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Nutritional education on fruit and vegetable consumption among food pantry clients: A systematic review and a meta-analysis

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Abstract

Poor nutrition has been linked to chronic illnesses among food pantry patrons. In response to this issue, food pantries have adopted nutrition education interventions focused on fruits and vegetables to encourage healthier eating habits. Though there have been studies that have analyzed nutrition education in other contexts, there is a knowledge gap on the effectiveness of nutrition education on fruit and vegetable consumption among food pantry participants. The study aim was to conduct a systematic review and meta-analysis evaluating the impact of nutrition education interventions on fruit and vegetable consumption among food pantry clients. We utilized PRISMA guidelines to conduct a systematic review in electronic databases such as Scopus, Sociological Abstracts, PubMed, and Food Science and Technology Abstracts, ending October 2022. Studies were included if they focused on nutritional education and increased fruit and vegetable intake, were designed and implemented among food pantry participants, reported on fruit and vegetable outcomes, and published in English as peer-reviewed articles. Nine articles, six cohort studies, and three cross-sectional studies were

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Conflict of Interests

The authors declare that they have no conflicts of interest.

Author Note

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included in the meta-analysis. All nine studies were conducted in U.S. food pantries/banks with 989 participants. The meta-analysis revealed a strong positive inverse association between nutritional education and fruit consumption and a negative inverse association with vegetable consumption. Our findings suggest that nutrition education, specifically cooking education and gift cards, was effective among food pantry participants.

Keywords
nutrition education, vegetables, fruits, food pantry, meta-analysis

Background

The United States is regarded globally as a wealthy country, yet despite adequate agricultural production, 13.5% (18.0 million) of U.S. households experienced food insecurity in 2023 (Rabbitt et al., 2024). Food insecurity, inadequate nutrition, and hunger continue to pose significant public health challenges in the U.S. (Martin et al., 2016; Pool & Dooris, 2022; Rodgers et al., 2007). Despite the national abundance, food-insecure households intermittently lack sufficient food for all members due to limited resources, such as income, at the household level (Coleman-Jensen et al., 2021). Many of these households include family members who are low-income, disabled, and from racially or ethnically minoritized groups (Wetherill et al., 2019). Members of these households consumed an average of 2.99 servings of fruits and vegetables per day, falling below the recommended 7 to 13 servings (Lee, 2022; Leung et al., 2014). The lower intake of fresh produce is estimated to contribute to millions of deaths related to heart disease and strokes each year (American Society for Nutrition [ASN], 2019; Seligman et al., 2010). Consequently, the well-being of food pantry patrons depends on increasing their consumption of fruits and vegetables (Bandoni et al., 2011; Mhurchu et al., 2010).

Prior studies have observed that fruits and vegetables (F&V) have low levels of protein fat and higher levels of fiber and are a source of carbohydrates, at varying levels (ASN, 2024; Whybrow et al., 2006). F&V have a good profile of micronutrients such as antioxidants, carotenoids, flavonoids, and vitamins (World Health Organization [WHO], 2002). Recent research has demonstrated that micronutrients are associated with improved hypertension, reduced oxidative stress, and weight loss (Chiu et al., 2020; Hamner, et al., 2023; Zhang et al., 2022). As Fulton et al. (2016) pointed out, intake of F&V has health advantages because of the direct biological effects of micronutrients. Additionally, increased F&V intake can improve health and well-being by transforming dietary quality; for example, food with a lower nutrition profile may be replaced with F&V (Fulton et al., 2016). The composition of F&V consists of low energy density and high water content, which makes it easy for individuals to consume large amounts of these types of food, reducing the overall number of calories consumed (Svendsen et al., 2007). Additionally, F&V have a higher content of fiber than other food groups, leading to satiety and minimizing the intake of other food that may contribute to weight gain and noncommunicable illnesses (Rolls et al., 2004; Slavin, 2005). However, Fulton et al. (2016) asserted that is not well understood whether the advantages of F&V are directly associated with the essential properties of these foods and micronutrient composition or the effect of their intake on dietary quality.

Therefore, the study aims to conduct a systematic review and meta-analysis evaluating the impact of nutrition education interventions on F&V consumption among food pantry clients. The objective was to investigate the effectiveness of nutrition education in increasing the consumption of F&V among food pantry participants through a meta-analysis of diverse study designs and contexts on F&V and nutrition education. The specific objective was to synthesize recent nutrition education intervention efforts that effectively increased F&V consumption and adopt those effective approaches in a Midwest food pantry to enhance the intake of F&V and dietary behavior among the participants. Additionally, the study aimed to develop recommendations for future research and increase awareness to enhance F&V consumption among pantry participants in the Midwest. To achieve our objectives, the review followed Preferred Reporting Items for Systematic Review and Meta-Analysis (PRISMA) guidelines to examine nutrition education holistically (Moher et al., 2015, p.1).

After the introduction and literature review, the article outlines the methods and systematic review, highlighting the strategies used to gather and analyze relevant literature related to nutrition education. The third section focuses on the statistical analysis, which includes five subsections: the PRISMA diagram, study design characteristics, intervention types, meta-analysis, and subgroup analysis. The fourth section discusses the results, guided by previous studies in the field of nutrition, and addresses the limitations of the study. The final section is the conclusion, presenting the key findings and recommendations for future research.

Fresh Produce

Increasing intake of fresh produce has been shown to help prevent and manage chronic illnesses (Li et al., 2014). Chronic illnesses are defined as health events that affect an individual for a year or more and may require continuous treatment or reduced activities to mitigate (Lee et al., 2022, p. 1); these illnesses include coronary heart disease, stroke, cancer, and diabetes and are the leading causes of death and disability in the U.S. (Barone et al., 2020; Depa et al., 2018; Lee et al., 2022). However, low-income households suffering from chronic illnesses have reported an inability to access food with high nutritional profiles due in part to cost-competing demands such as transportation, cost of rent or mortgage, and the high cost of fresh, nutrient-dense food itself (DeMartini et al., 2013; van der Velde et al., 2019). Since chronic illnesses constitute a primary concern of low-income, food-insecure households, food pantries must provide high-quality food to their clients (Ross et al., 2013).

Food products at food pantries and food banks historically have been nonperishable and thus have had limited nutritional profiles inadequate to improve health outcomes (Long et al., 2019). In the past decade, however, there has been a push to increase F&V inventories in the stock of food pantries to reduce the nutritional disparities. One way this is accomplished is through food recovery (e.g., gleaning); one example of this is when surplus food from grocery stores and restaurants is donated to charitable organizations, including food pantries (Wetherill et al., 2019). Feeding America, the nation's largest food emergency organization, partners with over 200 food banks across the country to provide nutrient-dense foods (Barone et al., 2020. Food banks collect food items, which they distribute to food pantries to ensure the availability of these foods at pantries (Barone et al., 2020).

Nutrition Education

In addition to community and civil society–based regional and national programming, federal policy also attempts to address the nutritionally low quality and low availability of food aid as health concerns. For example, the U.S. Department of Agriculture (USDA) Supplementary Nutritional Assistance Program (SNAP) expanded its focus beyond food security and hunger to SNAP-Education programming (USDA SNAP-Ed, 2014). Nutrition education is "any set of learning experiences designed to facilitate the voluntary adoption of eating and other nutrition-related behaviours, conducive to health and well-being" (Contento et al., 2015, p. 2). Nutrition education and other nutrition-related behavioral change programs are intended to reduce diet-related illnesses such as cardiovascular disease, diabetes, cancer, and hypertension; cardiovascular diseases alone affect over 102 million Americans in 2015, which is 41.5% of the population (Khavjou et al., 2016, p. 3-1). Various nutrition interventions have been promoted:

1. MyPlate (USDA SNAP-Ed, 2014): This education intervention presents information on how to make food choices for a healthy lifestyle. The MyPlate intervention offers an app with an interactive graphic that consists of five food categories arranged on a plate. The app provides information about how to include whole fruits and a diversity of vegetables, added grains and whole grains, low-fat or milk with less fat or yogurt, and a diversity of protein sources in one's meals. The app and related online materials were developed using the 2015 Dietary Guidelines for Americans (Maine SNAP-Ed, 2023). The objective of the information is to promote healthy eating. SNAP-Ed MyPlate guidelines have been developed and published in different languages for easy access across diverse audiences.

2. Eat a Rainbow of Iowa Fruits and Veggies (Growing Together, n.d.): The Growing Together program is an educational intervention that seeks to increase the consumption of F&V among food pantry clients in Iowa. One of the tools they use to share nutrition information is a card that has several F&V that depict the colors of the rainbow. This card plays an important role in reminding the pantry clients which F&V they need to choose to eat a variety of colorful F&V to have a healthy diet. This is supplemented by recipe cards that contain information for each vegetable or fruit concerning how it is prepared and eaten. The information also includes nutrition benefits and tips on selection, storing, cleaning, and preparing.

For the past two decades, such health and adult nutrition education programs have been created to encourage healthier food choices, including lessons on nutrition, meal planning, and cooking classes for pantry clients, especially those experiencing chronic illnesses associated with poor nutrition at a higher rate than the general population (Hardison-Moody et al., 2015).

These behavior-based nutrition education initiatives were intended to improve the health of individuals as a preventative mechanism against chronic diseases associated with poor nutrition (Wolfson & Sara, 2015; USDA, 2014). Funding for SNAP-Ed thus increased by $379 million in 2010 (USDA, 2014). SNAP-Ed provides financial support and educational materials to food pantry, food bank, and related organizations to enable pantry clients to make more nutritious food decisions within the scope of their limited resources, including F&V intake, which is a primary aim of the Dietary Guidelines for Americans (USDA, 2014). There is uncertainty, however, regarding the extent to which SNAP-Ed does increase fruit and/or vegetable intake. Gregory et al. (2013) argued that SNAP-Ed improves population health by improving nutritional quality and increasing F&V intake. On the other hand, Leung et al. (2012) and Middaugh et al. (2012) argued that the increase in F&V intake cannot be attributed solely to awareness-education programming such as that funded by SNAP-Ed but more broadly attributed to an interplay of factors such as socioeconomic status (SES), location, and culture. Those with low SES tend to have low intake compared to those of middle to higher SES (Reed et al, 2004; Shankar & Klassen, 2001).

That said, programmatic *access* to fresh produce has been improved through nutrition education, including through activities such as courses in cooking (Wolfson & Bleich, 2015). Such nutritional education programs focus on households that have a lower intake of F&V (Wolfson & Bleich, 2015). Wolfson and Bleich (2015) asserted that earlier studies have noted that nutritional education is linked to a rise in F&V intake. They cautioned, however, that as much as food pantries recognize the importance of nutritious food for patrons, there are no guidelines or incentives to reorganize food distribution based on nutritional value (Wolfson & Bleich, 2015). The purpose of this study, then, was to examine the extent to which nutrition education affects the intake of F&V separately, by patrons of food pantries and food banks.

Materials and Methods

We conducted a systematic literature review and meta-analysis of articles on the impact of nutrition education on fresh produce consumption.

Protocol and Registration

The protocol we developed was guided by the PRISMA guidelines to define the criteria of inclusion (Moher et al., 2015, p. 1). The guidelines consisted of utilizing an illustrative diagram to show the pathway of study selection and detailed recording of included and excluded studies. This method guards against arbitrary decision-making regarding how articles should be included or excluded, guides data extraction, and reduces duplication effort: Since planning is done in advance, it creates opportunities for the review team to predict potential problems (Moher et al., 2015). As Petticrew and Roberts (2008) emphasized, this approach ensures the results are replicable and presented concisely and precisely, without bias. The review protocol was registered on May 27, 2022, in the International Prospective Register of Systematic Reviews (PROSPERO registration ID: CRD4202233129).

Search Strategy

The literature search was performed in August 2022. After the protocol had been approved for data management, the search process commenced. The databases searched included Scopus, Sociological Abstracts, PubMed, and Food Science and Technology Abstracts. These databases were selected because they have diverse literature on community-related studies and interpersonal issues, covering a wide field of studies (Harvard Countway Library, 2024).

The search combined the following key terms: food pantry patrons* AND "fruits and vegetables OR nutrition education* OR food pantries OR intake of fruits* AND vegetables OR fruit" OR vegetable consumption* OR food pantry-based interventions OR fruits, vegetables* AND food pantry nutrition sciences. Additional important articles were manually searched for any extra references. All articles had to be written in English, and there was no restriction on study design or location. The updated search was closed in October 2022. Additionally, a search made in Google Scholar and ProQuest was reviewed. Articles that met the set criteria were included. We explored the bibliographies of eligible studies, reviewed them, and included any articles identified.

Study Selection

We applied the non-intervention interrogation of existing research using the sample, a phenomenon of interest, design, evaluation, and research type (SPIDER; Cooke et al., 2012). This approach is important for identifying qualitative and mixed-method studies (Cooke et al., 20212; Mansour et al., 2020). We used the SPIDER tool to capture both qualitative and quantitative articles; PRISMA eligibility criteria were based on the SPIDER tool guidelines (Cooke et al., 2012). The sample (S) was households that receive nutritional education at food pantries and food banks. The phenomenon of interest (PI) was the effect of nutritional education on F&V consumption among food pantry clients. Design (D) included all designs to enable a wide search of the findings. Evaluation (E) included any households that depend on food pantry/bank clients and that reported an increase in F&V consumption. Research type (R) included quantitative, qualitative, and mixed methods. The articles that were eligible for inclusion had to have been peer-reviewed and published in English between 2001 and 2022. The search range of 2001–2022 was chosen because 2000 was the time SNAP-Ed began to push for nutrition education among households facing the challenge of hunger across the nation (SNAP-Ed, n.d.).

Data Extraction Process

The selected articles were downloaded and uploaded to Rayyan QCRI for review (Ouzzani et al., 2016). Then, using Rayyan QCRI, two independent reviewers screened the articles based on the titles and abstracts for the initial inclusion, considered the first pass. The articles were reviewed and excluded during the initial screening when the reviewer could not determine from the study's title that nutrition education was the intervention for fruit and vegetable uptake. Then, abstracts were extracted for all publications and again excluded when the reviewer concluded from the abstract that the study failed to meet the criteria. The grading of each study guided this as eligible, not eligible, or might be eligible (Peters et al., 2015; van Tulder et al., 1997).

In the event of disagreement between the two reviewers, where the article could not be included or excluded based on the abstract, the entire article was evaluated. The inclusion of the full-text publication was examined by one reviewer MT and verified by LN.

The articles included in the study were those where the two independent reviewers, MT and LN, agreed that they met the criteria after examining the entire text. The study samples were representative of food pantry participants. One independent author extracted data from the included articles into an Excel spreadsheet (Higgins et al., 2019). Extracted data included the study design (cohort or cross-sectional), methodology (sample, data collection method, and analysis), measurement of F&V consumption (mean, standard deviation, and sample), and concluding remarks of each study. F&V measurements were recorded as cups per day and servings per day. The Excel Spreadsheet form was assessed and verified by the second reviewer.

Risk Assessment of Bias

For articles to be included in the study, a scale developed by van Sluijs et al. (2007) for assessing the quality of individual articles was used (see Table 1). Before the article was included, each reviewer assessed the article independently to determine whether the assessed item was present or absent. When the reviewer determined the item was not sufficient, then it was assigned an absent score. The article reviewers decided which were to be included in the study, but the reviewers' agreement was required to be at least at 80% (DerSimonian & Laird, 1986). In case of disagreement, the discussion continued until a resolution was found. Also, when there was disagreement between the reviewers, Cohen's K was used to assess the disagreements of the reviewers. Newcastle-Ottawa Scale (Deeks et al., 2003) was used as a guide to analyze the risk of bias.

Statistical Analysis of Extracted Data

This section presents a detailed analysis of the association between nutrition education and fresh produce consumption. The mean difference is an outcome measure of the changes in the quantity of fresh produce consumed due to nutrition education intervention. A random-effects model was applied to aggregate all results of the studies. The heterogeneity (i.e., tau^2) was determined using the DerSimonian-Laird estimator (DersSmonian & Laird, 1986). The Q-test for heterogeneity (Cochran, 1954) and the I^2 statistic were reported. Forest graphs were generated, and results were analyzed using the mean difference. If heterogeneity was detected (i.e., $tau^2 > 0$, irrespective of the results of the Q-test), a prediction interval for the results was reported. Studentized residuals and Cook's distances were used to interrogate studies that might be outliers that would have effect in the context of the model. Studies having a studentized residual greater than $100\times (1 - 0.05/(2k) \times r)^{th}$ percentile were acceptable. Influential studies had a Cook's distance greater than the median plus six times the interquartile range of the Cook's distance. To examine for a symmetry in the funnel plot, we utilized the rank correction and regression test, while using the standard error of the given outcome as a predictor (Frosolini et al., 2022).

Subgroup analysis was conducted to examine the effect of nutrition education on fresh produce consumption. This helped to determine whether consumption differed between study designs when

Table 1. Characteristics of U.S.-Based Studies on Fruit and Vegetables and Nutrition Education Included in this Study

Author/Ref	Study Design	Method	Sample	Weight (%)	Mean (95% CI)
Bertmann et al., 2021	Cohort study	Two-item screener food frequency questionnaire	165	0.04	0.04 (−0.18, 0.26) F
Fertig et al., 2021	Cross sectional study	FFG-Food frequency questionnaire	91	−0.05	−0.05 (−0.34, 0.24) V
Flynn et al., 2013	Cross sectional study	24-hour dietary recalls self-administered 24hr dietary assessment tool	38	0.81	0.81 (0.34, 1.28) F
Kleczynski, 2014	Cohort study	Pre-post assessment questionnaire	49	0.91	0.91 (0.49, 1.33) F
Orsega-Smith et al., 2020	Cohort study	10-item food frequency questionnaire	41	−0.02	−0.02 (−045, 0.41) V
St. Cyr, 2015	Cohort study	Photovoice sessions	21	1.27	1.27 (0.60, 1.93) F
Vardell, 2010	Cohort study	Interview	33	0.90	0.90 (0.39, 1.40) F
B. N. Wright et al., 2018	Cross-sectional study	Dietary recall on 10-item food categories	474	0.82	0.82 (0.69, 0.95) F
L. Wright et al., 2019	Cohort study	6-item food security scale Automated self-administered 24hr	77	−0.10	−0.10 (0.41, 0.22) V
		Total number of participants:	989		

considering (a) comparison of fruit with vegetable uptake, (b) nutrition education on fruit uptake, and (c) nutrition education on vegetable uptake. Post hoc analysis was performed to examine other factors that can affect nutrition education interventions—specifically, investigating how F&V uptake are separately influenced by different study designs (cross-sectional and cohort study design).

Results

Results of the Literature Search

The search of databases for systematic review and meta-analysis yielded a total of 2,954 articles. A manual search of other sources such as Google Scholar and Web of Knowledge yielded an additional 15 articles. After duplicates were removed, 1,335 were screened for inclusion. Using titles and abstracts, 1,301 articles were excluded. Thus 26 articles were retrieved and screened for inclusion. After a full-text review, nine studies met the eligibility criteria review objectives (Figure 1). The final total of nine articles included six cohort studies and three cross-sectional studies that we included in the meta-analysis. All nine studies were conducted in U.S. food pantries or banks with an aggregate total of 989 participants. Figure 1 displays the findings of the search approach and the basis for exclusion.

Study Characteristics

The characteristics of the studies included and their weight contributions are presented in Table 1.

Countries and Study

All included studies were conducted in the U.S. (Table 1). Three included in the study were cross-sectional (Fertig et al., 2021; Flynn et al., 2013; L. Wright et al., 2019); six were cohort studies, of which three utilized item-frequency questionnaires, one made use of photovoice sessions (St. Cyr, 2015), and one utilized interviewing (Vardell, 2010). Finally, one study adopted a pre-/post-assessment questionnaire design (Kleczynski, 2014)

Participant Characteristics

The studies included participants recruited from low-income households. One study's participants were predominately low-income patients with Medicaid as primary insurance, were overweight, and had two or more children (St. Cyr, 2015). Kleczynski (2014) recruited participants who were non-English speakers and illiterate. Seven studies recruited low-income, food-insecure participants (Bertmann et al., 2021; Fertig et al., 2021; Orsega-Smith et al., 2020; Flynn et al., 2013; Vardell, 2010; B. N. Wright et al., 2018; L. Wright et al., 2019). Finally, the study participant number varied significantly, from 20 (Kleczynski, 2014) to 600 participants (Bertmann et al., 2021).

Intervention Characteristics

Out of the nine included studies, four studies consisted of interventions with multiple components focusing on more than one domain such as eating habits, nutrition knowledge, cooking skills, family, weight, and children. The other five interventions focused on a single component, such as provision of gifts to facilitate purchase of fruits and vegetables (Vardell, 2010) or free distribution of fresh produce to households participating in the intervention (Flynn et al., 2013, B. N. Wright et al., 2018). Diverse means were used to engage the participants, including flyers, websites, social media, cookbooks, cooking classes, and nutrition training workshops. The durations for interventions differed significantly, ranging from four weeks (Kleczynski, 2014; Fertig et al., 2021) to multiple months (Flynn et al., 2013; L. Wright et al., 2019).

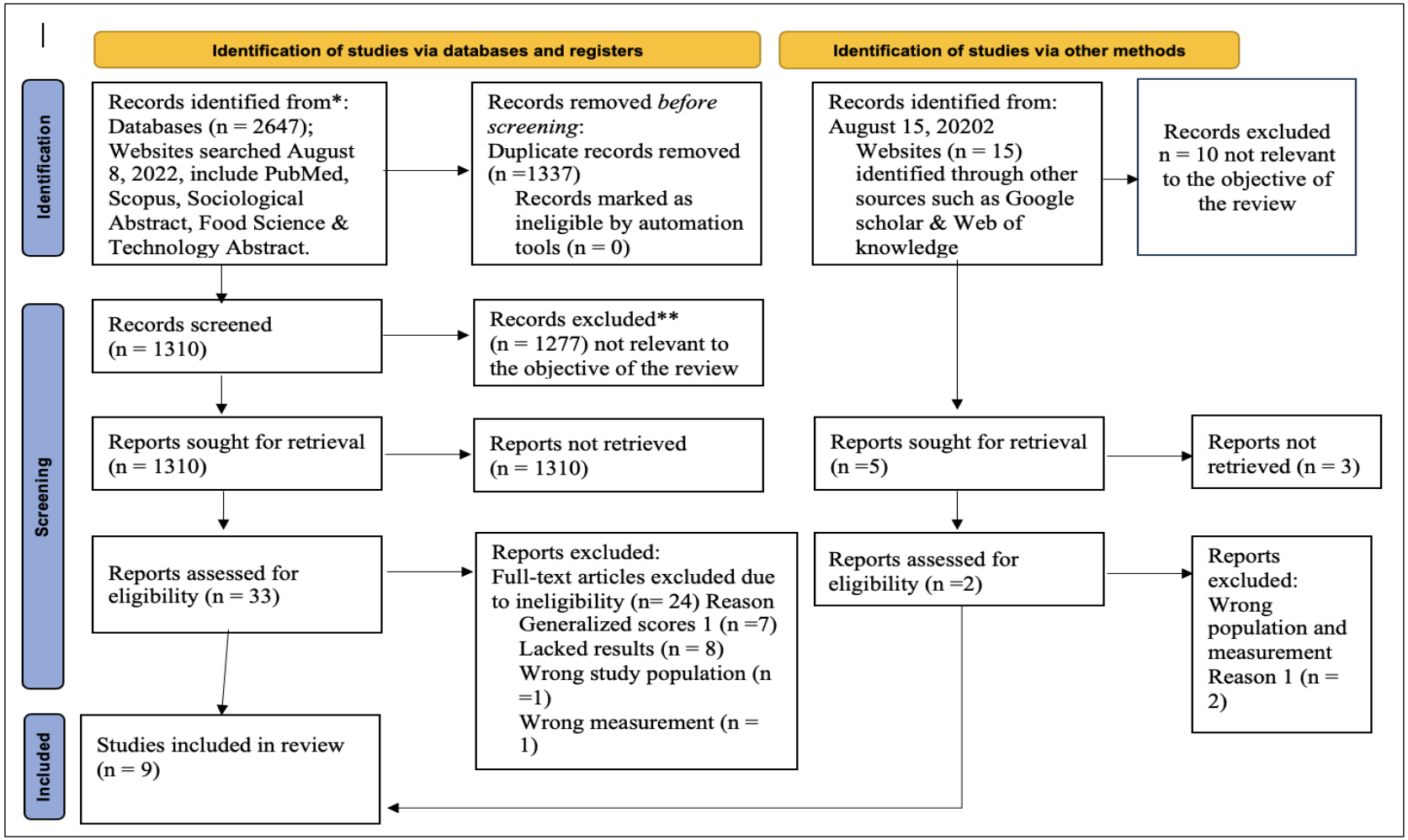
Analysis of Outcomes for Systematic Review

This section presents data according to the intervention and design (Table 2).

Subsidized interventions FV

The three studies in this section examined groups that received financial support to increase F&V intake. Fertig et al. (2021) used a Healthy Savings Program scan card coupled with nutrition and cooking education and a one-hour grocery tour. The goal of the intervention was to learn how to prepare healthy meals consisting of fresh produce and to learn food safety and cooking tips. By the end of two months, participants had increased intake of fruit from an average of 1.00 cup/day to 1.78 cups/day ($p < 0.001$). The second study

Figure 1. PRISMA 2021 Modified Preferred Reporting Items for Systematic Review and Meta-Analysis Flow Diagram of Included Studies



Note: The figure shows the flow of information through various stages of systematic review and maps number of records identified, included and excluded, and reasons for exclusion (Page et al., 2021).

Table 2. Food Pantry Patrons' Engagement, Goal, Outcome Measures, and Results

Author/Ref	Patrons' Engagement	Goal	Outcome Measures	Results
Subsidized interventions				
Flynn et al., 2013	Flyers advertising the program 6-week cooking program	Improve patrons' food purchase behavior, by using 6-week cooking program consisting of plant-based recipes	Self-administered questionnaire	Significant increase in fruit and vegetable uptake ($p < 0.01$) and decrease in the purchase of beef and carbonated drinks, desserts, snacks and total groceries ($p < 0.01$)
Fertig et al., 2021	1-hour grocery store tour part of the 6-week Cooking Matters for adult curriculum and a 2-hour cooking class	Assess the effectiveness of financial incentive to purchase fresh produce with experiential education focused on cooking	24-hour dietary recall conducted at the time of recruitment and post-intervention (60 days after recruitment)	Significant increase in uptake of fruit from average of 1.00 cups/day to 1.78 cups/day ($p < 0.001$). No significant change in vegetable uptake in relation to their capacity to organize a health meal.
Vardell, 2010	Intervention group 33 participants-over 3-months program receiving locally grown produce worth ($60). For control group 28- over 3-months got supermarkets gift cards	Assess difference in fruit and vegetable uptake and behaviors of those getting produce (intervention group) and those getting gift cards equivalent to the amount of produce	Pre- and post-program surveys distributed for local produce for 3 months consisting of 7-item behavior checklist score	Significant perceived diet quality ($p < 0.019$), where 25.0% of participants indicating excellent, very good, or good diet vs 14.0% for non-participants. There were no significant differences between the intervention and control group.
Multicomponent intervention				
Bertmann et al., 2021	Online Qualtrics survey on food access, food security, and purchasing etc.	Explore fruit and vegetable intake changes during COVID-19. Traditional 12 months was reduced to ~6 months to measure food security status since the onset of COVID-19 pandemic.	USDA's 6-item short-form food security module	Non–food pantry participants since the beginning reported significant minimum intake of fruit and vegetable (F&V) during the pandemic ($p < 0.001$). Food pantry participants at the beginning of the pandemic reported low F&V intake ($p < 0.001$). During the pandemic respondents 18 or older with children had significantly higher intake of F&V ($p < 0.049$) in first 6 months.
Kleczynski, 2014	Cookbook with 12 recipes distributed to the participants	Assess effectiveness of patron-oriented cookbook intervention to increase nutritional knowledge	Pre-/post-assessment questionnaire	No significant differences were found due to cookbook intervention ($p < 0.673$). The behavior change associated with meal preparations remained the same.

Table 2. Food Pantry Patrons' Engagement, Goal, Outcome Measures, and Results

Author/Ref	Patrons' Engagement	Goal	Outcome Measures	Results
Orsega-Smith et al., 2020	Mobile pantry food trucks distribution of produce box 2 times per month	Determine whether prescription programs have a positive influence on low-income groups' nutrition uptake	Pre- and post-program surveys distributed over 1 year. The 10-item survey assessed fruit and vegetable consumption, fruit and vegetables purchase behavior.	There was significant increase adult consumption of vegetables ($p < 0.001$) from pre- (2.22 ± 1.24 savings per day) to post-program (2.44 ± 1.03 servings per day). Fruit increased significantly ($p < 0.05$) from pre-program ($2.05 \pm .97$ servings per day) to post-program ($2.46 \pm .92$ servings). Child fruit uptake significantly increased ($p < 0.05$) from pre-program (2.51 ± 1.21 servings per day) to post-program (2.77 ± 1.16 servings). No observed significance difference ($p < 0.15$) in child vegetable consumption from baseline (2.03 ± 1.11 servings per day).
St. Cyr, 2015	Survey and photovoice	Assess effect of nutrition education on fruit and vegetable uptake	A survey to assess self-regulation related to fruit and vegetable consumption. Photovoice was used to assess effectiveness in intervention group.	The control group had significantly increased fruit uptake ($p < 0.0025$) more than the intervention group. After program intervention, participants increased whole fruit uptake significantly ($p < 0.002$). No significancy with control group.
B. N. Wright et al., 2018	Use of interviews in semi-private space. Participants completed an electronic or paper version of a questionnaire that elicited information on demographics and pantry use characteristics	Compare short-term dietary intake patterns before and after visit to food pantry, stratified by food security status	U.S Household Food Security Survey Module followed by the Automated Self-Administered 24-h Dietary Assessment Tool (ASA24-2014)	Significant improvement in the mean Healthy Eating Index 2010 total fruit (before: 1.2 ± 1.9, after: 1.7 ± 2.2, $p < 0.0001$) and whole fruit (before: 0.9 ± 1.8, after: 1.4 ± 2.1, $p < 0.0001$)
L. Wright et al., 2019	Participants completed assisted phone interview, within two weeks of pantry visit. Participants received $10 grocery gift card	Evaluate single day dietary intake patterns before and visiting food pantry among food-secure and food-insecure pantry clients	USDA Six-item Food security scale (FSS) was used to measure food security.	Significant improvement in food security over the 4-month program ($p < 0.0005$). Prior to the program, 61% of respondents indicated very low food security, 31% low food security, and 8% were food insecure. Fruits and vegetable intake increased from 4.65 servings per day prior to program to 4.96 after program ($p < 0.0005$).

(Flynn et al., 2013) used the Raising the Bar on Nutrition (RTB) protocol. The protocol consists of the contiguous periods: pre-period (four weeks) before cooking classes; six weeks of cooking class; and six months of follow-up by appointment. By the end of the program, there was an increase in F&V intake and a decline in purchase of beef, carbonated drinks, desserts, and snacks.

The third study (Vardell, 2010) was a random control trial. The intervention consisted of participants getting incentives such as cookbook valued at $20. At the post-test, the same participants received an incentive of a $5 Kroger grocery gift card. After the intervention, there was an increase in F&V intake participants' higher perceived diet quality ($p < 0.019$), where 25.0% of participants indicated excellent, very good, or good diet versus 14.0% for nonparticipants.

Multicomponent interventions

Seven studies utilized a multicomponent strategy for nutrition education intervention at food pantries. The multicomponent interventions focused on food insecurity and F&V intake targeting food pantry patrons (Bertmann et al., 2021; B. N. Wright et al., 2018; L. Wright et al., 2019), nutrition knowledge and uptake of F&V (St. Cyr, 2015), and cooking skills and F&V consumption (Kleczynski, 2014; Orsega-Smith et al., 2020). In the studies by Kleczynski (2014), Orsega-Smith et al. (2020), and B. N. Wright et al. (2018), the intervention included eating habits, tasting, and self-efficiency. There was an increase in the intake of F&V in all multicomponent interventions. A pooled analysis was conducted using the six studies (90 participants). The generated standardized mean differences (SMD) ranged from −0.0971 to 1.2675, with most estimates being positive (67%). Significant differences were observed between multicomponent interventions (SMD based on the random-effects model was 0.4580; 95% CI: 0.0141 to 0.9019; $I^2 = 92.97\%$). To have standardize mean difference measurement to be on same scale. Therefore, the average outcome of SMD differed significantly from zero ($z = 2.0220$, $p = 0.0432$).

Meta-Analysis of Fruit and Vegetable Intake by Intervention Type

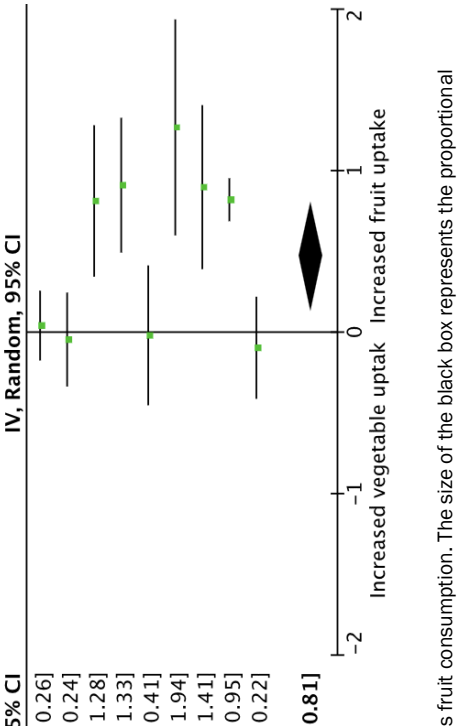
The initial meta-analysis heterogeneity among studies included in the analysis was significant $I^2 = 92.97\%$. To establish the sources of heterogeneity further analysis was conducted across different intervention types as indicated below.

Meta-Analysis Vegetable and Fruit Intake

The meta-analysis had a total of 9 studies included in the analysis (Figure 2). The standardized mean differences ranged from −0.0971 to 1.2675, with a positive estimate (67%). The pooled mean difference was calculated using the random-effects model, which was SMD = 0.4769 (95% CI: 0.1389 to 0.8148). Therefore, the average outcome was significantly different from zero ($z = 2.7659$, $p = 0.0057$). The Q-test showed the findings being heterogeneous ($tau^2 = 0.2269$, $I^2 = 90.65\%$, $p < 0.0001$). A 95% confidence interval for the predicated findings was -0.41 to 0.811 (Figure 2). Hence, although the average outcome was shown to be positive, in some studies the results were negative. With a thorough interrogation of the studentized residuals, we concluded none of the studies had a SMD value larger than ± 2.7729, which indicated there were no outliers in the context of this model. Based on Cook's distances, no study was found to be influential. Both the rank correlation and regression test did not show any funnel plot asymmetry ($p = 0.1802$ and $p = 0.2131$, respectively).

The analysis of study influence indicated that no individual study had a greater influence on the pooled association of nutrition education on increased F&V consumption. For visual inspection of the funnel plot, see Figure 3. The examination of the studentized residuals indicated that none of the studies had an SMD value larger than ± 2.7729, and therefore there was no indication of outliers in the context of this model. According to Cook's distances, none of the studies could be overly influential. This was supplemented with a visual examination of the funnel plot. Neither the rank correlation nor regression test indicated any funnel asymmetry ($p = 0.1802$ and $p = 0.1696$, respectively).

Figure 2. Forest Plot of Meta-Analysis on Association Between Fruit and Vegetable Consumption and Nutrition Education



Note: The left side of the graph shows increased vegetable consumption, and the right side of the graph is fruit consumption. The size of the black box represents the proportional weight given to each study, which is inversely proportional to the standard error of the means, while the horizontal lines represent the 95% confidence intervals (95% CI).

Subgroup Analysis of Nutrition Education on Increased Fruit and Vegetable Consumption of Varied Study Designs and Interventions

Due to the high heterogeneity (tau^2 = 0.2269, I^2 = 90.65%, $p < 0.0001$), meta-analysis was performed for nutrition education on F&V intake. A subgroup analysis of cross-sectional F&V study included three cross-sectional studies (Figure 3; Fertig et al., 2021; Flynn et al., 2013; B. N. Wright et al., 2018) and six cohort studies (Bertmann et al., 2021; St. Cyr, 2015; Kleczynski, 2014; Orsega-Smith et al. 2020; and L. Wright et al., 2019), involving a total of 989 participants (Table 1).

The subgroup analysis of cross-sectional studies was as follows: Out of three cross-sectional studies, two reported increased consumption of fruit (Flynn et al., 2013, Vardell, 2010). One study observed no significant effect on consumption of fruit and vegetables (Fertig et al., 2021). Pooled mean (95% CI) of nutrition education on fruit and vegetable uptake was (SMD -0.54 [95% CI −0.14 to 1.21], three studies, 155 participants, I^2 = 87%, $p < 0.001$[Hedge's g]) (Figure 3).

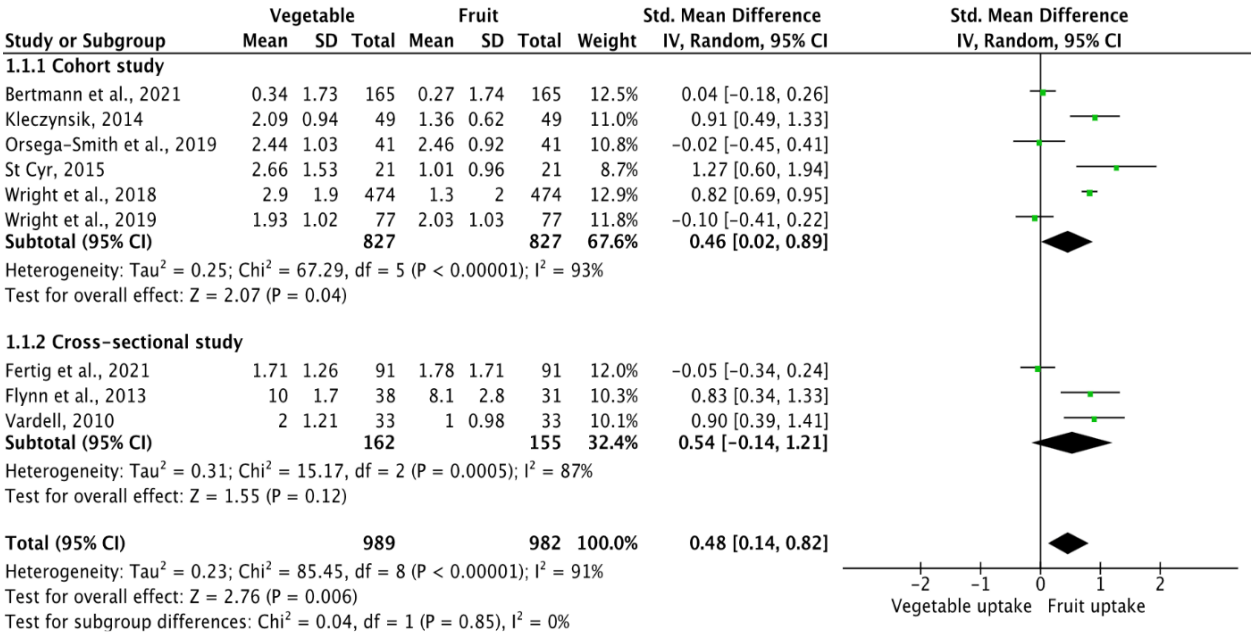
Meta-analysis for cohort studies showed a significant effect for fruit uptake (SMD = 0.46 [95% CI 0.02 to 0.89], six studies, 827 participants, I^2 = 67%, $p < 0.001$ [Hedge's g]) (Figure 3). The overall pooled heterogeneity for both study designs (SMD = 0.48 [95% CI 0.14 to 0.82], nine studies, 989 participants, I^2 = 91%, $p < 0.0001$, [Hedge's g]). Therefore, a slightly significant difference when the means were pooled indicated that the interventions influenced F&V intake.

The exploration of the cross-sectional and cohort studies revealed that nutrition education interventions in food pantries and food banks had a positive impact on fruit consumption (Figures 4 and 5). Conversely, the impacts of nutrition education on vegetable consumption were negative in the general meta-analysis and study design analysis.

Subgroup Analysis of Nutrition Education and Subsidized Interventions

A total of three studies were included in the analysis of nutrition education and subsidized interventions. The observed standardized mean differences ranged from −0.0464 to 0.9096, with most estimates being positive (67%). The estimated average

Figure 3. Funnel Plot for Analysis of Innervation of Nutrition Education Association of Vegetable and Fruits Increased Uptake



standardized mean difference based on the random-effects model was (SMD = 0.54 [95% CI: −0.08 to 1.15], three studies, 155 participants, $I^2 = 87\%$, $p < 0.0005$ [Hedge's g]) (Figure 4). A 95% confidence interval for the true outcomes is from −0.6267 to 1.7041. Hence, although the average outcome is estimated to be positive, in some studies, the true outcome may be negative. An examination of the studentized residuals revealed that one study (Fertig et al., 2021) had an SMD value larger than ± 2.3940 and may be a potential outlier in the context of this model. According to Cook's distances, none of the studies were overly influential. The regression test indicated funnel plot asymmetry ($p = 0.0043$), but the rank correlation test did not ($p = 1.0000$).

Subgroup Analysis of Nutrition Education and Multicomponent Interventions

A total of six studies were included in the analysis of nutrition education and multicomponent interventions. The observed standardized mean differences ranged from −0.0971 to 1.2675, with most estimates being positive (67%). Meta-analysis of multicomponent intervention for increasing F&V intake (SM = 0.54 [95% CI: 0.4370 to 0.6353], six studies, 827 participants, $I^2 = 92\%$, $p < 0.0001$ [Hedge's g]). One study (B. N. Wright et al., 2018) had a relatively large weight compared to the rest of the studies (a weight at least three times as large as having equal weights across studies; Figure 5). An examination of the studentized residuals revealed that several studies (B. N. Wright et al., 2018; L. Wright et al., 2019; Bertmann et al., 2021) had an SMD values larger than ± 2.6383 and may be potential outliers in the context of this model. According to Cook's distances, one study (B. N. Wright et al., 2018) could be overly influential. The regression test indicated funnel plot asymmetry ($p = 0.0178$), but the rank correlation test did not ($p = 0.7194$).

Subgroup Analysis of Nutrition Education and Cooking Classes and Gift Cards

A total of three studies were included in the analysis of the effect of nutrition education, cooking classes, and gift cards. The observed standardized mean differences ranged from 0.8119 to 0.9096, with most estimates being positive (100%). Meta-analysis of cooking classes and gift intervention for increasing F&V intake (SMD = 0.8268 [95% CI: 0.7049 to 0.9487], three studies, 538 participants, I^2

= 0.0000, $p = 0.9196$ [Hedge's g]) (Figure 6). Therefore, the average outcome differed significantly from zero ($z = 13.2908$, $p < 0.0001$). An examination of the studentized residuals revealed that none of the studies had a value larger than ± 2.3940. Hence, there was no indication of outliers in the context of this model. According to Cook's distances, none of the studies were overly influen-

Figure 4. Forest Plot of a Meta-Analysis of Subsidized Fruits and Vegetables Consumption for Cross-Sectional and Cohort Studies

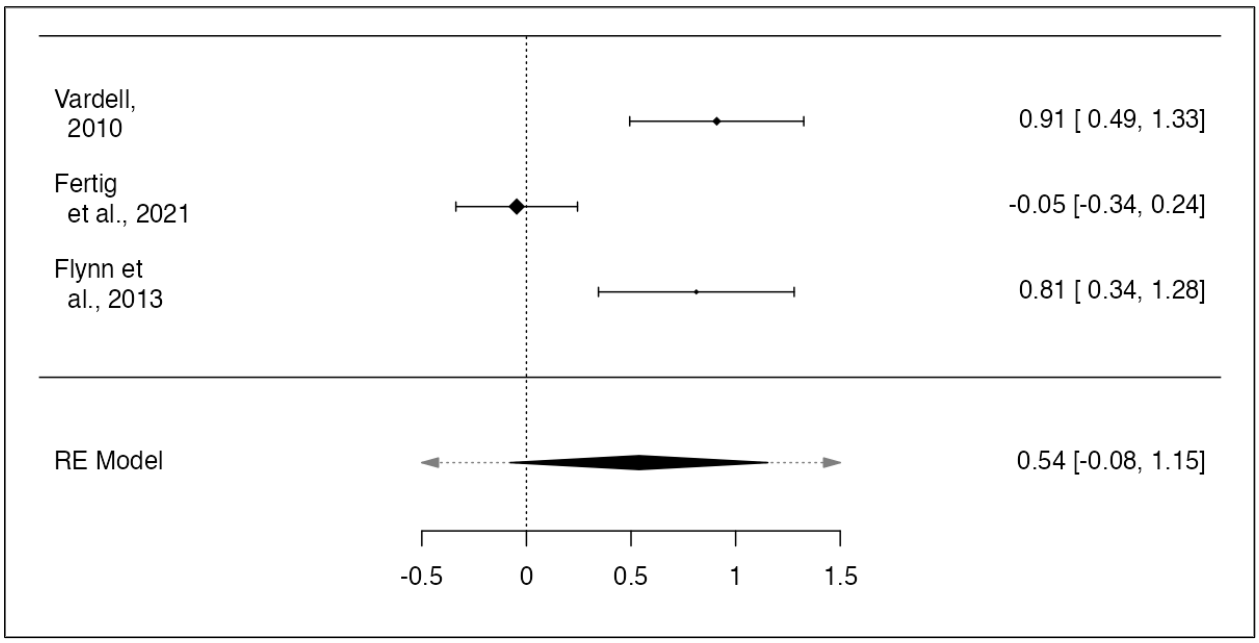


Figure 5. Forest Plot of a Meta-Analysis of Multicomponent Increased Vegetable And Fruit Consumption in Both Cross-Sectional and Cohort Studies

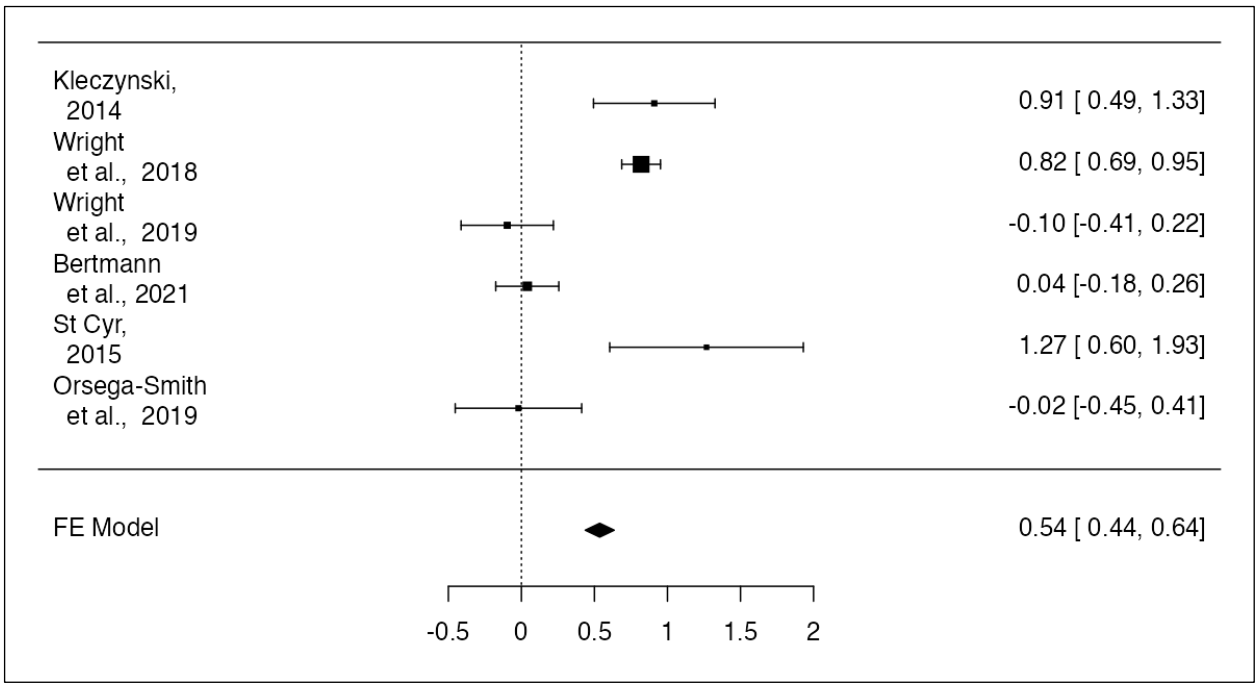
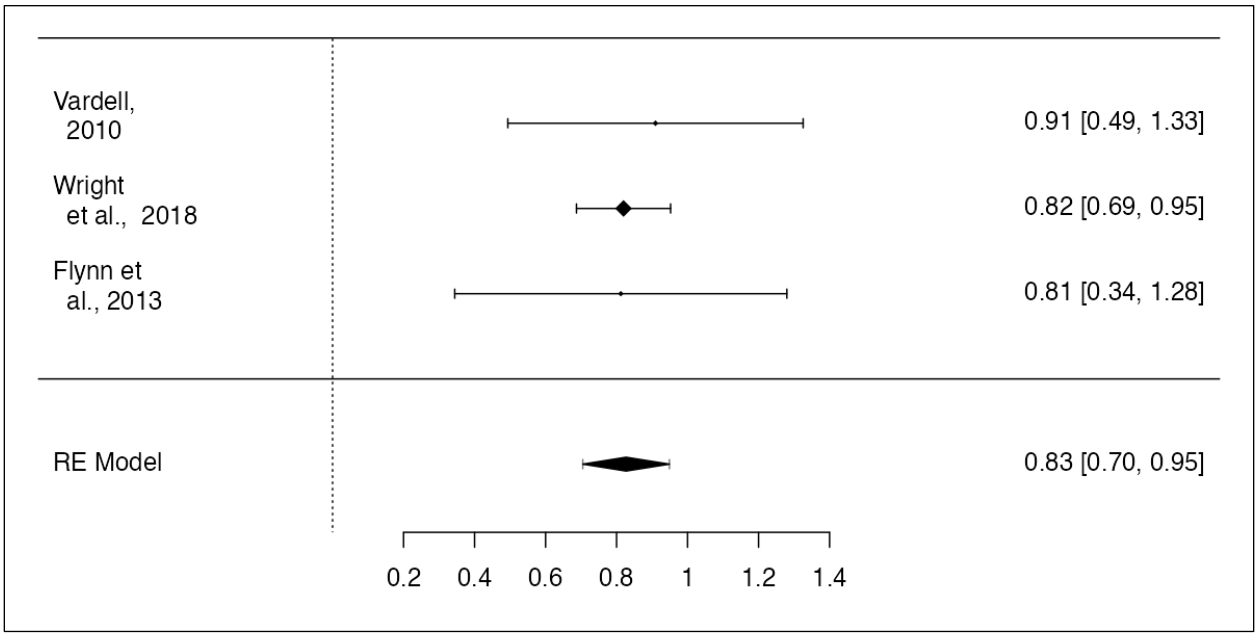


Figure 6. Forest Plot of a Meta-Analysis of Cooking Classes and Gift Cards F&V intake for both Cross-Sectional and Cohort Studies



tial. Neither the rank correlation nor the regression test indicated any funnel plot asymmetry (p = 1.0000 and p = 0.8079, respectively).

The subsidized interventions (tau^2 = 0.2550, I^2 = 86.8008%) and multicomponent interventions (tau²= 67.3895, I^2 = 92.5804%) contributed to larger heterogeneity (tau^2 = 0.2269, I^2 = 90.65%, p < 0.0001) in the analysis of education influence on the intake of F&V.

Discussion

Our findings suggest that food pantry and food bank participants have a higher intake of fruits than vegetables. Lower intake of vegetables is not fully in line with the 2020–2025 *Dietary Guidelines for Americans* (DGA), which requires adults to consume 1.5–2 cup equivalents of fruits and 2–3 cup equivalent of vegetables daily (Phillips, 2020). This crucial finding may be attributed to the nature of education, in which patrons are given recipes, nutrition handouts, classes, and fresh produce that may not be effective regarding vegetable consumption, since vegetables often require cooking.

We found that cooking classes and gift cards were most effective in increasing the intake of F&V among food pantry participants, with a significant effect size (SMD = 0.83, 95% CI: 0.7049 to 0.9487). This is unsurprising because participants will eat F&V while cooking and preparing. The gift card cards were restricted to buying fresh produce, which likely contributed to adequate consumption. This finding is consistent with Miyamoto et al.'s (2006) finding that patrons who attend nutrition education and cooking classes have a high intake of F&V compared to those who do not. Additionally, some participants might be motivated to eat F&V to improve their health. This aligns with Lin (2005), who notes that low-income households have difficulty meeting the daily recommended F&V servings. Therefore, the gift card could allow them to afford the produce they might have wanted to consume. For the multicomponent analysis of six studies, the pooled intervention (SMD = 0.5361, 95% CI: 0.4370 to 0.6353) had less effect on the intake of FV; this may have been because the follow-up period in the studies was short (3 months after the intervention). Such a short of period may not have been enough for some participants to report sufficient data on the F&V intake (Figure 5).

However, some studies had negative results compared to others, and this could be because of

differences in intervention characteristics, such as recipe distribution versus cooking classes. The high heterogeneity ($tau^2 = 0.2269$, $I^2 = 90.65\%$) observed in the meta-analysis has an impact on pooled results (Figure 2) . Further subgroup analysis was conducted to identify factors contributing the variability such as subsidized and multicomponent interventions (Figures 4 and 5) that may have accounted for higher variability after subgroup analysis. Therefore, cooking interventions had zero variability in the subgroup analysis (Figure 6),

Yet cooking is based on convenience and taste preference, not only on interest in obtaining nutrition. Additionally, many vegetables must be prepared, whether cut, peeled, or cooked; however, fruits are generally consumed whole and raw. Additionally, some vegetables have a shorter shelf-life than fruits: by the time patrons go to collect them, vegetables could be already spoiled and of poor quality (Ghahremani-Nahr et al., 2023, Long et al., 2022). Food pantries carrying vegetables that may not be recognizable by the clients could also hinder consumption (Long et al., 2022). The demographics could have had negative results in some studies because some participants may have a lower socioeconomic background which hinders their ability to afford healthy food and, therefore, more likely not to pay much attention when recording the servings per day or self-administered 24-hour dietary recall. Categorizing participants based on demographics will ease the extraction of data to conduct a meta-analysis predicated on demographics to mitigate issues regarding heterogeneity.

The recommended vegetables according to the 2020–2025 DGA guidelines include dark greens; red and orange vegetables; legumes such as beans, peas, and lentils; and starchy vegetables, among others (Phillips, 2020). Some of the vegetables, such as beans, peas, and lentils, require time and gas or electricity to prepare, yet a large percentage of households that depend on food pantries grapple with payment of utility bills. In such circumstances, it becomes harder for individuals to consume vegetables in quantities that meet the dietary requirements of the DGA.

It is important to consider these differences in the analysis of nutrition education as related to F&V intake. This study does this quantitatively rather than narratively. In comparing the meta-analysis to a narrative literature review, it is important to note that a meta-analysis allows the researcher to summarize the quantitative results across studies and to establish the generalizability of reported relationships (Pan & Sparks, 2012). Therefore Higgins et al. (2003) recommended determining the potential sources of between-study heterogeneity. There was significant heterogeneity observed in the meta-analysis between studies on fruit intake, vegetable intake, and nutrition education. The difference between studies could be attributed to sources such as the year of publication, the age of the participants, and other covariates that were not captured in the studies.

The findings of the systematic review and meta-analysis revealed that this is the first meta-analysis to investigate the association between F&V consumption and nutrition education among food pantries and food banks. Our systematic review was composed of nine independent studies reporting the outcome of increased fruit consumption due to nutrition education intervention, with a total of 989 participants. The findings from the main meta-analysis indicated that nutrition education innervation was significantly associated with increased fruit consumption, SMD = 0.4769 (95% CI: 0.1389 to 0.8148), whereas there was no significant association observed between the intervention and increased vegetable consumption (Figure 4). After adjusting for publication bias, the results remained significant for fruit consumption. Therefore, the overall effect size of the analysis indicated a more significant association between fruit and nutrition education compared to vegetables. Additionally, there was a higher heterogeneity between the studies ($tau^2 = 0.2269$, $I^2 = 90.65\%$, $p < 0.0001$), which affects confidence in the pooled results. The higher heterogeneity can be attributed to different categories of vegetables, the guidelines given for various F&V choices, the length of the intervention, and differences in the dietary advice and assistance offered to the patrons, which has the potential to influence the results (Fulton et al., 2016).

To address the heterogeneity issues, subgroup analysis was conducted to identify factors causing the variability, such as cross-sectional versus cohort study design, which revealed a significant inverse

association between increased fruit uptake and nutrition education. However, no significant inverse association was revealed between increased vegetable uptake and nutrition education in cohort versus cross-sectional studies.

Limitations

The study's limitations were the small number of studies (*N* = 9) included in the meta-analysis, which affected the statistical power and hindered the potential of making generalizable claims. A small number of studies limited the ability to conduct moderator analysis using meta-regression to try to explain some of the causes of heterogeneity. The few studies are attributed to databases that generated hardly more than 10 articles directly related to nutrition education in food pantries and food banks. Most articles were about food insecurity, access, and sugar-sweetened beverages. We found only nine studies exploring the association between nutrition education and fruit and vegetable consumption among food pantry and food bank participants.

The meta-analysis had higher heterogeneity because of the number of studies *(N* = 9) and total number of food pantry patrons (*N* = 989). Therefore, the results of the analysis should be read with caution. The meta-analysis exhibited higher heterogeneity due to the varying impact of the intervention. Given the small number of datasets, the opportunities to assess potential sources of heterogeneity are limited. A diversity of factors could be responsible for the heterogeneity: duration of the intervention, demographics, kind of fruits and vegetables, varying measurement units, and study designs. With varying measurements, we chose standard mean difference to standardize the measurements across the studies.

Another observed limitation was the self-reported data from studies (Bertmann et al., 2021; Flynn et al., 2013; St. Cyr, 2015). The participants had to report their own results, which was a potential source of bias. Additionally, F&V intake was captured using food frequency questionnaires or 24-hour dietary recall (Fertig et al., 2021; B. N. Wright et al., 2018), which could be a source of measurement error, where participants might have underestimated or overestimated the consumption. This could raise questions regarding the validity of the questionnaire.

Implications

Federal and state governments prioritize providing nutrition education to support increased consumption of F&V, improving the well-being of populations that depend on food pantries for their food resources. However, the average intake of F&V remains lower than recommended despite its benefit of reducing risks for chronic illnesses such as hypertension, diabetes, cancers, and obesity (Acosta et al., 2024). This indicates there is still more work to be done to increase the intake of F&V to meet the recommended quantity of five to seven servings per day. However, the success of nutritional education in increasing F&V consumption remains low. Nutrition education could push for other sources of consuming F&V to enhance dietary quality. Our assessment pointed to other sources, such as dried fruit and tropical fruits (Stanford Medicine, n.d.). However, patients with hypertension should be advised to limit their consumption of high-sugar fruits because it could lead to unintended consequences (Mamluk et al., 2017; Montonen et al., 2005), hindering people from meeting the goal of reducing the effects of chronic illness. The interventions of all studies included in the analysis used a top-down approach to engage the food pantry patrons in nutrition education programs to increase F&V intake. Utilizing participatory action strategies would better engage participants to understand how they may participate in various program interventions for their demographics. Therefore, future research could focus on how the participatory approach can play a role in increasing the intake of F&V among the food pantry community.

Conclusion

The study results support that food pantries and food banks had a positive influence on fruit consumption but no positive influence on vegetable consumption. Specifically, we found that cooking classes and gift cards were most effective in increasing the intake of F&V among food pantry participants. Through activities such as cutting vegetables, cooking and tasting, and collective

working, the constraints of cooking are reduced; this is very important since most families may not have the finances to pay for transportation and other secondary ingredients accompanying fresh produce. However, the small number of studies included in the analysis provided inadequate evidence to develop clear and informed recommendations. Further research must continue to understand and refine nutrition education to increase its effectiveness in increasing F&V among food pantry participants.

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