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Okezi Obrutu Date

Grady FVRx program impact on dietary practices and food security: A pre-post evaluation

By

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ABSTRACT

Objective

Food security affects dietary practices, which in turn influences chronic disease risk. We sought to identify the effect of the Grady Fruit and Vegetable Prescription (FVRx) program for low income patients on dietary practices and food security status as well as to characterize variations in effect by baseline food security status.

Methods

Analysis was done using pre- and post- program data from the 2018 and 2019 cohorts of Grady FVRx program. The USDA Healthy Eating Index (HEI) was used as a template to create scores for healthy food and beverage consumption, healthy purchase practices and food resource management. Food security status was assessed using the USDA 6-item household food security scale. A chi-square test was used to determine the association between baseline food security and direction of change in end line food security status. Poisson regression models were used to determine change in fruit and vegetable intake, while linear regression models were used to determine change in dietary practice scores.

Results

Participants experienced significant changes in food security status, fruit and vegetable intake, healthy food and beverage consumption, healthy purchase choices, and food resource management. At end line, 34% of participants had increased food security while 56% maintained their baseline status. Change in food security was significantly associated with baseline food security status, with 67% and 58% of very low and low food secure participants respectively reporting improved food security at end line ($p<0.0001$). Fruit and vegetable intake increased by 0.13(95% CI - 0.07,0.19) and 0.10(95%CI - 0.04,0.14) respectively. Dietary practice scores increased as follows: healthy food consumption [0.38 (95%CI - 0.23,0.51)], healthy beverage consumption [0.27 (95%CI - 0.11,0.36)], healthy purchase choices [0.59 (95%CI - 0.44,0.67)] and food resource management [0.61 (95%CI - 0.44,0.65)]. Magnitude of change in dietary practice score was significantly lower among very low and low food insecure participants.

Conclusion

Grady's FVRx program effected improved food security and dietary practices among participants. Baseline food security status impacted the magnitude of change in dietary practices. More research is necessary to understand the specific needs of food insecure populations in order to develop effective nutrition interventions for them.

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LITERATURE REVIEW

Cardiovascular disease

Cardiovascular Disease (CVD) is a term that is used to describe diseases of the heart and major blood vessels. These include ischemic heart disease conditions, which involve the cerebral, carotid, and peripheral circulation. CVD is a leading cause of death globally, representing 31% of all global deaths in 2016 ("Cardiovascular diseases (CVDs)," n.d.).

According to the American College of Cardiology (ACC), CVD was responsible for 840,768 deaths in the United States in 2016. The annual cost of CVD in the United States was estimated at $351.2 billion in 2014-2015, with $213.8 billion in direct cost, including 46% for inpatient care (*AHA 2019 Heart Disease and Stroke Statistics*, n.d.).

Five major modifiable cardiovascular risk factors including diabetes, hypertension and hyperlipidemia collectively accounted for half of all cardiovascular deaths in U.S. adults aged 45 to 79 years in 2009 to 2010 (Patel et al., 2015). This study also observed that the preventable fraction of cardiovascular mortality associated with complete elimination of these risk factors was 54.0% for men and 49.6% for women. Four of these risk factors – obesity, blood cholesterol levels, uncontrolled hypertension and uncontrolled diabetes – can be influenced by diet (*Vegetables and Fruits*, 2012).

What is the role of dietary intake?

Various dietary patterns have been studied to describe the best strategy for reducing CVD risk. Two patterns that have been widely studied are the Mediterranean diet and The Dietary Approach to Stop Hypertension (DASH) diet type. While both have variations in their core components, they emphasize high fruit and vegetable intake (Ravera et al., 2016). Current evidence indicates that diets that are high in fruits and vegetables but relatively low in carbohydrates (energy), saturated fats, sugar and salts are most protective against CVD (The United Nations University, 2001). A review by Mozaffarian also showed that

increased intake of fruits, non-starchy vegetables, nuts and legumes are a part of evidenced-based dietary priorities for reducing CVD risk (Mozaffarian, 2016). Similarly, the review of various dietary recommendations by Ravera *et al* observed the following dietary recommendations for primary prevention of CVD: increased intake of fruit, vegetable and whole grains, limited energy, fatty acid and salt intake, and moderate consumption of alcoholic beverages (Ravera et al., 2016). These findings draw attention to the need to focus on dietary intake especially for populations at risk or at early stages of CVD to minimize morbidity and prevent mortality.

Although research shows this evidence about diet being a relevant component of disease prevention, data from NHANES 2007-2010 showed that fruit and vegetable intake was low for most Americans. Except for children aged 1 – 8years, average intake of fruits was less than recommended, with one-third of all consumption among US adults coming from fruit juices. Also, low average intake of vegetables was seen across all age-sex groups and for most vegetable subgroups with a few exceptions (potatoes, tomatoes, lettuce, and onions). In addition, the average diet contained excess sodium, saturated fat and calories from added sugars (*A Closer Look at Current Intakes and Recommended Shifts - 2015-2020 Dietary Guidelines | Health.Gov*, n.d.). Physical and economic factors likely affect these dietary choices. Specific physical and economic determinants include access, education, cooking skills, time, and cost (Committee on Examination of the Adequacy of Food Resources and SNAP Allotments et al, 2013). The problem of poor dietary intake could be exacerbated among low income populations who may face food insecurity in addition to other challenges.

The problem of food insecurity

Food insecurity is a condition in which individuals or households experience a lack of reliable access to sufficient quantities of affordable, nutritious food due to a lack of money or other resources (Food and Agriculture Organization of the United Nations, 2009). In the US, food security is categorized using the

USDA food security questionnaire as very low, low, marginal, or no food security. In general, individuals within the low or very low food security categories are considered to be food insecure (*Interactive Data | Feeding America*, n.d.). Food insecurity is caused by many factors including poverty, unemployment, catastrophic life events and lack of resources at national and local levels.

Based on estimates by the USDA Economic Research Service, a total of 14.3 million US households were food insecure at some point in 2018. This corresponds to 6.8% of all households having low food security and 4.3% having very low food security (*Interactive Data | Feeding America*, n.d.). Households with significantly higher food insecurity levels than the general population include those with children, those headed by women, Black non-Hispanic households, Hispanic households, and low-income households with incomes below 185 percent of the poverty threshold.

Effects of food insecurity

Food insecurity can have variable effects, depending on factors like personal health status, age, duration of exposure, and access to support systems. Studies have shown that food insecurity has direct and indirect impacts on physical and mental health for all people (Gundersen & Ziliak, 2015). Several mechanisms have been hypothesized by which food insecurity increases the risk for chronic diseases, including CVD. Firstly, food insecurity might increase preference for consumption of energy dense food. Additionally, it may result in stress that causes increased visceral fat accumulation, which contributes to obesity and diabetes; factors that worsen CVD risk and prognosis (Laraia, 2013). Food insecurity also contributes to worse prognosis by forcing patients to adopt harmful coping strategies such as medication underuse/non-adherence and postponing/forgoing necessary medical care ("Hunger and Health - The Impact of Poverty, Food Insecurity, and Poor Nutrition on Health and Well-Being," n.d.).

Several studies have examined the relationship between food insecurity and dietary intake, nutritional status, and chronic disease risk. A review by Laraia observed an association between household food

insecurity and lower fruit and vegetable intake across studies for women and older Americans (Laraia, 2013). Food insecurity was also seen to be associated with obesity, diabetes, and dyslipidemia in women. These findings were consistent across studies despite the use of inconsistent measures of food security status and nutrition outcomes, non-representative sample sizes, and cross-sectional study designs. Another study of a nationally representative sample of US young adults found that compared to food secure participants, food-insecure participants had greater odds of self-reported poor health, diabetes, hypertension, being "very overweight", and obstructive airway disease (2.63, 1.67, 1.40, 1.30, and 1.48, respectively). There was no observed association between food security and inadequate disease control among those with diabetes and hypertension (Nagata et al., 2019). A cross-sectional analysis of a nationally representative sample of adults from NHANES showed a higher likelihood of Non-alcoholic Fatty Liver Disease (NAFLD) among food insecure participants. Analysis of a nationally representative sample of children from the National Health Interview study also showed higher rates of lifetime asthma diagnosis and depressive symptoms (19.1% and 27.9%) among food insecure children using propensity scoring techniques (Thomas et al., 2019).

A recognition of the complex interplay between food security, dietary intake and chronic disease risk has led to the development of several nutrition interventions which focus on these factors individually or in combination for CVD prevention.

Food insecurity interventions

Many interventions are specifically “aimed at addressing household food insecurity by ensuring that households no longer worry about exhausting food supplies, compromising qualitative aspects of their diet, or going without food” (Loopstra, 2018). These interventions could be broadly categorized into social protection policies, food banks, or community food programs. Social protection policies such as the Supplementary Nutrition Assistance Program (SNAP) by the US government are instituted to mitigate the

effects of low income on household food security. Many low-income people who qualify for this program as well as those that do not are still likely to be susceptible to food insecurity because of the income cut-off level and other highly selective criteria (Wilde, 2007). Foodbanks provide groceries free of charge to individuals in need. While they do not generally have strict criteria for accessing services, they are known to ration the amounts they give out to stretch their supplies as far as possible (Tarasuk & Eakin, 2003). Community food programs are an alternative way to provide no- or low-cost food to people and often enhance the types of services offered by foodbanks (Loopstra, 2018). Within this context, certain programs incorporate nutrition components with the intention to positively change dietary practices and reduce chronic disease risk among food insecure populations. This is achieved by providing additional benefits such as counselling, cooking classes, nutrition education, and community kitchens. Fruit and vegetable prescription programs generally fall into this category.

Fruit and Vegetable Prescription (FVRx) programs

FVRx programs (also known as produce prescription programs) are a relatively new form of nutrition intervention commonly based on partnerships between community-based organizations, farmers' markets, and community health clinics. They provide prescriptions for subsidized produce to participants identified by health providers based on income-levels, chronic disease risk status or both (Swartz, 2018). Prescriptions are redeemed at partner locations which are usually local farmers' markets, supermarkets, or community gardens. Many programs also provide additional nutrition education and cooking skills as part of their intervention. A review of 12 studies providing financial incentives for dietary behavior change showed positive effects on dietary behavior, at least in the short term (Purnell et al., 2014). The studies had a range of participation criteria, methods, and behavioral outcomes.

Trapl *et al* evaluated the effect of a 12-month clinical produce prescription program for hypertensive food insecure patients (Trapl et al., 2018). The findings showed significant changes in dietary behavior at follow-

up with a mean(SD) of 0.8(0.1) increase in servings of fruit consumed daily, and 0.8(0.2) in servings of vegetables consumed daily. A significant decrease in fast food consumption from 1.3 to 0.7 days per week was also observed. Increased communication about diet including fruit and vegetable consumption among health care providers was noted by participants. A similar intervention was designed by medical students at Penn State University (Forbes et al., 2019a). This was a smaller program that enrolled a total of 10 families. The nutrition education component was delivered by medical students who also accompanied household heads for produce shopping at farmers markets during the 6-week duration of the intervention. Among participating households, daily fresh fruit consumption increased from 37.5% at baseline to 62.5% after the program. Consumption of green vegetables at least once per week increased from 62.5% to 87.5%, of orange-colored vegetables from 38% to 87.5% and 'other' vegetable consumption increased from 13% to 33%. Fruit juice consumption decreased, with 44% of participants reporting "never" after the program (vs 25% pre-program). Statistical significance was not reported as the study was not powered sufficiently. There was no quantitative assessment of maintenance of behaviors after the program ended, however, a follow-up qualitative assessment was done after 3 years to assess the long-term impact of the program. While participants generally reported a positive influence on their eating habits, they also acknowledged that they experienced limitations in eating healthy after the subsidization ended due to cost and affordability. Another study by Ridberg *et al* assessed the extent to which exposure to an FVRx program was associated with changes in consumption among obese/overweight children aged 2 to 18 years (Ridberg et al., 2019a). The program provided in-clinic nutrition education and obesity treatment counseling through a physician, nutritionist, and/or trained health educator at monthly clinical visits for a span of 4-6 months. Prescriptions were worth $0.50 - $1 per household member per day. Using a propensity dose-adjusted model, participants had an increase of 0.32 cups of fruit and vegetables (95% CI: 0.19,0.45) for each additional visit after accounting for predicted

number of visits and site. An equal portion of the change-score was attributed to vegetable and fruit consumption (β=0.16 for each).

Although the FVRx model was initially developed in the US, similar interventions have been implemented in other high-income countries. A study of the effect of an FVRx program among patients attending a primary health center in a deprived area in the UK found that there was no significant change in self-reported fruit and vegetable consumptions or purchasing behavior (Buyuktuncer et al., 2014). There was however an increase in knowledge about recommended daily portions of fruits and vegetables from baseline. Another on-going program provided subsidized weekly boxes of fruits and vegetables to Aboriginal children in rural Australia complemented with seasonal recipes, practical cooking and nutrition education sessions (Black et al., 2013). An evaluation using baseline and 12-month follow-up assessments showed no changes in self-reported fruit and vegetable intake after 12 months. However, there were significant increases in blood levels of biomarkers of fruit and vegetable intake [b-cryptoxanthin (18%), vitamin C (21%) and lutein–zeaxanthin (11%)] consistent with increased intake. A systematic review of field interventions that provided monetary subsidies to promote healthier food purchases and consumption examined studies from several high-income countries, including USA, Canada, France, Germany, Netherlands, South Africa and the UK (An, 2013). All other countries apart from the US contributed one study each to the review. All but one study reported significantly increased purchase and consumption of healthier foods as a result of the subsidies provided. The singular null finding was attributed to the small financial incentive provided – store coupons worth 50 cents towards the purchase of any fruit or vegetable (Kristal et al., 1997). The review also acknowledged limitations to the various studies including limited external validity due to small and convenience samples, short intervention and follow-up durations that did not allow for determination of long-term impact, and lack of information about cost-effectiveness and overall diet quality.

To counter the paucity of randomized studies that assess these interventions, Herman *et al* utilized an experimental design to determine whether an additional economic subsidy for postpartum WIC participants would result in increased consumption of fruits and vegetables. Fruit vouchers were provided to participants in randomized WIC clinics versus a minimal non-food incentive to the control group for 6 months (Herman et al., 2008). They observed a statistically significant increase in consumption of fruits and vegetables among intervention participants that was sustained 6 months after the intervention was terminated (model adjusted R^2=0.13). Farmers' market participants showed an increase of 1.4 servings per 4186 kJ (1000kcal) of consumed food from baseline to the end of intervention compared with controls, while supermarket participants showed an increase of 0.8 servings per 4186 kJ. Another randomized trial assessed the effects of incentivizing fruit and vegetable intake while concurrently restricting purchase of less nutritious foods (sugar sweetened beverages, sweet baked goods, or candy) among low-income participants who were not enrolled in SNAP (Harnack et al., 2016). The group that received both incentives and restriction recorded reduced intake of energy, discretionary calories, sugar sweetened beverages, sweet baked goods, and candies compared to the control group. They also had increased intake of solid fruits (0.2 servings/d, SE 0.1); and improved Healthy Eating Index score (4.1 points, SE 1.4). These improvements were lower in the intervention and restriction only arms.

Gaps in existing literature

Limited studies have evaluated the combined impact of nutritional interventions on food security and dietary intake. Among the few that have been conducted, independent effects on food security and dietary intake have been demonstrated. However, very few studies have addressed whether baseline food security status can differentially affect the response to interventions. Therefore, there is a need to understand how food security status affects the impact of nutritional interventions on dietary changes in order to accurately characterize these associations. Furthermore, current studies have focused on outcome measures almost exclusively related to dietary consumption, i.e. change in intake of calories,

fruits, and vegetables. There remains a need to understand the impact of these interventions on other factors such as purchase choices and resource management which influence the ability of participants to maximize resources for healthy eating following program engagement. Understanding these effects will contribute to better prioritization and targeting of interventions that aim to influence dietary intake and consequently, CVD risk for the most vulnerable populations.

MANUSCRIPT

Introduction

Food insecurity exists when individuals or households lack reliable access to sufficient quantities of affordable, nutritious food due to a lack of money or other resources (Food and Agriculture Organization of the United Nations, 2009). Based on estimates by the USDA Economic Research Service, a total of 14.3 million US households were food insecure at some point in 2018 (*Interactive Data | Feeding America*, n.d.). This corresponds to 6.8% and 4.3% of all households having low and very low food security respectively. Studies have shown that food insecurity has direct and indirect impacts on physical and mental health for all people (Gundersen & Ziliak, 2015). Poor dietary intake is commonly exacerbated among low income populations who may face food insecurity in addition to other challenges. Unfortunately, poor diet contributes to four of the major modifiable risk factors that account for a major proportion of cardiovascular deaths in U.S. adults (Patel et al., 2015; *Vegetables and Fruits*, 2012).

Food insecurity interventions are specifically aimed at minimizing the need for vulnerable households to worry about exhausting food supplies, compromise qualitative aspects of diet, or go without food (Loopstra, 2018). Recently, more comprehensive interventions targeting food insecure populations have been developed which include incentives to promote healthy nutrition. An example of this is the Fruit and Vegetable Prescription program (FVRx) which is also called a produce prescription program. Several studies have shown positive effects of FVRx on dietary practices among food insecure/low income populations (An, 2013; Forbes et al., 2019a; Purnell et al., 2014; Ridberg et al., 2019a; Trapl et al., 2018). However, a few studies found no effects on self-reported healthy food consumption (Black et al., 2013; Buyuktuncer et al., 2014).

Despite the prevalence of evidence that supports the effectiveness of nutrition interventions on dietary intake, there is a lack of studies that determine the differential effect among participants in various food

security categories. In addition, there is scarcity of information about the impact of these interventions on other factors that influence the ability of participants to maximize resources for healthy eating following program engagement. Understanding these effects will contribute to better prioritization of programs and targeting of beneficiaries to influence dietary intake and consequently, CVD risk for food insecure populations.

The objectives of this study are to i) assess the change in food security status, dietary intake, purchase choices and food resource management skills among participants in the Grady FVRx program ii) describe the variation in change among participants at different levels of food security.

Methods

Intervention

Grady FVRx is 6-month intervention jointly implemented as a partnership between Grady Health System, Wholesome Wave Georgia, Open Hand Atlanta, and The Common Market in Atlanta, Georgia. It was launched in 2017 and serves low income patients that receive care from Grady Health System. The intervention is a multicomponent clinic-based program that aims to reduce food insecurity and reduce diet related chronic disease risk among low income patients receiving care at Grady. It begins with Cooking Matters® classes delivered by dieticians with Open Hand for the first 6 weeks. These classes cover the basics about meal preparation with seasonal produce, grocery shopping, food budgeting and nutrition. Participants also get an opportunity to practice cooking skills, including proper knife techniques, reading ingredient labels, and making a healthy meal for a family of four on a $10 budget. Fresh produce is provided to participants during the weekly classes so that they can practice the recipes learned at home. Following the 6-week cooking classes, participants attend monthly “Eat well, Live well” classes where they consolidate the lessons learned from the cooking matters classes and learn about other topics related to nutrition and wellness like urban gardening, meal planning, the importance of exercise, and healthy eating

during special occasions. In these follow-up classes, they are given fruit and vegetable prescriptions based on family size to be redeemed weekly at partner locations including fresh MARTA markets and a local farmers' market in one case. Prescriptions are given in the form of a voucher that provides a food subsidy of $1/family member/day.

Study Area & population

This study was conducted using data from the participants in the 2018 and 2019 cohorts of the Grady FVRx program. Participants were referred to the program by Grady clinicians based on Food security status determined by the USDA 2-item food security questionnaire and willingness to commit for the 6-month duration of the program. Criteria for enrollment was age ≥18 years, household income ≤130% of the national poverty line, and positive screening for food insecurity. All clients enrolled were deemed to be at risk for ≥1 diet-related chronic disease. The table below shows the study sites and cohort sizes for 2018 and 2019.

Clinic Locations	Cohort size	
	2018	**2019**
Grady primary care clinic	20	46
Grady diabetes clinic	30	40
Asa G Yancey health center	25	24
East Point health center	--	22
Total	75	132

Data collection

Participant data was collected at baseline, post Cooking Matters course (6 weeks) and end line (at the end of the 6-month period when participants graduated from the program). At baseline, demographic information was collected as well as information about food security, fruit and vegetable consumption, eating habits, attitudes and beliefs towards healthy food consumption and confidence in preparing healthy meals. Food security was assessed using the USDA 6-item Household Food Security Survey Module (HFSSM), and fruit and vegetable consumption was assessed using non-quantitative participant recall of all fruits and vegetables consumed the day before. At midline, the same information was collected excluding the demographic section, and at end line additional information about general health, medication use and purchasing behavior was obtained.

Measures

The outcomes assessed were as follows 1) change in food security status 2) change in dietary practices – fruit and vegetable intake, healthy food consumption, healthy beverage consumption, healthy purchase practices and food resource management. In addition, we assessed the changes in the above parameters with stratification by baseline food security status and end line direction of change in food security. Food security status was determined by an assessment of participants' experience in the month prior to data collection using the USDA 6-item household food security scale (Economic Research Service, USDA, 2012). Respondents were categorized into high (or marginal) food security, low food security and very low food security according to their raw scores as recommended by USDA. A variable for end line change in food security status was created by categorizing participants according to movement between food security levels from baseline to end line (increase, decrease, no change). Fruit and vegetable intake were measured by a count of the number of unique fruit and vegetable types that participants had eaten in the prior 24 hours (daily unique fruit/vegetable count). Healthy food consumption was assessed with a scale modified

from the USDA Healthy Eating Index (HEI) (Center for Nutrition Policy and Promotion (CNPP), n.d.). The HEI describes adequacy components as practices that are desired, while moderation components refer to those that are not. Healthy beverage consumption, healthy purchase practices and resource management practices were assessed using a similar scoring system.

Positive scores were given for all adequacy components with a one-point increment from zero for "never" or "not at all", and a maximum score of 4 for "always" or "more than once a day". These scores were inverted for moderation components, with a score of zero corresponding to "always" or "more than once a day", and 4 corresponding to "never" or "not at all". Healthy food consumption score was created as a total of the responses from answers to how often participants ate fruits, salads, dark green vegetables, other green vegetables, non-fried potatoes, fried potatoes and from all food groups. All the variables listed except "eat fried potatoes" were considered as adequacy components. Healthy beverage consumption score was created from responses about how often participants drank water, fruit juice and soda. Drinking soda was the only variable considered as a moderation component in this category. Healthy purchase score was derived from participants' response to frequency of purchasing low fat milk, low fat dairy, lean meat, whole grain, low-sodium foods and reviewing nutrition labels when purchasing foods. A food resource management score was derived from participants' response about how often they compare prices when shopping, plan meals, use shopping lists, cook meals at home, and adjust meals to include more budget-friendly ingredients. The total scores were ascertained as a proportion of total applicable, so for example, participants who were vegetarian had their totals exclude 4-points for purchasing lean meat. The total obtainable score was 10 for all variables.

Statistical analysis

Data analysis was conducted with STATA 16.0 software (StataCorp LLC, College Station, TX; 2019). Poisson regression models were used to estimate coefficients for change in unique fruit and vegetable counts

from baseline to end line, while linear regression models were used for change in all dietary practice scores. End line measures were modeled as dependent variables, and baseline measures were modeled as independent variables. Additionally, all regressions were repeated with participants stratified by baseline food security levels and end line direction of change in food security. A chi-square test was used to assess the association between baseline food security status and end line direction of change in food security. Polytomous regression was used to assess the relationship between end line resource management and end line direction of change in food security. Age, sex educational status, SNAP enrollment, income level, employment status and receipt of public assistance were considered as potential confounders. The most parsimonious model that adequately controlled for confounding was chosen. All models were tested for collinearity using variance inflation factors; the variables included in the final model had a VIF of <10. Variables controlled for in the final model include age, education, SNAP enrollment, employment status and cohort. Baseline food security status was included in the linear regression model stratified by end line direction of change and the polytomous regression model for end line resource management. Analysis was limited to participants who attended a minimum of 3 sessions and completed baseline and end line surveys. Statistical significance was considered as $p<0.05$. Beta coefficients and 95% confidence intervals were reported for all measures assessed.

Results

Participant characteristics

Majority of participants were ≥50years (82%), female (74%), had high school or some college education (77%) and had an annual income of less than 25,000 (83%). Over half also received public assistance including SNAP (55%) and public health insurance (63%). Race/ethnicity was virtually homogenous with 93% of the population being Black/African American. At baseline, low and very low food security in the previous month were reported among 41% and 16% respectively (Table 1).

Changes in food security

Participants experienced increased food security (based on an assessment of their experience in the month prior to end line data collection) as evidenced by reductions in low and very low food security proportions to 32% and 6% respectively (Table 2). About 34% had an increase in baseline food security status while 56% maintained their status. Only 9.9% experienced a decline in food security levels from baseline to end line. Change in food security level was significantly associated with baseline food status ($p<0.0001$). About 67% of those with very low food security and 58% of those with low food security reported improved food security status at end line (Table 3). However, 21% of the high food security group reported a decline at end line.

Changes in dietary practices

Table 2 describes the changes in dietary intake and associated practices from baseline to end line. At baseline, the mean(SD) for daily unique fruit count and daily unique vegetable count was 1.39(1.47) and 1.99(1.77) respectively. Mean(SD) of baseline scores for healthy food consumption, healthy beverage consumption, healthy purchase choices and food resource management were 3.86(1.29), 5.14(1.70), 5.64(1.86) and 6.30(1.95) respectively. After adjusting for age, educational status, SNAP enrollment and employment status, statistically significant increases were noted in unique fruit count [β=0.13(95%CI: 0.07,0.19)], unique vegetable count [0.10(0.04,0.14)], scores for healthy food consumption [0.38 (0.23,0.51)], healthy beverage consumption [0.27 (0.11,0.36)], healthy purchase choices [0.59 (0.44,0.67)] and food resource management [0.61 (0.44,0.65)].

Changes in dietary practices: Stratification by baseline food security status

The effect of the intervention differed by participants' baseline food security status (Table 4). Among those with high food security status at baseline, scores improved significantly for several indicators– healthy food consumption [β=0.60 (95%CI: 0.43,0.81)], healthy beverage consumption [0.28 (0.05,0.48)], healthy purchase choices [0.74 (0.55,0.85)], and food resource management [0.71 (0.48,0.80)]. Those with

low food security at baseline showed significant improvements in all scores except for the healthy food consumption score (Table 4). Conversely, those who had very low food security at baseline reported significant improvement in only one score, food resource management [0.65 (0.25,0.83)]. Overall, there was a decrease in the magnitude of change observed from high to very low food security categories except for daily unique vegetable count and resource management score.

Changes in dietary practices: Stratification by direction of change in food security status

Participants across all categories of food security change from baseline to end line (decline, improve, maintain) demonstrated improvements in diet, purchase choice and resource management scores. However, participants who experienced a decline in their food security status from baseline to end line experienced larger magnitude improvements across all measures of dietary practices except daily unique vegetable count–healthy food consumption [(β=0.55, (95%CI: -0.11,1.33)], healthy beverage consumption [0.76, (0.09,1.09)], healthy purchase choices [0.76, (0.35,1.03)], resource management [0.85, (0.30,0.89)]. Participants who improved their food security status had the lowest magnitude of change except for daily unique vegetable count and healthy beverage consumption (Table 5). End line direction of change in food security status was not significantly associated with end line resource management [Increase: OR – 1.12 (95% CI: 0.88,1.42); Decrease: OR – 0.77 (95% CI: 0.55,1.08)] (Table 6).

Discussion

These findings show an overall positive effect of the Grady FVRx program on fruit and vegetable intake, healthy food consumption, healthy beverage consumption, healthy purchase choices, food resource management and food security status. Participants with higher food security in the month prior to baseline appeared to have benefited the most from the intervention, achieving a higher magnitude of change in dietary intake, healthy purchase choices and food resource management, though significant improvements were also observed among those who were food insecure at baseline.

Other similar interventions have documented a positive impact on healthy food consumption. Studies among low income/food insecure populations found increased fruit and vegetable intake, including green vegetable consumption (Forbes et al., 2019b; Ridberg et al., 2019a; Trapl et al., 2018). Others have also reported reductions in calorie intake, fast food consumption and improved purchasing behaviors (Harnack et al., 2016; Trapl et al., 2018). For example, Trapl *et al* found a significant decrease in fast food consumption from 1.3 to 0.7 days per week. It should be noted that some studies found no change in fruit and vegetable consumption or purchasing behavior (Buyuktuncer et al., 2014). This may be related to a study design that entailed a one-time distribution of prescriptions to potential participants and follow-up phone calls with a subset to assess behavior change. Most of the other studies specifically enrolled participants and provided prescriptions at regular intervals for the program duration.

We used measures that include multiple behavioral components to assess dietary intake and related practices, although this presents a challenge with comparing findings between various studies. While cups/servings have been described as standardized measures, participants in our study had difficulty conceptualizing servings and our team was unable to individually support participants in recalling this information due to financial and human resource constraints. As such we utilized Likert scale assessments of daily/weekly intake that have been approved by the USDA for use in SNAP-education populations (*MT1: Healthy Eating* – SNAP-Ed Toolkit*, n.d.).

Our observation of improved healthy purchase choices and food resource management suggest program impact beyond the direct benefits of the vouchers provided. Since purchase choices likely directly contribute to dietary intake, this finding is encouraging for potential retention of changes in diet and mitigation of chronic disease risk in the long term especially in the context of food insecurity.

We also noted improved food security status over the project period in line with others (Ridberg et al., 2019b; Aiyer et al., 2019). However, the magnitude of effect was smaller in our study potentially because

of the relatively high proportion with high food security at baseline (44%). About 34% of participants experienced an increase in their food security category from baseline to end line, with the very low food security participants experiencing the highest proportion of increase (67%). While it is encouraging that changes in dietary intake and purchasing habits improved even among those who were food insecure at baseline, the smaller effect sizes suggest that food insecure populations may struggle more to improve their diet and purchasing patterns compared to food secure populations. This group of people likely require additional or longer-term efforts to achieve the same level of improvement.

Additionally, there is an opportunity to explore research which demonstrates that food insecurity influences chronic disease morbidity through pathways beyond diet (Franklin et al., 2012; Laraia, 2013). Significant among these is mental health including stress, anxiety, and depression pathways. Mental health outcomes were not measured in our study and we are not aware of other studies that have examined how these programs affect participant mental health. Given the evidence on these pathways it would be useful to include such outcomes in future studies to allow for a greater understanding of the full potential impacts of these types of interventions on diet related chronic disease.

Limitations to this study include measuring fruit and vegetable intake based on superficial recall rather than an objective measure. Another study by Black *et al* utilized biomarker assessments which showed a significant improvement in intake, although self-report suggested none. While the methods we used are approved for programs monitoring USDA SNAP-Ed, there are more robust measures like weighted diet records, quantitative 24-hr diet recalls and expanded food frequency questionnaires (FFQ) that have been used in nutrition research. None of these were feasible in the context of delivering our intervention, because of limited staff capacity to support administration of the tools to individual participants. In the future, an alternative to consider would be the Block fruit and vegetable FFQ developed from a one-page rapid food screener. This screener was found to have moderate correlation (0.6–0.7) for fruit, vegetable and fat intake with a 100-item fully validated questionnaire (Block et al., 2000). Also, the lack of a control

group means that improvements may not be attributable to the intervention effect with certainty. Lastly, due to project timelines and financial limitations, we were unable to examine the ability of participants to sustain behaviors and improved food security status over time, for example through post-program evaluation. Given that the vouchers end after participants complete the 6-month timeline, there is concern for rebound food insecurity to occur, with those who had very low food security at baseline and end line likely to be most affected. Despite these limitations, our findings are validated by the high rate of participant retention from baseline to end line (96%). This shows that participants derived significant value from the intervention and reduced the chance of selection bias from loss to follow-up. Accounting for measured confounders including cohort effect improves the validity of our estimates. Utilizing data from an intervention executed in a real-world context ensures that these findings are relevant to program managers addressing improved nutrition and food security. Significant improvements in food resource management skills may buffer the effects of voucher discontinuation, but further research is needed to explore this relationship.

Based on these results, we conclude that the Grady FVRx intervention achieved the aim of improving food security, diet and food resource management skills for a large proportion of participants, though improvements in dietary practices were not equally achieved by those with very low food security at baseline. Recommendations for future interventions include targeted design to meet the unique needs of participants in low and very low food security categories and follow-up evaluation to ascertain the long-term retention of effects. Finally, an evaluation of the change in biological risk indicators associated with the changes we observed would be useful to characterize the program's effect on reduction of chronic disease risk.

Tables

Table 1 – Demographic characteristics by baseline food security status

		By baseline food security status		
		High food security	Low food security	Very low food security
	N (%)	N (%)	N (%)	N (%)
SITE				
Grady Asa Yancey	46(23.1)	17(20)	25(30.1)	4(12.9)
Grady Diabetes	66(33.2)	29(34.1)	25(30.1)	12(38.7)
Grady PCC	65(32.7)	26(30.6)	28(33.7)	11(35.5)
East Point	22(11.1)	13(15.3)	5(6)	4(12.9)
Total	199(100)	85(100)	83(100)	31(100)
Age category (years)				
18-29	4(2.1)	2(2.4)	2(2.5)	0(0)
30-39	7(3.6)	3(3.6)	3(3.7)	1(3.2)
40-49	24(12.3)	10(12)	5(6.2)	9(29)
50-59	83(42.6)	32(38.6)	37(45.7)	14(45.2)
≥ 60	77(39.5)	36(43.4)	34(42)	7(22.6)
Total	195(100)	83(100)	81(100)	31(100)
Sex				
Female	146(73.7)	64(76.2)	60(72.3)	22(71)
Male	52(26.3)	20(23.8)	23(27.7)	9(29)
Total	198(100)	84(100)	83(100)	31(100)
Education				
<HS degree	26(13.5)	13(16.3)	9(11)	4(12.9)
HS or GED	79(40.9)	33(41.3)	37(45.1)	9(29)
Some college	70(36.3)	27(33.8)	32(39)	11(35.5)
College degree	8(4.1)	3(3.8)	1(1.2)	4(12.9)
More than college degree	10(5.2)	4(5)	3(3.7)	3(9.7)
Total	193(100)	80(100)	82(100)	31(100)
Employment status				
Not employed	19(9.6)	4(4.8)	13(15.9)	2(6.5)
On Disability	68(34.5)	26(31)	27(32.9)	15(48.4)
Working full-time	15(7.6)	8(9.5)	7(8.5)	0(0)
Working part-time	22(11.2)	12(14.3)	5(6.1)	5(16.1)
Retired	58(29.4)	29(34.5)	25(30.5)	4(12.9)
Other	15(7.6)	5(6)	5(6.1)	5(16.2)

Total	197(100)	84(100)	82(100)	31(100)
Income				
<25,000	165(83.3)	63(74.1)	74(90.2)	28(90.3)
25 – 35,000	14(7.1)	10(11.8)	3(3.7)	1(3.2)
>35,000	11(5.6)	9(10.6)	1(1.2)	1(3.2)
Don't know	8(4)	3(3.5)	4(4.9)	1(3.2)
Total	198(100)	85(100)	82(100)	31(100)
Receipt of public assistance				
No public assistance	66(33.3)	26(30.6)	36(43.9)	4(12.9)
Some public assistance	132(66.7)	59(69.4)	46(56.1)	27(87.1)
Total	198(100)	85(100)	82(100)	31(100)
SNAP enrollment				
No	89(44.9)	37(43.5)	42(51.2)	10(32.3)
Yes	109(55.1)	48(56.5)	40(48.8)	21(67.7)
Total	198(100)	85(100)	82(100)	31(100)
Health insurance				
No insurance	44(22.2)	16(18.8)	23(28)	5(16.1)
Public insurance	125(63.1)	59(69.4)	47(57.3)	19(61.3)
Other insurance	29(14.6)	10(11.8)	12(14.7)	7(22.6)
Total	198(100)	85(100)	82(100)	31(100)

Table 2 – Change in food security and dietary practices from baseline to end line

	Baseline		**End line**		Change in characteristics from baseline to end line	
	Mean	SD	Mean	SD	Crude model β [95% CI]	Adjusted model† β [95% CI]
Daily unique fruit count	1.39	1.47	2.39	1.45	0.13*** [0.07,0.19]	0.13*** [0.07,0.19]
Daily unique vegetable count	1.99	1.77	2.77	1.69	0.11*** [0.06,0.15]	0.10*** [0.04,0.14]
Healthy food consumption score	3.86	1.29	4.38	1.27	0.40*** [0.26,0.53]	0.38*** [0.23,0.51]
Healthy Beverage consumption score	5.14	1.70	4.98	1.44	0.29*** [0.13,0.37]	0.27*** [0.11,0.36]
Healthy Purchase score	5.64	1.86	6.70	1.74	0.60*** [0.45,0.66]	0.59*** [0.44,0.67]
Resource management score	6.30	1.95	7.10	1.74	0.55*** [0.38,0.59]	0.61*** [0.44,0.65]
Food security status‡						
High	84.0(43.8)		120.0(62.5)			
Low	78.0(40.6)		61.0(31.8)			

Very low	30.0(15.6)	11.0(5.7)	

* p<0.05, ** p<0.01, *** p<0.001

†Adjusted model controls for age, education, SNAP enrollment, employment status and cohort

‡Frequency (%)

Table 3 – Comparison of change in food security levels by baseline food security status

	High food security	**Low food security**	**Very low food security**	**Total**
Decline in status	18(21.4)	1(1.3)	0(0.0)	19(9.9)
No change in status	66(78.6)	32(41.0)	10(33.3)	108(56.3)
Increase in status	0(0.0)	45(57.7)	20(66.7)	65(33.9)
	Fisher's exact p < 0.001			

Table 4 – Comparison of mean change in dietary practices by baseline food security status

Outcome	β [95% CI]		
	High Food security (n=84)	**Low food security (n=78)**	**Very low food security (n=30)**
Daily unique fruit count	0.14 [0.02, 0.26]	0.11 [0.02,0.21]	0.04 [-0.14,0.24]
Daily unique vegetable count	0.08 [-0.00, 0.16]	0.11 [0.03,0.19]	0.12 [-0.02,0.25]
Healthy Food consumption score	0.60*** [0.43,0.81]	0.19 [-0.04,0.35]	-0.013 [-0.54,0.51]
Healthy Beverage Score	0.28* [0.05,0.48]	0.26* [0.02,0.40]	0.22 [-0.16,0.51]
Healthy Purchase Score	0.74*** [0.55,0.85]	0.56*** [0.34,0.71]	0.16 [-0.25,0.59]
Resource management score	0.71*** [0.48,0.80]	0.55*** [0.30,0.70]	0.65** [0.25,0.83]]

* p<0.05, ** p<0.01, *** p<0.001

Table 5 - Comparison of mean change in dietary practices by direction of change in food security status

Outcome	β [95% CI]		
	No change in food security (n=108)	**Decline in food security (n=19)**	**Increase in food security (n=65)**
Daily unique fruit count	0.14 [0.06,0.22]	0.15 [-0.19,0.49]	0.11 [-0.01,0.24]
Daily unique vegetable count	0.12 [0.05,0.19]	0.06 [-0.13,0.25]	0.07 [-0.02,0.16]
Healthy Food consumption score	0.47*** [0.26,0.62]	0.55 [-0.11,1.33]	0.11 [-0.14,0.38]
Healthy Beverage Score	0.26** [0.06,0.40]	0.76* [0.09,1.09]	0.29* [0.03,0.44]
Healthy Purchase Score	0.58*** [0.37,0.68]	0.76** [0.35,1.03]	0.42*** [0.20,0.64]

Resource management score	0.64*** [0.47,0.79]	0.85** [0.30,0.89]	0.53*** [0.25,0.61]

* p<0.05, ** p<0.01, *** p<0.001

Table 6 – Effect of end line resource management score on direction of change in food security status

	OR	95% CI
Increase in food security status	1.12	0.88, 1.42
Decrease in food security status	0.77	0.55, 1.08
No change in food security status	1	Ref.

PUBLIC HEALTH IMPLICATIONS

This evaluation shows that Grady FVRx intervention positively impacted food security, dietary intake, purchase choices and food resource management among low income patients at risk for chronic disease. Although the program was implemented strictly among participants who were below the federal poverty threshold, we found different levels of baseline food security and magnitude of effect. Participants with high food security at baseline appeared to have benefited the most from the intervention, achieving a higher magnitude of change in dietary intake, healthy purchase choices and food resource management. Majority of participants who started out with low/very low food security experienced improvements in food security levels at end line.

These findings highlight several issues that are relevant to public health practice including research and policy. Firstly, the differences in baseline food security levels despite participants being below the poverty threshold underscores a possible gradient effect of poverty. It is important to consider that people living in poverty may not be homogenous in their experiences of food insecurity while developing interventions for this group. Even though it makes sense to use income thresholds for policy purposes, it would be beneficial for programs that address nutrition and food insecurity among low income populations to give careful thought to the spectrum of needs represented in order to promote equitable delivery of alleviatory services. Addressing other factors like purchase choices and resource management in the context of nutrition interventions appears to be a promising pathway to maximize benefits for all participants, regardless of their baseline food security status. In addition, these components potentially increase the chances of maintaining recommended dietary intake after benefits cease post-program. It would be of benefit to explore other related factors that fit into this category and standardize their inclusion in similar interventions.

Furthermore, program evaluators should consider designing qualitative studies to explore the nuances in experiences among program participants. This will help to understand the mechanisms by which interventions drive change and to gain feedback that could be useful to increase impact especially among the most vulnerable participants. More so, it would improve understanding of the challenges that individuals within this group experience related to utilizing incentives provided and maintaining healthy diets. Future interventions should also seek to implement long term (e.g. 1-year post-program) follow-up evaluation to ascertain retention of effects.

For researchers, our findings reveal areas to consider in the design of studies around food security, dietary intake, and related practices. More research is necessary to understand peculiar needs and develop strategies to address dietary practices among populations with very low food security. Also, there is a need to further develop objective but practical measures for assessing dietary intake to improve comparison of dietary intake across studies. Furthermore, additional exploration of the pathways between food insecurity and chronic disease could identify other modifiable factors apart from diet to be tackled in tandem or at least acknowledged by practitioners and program designers on the field. Another research implication is the need to quantify the change in biological risk indicators that result from interventions like this. This would require collection of physiologic measures or biomarkers beyond the program end line and provide more detail about the role of interventions in ultimately addressing chronic disease risk.

A policy consideration from this study is that current criteria for providing food benefits may not be effectively serving the most food insecure. While income levels are likely to directly impact food insecurity, there are other factors that are not covered by these criteria for determining benefits which could contribute to increased need. For example, while two people might be at the same income level, one might have higher healthcare spending due to a chronic disease and as such have less leftover income to spend on food, resulting in higher food insecurity. Although simplifying conditions to receive benefits may

be easier at the policy level, these complexities need to be considered if the motivation for providing nutrition assistance is to alleviate hunger.

All around the world, there has been massive increase in life expectancy driven by decline in mortality from infectious diseases over the last century. Going forward, the increasing prevalence of chronic disease resulting in morbidity that translates to reduced quality of life and mortality could threaten the gains that have been made. Nutrition must be considered as a focus for disease prevention – similar to traditional considerations of other public health interventions like vaccination – to maintain progress towards a healthier world.

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