14	33.33%	1	1.67%
	Cucumber	23	13.29%	22	52.38%	1	1.67%
	Bell pepper	32	18.50%	29	69.05%	1	1.67%
	Garlic	31	17.92%	29	69.05%	1	1.67%
	Jicama	6	3.47%	5	11.90%	1	1.67%
	Sweet corn	32	18.50%	29	69.05%	1	1.67%
	Mushrooms	5	2.89%	4	9.52%	1	1.67%

Appendix A4: Descriptive statistic results of purchased FV influenced by video demonstration

Explanatory variable		Full sample (n = 173)		Paired sample (n = 42)		Food "insecure" sample (n = 60)	
		Freq.	%	Freq.	%	Freq.	%
Purchased by video demonstration							
Fruit	*Melon*	19	10.98%	19	45.24%	0	0%
	Grapes	23	13.29%	22	52.38%	0	0%
	Orange	25	14.45%	25	59.52%	1	1.67%
	Strawberry	10	5.78%	10	23.81%	0	0%
	Avocado	16	9.25%	16	38.10%	0	0%
	Pineapple	20	11.56%	20	47.62%	0	0%
	Kiwi	1	0.58%	1	2.38%	0	0%
	Plum	0	0%	0	0%	0	0%
Green	*Cabbage*	14	8.09%	14	33.33%	0	0%
Other veg.	*Winter squash*	10	5.78%	10	23.81%	0	0%
	Beet	0	0%	0	0%	0	0%
	Broccoli	5	2.89%	5	11.90%	0	0%
	Carrot	27	15.61%	26	61.90%	0	0%
	Summer	17	9.83%	17	40.48%	0	0%
	Cucumber	19	10.98%	19	45.24%	0	0%
	Bell pepper	27	15.61%	26	61.90%	0	0%
	Garlic	26	15.03%	26	61.90%	0	0%
	Jicama	0	0%	0	0%	0	0%
	Sweet corn	26	15.03%	24	57.14%	0	0%
	Mushrooms	1	0.58%	1	2.38%	0	0%

Appendix B: Excluded questions in shorter pre-intervention survey

Survey question or variable description	*Possible outcomes*
How long have you been shopping at [your most frequented Somali grocery store]?	TEXT
Do you have an account at [your most frequented Somali grocery store]?	Yes / No
What are some of the reasons for your preference for this particular store? Why do you like to shop at [your most frequented Somali grocery store?	TEXT
How do you generally travel to the place where most of your family groceries are bought?	CAR/CARPOOL/ WALK
The fresh fruits and/or vegetables are of high quality [at your most frequented grocery store].	STRONGLY AGREE / AGREE / NEITHER AGREE NOR DISAGREE / DISAGREE / STRONGLY DISAGREE
A large selection of fresh fruit and/or vegetables is available [at you most frequented grocery store].	AGREE / AGREE / NEITHER AGREE NOR DISAGREE / DISAGREE / STRONGLY DISAGREE
Fruits and vegetables are affordable at the stores [at you most frequented grocery store].	AGREE / AGREE / NEITHER AGREE NOR DISAGREE / DISAGREE / STRONGLY DISAGREE
It is easy to find fresh fruits and vegetables [at you most frequented grocery store].	AGREE / AGREE / NEITHER AGREE NOR DISAGREE / DISAGREE / STRONGLY DISAGREE
Think of the last time you went grocery shopping. What did you buy? (4)	TEXT
Breakfast/Lunch/Dinner/Snack time	Any real time
Breakfast/Lunch/Dinner/Snack place	Any real place
Breakfast/Lunch/Dinner/Snack food items	Any real food item
Which of these statements best describes the food eaten in your family in the last 12 months?	ENOUGH BUT NOT THE FOOD WE WANT / ENOUGH OF THE FOOD WE WANT / OFTEN NOT ENOUGH / SOMETIMES NOT ENOUGH

Appendix C1: Code book by variable and model usage

Variable	*Survey question or variable description*	*Possible outcomes*	*Applicable models*
Post	Post-intervention indicator	1 = endline 0 = baseline	1, 2
Weekly fruit consumption	During the past month, how often did you eat FRUIT? Include fresh, frozen, or canned fruit. Do NOT include juices. (Week)	Any real number ≥ 0	1, 2
Weekly greens consumption	During the past month, how often did you eat a green leafy or lettuce SALAD, with or without other vegetables? (Week)	Any real number ≥ 0	1, 2
Weekly other vegetables consumption	During the past month, how often did you eat vegetables other than green leafy vegetables, potatoes and cooked dried beans? (Week)	Any real number ≥ 0	1, 2
Vitamin A-rich fruit consumption ($VitaminA\ Y_{iFruit}$)	Please tell me if you ate any of the following in the last 24 hours, in any form. - VITAMIN A RICH FRUITS such as ripe mangoes, cantaloupe, apricots (fresh or dried), ripe papaya, dried peaches + other locally available vitamin A-rich fruits	1 = yes 0 = no	3, 4
Daily vitamin A-rich greens consumption ($VitaminA\ Y_{iGreenLeafy}$)	Please tell me if you ate any of the following in the last 24 hours, in any form. - DARK GREEN LEAFY VEGETABLES such as dark green/leafy vegetables, including wild ones + locally available vitamin-A-rich leaves such as amaranth, cassava leaves, kale, spinach, etc.	1 = yes 0 = no	3, 4
Daily vitamin A-rich vegetable consumption ($VitaminA\ Y_{iVegetables}$)	Please tell me if you ate any of the following in the last 24 hours, in any form. - VITAMIN A RICH VEGETABLES AND TUBERS such as pumpkin, carrots, squash, or sweet potatoes that are orange inside + other locally available vitamin-A rich vegetables	1 = yes 0 = no	3, 4
Income	What is your annual family income? (In thousands of dollars)	Any real number ≥ 0	1, 2, 3, 4
SNAP	In the last 12 months did you or anyone in your family receive SNAP or food stamp benefits?	1 = yes 0 = no	1, 2, 3, 4
WIC	In the last 12 months did you or anyone in your family receive WIC benefits?	1 = yes 0 = no	1, 2, 3, 4
Free or reduced lunch	In the last 12 months did you or anyone in your family receive free or reduced lunch?	1 = yes 0 = no	1, 2, 3, 4

Appendix C2: Code book by variable and model usage (continued)

Variable	*Survey question or variable description*	*Possible outcomes*	*Applicable models*
Increased patronage (μ)	Compared to a year ago, are you shopping more or less often at Somali grocery stores?	1 = yes 0 = no	3, 4
Unplanned FV purchases (τ)	Have you purchased a fruit or vegetable because you saw it at the Somali grocery store despite not planning to buy it there?	1 = yes 0 = no	3, 4
Birth year	What is your year of birth?	Any valid year $\leq$ 2002	1, 2, 3, 4
Year moved to St. Cloud	In what year did you move to Saint Cloud?	Any valid year $\leq$ 2021	1, 2, 3, 4
Household size	How many people live in your home with you? INCLUDE the number of people meals are prepared for in your kitchen in a typical month. Count yourself too.	Any real number $\geq$ 0	1, 2, 3, 4

Appendix D: 10-item food security module

FSS (FOOD SECURITY STANDARD)	*Survey question or variable description*	*Possible outcomes*
FSS1	We worried whether our food would run out before we got money to buy more in the last 12 months. .	OFTEN / SOMETIMES / NEVER
FSS2	The food that we bought just didn't last, and we didn't have money to get more in the last 12 months.	OFTEN / SOMETIMES / NEVER
FSS3	We couldn't afford to eat balanced meals in the last 12 months.	OFTEN / SOMETIMES / NEVER
FSS4	Did you or other adults in our family cut the size of our meals or skipped meals at least once because there wasn't enough money for food in the last 12 months?	YES / NO
FSS5	How often did this happen?	ALMOST EVERY MONTH / SOME MONTHS BUT NOT EVERY MONTH / ONLY 1 OR 2 MONTHS
FSS6	Did you or other adults in your family eat less than you felt you should at least once because there wasn't enough money for food in the last 12 months?	YES / YES, LACK OF SOURCES / YES, NOT ENOUGH FOOD / NO
FSS7	Were you or other adults in your family hungry but didn't eat because there wasn't enough money for food at least once in the last 12 months?	YES / YES, LACK OF SOURCES / YES, NOT ENOUGH FOOD / NO
FSS8	In the last 12 months, did you lose or gain weight because there wasn't enough money for food?	YES, LOST / YES, GAINED / NO
FSS9	In the last 12 months, did you or other adults in your family ever not eat for a whole day because there wasn't enough money for food?	YES / YES, LACK OF SOURCES / YES, NOT ENOUGH FOOD / NO
FSS10	How often did this happen?	ALMOST EVERY MONTH / SOME MONTHS BUT NOT EVERY MONTH / ONLY 1 OR 2 MONTHS

Coding

Affirmative responses (i.e., coded equal to 1) include “yes,” “often,” “sometimes,” “almost every month,” and “some months but not every month.” Otherwise, all other responses are non-affirmative and coded as 0. A raw score for each respondent is the sum of affirmative responses from *FSS1-FSS10*. High food security individuals report a score of 0, marginal food security adults report a score of 1-2, low food security adults report a score of 3-5, and very low food security adults report a score of 6-10.

Appendix E1: Model 1 OLS Control Variables Regression Results

OLS Explanatory variables	Weekly consumption (servings)			
	Fruit	Green Leafy Veg.	Other Veg.	Total Veg.
$Household\ size$	-0.17	-0.11	-0.04	-0.15
	(0.17)	(0.17)	(0.15)	(0.29)
$Very\ low\ food\ security$	-2.83**	0.01	3.80	3.80
	(1.39)	(3.44)	(3.41)	(6.67)
$Low\ food\ security$	-2.20*	-2.22**	-1.12	-3.33*
	(1.31)	(1.03)	(1.03)	(1.90)
$Marginal\ food\ security$	-0.36	-0.88	-0.12	-1.00
	(0.83)	(0.75)	(0.85)	(1.37)
$Millennial + Generation\ Z$	1.29	1.46	1.73**	3.19*
	(1.05)	(1.05)	(0.80)	(1.64)
$Generation\ X$	1.39	3.15**	2.39**	5.54**
	(1.10)	(1.22)	(1.09)	(2.14)
$Less\ than\ 5\ years\ in\ St.Cloud$	0.79	0.87	0.52	1.39
	(1.09)	(0.94)	(0.89)	(1.69)
$Between\ 6\ to\ 10\ years\ in\ St.Cloud$	0.15	-0.01	-0.79	-0.81
	(1.01)	(1.07)	(1.04)	(1.92)

Notes

*** p-value ≤ 0.01

** p-value ≤ 0.05

* p-value ≤ 0.1

Appendix E2: Model 2 OLS Control Variables Regression Results

OLS	Weekly consumption (servings)			
Explanatory variables	**Fruit**	**Green Leafy Veg.**	**Other Veg.**	**Total Veg.**
$Household\ size$	-0.32	0.04	0.01	0.06
	(0.21)	(0.18)	(0.25)	(0.34)
$Very\ low\ food\ security$	-1.31	1.04	3.20	4.24
	(1.19)	(2.25)	(3.14)	(5.02)
$Low\ food\ security$	-0.72	-0.32	-0.42	-0.74
	(1.03)	(1.00)	(1.44)	(2.10)
$Millennial + Generation\ Z$	2.47	1.63	2.88*	4.51
	(1.52)	(1.45)	(1.59)	(2.72)
$Generation\ X$	1.83	3.61*	3.58*	7.19**
	(1.56)	(1.57)	(2.12)	(3.34)
$Less\ than\ 5\ years\ in\ St.Cloud$	-1.51	-3.08*	-1.53	-4.61
	(0.96)	(1.77)	(1.77)	(3.17)
$Between\ 6\ to\ 10\ years\ in\ St.Cloud$	3.07**	-0.19	0.70	0.51
	(1.16)	(1.59)	(1.90)	(2.97)

Notes
*** p-value ≤ 0.01
** p-value ≤ 0.05
* p-value ≤ 0.1

Appendix E3: Model 3 LPM Control Variables Regression Results

LPM	Weekly consumption (servings)			
Explanatory variables	Fruit	Green Leafy Veg.	Other Veg.	Total Veg.
$Low\ food\ security$	0.20	0.06	0.02	-0.03
	(0.22)	(0.21)	(0.18)	(0.18)
$Marginal\ food\ security$	-0.06	-0.05	-0.15	-0.11
	(0.22)	(0.21)	(0.18)	(0.18)
$Millennial + Generation\ Z$	-0.43	-0.28	-0.18	-0.19
	(0.30)	(0.29)	(0.25)	(0.25)
$Generation\ X$	-0.24	-0.13	-0.07	-0.13
	(0.33)	(0.32)	(0.27)	(0.27)
$Less\ than\ 5\ years\ in\ St.Cloud$	0.03	0.08	0.25	0.13
	(0.22)	(0.22)	(0.18)	(0.18)
$Between\ 6\ to\ 10\ years\ in\ St.Cloud$	-0.01	0.04	0.04	-0.02
	(0.28)	(0.26)	(0.23)	(0.23)

Notes
*** p-value ≤ 0.01
** p-value ≤ 0.05
* p-value ≤ 0.1

Appendix E4: Model 4 LPM Regression Results

LPM	Consumption of Vitamin A-rich FV in the past 24 hours		
Explanatory variables	Fruit	Green Leafy Veg.	Other Veg.
$Very\ low\ food\ security$	0.02	0.19	0.10
	(0.21)	(0.28)	(0.29)
$Low\ food\ security$	0.47***	0.62***	0.56**
	(0.15)	(0.21)	(0.21)
$Marginal\ food\ security$	0.40**	0.48**	0.34
	(0.15)	(0.22)	(0.22)
$Millennial + Generation\ Z$	0.06	0.11	0.14
	(0.12)	(0.16)	(0.17)
$Generation\ X$	0.03	-0.02	0.03
	(0.12)	(0.16)	(0.17)
$Less\ than\ 5\ years\ in\ St.Cloud$	0.07	0.01	-0.02
	(0.10)	(0.14)	(0.14)
$Between\ 6\ to\ 10\ years\ in\ St.Cloud$	0.13	0.35**	0.08
	(0.11)	(0.15)	(0.15)

Notes
*** p-value ≤ 0.01
** p-value ≤ 0.05
* p-value ≤ 0.1

Appendix F: Baseline consumption averages comparison by full sample, paired sample, and unpaired sample

	Full sample		Paired sample		Non-paired samples	
Weekly consumption (servings)	**Baseline Mean**	**Baseline Median**	**Baseline Mean**	**Baseline Median**	**Baseline Mean**	**Baseline Median**
Fruit	7.08	7	7.31	7	6.98	7
Green and leafy vegetables	6.48	7	6.61	7	6.39	7
Other vegetables (not potatoes or beans)	6.48	7	7.23	7	6.06	7
Total vegetables (greens + other veg.)	12.97	14	13.83	14	12.45	13.5

Appendix G: Scatterplot of income by recoded weekly consumption of fruit, greens, other vegetables and total vegetables in full sample (n = 173)