

Effect of Supplemental Nutrition Assistance Program–Education (SNAP-Ed) on food security and dietary outcomes

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The Supplemental Nutrition Assistance Program–Education (SNAP-Ed) is the nutrition promotion component of SNAP, formerly known as food stamps. SNAP-Ed assists low-income populations in the United States improve dietary intake and reduce food insecurity through nutrition education. This narrative review summarizes current investigations of SNAP-Ed's effectiveness at improving food security and dietary outcomes, and it can help inform future policy and implementation of the program. There was stronger evidence for SNAP-Ed as an effective means of improving food security (n = 4 reports) than for its effects on nutrition or dietary outcomes (n = 10 reports). Inconsistency in measurement tools and outcomes and a lack of strong study designs characterized the studies that sought to evaluate the effectiveness of SNAP-Ed at improving nutrition or dietary outcomes. Additional rigorous study designs in diverse population groups are needed to strengthen the evidence. In the face of reduced financial SNAP benefits, SNAP-Ed may play an important role in helping to eliminate food insecurity and improve dietary outcomes and, ultimately, the health of low-income Americans.

INTRODUCTION

Food insecurity, “the limited or uncertain availability of nutritionally adequate and safe foods or limited or uncertain ability to acquire acceptable foods in socially acceptable ways,” is a serious public health problem that negatively impacts nutrition and health.¹ At some time during 2017, food insecurity characterized 11.8% of US households, affecting 40 million people, according to the United States Department of Agriculture (USDA) Economic Research Service.² Food-insecure households have difficulty obtaining the foods they normally eat; thus the type and quality of the foods consumed during times of food insecurity may be compromised.^{3,4}

The overall dietary intake of the US population is not ideal; an overwhelming majority do not meet the recommendations in the Dietary Guidelines for Americans (DGA).⁵ Subsets of the US population, such

as low-income groups, are more likely to be food insecure and have poor dietary intake and a heightened risk for chronic disease compared with the population as a whole.^{5–7} The USDA Food and Nutrition Service has provided all states with the opportunity to deliver a federally supported nutrition education intervention to improve diet and food insecurity among low-income households eligible for nutrition assistance through the Supplemental Nutrition Assistance Program (SNAP), formerly known as the Food Stamp Program. The purpose of this narrative review is to provide a critical appraisal of the small but growing body of scientific literature examining the contributions of the direct nutrition education provided through Supplemental Nutrition Assistance Program–Education (SNAP-Ed) to the problems of food insecurity and poor dietary intake in the US low-income adult population.

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903

Association of food insecurity with preventable poor dietary and health outcomes in the United States

The definitions and measurement of food security in the United States have been thoroughly described elsewhere.⁸ In brief, survey instruments developed by the USDA quantify the food security of the entire household, adults in the household, and children in the household.⁹ Food security status may be classed as high, marginal, low, or very low, with the latter 2 categories representing food insecurity.^{9,10} Food that is reported to be of lower quality, variety, and desirability characterizes low food security, whereas very low food security is indicated when the amount of food intake is reduced.³ Food insecurity has been associated with overall poor dietary intake and reduced intake of dairy foods, vegetables, and fruit, likely resulting in reduced intakes of several micronutrients in food-insecure compared with food-secure US adult populations.¹¹ Poor nutrition-related health outcomes, such as diabetes and hypertension, have also been associated with food insecurity (Figure 1).^{6–8,11} Chronic disease treatment represents a substantial use of national resources that may be reduced with appropriate prevention. Healthcare costs saved as a result of preventative interventions are estimated to be \$16 billion annually over 5 years.¹² Federal nutrition education is a widely available preventative intervention that has been shown to be cost-beneficial and cost-effective for nutrition-related chronic disease.^{13–15}

Effect of federal nutrition assistance and direct nutrition education programs on food security and dietary outcomes in low-income households

The USDA supports 15 federal nutrition assistance programs to assist low-income US populations in meeting their dietary needs and improving food security. The largest program in funding and participation is SNAP. SNAP aims to reduce and prevent food insecurity by providing low-income households with gross monthly incomes at or below 130% of the federal poverty guideline who meet specific resource requirements with financial benefits to purchase supplemental foods from authorized stores.¹⁶ A large body of literature evaluating the impact of financial food assistance through SNAP has documented successful improvement in food security among participants compared with eligible nonparticipants; however, adult SNAP participation is associated with lower diet quality compared with income-eligible nonparticipants in previous research limited by self-selection bias and observational study

design.^{17,18} Enhanced dietary quality to support health and reduce chronic disease disparities is a current need in the SNAP-eligible population. Nutrition education to improve dietary choices has the potential to sustain improvements in dietary intake beyond the limits of food assistance provided through SNAP. Nutrition education evaluation is not limited by ethical constraints of withholding or delaying food assistance.¹⁹ Studies using all types of study designs, including randomized controlled trials, are possible for SNAP-Ed, whereas they may not be for evaluation of SNAP.

SNAP-Ed is the complementary educational program to SNAP that aims to align household dietary choices with the DGA recommendations and support the food security goals of SNAP.²⁰ Compared with SNAP, SNAP-Ed is a much smaller program in terms of funding, participation, and attention in the literature. SNAP-Ed started as the Food Stamp Nutrition Education (FSNE) program in 1988 and has consistently provided nutrition education to an audience qualifying for federal means-tested assistance programs or low-income communities ($\leq 185\%$ of the federal poverty guideline).²⁰ SNAP-Ed may be directed by one or multiple agencies in each state, such as Cooperative Extension at land-grant universities, public health departments, or private nonprofit organizations. SNAP-Ed is a nonentitlement program. Participation in SNAP-Ed does not require participation in SNAP and vice versa; however, the SNAP-eligible population is the target audience for SNAP-Ed.^{21,22} Although this review focuses on adult programs, SNAP-Ed also provides age-appropriate programs to children. In both adults and children, SNAP-Ed centers on 2 broad key behavioral outcomes from the DGA: promoting the consumption of nutrient-dense foods and beverages and achieving and maintaining a healthy weight through caloric balance over time.⁵

Agencies in each state that implement SNAP-Ed are encouraged to use the SNAP-Ed toolkit to develop evidence- and practice-based curricula and interventions that fulfill the federal SNAP-Ed *Plan Guidance* document, which outlines how to address the key behavioral outcomes.²² SNAP-Ed programs have traditionally offered behaviorally focused programming through direct nutrition education delivered individually or to groups by nutrition education professionals or paraprofessionals using a range of curricula based on a variety of health behavior change theories. The expected outcomes for SNAP-Ed participants may include adherence to MyPlate recommendations, increased physical activity, and improved food security, among several others.^{21–23} More recently, programs are also required to intervene in a broadly focused community scope at 1 of 3 other levels of influence (settings, sectors, and

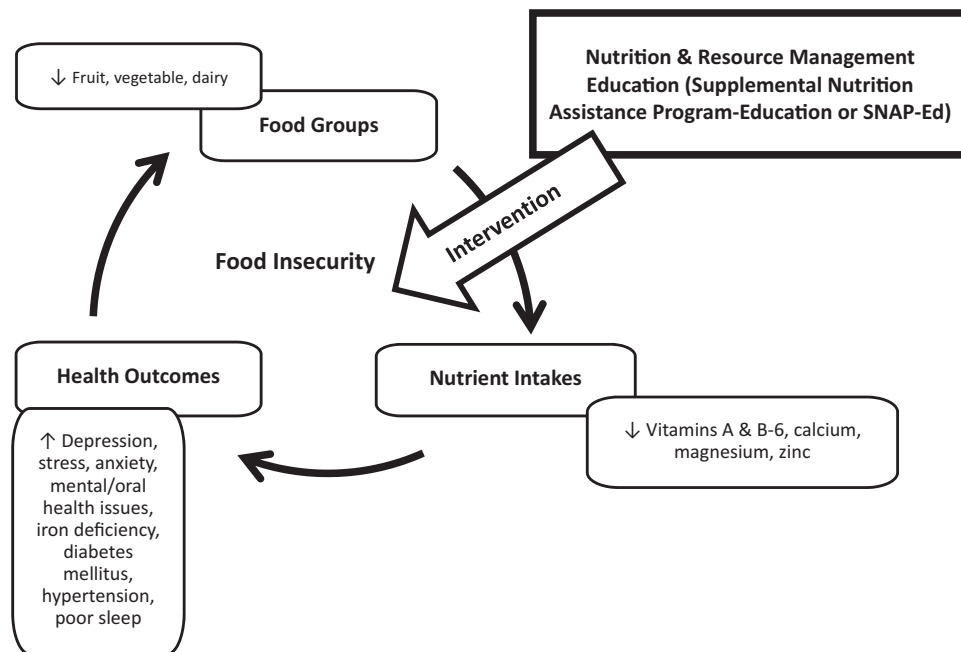


Figure 1 Conceptual model of the impact of food insecurity on dietary intake and health outcomes. Food insecurity is associated with decreased intake of certain food groups, resulting in decreased intake of important nutrients, and causes poor health outcomes,^{6–8,11} which in turn perpetuates food insecurity. Additionally, food insecurity directly impacts any construct on this cycle. Supplemental Nutrition Assistance Program–Education (SNAP-Ed) may be an important component of the multifaceted approach needed to reduce food insecurity and improve nutrition and health outcomes.

social and cultural norms) of the Social Ecological Model (SEM) from the DGA.⁵ However, few published, peer-reviewed studies have evaluated the impact of these community-directed interventions; as such, this review focuses on direct nutrition education interventions through SNAP-Ed at the individual level among adults.

Evidence base for direct nutrition education as an effective intervention among the Supplemental Nutrition Assistance Program–eligible population

Nutrition education has been shown to effectively promote nutrition knowledge, positive attitudes toward healthy food-related behaviors, and intake of fruits and vegetables.^{24–27} Nutrition knowledge and attitudes are conceptualized as internal determinants that precede changes in dietary intake and quality following the Transtheoretical Model, a widely used approach to nutrition-related behavior change.^{21,22} Demonstration of greater nutrition knowledge and more positive attitudes regarding the value of consuming fruits and vegetables and other healthful foods indicates preparation for actions to increase dietary intake of these foods.²² Exemplification of this link is shown by increased nutrition knowledge and nutrition-related attitudes moderating the association of social economic status and education on intake of fruit and vegetables and diet

quality.²⁵ Nutrition education indirectly addresses disparities in education, employment, and income that are characteristic of the SNAP-eligible population through improved health literacy and resource management skills, enabling participants to overcome nutrition-related disparities by making informed and economically savvy nutrition decisions.²⁶

In 1 sample of 154 SNAP-eligible study participants, only 37% were found to have adequate health literacy, and less than one third of study participants reported using the ingredient list, serving size information, or health claims labels on food packaging.²⁸ Within the state SNAP-Ed protocol, direct SNAP-Ed at the individual SEM level has a degree of flexibility to address the unique nutrition-related disparities of target populations by adapting to specific client needs while assisting participants to access interventions at other SEM levels.²⁹ For example, SNAP-Ed may provide client-tailored budgeting exercises to give participants practical experience optimizing SNAP financial benefits to purchase food and guidance to maximize nutrition per food dollar in a specific situation and environment. Unlike financial nutrition assistance, which may be temporary for many participants, the skills learned via nutrition education may be used for years to come and can be shared with an unlimited number of household and family members or friends, making it a potentially sustainable part of the solution to long-term change

that may ameliorate several nutrition-related disparities.³⁰ Thus, nutrition education has been used as a successful intervention to improve resource management and nutrition knowledge, attitudes, and intake of fruits and vegetables with high potential to improve food security and dietary outcomes, providing a justification for the hypothesized effectiveness of SNAP-Ed.

Scientific evaluation of Supplemental Nutrition Assistance Program–Education effectiveness on food security and dietary intake

The specific aim of this narrative review is to identify and synthesize the results of the scientific evaluation of direct SNAP-Ed to improve food security and dietary intake to clarify the evidence base for SNAP-Ed. Goals inherent to scientific evaluation include provision of evidence of a causal relationship; elimination of alternative explanations; bias mitigation; and sufficient description of study design, sampling, intervention, and analysis to replicate hypothesis testing. Reproducibility of results in different populations, times, and places is also important evidence to support an inclusive basis for program effectiveness. A review summarizing these aspects of published direct SNAP-Ed evaluation research from across the disciplines of nutrition, applied economics, agricultural economics, social and behavioral science, and others will fill a gap in understanding the program impact on food security and dietary intake outcomes of SNAP-eligible adults.

Aside from scientific evaluation, program evaluation is a common reporting mechanism for SNAP-Ed. The USDA Food and Nutrition Service Office of Analysis, Nutrition and Evaluation provides guidance on evaluation of nutrition education interventions to demonstrate program effectiveness through impact and outcome assessment.³¹ Outcome assessment is defined as the determination of change observed with an intervention delivery, whereas impact assessment is the determination of the change resulting from an intervention applying the scientific method and rigorous methodology to exclude potential biases through the use of a control or comparison group.³¹ Both impact and outcome assessment are important to determine the effectiveness of various aspects of the program and to inform program changes and expansion.³¹ Impact evaluation is specifically required to determine the effect of nutrition education on an outcome. The distinction between scientific evaluation and program evaluation may influence the study design and results but is not always clear in reports. For example, program evaluation results may be biased toward positive impact by program administrators or staff in order to show program effectiveness and a basis for further funding.

However, a rigorous outcome or impact evaluation may indeed fulfill criteria as a scientific evaluation even if it does not include a randomized controlled study design.

Impact and outcome evaluations typically occur at an individual level where the exposure to nutrition education is quantifiable for each person. Ecological studies assess the effectiveness of policies or programs at a group or population level where a population or group is expected to have received an intervention but the exposure is not quantifiable at an individual level. Ecological studies are often used in the fields of applied economics or agricultural economics and may allow inclusion of policy-level or additional population-level outcomes or covariates. Although these types of studies are cross-sectional and cannot show causality, they may provide insight on policy or population-level associations and contribute to hypothesis generation. Population-level studies that use data across multiple time points may provide stronger evidence toward causality compared with single time point cross-sectional data; however, the exposure on the individual-level is estimated using a nondirect, or proxy, measure.

Study selection and methods for narrative review

Studies reviewed met the following criteria: the study was suitable as a scientific evaluation of the effectiveness of a direct SNAP-Ed program delivered to individuals or a population on the outcomes of food security, including food resource management skills, or dietary outcomes, including the nutrition-related behaviors of knowledge, attitudes, self-efficacy, and intent to change, in addition to dietary intake and quality; the direct SNAP-Ed program evaluated was delivered to adults and distinguishable from other nutrition education programs; and results were published as original research in peer-reviewed scientific journals or government reports accessible through USDA websites. The studies evaluated direct SNAP-Ed, but the direct education could be delivered via individual, group, or online formats. Searches were performed in June 2017 and October 2018 in the Purdue University Libraries online database (www.lib.purdue.edu) using the peer-reviewed filter, as well as in the following databases: PubMed, AgEcon, JSTOR, Google Scholar, and EconLit. Search terms included “SNAP-Ed,” “Supplemental Nutrition Assistance Program–Education,” “SNAP Education,” or “Food Stamp Nutrition Education.” The USDA Nutrition Education Research webpage and the USDA SNAP-Ed Connection Library webpage were searched for relevant research articles and reports. In addition, the reference lists of articles chosen for review through the searches were examined for relevant articles that may have been missed in the databases.^{32,33} Titles and

abstracts of articles were reviewed to identify whether articles satisfied the inclusion criteria. Where unclear, the article text was reviewed for clarification. The majority of studies included for review were retrieved from the nutrition field because few of the applied or agricultural economics articles that evaluated SNAP-Ed included the food security- or diet-related outcomes focused on in this review or, most often, the focus was evaluation of policies around SNAP rather than a SNAP-Ed intervention. Fourteen articles met the inclusion criteria (Table 1)^{34–47}; 4 evaluated food security, and 10 evaluated dietary outcomes. The majority of scientific articles were published in the *Journal of Nutrition Education and Behavior* (n = 6),^{34–39} *The Journal of Nutrition* (n = 1),⁴⁰ *Journal of the American Dietetic Association* (n = 1),⁴¹ *Journal of Nutrition in Gerontology and Geriatrics* (n = 1),⁴² *Preventing Chronic Disease* (n = 1),⁴³ *International Food and Agribusiness Management Review* (n = 1),⁴⁴ and *California Agriculture* (n = 1)⁴⁵ were also represented. The venue for dissemination of the government reports (n = 2)^{46,47} was the USDA website.

RESULTS

Food security outcomes

SNAP-Ed has been shown to be effective at improving food security (Table 1).^{9,34,40} Results from a recent 1-year, long-term, randomized, controlled SNAP-Ed intervention study conducted in 2013–2014 and a 4–5-week, short-term, randomized, controlled FSNE intervention study conducted in 2005 revealed that FSNE and SNAP-Ed significantly increased household food security in Indiana households eligible for FSNE/SNAP-Ed ($P < 0.01$; $P = 0.03$).^{34,40} Food resource management skills are an important component of improving food security; questions in the US Household Food Security Survey Module query aspects of managing food resources.¹⁰ Evidence from a 4-week, short-term, prospective, pre/post-test study conducted from 2011 to 2013 in California suggested improvement in food security indicated by 1 question asking participants how often they ran out of food by the end of the month after receiving SNAP-Ed lessons focused on food resource management skills.³⁵ The improvement was greater among participants receiving SNAP benefits compared with those not receiving benefits.³⁵ A quasi-experimental study with a comparison group determined significant increases in food resource management skills in the intervention group in contrast with the comparison group using propensity score matching ($P < 0.05$).³⁸ Although the studies numbered only 4, the evidence is strong due to the randomized, controlled,

and longitudinal nature of the study designs used^{34,40}; the consistent results across various places, times, and samples^{34,35,38,40}; and the practical strength demonstrating that the food security status of a participant could change from one class of food security to another.^{34,35,40} Experimental and longitudinal study designs greatly reduce the chance that SNAP-Ed improvement in food security is due to external influences or residual confounding. The evidence may be strengthened further by evaluating effectiveness in diverse populations across the United States representing other low-income groups reached through SNAP-Ed.

Dietary outcomes

Attitudes toward nutrition-related behaviors. A person's willingness to shift their attitude in regard to dietary behaviors is an internal determinant of behavior change and a focus of SNAP-Ed interventions. Recent social psychology evidence has shown that attitudes may predict behavior when the measure used has high construct and criterion validity.^{57,58} Attitudes, described as “a weighing of pros and cons,” may be an indication of a participant's willingness to adopt a targeted health behavior or internalize its perceived importance.⁵⁹ A new experience or gain in knowledge can shift attitude and ultimately influence behavior. Only 1 study assessed attitudes, and it found a significant dose–response effect of the number of SNAP-Ed classes attended at farmers' markets with increased willingness to try new fruits and vegetables and a higher rating of the importance of eating fruits and vegetables ($P < 0.001$).³⁷ The study was an after-only, quasi-experimental design with a nonequivalent and inactive control group,⁶⁰ and participants were surveyed over a short-term period of 1 week during 2012.³⁷

Self-efficacy for nutrition-related behaviors. Self-efficacy, the personal belief or confidence in one's capability to carry out actions toward a goal,^{61,62} applies to nutrition-related behaviors as established in health behavior change theories and promoted by the USDA.^{22,63} Development of self-efficacy is a second internal determinant of health behavior change and major focus of direct SNAP-Ed. The same study that assessed attitude also evaluated self-efficacy and found participants who attended at least 2 SNAP-Ed classes at farmers' markets reported significantly greater self-efficacy to prepare and consume fruits and vegetables compared with those that attended only 1 or no classes ($P = 0.005$).³⁷

Intention to change nutrition-related behaviors. Intention to change, or the motivation to change specific future behaviors, is a third internal determinant of nutrition-related behavior change related to

Table 1 Summary of studies evaluating the outcome or impact of Supplemental Nutrition Assistance Program–Education (SNAP–Ed) direct nutrition education on food security and dietary intake in adult participants

Primary outcome	Reference	Specific outcome	Tool	Study design	Theory/model/framework	Study results
Food security	Eicher-Miller et al (2009) ³⁴	Household food security	6-item USDA US Household Food Security Survey Module ⁹	Experimental	Social Cognitive Theory	FSNE-eligible adult women in Indiana increased household food security by 0.37 ± 0.17 (mean \pm SD) units on the United States Household Food Security Scale ranging 0–6 ($P = .03$) after receiving 5 FSNE lessons over 5 weeks in the intervention group ($n = 137$) compared with a control group ($n = 82$)
	Kaiser et al (2015) ³⁵	Running out of food before the end of the month	Question from EFNEP evaluation tool “How often do you run out of food before the end of the month?” ⁴⁸	Prospective pre/post-test	Social Cognitive and Adult Learning Theories	Adult participants receiving SNAP benefits and who increased food resource management skills also increased food security as indicated by running out of food by the end of the month by 0.04 ± 0.009 (mean \pm SE) ($P = .001$) compared with SNAP-eligible nonparticipants after all participants ($n = 3,744$) received 4 SNAP–Ed lessons over a 1-month period.
	Rivera et al (2016) ⁴⁰	Household food security; Food security among household adults and children	18-item USDA US Household Food Security Survey Module ⁹	Experimental	Social Cognitive Theory	Indiana SNAP–Ed eligible households increased food security by 1.2 ± 0.4 units (mean \pm SEM) on the United States Household Food Security Scale ranging 0–18 ($P < .01$) from baseline to 1 year follow-up after receiving ≥ 4 SNAP–Ed lessons over a 4–10 week intervention period in the intervention group ($n = 163$) compared with a control group ($n = 165$). Food security among adults in the household also improved by 0.9 ± 0.3 units on the United States Adult Food Security Scale ranging 0–10 ($P < .01$).
	Adedokun et al (2018) ³⁸	Food resource management skills	5 items from EFNEP Behavior Checklist ⁴⁹	Quasi-experimental	Adult Learning Theory	Intervention group participants ($n = 413$) who received SNAP–Ed over a 7-week period increased food resource management skills by an average of 3.8 points ($P < .05$) on a scale created by summing responses to 5 items compared with a control group ($n = 113$) among a sample of SNAP–Ed-eligible adults from 16 Kentucky counties.

(continued)

Table 1 Continued

Primary outcome	Reference	Specific outcome	Tool	Study design	Theory/model/ framework	Study results
Dietary intake	Block Joy et al (2004) ⁴⁵	Intake of fruit, dairy, and other, non-nutritious foods	24-hour dietary recall	Prospective pre/post-test	Home Study Method	California Food Stamp Nutrition Education Program participants in Los Angeles (n=167) and Merced (n=263) counties increased the number of servings of fruit (0.4 servings) and dairy (0.2 servings) consumed and decreased the number of other, non-nutritious foods (0.4 servings) after receiving 1 nutrition education lesson in person and receiving materials from 5 lessons in the mail ($P<.05$). Dietary intake was assessed using a 24-hour recall administered in person before the nutrition education lesson and over the phone postintervention. Mean of naturally occurring food folate ($P=.009$) and total folate from all sources ($P=.045$) was significantly higher in intervention group (n=77) low-income nonpregnant women of childbearing age who received a 2.5-hour Food Stamp Nutrition Education lesson on folate compared with participants in a control group (n=78) who received education on resource management. Intervention group participants receiving WIC benefits (n=46) had higher intakes of folate from naturally occurring food folate ($P=.004$), synthetic folic acid from fortified foods ($P=.009$), and total folate from all sources ($P=.035$) compared with control group participants receiving WIC benefits (n=36). Intervention group participants not receiving Food Stamp benefits significantly increased folate intake from these three sources compared with intervention group participants receiving Food Stamp benefits.
	Cena et al (2008) ⁴¹	Intake of folate	Block Dietary Folate Equivalents (DFE) Screener (Block Dietary Data Systems, Berkeley, CA)	Experimental	Learner-Centered Education Framework	Intervention group participants significantly increased frequency of using Nutrition Facts labels compared with control group ($P<.05$) and there was a trend observed for increase in planning meals ahead of time ($P=.055$).
		Behaviors	FSP Food Behavior Checklist ⁵⁰			

(continued)

Table 1 Continued

Primary outcome	Reference	Specific outcome	Tool	Study design	Theory/model/ framework	Study results
	Bonanno and Goetz (2012) ⁴⁴	Intake of 5 fruits and vegetables per day	Centers for Disease Control and Prevention Behavioral Risk Factor Surveillance System (BRFSS) ⁵¹ survey (state level aggregates)	Time series from continuous cross-sectional survey (population-level)	None	Generalized Method of Moments (GMM) and Ordinary Least Squares (OLS) modeling revealed that a \$1 increase in SNAP-Ed spending per person across the United States predicted an increase of 1.4%–1.8% in incidence of daily consumption of 5 fruits and vegetables (n=423). SNAP-Ed was included as a covariate in modeling. BRFSS data was used covering years 1998–2006.
	Dannefer et al (2015) ³⁷	Intake of fruits and vegetables Attitude toward fruit and vegetable consumption Self-efficacy to prepare and consume fruits and vegetables	University of California Cooperative Extension Food Behavior Checklist ⁵² Extension program evaluation instrument ⁵³ Fruit and Vegetable Inventory ⁵⁴	Quasi-experimental	Social-Ecological Model	Attending ≥2 SNAP-Ed classes (n=736) at a Farmers' Market compared with attending 1 class (n=656) or 0 classes (n=671) was associated with increased consumption of fruits and vegetables each day (4.62 cups vs 4.17 cups, $P<.001$), usually or always consuming meals with ≥2 cups of fruits and vegetables ($P<.001$), and usually or always consuming fruits and vegetables as snacks ($P<.001$) in a dose-response manner after controlling for covariates. There was a significant dose-response effect of the number of classes with increased willingness to try new fruits and vegetables and importance of eating fruits and vegetables ($P<.001$). Participants who attended ≥2 classes reported higher self-efficacy to prepare and consume fruits and vegetables ($P=.005$) with no difference between those attending 1 compared with no classes.
	Savoie et al (2015) ³⁶	Intention to change behavior	Survey developed by Utah State University faculty	Retrospective post-then-pre-test	Theory of Planned Behavior	Adult participants in Utah (n=203) increased intent to engage in specific nutrition-related behaviors from sometimes to usually ($P<.001$) after receiving 1 SNAP-Ed lesson.
	Molitor et al (2015) ⁴³	Intake	California Health Interview Survey items related to fruit and vegetable, fast food, and sugar-sweetened beverage consumption	Cross-sectional (population-level)	None	California adults (n=4245) in high SNAP-Ed reach census tracts reported consuming fruits and vegetables a greater number of times per day (1.79) ($P<.05$) and lower number of fast food intake per week (-2.08) ($P<.05$) compared with no SNAP-Ed reach.

(continued)

Table 1 Continued

Primary outcome	Reference	Specific outcome	Tool	Study design	Theory/model/framework	Study results
	Gabor et al (2012) ⁴⁶	Intake	FSP Fruit and Vegetable Checklist ⁵⁵ University of California Cooperative Extension Food Behavior Checklist ⁵²	Experimental	Satter Model of Eating Competence	SNAP participating or eligible adult women (n=202) aged 18–45 in Pennsylvania did not improve eating competence scores or daily intake of fruits alone, vegetables alone, or combined fruits and vegetables after completing a 5 lesson SNAP-Ed web-based program compared with a control group. Overall diet quality was not different between the treatment groups
	Long et al (2013) ⁴⁷	Intake of fruits and vegetables Behavior	24-hour dietary recall University of California Cooperative Extension Food Behavior Checklist ⁵²	Quasi-experimental	BEHAVE Framework	Seniors aged 60–80 (n=510) from 17 intervention senior lefts in Michigan improved daily intake of combined fruits and vegetables by a mean of 0.52 cups (0.23–0.82) (95% CI, $P \leq .01$) and fruits alone by a mean of 0.20 cups (0.01–0.38) (95% CI, $P \leq .05$) and vegetables alone by 0.31 cups (0.16, 0.47) (95% CI, $P \leq .01$), and added fruits or vegetables as ingredients to meals by 1.93 days in the past week (1.14–3.27) (95% CI, $P \leq .05$) after receiving 4 SNAP-Ed lessons compared with seniors from 16 comparison lefts. Primary and secondary results were reported in the Supplemental Nutrition Assistance Program Education and Evaluation Study (Wave II) report by the USDA ⁴⁷ and are summarized in the row above. Additional secondary results indicated a significantly higher percentage of seniors aged 60–80 (n=510) from 17 intervention senior lefts in Michigan talked about fruits and vegetables they should not eat with a health care provider (9.4% mean difference $P \leq .01$) and talked about how to increase consumption of fruits or vegetables each day with friends or family (29.18% mean difference $P \leq .01$) after receiving 4 SNAP-Ed lessons compared with seniors from 16 comparison lefts
	Hersey et al (2015) ⁴²	Intake of fruits and vegetables Behavior	University of California Cooperative Extension Food Behavior Checklist ⁵²	Quasi-experimental	BEHAVE Framework	

(continued)

Table 1 Continued

Primary outcome	Reference	Specific outcome	Tool	Study design	Theory/model/framework	Study results
	Molitor et al (2016) ³⁹	Intake Diet quality	24-hour dietary recall ⁴⁸ Healthy Eating Index (HEI)–2010 ³⁶	Cross-sectional (population-level)	None	Low-income mothers (n=6 355) in high reach SNAP-Ed California census tracts had higher intakes of fruits and vegetables (0.3 ± 0.1) ($P < .01$) and fruits and vegetables from fast food restaurants (0.03 ± 0.015) ($P = .05$), lower intake of calories from high fat foods (-34.6 ± 13.6) ($P = .01$), sugar-sweetened beverages (-0.17 ± 0.086) ($P = .05$), and calories from high fat foods from fast food restaurants (-13.3 ± 6.15) ($P = .03$) compared with no or low SNAP-Ed reach areas. No association between HEI-2010 and SNAP-Ed reach was found. Mean HEI-2010 was 50.6 controlled for race/ethnicity and education

Abbreviations: EFNEP, Expanded Food and Nutrition Education Program; FSNE, Food Stamp Nutrition Education; FSP, Food Stamp Program; GMM, generalized method of moments; HEI, Healthy Eating Index; OLS, ordinary least squares; SE, standard error; SEM, standard deviation; SNAP, Supplemental Nutrition Assistance Program; SNAP-Ed, Supplemental Nutrition Assistance Program–Education; USDA, United States Department of Agriculture; WIC, Special Supplemental Nutrition Assistance Program for Women, Infants, and Children.

self-efficacy. Social psychology literature has shown that behavior can be predicted by measuring intention.⁶² In 1 retrospective post-then-pre-test study, where postintervention outcomes followed by preintervention outcomes are sequentially assessed after attending an educational lesson, participants reported a significant increase in the intention to change specific nutrition-related behaviors after receiving 1 SNAP-Ed lesson either on menu planning and shopping or MyPlate ($P < 0.001$).³⁶

Nutrition-related behaviors. Nutrition-related behaviors promoted by direct SNAP-Ed may include planning meals ahead of time, using a grocery list while shopping, reading Nutrition Facts labels to assist purchasing decisions, and applying cost-efficient ways to incorporate more fruits and vegetables in meals. A variety of these targeted behaviors were evaluated in the studies reviewed (Table 1).^{37,41,42,47} In 2011, a 4-week, short-term, quasi-experimental study evaluated a SNAP-Ed program for seniors as a demonstration project through the USDA; results were reported by both Long et al⁴⁷ and Hersey et al.⁴² Significantly more participants in the intervention group compared with the control group strongly affirmed that they “add fruits and vegetables as ingredients to meals to help eat more fruits or vegetables” from baseline to postintervention assessment ($P \leq 0.05$).^{42,47} In addition, significantly more intervention participants compared with a no treatment control group talked with a healthcare provider and friends and family about eating fruits and vegetables ($P \leq 0.01$).^{42,64} Participants who attended > 2 SNAP-Ed classes at farmers’ markets reported eating fruits and vegetables as snacks and including > 2 cups of fruits and vegetables at meals compared with participants who attended only 1 or no class.³⁷ A 1-lesson, short-term, experimental study in 2006 assessed behaviors along with intake and found that intervention group participants who received a 2.5-hour nutrition lesson increased the frequency with which they used Nutrition Facts labels compared with an active control group that received a resource management lesson.⁴¹

Dietary intake. Dietary intake is the most direct measure for the targeted behavior change of improving diet, and fruit and vegetable intake has been a major focus of SNAP-Ed. An additional USDA demonstration project was a 4-lesson, short-term, experimental study; the on-line SNAP-Ed intervention was found to have no effect on fruit or vegetable intake.⁴⁶ The 2006 experimental study mentioned previously in the “Nutrition-related behavior” section focused on folate intake, a nutrient rich in fruits and vegetables, and found an increased intake of folate-rich foods and sources by nonpregnant women of child-bearing age in the intervention group

after receiving one 2.5-hour FSNE lesson on folate compared with a control group.⁴¹ Five studies measured self-reported average daily intake of cups of vegetables, cups of fruit, and combined cups of fruit and vegetables, with responses ranging from “none” to “three or more cups.”^{37,39,42,43,46,47} Participants who attended at least 2 SNAP-Ed classes reportedly increased daily intake of fruits and vegetables by one half serving compared with those that attended only 1 or no classes in the quasi-experimental studies.^{37,42,47} Results from 1 study revealed a dose-response effect by the number of classes, with a nearly 20% increase of cups of fruits and vegetables consumed each day with each additional class taken.³⁷ Variety of fruits and vegetables consumed in the past week was also assessed in studies by quantifying the number of days participants consumed > 1 type of fruit or vegetable, but a statistically significant change was not discovered ($P > 0.05$).^{42,46,47}

Two population-level, cross-sectional studies determined the association between dispersion of SNAP-Ed reach (high, medium, low, or no reach) and self-reported intake of fruits and vegetables, fast food, and sugar-sweetened beverages among low-income adults and among low-income mothers in California.^{39,43} Adults in Census tracts with a high dispersion of SNAP-Ed reach reported consuming fruits and vegetables more frequently than adults in Census tracts with no to moderate dispersion of SNAP-Ed reach.⁴³ Similarly, low-income mothers in high-dispersion SNAP-Ed reach Census tracts reported greater intake of fruits and vegetables.³⁹ A national-level study predicted the relationship of SNAP-Ed funding with intake of 5 fruits and vegetables per day using a time series model with continuous cross-sectional data.⁴⁴ State-level data from the 1998–2006 Centers for Disease Control and Prevention (CDC) Behavioral Risk Factor Surveillance System (BRFSS) was used to create an “eating habits” variable from the percentage of adults who reported eating > 5 servings of fruits and vegetables each day.⁴⁴ A major finding of this observational study was that an increase in \$1 per year in SNAP-Ed funding per person in the United States would result in an increase in the incidence of people consuming 5 fruits and vegetables daily by 1.4%–1.8%.⁴⁴

Dietary components besides fruits and vegetables are promoted in SNAP-Ed and were also investigated. A short-term, prospective, pre/post-test study conducted during 2001–2002 determined increases in dairy, along with fruit and vegetable intake, in addition to decreases in “other, non-nutritious” foods after participants received 1 in-person SNAP-Ed lesson and the lesson materials for 5 lessons in the mail or 4–6 hours of in-person nutrition education.⁴⁵ Low-income mothers in areas with high penetration of SNAP-Ed reach reported lower intake of calories from high-fat foods,

calories from high-fat fast foods, and sugar-sweetened beverages compared with those in areas with no or low SNAP-Ed reach.³⁹ An association was found between residing in areas with high penetration of SNAP-Ed reach and an average of 2 fewer instances of fast food consumption compared with no SNAP-Ed reach among low-income adults.⁴³ No studies were found that determined changes in usual intake. Only associations between direct SNAP-Ed and a single-day dietary intake or single type of dietary assessment have been presented in the literature. Usual intake includes the mitigation of measurement error through multiple dietary assessments, and such estimation would provide insight into the associations and impact of SNAP-Ed on long-term average dietary intake.⁶⁵

Diet quality. Diet quality, as measured using the Healthy Eating Index (HEI), is a comprehensive, density-based score relating to how closely the daily diet aligns with the standards of the DGA.⁶⁶ Currently, there is scant and null evidence on the effect of SNAP-Ed on overall diet quality.³⁹ In the 1 study where dietary quality was quantified, high dispersion of SNAP-Ed was not associated with higher HEI scores among low-income women.³⁹

Overall, the existing research suggest that direct SNAP-Ed may have a positive and meaningful impact in regard to attitudes, self-efficacy, intentions, and behaviors toward increasing intake of nutrient-dense foods. Reported increased intake of fruits, vegetables, dairy, and folate-rich foods and sources and decreases of “other, non-nutritious” foods, calories from high-fat foods, fast foods, and sugar-sweetened beverages represent actual change in dietary intake, but the strength of this evidence for causality is limited by the study designs. Despite the number of studies evaluating dietary outcomes and several positive results, the evidence provides a weak basis for SNAP-Ed dietary improvement due to the lack of randomized, controlled, and longitudinal study designs. All of diet-related studies except for one were short-term (1–2-month study periods) or cross-sectional, and all but two lacked a randomized control group.^{41,44,46} The impact of direct SNAP-Ed to increase several important dietary outcomes, including consumption of whole grains, legumes, fiber, calcium, and healthy sources of fats and reading of nutrition facts labels, has not been assessed.⁶⁷ Without further investigation, the impact of direct SNAP-Ed on intake of the breadth of dietary components of concern, dietary behaviors, and overall diet quality remains unknown, and alternative causes outside of SNAP-Ed for the positive results demonstrated by these studies cannot be ruled out.

DISCUSSION

Study design

The study design is a major factor in the strength of the evidence provided to demonstrate causality or the impact of SNAP-Ed on dietary outcomes and food security. The highest quality study designs, where the SNAP-Ed intervention was the only variable manipulated by researchers between the treatment and control groups, included 2 experimental studies with dietary outcomes and 2 with food security outcomes.^{34,40,41,46} Thus, the change in outcome is attributed to the intervention, but also may be due to factors that made control participants different from intervention participants. For example, participants might have been designated to the intervention group because they did not want to wait to receive the intervention. Randomization provides the strongest evidence for causality because participants are not assigned to the control or intervention group based on any characteristic or situation, removing this potential difference as a cause for the behavior change. The participants in the experimental food security studies were not completely randomized according to the most common random sampling methods, but the randomization procedures were clearly reported, along with inactive control groups.^{34,40} One study with dietary outcomes randomized recruitment sites and implemented an active control group.⁴¹ The second study with dietary outcomes did not describe the randomization procedure other than being fully randomized, and determination of whether the control group was active or inactive was not possible because the control group website was not described.⁴⁶ Despite incomplete reporting of details on the assignment of treatment groups, use of randomization in these studies provides stronger evidence compared with nonrandomization as in the 3 quasi-experimental studies with dietary outcomes.^{37,42,47}

Although the quasi-experimental studies included a control or comparison group, the lack of randomization means that internal validity is threatened and the results cannot be attributed solely to the SNAP-Ed intervention.^{37,38,42,47} Differences in participant characteristics between the treatment groups that may potentially confound the results are generally evenly distributed with randomization but may also be accounted for and controlled for in analysis. Weaker evidence is provided by nonrandomized control, comparison, or delayed intervention groups in quasi-experimental study designs. Creation of a comparison group by propensity matching in the study evaluating food resource management skills is a pragmatic method used when randomization may be difficult, such as in training and encouraging

SNAP-Ed educators to randomize participants to receive education or delay education.³⁸ A comparison group may not be as rigorous as a control group, but it is an improvement on no comparison group for making claims on the effectiveness of SNAP-Ed because the participant characteristic differences between intervention and comparison groups that may be influential on the outcome can be controlled for in analysis.³⁷ Documentation of the control or comparison group assignment protocol, details on whether the control or comparison group received education during or after the study, and results of the comparison of study groups is critical for determining the biases inherent to results. For example, in 1 study the treatment groups were nonrandomly assigned at a single assessment time point based on the number of lessons participants received before the assessment.³⁷ These potentially biased study design characteristics limit the strength of the study's positive findings because the group that received lessons was self-selected.³⁷

A retrospective post-then-pre-test study design used in 1 of the studies may reduce response-shift bias; however, recall, participant, and response biases remain.³⁶ Although a retrospective post-then-pre-test study design increases the likelihood of complete responses from all participants because the post-intervention and pre-intervention outcomes (retrospectively) are assessed after the intervention compared with a prospective pre-then-post-test design where the pre-intervention outcomes are assessed before the intervention period and the post-intervention outcomes are assessed after the intervention period,^{35,37,38,41,45,68} the former lacks important information on participants who dropped out of the program. Therefore, determination of how program noncompleters differ from completers is missing, in addition to information that could be used to tailor the program to those at risk of noncompletion and who may benefit most from SNAP-Ed. Administering a pretest immediately before and posttest after each lesson is 1 method to reduce influence of recall bias compared with delivering a series of lessons and then administering the assessment; in the second case, participants may not remember their behaviors and dietary intake before the lessons began. The greatest improvement in outcomes is expected and reflected in a posttest immediately following the nutrition education; however, attenuated effects are expected over time, thus highlighting the importance of longitudinal follow-up study periods to determine the long-term, or actual, impact of the intervention.

The length of study and follow-up periods is another important study design feature to document. Temporality is necessary to determine that changes in outcomes are due to the SNAP-Ed intervention; the

exposure must predate the outcome, and assessments should match the study and follow-up periods.⁶⁹ The California-based, population-level studies were cross-sectional, eliminating demonstration of temporality and causality.^{39,43} The national-level study attempted to provide evidence that SNAP-Ed causes “healthier eating” by increasing the number of people who consume 5 fruits and vegetables a day by analyzing data over an 8-year period.⁴⁴ All prospective studies, except 2, were short-term.^{34,35,37,38,40–42,45–47} A longitudinal follow-up allows determination of change and continuation of impact over time. For example, in the single longitudinal study represented, a significant impact on food security was only detected at the 1-year follow-up ($P < 0.01$) with no impact detected over the short-term assessment ($P > 0.05$).⁴⁰ If only a short-term follow-up period was included, the results would have indicated a null impact of SNAP-Ed on food security. These findings support the use of a follow-up period of at least 1 year. An overall strength in study designs was that the length of time that participants were asked to reflect upon in the assessments matched the study periods. This is especially important in longitudinal studies to ensure temporality, where results reflect the intervention and not some other external influence not measured in the study.

Health behavior change theories

The inclusion of health behavior change theories, models, instructional design methods, and frameworks in designing and evaluating SNAP-Ed programs was reported for each study and provides a guide to improving and measuring food security and dietary outcomes and a context in which to interpret the application of results. The Social Cognitive Theory was the theory that most commonly formed the basis of nutrition education programs reported, although a variety of others was used.^{34,35,40} For the 3 population-level studies, use of a theoretical framework to guide their investigations was not reported, but the importance of evaluating SNAP-Ed at various levels of the SEM in future research was mentioned.^{39,43,44} One multilevel intervention implemented direct SNAP-Ed at the individual level through nutrition education lessons and concurrently in the community setting of farmers’ markets.³⁷ The goal of multilevel SNAP-Ed interventions is to reinforce concepts and skills learned through direct SNAP-Ed on the individual level; however, analysis of the contribution from the level of settings, sectors, and social/cultural norms levels on change in participants’ dietary intake or food security is a recent consideration emerging in the evaluation literature.^{70,71} The influence of multilevel SNAP-Ed interventions on the impact of individual-

level direct SNAP-Ed to improve dietary intake and food security remains unknown.

Intervention

Three group- or population-level studies assessed associations of SNAP-Ed presence with dietary outcomes, and none assessed associations with food security outcomes.^{39,43,44} In these studies, the implementation of a SNAP-Ed intervention was not able to be confirmed or quantified, but rather estimated using proxy data. Inflation-adjusted, per-capita SNAP-Ed expenditures obtained from the USDA Food and Nutrition Service served as a proxy for federal spending on nutrition education programs in 1 study.⁴⁴ The other 2 publications reported on related studies where penetration of SNAP-Ed reach was characterized by dividing the number of California SNAP-Ed participants by the number of SNAP-Ed-eligible residents in a Census tract area.^{39,43} The SNAP-Ed participation data came from the 2011 and 2014 USDA’s Education and Administrative Reporting System, and SNAP-Ed eligibility was determined using income information from Census tract data.^{39,43} The major limitation of not quantifying or confirming receipt of SNAP-Ed by study participants is the inability to attribute impact on outcomes due to SNAP-Ed, and at best, weak associations between estimated presence of SNAP-Ed and outcomes.

SNAP-Ed interventions of individual-level studies differed by dose or exposure, method of delivery, and content. Studies measured the dose of exposure in terms of number of lessons and defined the intervention as 1 or > 2 classes;³⁷ 2 select lessons (Menu Planning; Shopping and MyPlate);³⁶ or 4 or 5 core lessons that best reflected the DGAs and covered the USDA key behavioral outcomes.^{34,35,40} One study did not specify the number of classes, only that intervention participants completed a post-test upon “exit” of the program, which usually takes 7 weeks to complete.³⁸ The variability in the interventions across the studies may be considered as both a strength and weakness for determining the effectiveness of SNAP-Ed. On the one hand, variety across interventions allows for building a broad evidence base and provides flexibility to choose an intervention that best serves the population. On the other hand, a large number of different interventions may also result in fewer evaluations per intervention and weaker overall evidence of program effectiveness as a whole. This latter situation characterizes the current state of the science regarding the determination of SNAP-Ed to improve food security and dietary outcomes.

Outcomes and measurement

Surveys were the main measurement tool used to assess dietary and food security outcomes. In 1 study researchers created their own survey questions³⁶; others implemented existing survey instruments or adapted questions from existing surveys^{34,35,38,40–42,46,47} or used a combination.³⁷ Adapting questions from other surveys is beneficial, especially if those questions have already been tested for reliability and validity in similar study populations, but adaptation may result in the loss of reliability and validity from previous testing. Developing new survey questions could advance the field by contributing measures using the most up-to-date information. Townsend systematically described the stages for developing and implementing credible survey tools with validity, reliability, and sensitivity⁵⁷; however, a lack of the consistent use of validated and reliable measurement instruments persists and contributes to the current weak evidence of the effectiveness of SNAP-Ed to improve dietary intake and quality. The use of validated and reliable surveys to measure or classify food security in the studies contributes a strength.

Food security. Three of the 4 reviewed studies with food security outcomes described similar definitions of food security,^{4,34,35,40} hypothesized a similar mechanism of how SNAP-Ed may improve the food security of participants, and used validated and reliable surveys, but varied in the quantification and classification of food security. The fourth study did not specifically state food security as an outcome but described food resource management skills as being influential on food security and quantified food resource management skills similar to how “food security” was quantified in a different study based on 1 question.^{35,38} These 2 food security-related studies are not comparable with the 2 experimental studies because food resource management skills were quantified.^{35,38} Justification for query of food resource management to assess “food security” was provided by citing another study that had also measured food security using the same question,^{35,72} but validation of this single question as an indicator of food security as defined by the USDA Economic Research Service is not known. In addition, the food security classification (ie, full, marginal, low, or very low food security) and indication of household or adult food security is not specified by this 1-item measure. The authors were forthcoming in noting this situation as a limitation; however, the conclusion that the SNAP-Ed intervention in the study improved food security is tempered by these limitations. Use of any of the US food security survey modules would provide comparatively stronger evidence for the effectiveness

of SNAP-Ed to improve food security. Comparison of food resource management skills is not a direct and specific measure of food security status and scores as measured by US food security survey modules but provides important information on the components and barriers to improving food security that are impacted by SNAP-Ed.

The 2 experimental studies quantified food security using the USDA US Household Food Security Scale and classified food security status based on the methods detailed by the USDA ERS Guide to Measuring Household Food Security^{10,34,40}; the long-term study administered the 18-item survey with a 12-month and a 30-day reference period,⁴⁰ and the short-term study used the 6-item survey with a 30-day reference period.³⁴ Because the 18-item survey queries similar concepts as the 6-item, the results from these studies are comparable on the household level and align with the definition of food security, which includes everyone in the household. Classifying food security outcomes using the USDA ERS procedures aligns SNAP-Ed evaluation with national standards, allowing for comparisons of results not only across SNAP-Ed studies but also across studies in other US populations using the same measure and outcome.

In addition to the classification of food security status, it is important to be able to capture information on movement among any of the classifications before and after the SNAP-Ed intervention because of the health-related outcomes associated with each of the 4 classifications.⁷³ Chi-square tests in the experimental food security outcome studies revealed positive improvement in the intervention compared with the control groups; the overall improvement due to the SNAP-Ed intervention is affirmed by linear regression models using the raw food security score as the dependent outcome variable.^{34,40} A limitation of the 6-item survey is an inability to distinguish between full or marginal food security classifications, resulting in only 3 food security classes by combining the full and marginal food secure classes into 1.³⁴ The long-term experimental study retained the 2 food-secure classes but combined the low and very low food-insecure categories into 1 food-insecure class.⁴⁰ The study population prevalence among all 4 food security classifications was not presented in any of the studies and would have added novel descriptive information on the prevalence of the SNAP-Ed-eligible population in each of the 4 food security classes to inform future studies.

Determination of the specific level of food security status where SNAP-Ed is most impactful was not a goal of any of the studies. Participants with higher food security may be able to improve their food security more easily compared with participants with lower food

security. Wider score ranges comprise food insecurity compared with a narrow score range for food security. Constructs that group participants into lower food security increase in severity, constrained resources, and difficulty to overcome. Alternatively, participants with higher food security may not have as much room to improve their food security compared with participants with lower food security. These inherent constructs to the food security scale present future opportunities to determine the level of food security where SNAP-Ed interventions are most effective.

Dietary intake. Increased nutrition knowledge, improved attitudes toward healthy food-related behaviors, and greater intent to change food-related behaviors are internal determinants that may precede dietary behavior change, but they are not directly representative of actual improvements in dietary intake. Thus, these indicators do not demonstrate effectiveness of dietary intake improvement by direct SNAP-Ed. Observation of change in these internal determinants of behavior may be easier to query with surveys using Likert scales and easier to change in a short-term period compared with dietary behavior change.^{37,42,46,47} Limitations on using such scales include the inability to define the relationship among the categories, whether response categories are ordinal or nominal, and whether labels introduce social desirability bias.⁷⁴ In an attempt to address issues characteristic of Likert scales, a dichotomous variable was created and reported for 2 studies instead of an average score.^{42,47} This dichotomous variable presented a clear determination that participants did not engage in a targeted behavior and did not improve targeted behaviors over time due to the SNAP-Ed intervention.

Barriers to quantifying dietary intake. Measures to quantify dietary intake pose challenges to evaluation; however, they provide a quantitative representation of dietary intake compared with describing change in internal determinants of behavior. Assessment of self-reported intake of foods is 1 practical and direct method to quantify changes in dietary intake due to a SNAP-Ed intervention. The difficulty in effectively measuring self-reported intake due to measurement error may be 1 explanation as to why so few studies quantify dietary intake of SNAP-Ed participants even though the goal of SNAP-Ed is to improve dietary intake. Measurement error is the difference between the self-reported (observed) value and the true value and may be influenced by both random and systematic error. Statistical methods exist to reduce dietary measurement error, yet these methods have not been applied to SNAP-Ed evaluation. Alternative dietary measurement methods are also subject to error and difficult and costly to implement in

community intervention evaluations.⁷⁵ Dietary recovery biomarkers are limited to energy, protein, sodium, and potassium in weight-stable individuals.⁷⁶ Other nutritional status biomarkers are homeostatically regulated and not reflective of specific information as to the dietary source, food groups, or types and amounts of foods consumed.⁷⁵ SNAP-Ed focuses on consumption of foods and food groups and less on specific nutrients; therefore a measurement tool capable of providing this important information is consistent with the SNAP-Ed content.

The estimation of usual dietary intake is the most useful outcome to determine how SNAP-Ed may impact behaviors over time, not just 1 day or as a snapshot. Although dietary intake can be collected using food records, food-frequency questionnaires, and 24-hour dietary recalls, each method has unique biases and characteristics that complement certain study designs and are more amenable to certain populations.⁷⁷ Two 24-hour dietary recalls are sufficient to estimate the mean usual intake for the study sample before and after the intervention.⁷⁷ Compared with survey questions used in most of the studies and with the more time-consuming and computationally burdensome food-frequency questionnaire, 24-hour dietary recalls provide a less biased, lower burden, and more detailed method to determine changes in dietary intake. A shorter survey, such as a food intake screener,^{78,79} may be easier to implement, but the ability to estimate usual dietary intake is lost.^{48,77,80}

The methods previously described to estimate usual dietary intake (ie, 24-hour dietary recall and food-frequency questionnaire) are also used to characterize dietary quality at the individual and population-level through the HEI.⁶⁶ Measuring dietary quality is important to obtain an overall evaluation of dietary intake because observed improvements in a few dietary components (ie, increased fruit intake) may actually be negatively compensated for by behaviors that counterbalance positive improvements in overall diet quality. The HEI uses a density-based approach to evaluate dietary quality and is updated approximately every 5 years by researchers at the National Cancer Institute and the USDA in order to maintain consistency with the DGA.⁸¹ The HEI is an ideal tool to assess diet quality changes with SNAP-Ed because SNAP-Ed promotes dietary compliance with the recommendations in the DGA.⁶⁶ An HEI score with a range from 0–100 is created by summing scores from dietary components encouraged to increase, such as dairy foods, fruits, and vegetables, along with dietary components to consume in moderation, such as saturated fat and added sugars. A score of 100 indicates perfect compliance with the DGA, whereas a score closer to 0 indicates poor compliance.

Advancements in technology enhance the affordable and convenient facilitation and estimation of usual

dietary intake and quality.⁸⁰ When completed on a computer, the Automated Self-Administered 24-hour dietary recall assists portion size estimation with built-in visual aids.⁴⁸ Utilizing similar strategies as described in a study, such as providing visual aids to guide accurate portion size estimation, can reduce attenuation or exaggeration of observed change in dietary outcomes common in prospective pre/post-test study designs.³⁷ An example of this response shift bias is an improved ability to identify whole grains or estimate portion sizes after having received nutrition education compared with baseline assessments. Estimating dietary intake using a retrospective post-then-pre-test study design is especially susceptible to social desirability and recall bias that may not be improved using visual aids.³⁶

Other barriers to implementing measurement of dietary intake include the burden on participants, researchers, and program staff. Erroneous reporting may be related to low literacy and is associated with participant characteristics that may more prevalently impact the population receiving direct SNAP-Ed compared with the general population, such as being overweight,⁸² of female gender,^{82,83} or having a desire to please or impress the nutrition educators.⁸⁴ Determination of the true effect of direct SNAP-Ed on dietary intake requires minimization of these potential biases and a dietary assessment that will not require a high reading level or include a computational demand on participants.

Analysis

Overall the methods of statistical analysis were appropriate for the study designs, but justification for specific statistical methods should have been explained in more detail to improve transparency. One study used a Wilcoxon signed rank test with a Bonferroni correction for multiple comparisons and paired *t* test.³⁶ Ordinary Least Squares, or OLS, and the Generalized Method of Moments, or GMM, were used in one population-level study to estimate and control for endogeneity of some explanatory covariates in the model.⁴⁴ Several evaluations used general or mixed linear or logistic regression modeling depending on the type of outcome variable and controlled for factors that may have influenced the change in outcome such as demographics.^{34,35,37–43,46,47} When linear regression models are used for pre-post intervention analysis, controlling for the baseline outcome measure is important because the change in outcome post-intervention is correlated with the baseline status.^{34,40,41} For example, a participant who reports consuming half a cup of fruit per day has greater potential to significantly increase fruit intake compared with a participant who reports consuming four cups of fruit per day. Controlling for baseline consumption allows

for comparison of participants with differential levels for fruit consumption increase.

Potential bias due to attrition and the representativeness of the sample compared with the general SNAP-Ed participant population were rarely described and pose threats to external validity. Attrition presents the issue of participants who finish the study being different from the recruited sample and different from the population of program participants. Only 1 study reported the differences between participants who completed the study and those that dropped out,⁴⁰ and another study reported the sample was similar in race/ethnicity to the counties where participants were recruited.³⁵ There may be characteristics more common to the target audience that influence some participants to complete the program and others to drop out. For example, in the long-term food security outcome study, participants who were younger, not married, or from smaller households were more likely to drop out of the study.⁴⁰ Consideration of participant characteristics is important information to determine whom the program impacts and provide insight for whom the program is not effective. In addition, this was also the only study to compare characteristics of the study sample to the population participating in the program across the state to provide rationale that results would be generalizable to the state SNAP-Ed population.⁴⁰ Similarly, 1 study that reported on food resource management skills compared baseline participant characteristics between the intervention and comparison groups and found important differences that were controlled for in the analysis and noted the limitations on generalizability of the study results.³⁸

A diverse study sample is also important for demonstrating external validity of SNAP-Ed. Potentially influential participant characteristics on dietary and food security outcomes reported in the studies include sex,^{37,38} race/ethnicity,^{37–39,41,43} age,^{35,37,38,40,41,43} food assistance program participation,^{35,40,41} household size,⁴⁰ education level,^{37–39,43} and employment status.³⁴ The sample populations recruited from Utah and Indiana were not racially diverse except for some participants identifying as Hispanic or Latino ethnicity with the majority of participants identifying as white.^{34,39,40} Kentucky participants were predominantly white compared with “Other”.³⁸ The California study populations ranged 42%–65% Hispanic.^{35,39,41,43,45} The most racially and ethnically diverse sample populations were recruited from farmers’ markets in New York City and California.^{37,39,43} Two studies did not report the demographics of the sample populations other than age and sampling from Michigan and Pennsylvania.^{42,46} The senior SNAP-Ed sample included diversity: 31% of participants identifying a race other than white, represented both sexes were represented, and participants were aged

60–80 years.^{42,47} The other sample populations were predominately adults aged < 65 years and female.^{34–39} One other study did not report age.⁴⁵ Interpreting the results and determining whether the assessment tools and outcomes were appropriate are difficult without a detailed description of the study population.

An additional study bias was the recruitment of small sample sizes. High attrition rates are common in community nutrition intervention studies, especially long-term studies; thus a small baseline sample size may result in a lack of power or limit the ability to detect statistically significant differences among groups or changes over time. Appropriate sample size estimates based on previous studies of similar relationships are critical to determining a difference in the quantified outcomes; therefore estimates from the studies that mentioned the use of power calculations to determine sample size can be used to inform the sample sizes of future studies.^{36,40,42,46,47} A strength of the group- or population-level studies is inclusion of a large number of participants or geographic coverage.

IMPLICATIONS AND FUTURE DIRECTIONS

The 4 studies comprising the scientific literature on the impact of SNAP-Ed to improve food security included study designs that reduce bias, had consistent positive results across studies, and provide a strong foundational evidence base for future studies to build upon.^{34,35,38,40} Although a greater number of studies with nutrition-related outcomes were reviewed, limitations within and across the studies contribute to a weak body of scientific literature on the effectiveness of SNAP-Ed to improve dietary intake. In addition, an inability to attribute improvements in nutrition-related outcomes to the SNAP-Ed intervention was an issue in all but 1 evaluation;^{42,47} an experimental study showed no improvement.⁴⁶ Standardization of measures and outcomes will allow for more consistent comparisons and the aggregation of outcomes in a meta-analysis to build stronger evidence across a variety of SNAP-Ed interventions, diverse populations, and different study designs.

Inclusion of a control or comparison group, randomization, and long-term study periods of at least 1 year are additional critical components of high-quality studies to provide a strong basis for attributing changes in food security and dietary intake to SNAP-Ed interventions. Intervention details, study design, outcome measures, and method of data analysis in the studies directly relate to the quality and rigor of the study and the presence of bias in results. Funding specifically for longitudinal, randomized, controlled, rigorous impact evaluations is necessary, and the expense may be justified by the addition of more current group- or population-level studies.

The mechanisms and magnitude of how direct nutrition education through SNAP-Ed works to improve food security or dietary intake are currently not fully known. Evaluations combining validated food security survey modules with dietary assessment methods will lead to a more comprehensive perspective on the important public health areas of food security and dietary intake. An interdisciplinary approach using methodology from nutrition, applied economics, agricultural economics, public policy, and social and behavioral science is required for future research to better understand the impact of direct SNAP-Ed and potential synergistic effects of SEM-level interventions on internal constructs of nutrition-related behavior change, actual behavior change, and the outcomes of food security and dietary intake.

CONCLUSION

Direct nutrition education through SNAP-Ed is effective to improve food security. Inconsistency and limited evidence support SNAP-Ed effectiveness to improve dietary intake. The potential for SNAP-Ed to influence long-term healthy nutrition-related behaviors of entire households and communities suggests a value greater than the cost of SNAP-Ed and benefits beyond improving the food security- and diet-related outcomes of individual participants. With the recent focus on interventions to target the policy, systems, and environmental sectors of the SEM, SNAP-Ed may have an expanded potential for impact by reinforcing direct nutrition education with additional SEM intervention to support resources that may be accessible by all community members, including those that do not qualify or participate in the nutrition assistance safety net. SNAP-Ed provides jobs across each state in both rural and urban areas, fosters community development and partnerships, and equips individuals and families with sustainable knowledge to improve diet and health. Yet, these impacts must be scientifically evaluated rather than assumed. SNAP-Ed is an important component of the federal food safety net, but requires the political support, research attention, and funding necessary to scientifically determine the program's impact on the food security and dietary intake of participants.

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Declaration of interest. The authors have no relevant interests to declare.

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