Review

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Impact of Garden-Based Youth Nutrition Intervention Programs: A Review

RAMONA ROBINSON-O'BRIEN, PhD, RD; MARY STORY, PhD, RD; STEPHANIE HEIM, MPH

ABSTRACT

Garden-based nutrition-education programs for youth are gaining in popularity and are viewed by many as a promising strategy for increasing preferences and improving dietary intake of fruits and vegetables. This review examines the scientific literature on garden-based youth nutrition intervention programs and the impact on nutrition-related outcomes. Studies published between 1990 and 2007 were identified through a library search of databases and an examination of reference lists of relevant publications. Studies were included if they involved children and adolescents in the United States and examined the impact of garden-based nutrition education on fruit and/or vegetable intake, willingness to taste fruits and vegetables, preferences for fruits and vegetables, or other nutrition-related outcomes. Only articles published in peer-reviewed journals in English were included in the review. Eleven studies were reviewed. Five studies took place on school grounds and were integrated into the school curriculum, three studies were conducted as part of an afterschool program, and three studies were conducted within the community. Studies included youth ranging in age from 5 to 15 years. Findings from this review suggest that garden-based nutrition intervention programs may have the potential to promote increased fruit and vegetable intake among youth and increased willingness to taste fruits and vegetables among younger children; however, empirical evidence in this area is relatively scant. Therefore, there is a need for well-designed, evidenced-based, peer-reviewed studies to determine program effectiveness and impact. Suggestions for future research directions, including intervention planning, study design, evaluation, and sustainability are provided.
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R. Robinson-O'Brien is an assistant professor, Nutrition Department, College of Saint Benedict+Saint John's University, St Joseph, MN; at the time of the study she was a postdoctoral fellow, Adolescent Health Protection Research Training Program, Division of Epidemiology and Community Health, University of Minnesota, Minneapolis. M. Story is a professor, Division of Epidemiology and Community Health, School of Public Health, University of Minnesota, Minneapolis. S. Heim is a clinical dietitian, Department of Endocrinology, Mayo Clinic, Rochester, MN; at the time of the study, she was an adolescent health fellow, Division of Epidemiology and Community Health, University of Minnesota, Minneapolis.

Address correspondence to: Ramona Robinson-O'Brien, PhD, RD, Nutrition Department, College of Saint Benedict+Saint John's University, 37 South College Ave, St Joseph, MN 56374. E-mail: rrobinsonobrien@csbsju.edu

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Concern for the health and nutritional intake of youth in the United States remains a national priority, and food and nutrition professionals and nutrition educators continue to seek innovative and effective approaches to improving dietary intake among children and adolescents. Optimal fruit and vegetable intake is associated with good health and reduced disease risk. Research documents that fruit and vegetable consumption plays a protective role in the prevention of cardiovascular disease, certain cancers, obesity, and other chronic conditions (1,2). Despite the evidence in support of health benefits associated with fruit and vegetable intake (1), national data indicate that fewer than half of boys and girls ages 4 to 18 years consume ≥5 servings of fruits and vegetables daily (3). National efforts are currently underway to promote increases in fruit and vegetable intake among youth. There is evidence indicating that school-based nutrition-education programs may produce moderate increases in fruit and vegetable consumption among youth (4). However, nutrition intervention strategies may be more effective in increasing fruit rather than vegetable intake (5). Garden-based nutrition-education programs may be an ideal venue to encourage increased intake of vegetables as well as fruits, as they often include the opportunity for youth to plant, harvest, and prepare a

vast array of vegetables and some fruits (eg, berries, melons). With multiple exposures to fruits and vegetables through hands-on experiences among their peers, youth may increase their fruit and vegetable intake (6).

Youth garden education programs have been implemented within school and community settings throughout the United States. The National Gardening Association indicates a proliferation of garden education programs across the country (7). There have been numerous anecdotal reports of a variety of healthful youth development outcomes resulting from youth participation in garden programs (8); however, evidenced-based, peer-reviewed research evaluating the impact of participation in garden programs on nutritional outcomes is limited. Garden program leaders have noted improvements in a wide range of characteristics among youth, including environmental attitudes, community spirit, social skills, self-confidence, leadership skills, volunteerism, motor skills, scholastic achievement, and nutritional attitudes (7). In recent years, numerous local and national initiatives have included components to teach food and nutrition through connections with gardens. Examples of these initiatives include: The Edible Schoolyard in California (9), The Youth Farm and Market Program (10), Community Design Center in Minnesota (11), The National Farm-to-School Program (12), and The National Gardening Association, Kids Gardening Initiative (13). Garden programs have the potential to result in a range of benefits associated with positive youth development and offer a hands-on opportunity to develop a greater understanding of food systems through the cultivation of connections with food, the environment, and community.

While garden-based nutrition-education programs may be a promising strategy for improving dietary intake among youth, there is a need for a preliminary evaluation of existing peer-reviewed literature regarding this intervention approach. This review includes articles published in peer-reviewed journals and provides an evaluation of garden-based nutrition intervention programs and their impact on youth fruit and vegetable intake, willingness to taste fruits and vegetables, preferences for fruits and vegetables, and other nutrition-related outcomes. As registered dietitians and food and nutrition professionals continue to seek creative, innovative, and effective nutrition-education strategies aimed at improving youth dietary intake, this review offers insight into the potential effectiveness of utilizing garden-based nutrition intervention programs and provides suggestions for future research directions.

METHODS

Articles published from 1990 through June 2007 were identified by searching PubMed, Argricola, ERIC, and PsychINFO databases. The following keywords were searched singularly and in various combinations: youth, children, school gardens, community gardens, nutrition education, and dietary behaviors. Articles were included in this review if they examined the impact of garden-based nutrition education on youth fruit and vegetable intake, willingness to taste fruits and vegetables, preferences for fruits and vegetables, or other nutrition-related outcomes. Articles were limited to those that targeted children and adolescents in the United States. Only articles published in peer-reviewed journals in English were included in this review. Articles were excluded if the target population focus was on adults, elders, or the community as a whole. Eleven studies were identified that met the review criteria (14-24).

The review is organized by first providing an overview of the study characteristics. Then descriptions of intervention methodologies and measurement tools, and summaries of study outcomes are provided for two general categories of studies: in-school garden-based nutrition-education research and afterschool or community garden-based nutrition-education research. Implications for future research are discussed.

Overview of Study Characteristics

The 11 studies represented a variety of geographic regions, including year-round warm-weather climates and those with colder-winter climates. The studies utilized a variety of intervention designs and measurement tools ranging in intensity and rigor. The studies differed in intervention design methodology and in the types of evaluation tools utilized to evaluate outcomes. Five studies were located on school grounds and were integrated within the school curriculum (14-18), three were conducted as part of an afterschool program (19-21), and three were conducted within the community (22-24). Studies included youth ranging in age from 5 to 15 years, with the majority of participants in third through sixth grade. Five of the 11 studies included intervention and control or comparison groups (14-16,19,21), of which three studies included a comparison of garden-based nutrition education with nutrition education alone (14,15,21), five studies used pre–post tests within the same population (17,18,20,22,24), and one study reported themes from focus groups (23). Investigations routinely relied on convenience samples and varied in intensity as well as duration; with one study reporting 6-month follow-up data (15). Evaluation tools included 24-hour recall workbooks, surveys, one-on-one interviews, and focus groups. The majority of investigators reported attempts to use tools with known reliabilities and/or validated measures.

Outcomes evaluated in this review include fruit and vegetable intake (14,17,20,22), willingness to taste fruits and vegetables (15,16,18), and fruit and vegetable preferences (15-17,19,21,24). This review also includes outcomes of fruit and vegetable knowledge (16,18,19,21,24), self-efficacy to consume fruits and vegetables (19,21), and other nutrition-related outcomes. Findings from a qualitative study with youth who participated in a summer gardening program are also included in this review (23).

Overview of Studies

Figure 1 represents the characteristics of each study reviewed, including study location, population, design and duration, measurement tools utilized, and study outcomes. The following overview of the literature provides more detail about study design, measurement tools and methodologies, and the impact of youth garden-based nutrition education on fruit and vegetable intake, willingness to taste fruits and vegetables, fruit and vegetable preferences, and other nutrition-related outcomes.

Author, year	State	Study population (n)	Design (duration)	Measures	Measurement tools	Nutrition outcomes
In-School						
McAleese and Rankin, 2007 (14)	ID	Sixth-grade male/female (99) Garden+nutrition education (45) Nutrition-education only (25) Control (25)	Pre–post, intervention/control (12 weeks)	FV[a] intake	3-day 24-hour recall workbooks	Significant increase in FV intake among garden+nutrition-education group above nutrition-education only and control group. Significant increase in vitamin A, vitamin C, and fiber among garden+nutrition-education group.
Morris and Zidenberg-Cherr, 2002 (15)	CA	Fourth-grade male/female (213) Garden+nutrition education (81) Nutrition-education only (71) Control (61)	Pre–post, intervention/control (9 lessons in 17 weeks; 6-month follow-up data)	Vegetable preferences, willingness to taste vegetables, nutrition knowledge	Questionnaires	Posttest preference scores for carrots and broccoli were significantly greater for garden+nutrition education and nutrition education only group above control group. Posttest preference scores for snow peas and zucchini were significantly greater for garden+nutrition-education group above nutrition-education only and control group. At 6 months, garden+nutrition-education group retained a significantly greater preference for broccoli, snow peas and zucchini. There were no differences between groups in willingness to taste vegetables. Significant increase in general nutrition knowledge among garden+nutrition-education group and nutrition-education only group above control group.
Morris and colleagues, 2001 (16)	CA	First-grade male/female (97) Intervention (48) Control (49)	Pre–post, intervention/control (lessons throughout school year)	Vegetable preferences, willingness to taste vegetables, nutrition knowledge	One-on-one interviews	No significant improvement in vegetable preferences. Intervention students were more willing to taste spinach, carrots, peas, broccoli, zucchini, and red bell pepper. Significant improvements in knowledge to identify food groups, but not ability to identify vegetables.
Lineberger and Zajicek, 2000 (17)	TX	Third- to fifth-grade male/female (111)	Pre–post (10 lessons, delivered to accommodate classroom schedules)	FV intake FV preferences	24-Hour recall journal, preference questionnaire	No increase in FV intake. Significant increases in vegetable preference, but not fruit preference. Significant increase in FV snack preference.
Cason, 1999 (18)	SC	Kindergarten (n not reported)	Pre–post (weekly lessons, duration not reported)	Willingness to taste FV FV identification	Interviewer-led survey	Increase in willingness to taste FV. Increase in number of students able to identify fruits and vegetables.
Afterschool						
O'Brien and Shoemaker, 2006 (19)	KS	Fourth-grade male/female (38) Intervention (17) Control, no intervention (21)	Pre–post, intervention/control (10 weeks)	FV Preferences, nutrition knowledge, self-efficacy to consume FV	Questionnaires	No improvements in FV preferences or knowledge. Increased self-efficacy to consume FV, statistical significance not reported.
Hermann and colleagues, 2006 (20)	OK	Third- to eighth-grade male/female (43)	Pre–post (1 day per week, duration not reported)	Vegetable intake	Single-item survey question	Significant increase in report of daily vegetable intake.
Poston and colleagues, 2005 (21)	KS	Third- to fifth-grade male/female (29) Intervention (18) Comparison, nutrition-education only (11)	Pre–post, intervention/control (8 lessons 1/week)	FV preferences, nutrition knowledge, and self-efficacy to consume FV	Questionnaires	No significant improvements in FV preference, knowledge, or self-efficacy among participants in intervention or comparison groups.
Community						
Lautenschlager and Smith, 2007 (22)	MN	8-15 y male/female (96-pre, 66-post)	Pre–post (10 weeks, 3 days/week)	FV Intake	24-hour recall and survey	Significant increases in FV intake, boys only.
Lautenschlager and Smith, 2007 (23)	MN	9-15 y male/female (40) Gardeners (26) Nongardeners (14)	Focus groups (3 gardener/3 nongardener groups)	Beliefs, knowledge, and values with regard to nutrition and cooking	Focus groups	Youth gardening program participants were more willing to eat nutritious food, try ethnic and unfamiliar food, greater likelihood to cook and garden, and expressed a greater appreciation for other individuals and cultures.
Koch and colleagues, 2006 (24)	TX	Second- to fifth-grade male/female (56)	Pre-mid-post (duration ranged from 1 day/week for 12 weeks to daily for 1 week)	FV Preferences, Consumption of healthy snack, knowledge of the benefits of FV	Preference questionnaire, multiple choice exam, and interview	No significant differences in FV preferences. Significant improvements in healthy snack consumption and knowledge of the benefits of FV.

Figure 1. Summary of study characteristics and impacts of youth garden-based nutrition education on fruit and vegetable intake, willingness to taste fruits and vegetables, and fruit and vegetable preferences. [a]FV=fruits and vegetables.

In-School Garden-Based Nutrition Education Research

McAleese and Rankin (14) evaluated the impact of a 12-week in-school intervention on fruit and vegetable intake among sixth-grade students from three southeast Idaho elementary schools: two intervention schools (n=70) and one control school (n=25). The intervention schools were divided into nutrition education alone (n=25) and nutrition education combined with food preparation and gardening activities (n=45), including weeding, watering, and harvesting strawberries, cantaloupe, and a variety of fall crops. Three 24-hour food recalls in the form of workbooks were completed by students at baseline and again 12 weeks later. Classroom teachers administered food-recall workbooks, which included age-appropriate instructions and portion-size illustrations. Students participating in the nutrition education combined with garden experiences increased significantly ($P<0.001$) their daily intake of fruits and vegetables from 1.9 to 4.5 servings, when compared to 2.1 to 2.2 servings among students in the nutrition-education–only group and 2.4 to 2.0 servings among students in the control group. In addition, students participating in the nutrition education combined with garden experiences significantly increased vitamin A, vitamin C and fiber intake. A strength of this study design was that it evaluated whether garden participation would enhance intake more than nutrition education alone.

Morris and Zidenberg-Cherr (15) evaluated the impact of a 17-week, in-school intervention (delivered every other week) on vegetable preferences, willingness to taste vegetables, and nutrition knowledge among students (n=213; fourth grade) from three California elementary schools: two intervention schools and one control school. The nutrition-education program was based on the Social Cognitive Theory. One intervention school received nutrition-education–only using a nine-lesson classroom-based nutrition curriculum developed by investigators. The second intervention school received nutrition education combined with garden activities, including experiences with planting, maintaining, and harvesting. Study evaluation was conducted in the fall (pretest) and spring (posttest), and included 6-month postintervention follow-up data. Investigators reported utilizing previously validated methodology to assess vegetable preferences (25-27). Compared to the control group, posttest preference scores for carrots and broccoli were greater for the garden activities and nutrition education group and nutrition-education–only group. Compared to the control and nutrition-education–only groups, posttest preference scores for snow peas and zucchini were greater for garden activities and nutrition-education group. At 6 months, the garden activities and nutrition-education group retained greater preferences for broccoli, snow peas, and zucchini. No differences between groups were found in willingness to taste vegetables. Nutrition knowledge was also assessed via a nutrition-knowledge questionnaire, previously tested for reliability and content validity. Compared to the control group, students in the garden activities and nutrition-education group and nutrition-education–only group had considerably higher posttest nutrition-knowledge scores, adjusted for pretest scores, and improvements were maintained at 6-month follow-up. A strength of this study was that it evaluated whether garden participation would enhance outcomes more than nutrition education alone and it included 6-month postintervention follow-up data.

Morris and colleagues (16) evaluated the impact of an 8-month in-school, feasibility/pilot study on vegetable preferences, willingness to taste vegetables, and nutrition knowledge among students (n=97; first grade) from two California elementary schools: one control school and one intervention school. The nutrition-education program was guided by Social Cognitive Theory. The intervention school included nutrition-education curriculum and garden activities, including planting, maintaining, and harvesting fall and spring gardens growing spinach, carrots, peas, and broccoli. The control school received no formal nutrition education or garden opportunities. Vegetable preferences and willingness to taste vegetables were assessed via one-on-one interviews with trained interviewers in fall (pretest) and spring (posttest). Investigators reported using previously validated methodology for the vegetable tasting assessment (25). Posttest preferences for vegetables were not substantially improved in the intervention or control group, averaging $\geq$1.25, on a scale of 0 to 2. At posttest, intervention students were more willing than control students to taste spinach, carrots, peas, broccoli, zucchini, and red bell pepper ($P<0.005$). Authors speculated that the limited number of taste-testing opportunities may have influenced their preference results, although it is unclear how many taste-testing opportunities children received. Nutrition knowledge, within the intervention group indicated substantial improvements in the ability to identify food groups, but no change in ability to correctly identify vegetables. A strength of this study was that it provided information about young children's willingness to taste vegetables grown in the garden.

Lineberger and Zajicek (17) evaluated the impact of a 10-unit, 1 year, in-school intervention on fruit and vegetable intake and fruit and vegetable preferences among students (n=111; third to fifth grade) from five Texas elementary schools. All students were exposed to the intervention, including nutrition education combined with garden and food preparation activities. Teachers introduced information from each of the 10 units in the curriculum, but were allowed to adapt materials to accommodate classroom schedules. Fruit and vegetable intake and fruit and vegetable preferences were assessed in the spring (pretest) and again the following spring (posttest). Fruit and vegetable intake was assessed via 24-hour food-recall workbooks. No improvements in fruit and vegetable intake were found. Fruit and vegetable preferences were assessed via a previously developed fruit and vegetable preference questionnaire (28). Students showed improvements in vegetable preferences and preferences for fruits and vegetables over another snack item; however, no changes in fruit preferences were detected. A strength of this study was that it included students from five different schools.

Cason (18) evaluated the impact of an in-school intervention on willingness to taste fruits and vegetables and fruit and vegetable identification among kindergarten students from three classes at one elementary school in South Carolina. This study was not presented as a research article, but rather as a description of an innovative approach to nutrition education. A *KinderGarden* committee, consisting of teachers, school administrators, par-

ents, business and industry volunteers, and extension educators were involved with planning and implementation of the intervention. All students were exposed to nutrition education and garden activities. Nutrition education was integrated into existing language arts and science curriculum, delivered for 30 minutes each week, and included food preparation and tasting activities. Garden exposure included 30 minutes per week (working in groups of 10) in the school garden. Pre- and postdata indicated a 69% increase in willingness to taste fruits and vegetables. In addition, the percentage of students able to correctly identify fruits increased from 52% to 94% and vegetables increased from 43% to 86%. A strength of this study was that it included the use of a committee to develop and implement the intervention.

Afterschool and Community Garden-Based Nutrition-Education Research

Guided by Social Cognitive Theory, O'Brien and Shoemaker (19) evaluated the impact of a 10-week (weekly, 80 minutes), afterschool intervention on fruit and vegetable preferences, nutrition knowledge, and self-efficacy to consume fruits and vegetables among children (n=38; fourth grade) from two similar Kansas elementary schools: one control group (n=21) and one intervention group (n=17) of participants in an afterschool gardening club. Each week, children in the intervention group received nutrition lessons, gardened for 30 minutes and consumed a healthful snack. Fruit and vegetable preferences, nutrition knowledge, and self-efficacy to eat fruits and vegetables were assessed. Fruit and vegetable preference (28) and self-efficacy (27) questions were based on previously validated measures. There were no significant improvements in fruit and vegetable preferences or nutrition knowledge; however, investigators noted that these scores were high at the beginning and end of the intervention. Self-efficacy to consume fruits and vegetables increased among the intervention group participants, but investigators did not report whether or not this increase was statistically significant.

Hermann and colleagues (20) evaluated the impact of an afterschool intervention facilitated through Oklahoma Cooperative Extensive Services (1 day per week, for 90 minutes) on vegetable intake among youth (n=43; third to eighth grade). The intervention utilized existing curricula and the garden embraced the "three sisters" garden (corn, beans, and squash) of the Native American culture. Native American youth comprised nearly 75% of the sample. Youth planted, maintained, and harvested a dozen vegetables in the garden. Youth received nutrition education and prepared healthful meals and snacks with the harvested produce. Vegetable intake was assessed with a single question at baseline and follow-up. The percent of youth who reported, "I eat vegetables every day," significantly increased ($P<0.02$) from 22% at baseline to 44% at follow-up. Strengths of this study included the use of diverse hands-on activities as well as the involvement of community members and parents who assisted with garden activities and local businesses who donated supplies. Furthermore, schoolteachers utilized the garden with their classes, which resulted in the school seeking and receiving financial resources to purchase a greenhouse.

With Social Cognitive Theory as a framework, Poston and colleagues (21) evaluated the impact of an intervention on fruit and vegetable preferences, knowledge, and self-efficacy to consume fruits and vegetables among children (n=29; third to fifth grade) recruited from a Boys and Girls Club in Kansas. Eighteen children participated in an 8-week (20 to 60 minutes/lesson) Junior Master Gardener's program, while 11 participated in a five-lesson (30 to 60 minutes/lesson) nutrition-education–only program. The program was implemented in the fall and summer with one intervention each time and one comparison group in the summer. Children in the intervention group consumed a healthful snack, completed the lesson, and gardened for 10 to 15 minutes. Fruit and vegetable preference (28) and self-efficacy (27) questions were based on previously validated measures. There were no increases in fruit and vegetable preferences, nutrition knowledge, or self-efficacy to consume fruits and vegetables in either group. Investigators suggested that the small sample size, limited program length, and limited garden time may have influenced outcomes.

Lautenschlager and Smith (22) evaluated the impact of a 10-week community-based intervention (3 days a week for 10 weeks) on fruit and vegetable intake among youth (n=96 baseline, n=66 follow-up; ages 8 to 15 years) in Minneapolis/St Paul, MN. Participants were exposed to nutrition, cooking, and gardening lessons in the summer. Fruit and vegetable intake was determined by a combination of measurement tools, survey questions, and recall data. Responses to survey questions "How many pieces of fruit did you eat yesterday?" and "How many vegetables did you eat yesterday?" were averaged with fruit and vegetable intake data derived from 24-hour recalls. Boys' fruit and vegetable intake significantly increased from baseline to follow-up, whereas girls' intake did not change. Boys intake of fruit increased from 2.0 to 3.0 servings ($P=0.029$) and vegetables increased from 2.0 to 3.4 ($P=0.007$). Lautenschlager and Smith (23) also conducted six focus groups with two populations of inner-city youth: those involved in the garden program (three groups, n=26) and those with no exposure to the program (three groups, n=14). Investigators determined that when compared to the nongarden participants, youth garden participants were more willing to eat nutritious food, try ethnic and unfamiliar food, expressed a greater appreciation for individuals and cultures, and were more likely to cook and garden.

Koch and colleagues (24) evaluated the impact of a community-based intervention on fruit and vegetable preferences, consumption of a healthful snack, and knowledge of the benefits of fruits and vegetables among youth (n=56; second to fifth grade) in four Texas counties. Intervention delivery was determined by each county agent and ranged from a 1-week summer camp format to once per week for 12 weeks. All participants were exposed to the intervention, which included nutrition education and garden activities. Fruit and vegetable preferences were assessed via a previously developed questionnaire (28). Following the intervention there were no improvements in fruit and vegetable preferences; however, improvements in healthful snack consumption and knowledge about the benefits of eating fruits and vegetables were reported.

Summary of Outcomes

Outcomes investigated in this review included four studies evaluating changes in fruit and/or vegetable intake (14,17,20,22), six studies evaluating changes in fruit and/or vegetable preferences (15-17,19,21,24), and three studies evaluating changes in willingness to taste fruit and/or vegetables (15,16,18). Three studies reported that exposure to garden-based nutrition education was associated with increased fruit and vegetable intake (14,22) or vegetable intake (20) among youth, one study reported that significant increases in fruit and vegetable intake were only seen in boys (22). One study reported no improvements in fruit and vegetable intake (17). Two studies reported that exposure to garden-based nutrition education was associated with increased preference for vegetables (15,17), whereas four studies reported no improvements in preferences for fruits (17,19,21,24) or vegetables (16,19,21,24). One study found that children reported an increase in fruit and vegetable snack preference upon exposure to garden-based nutrition education (17). Two studies with younger children in kindergarten and first grade reported that exposure to garden-based nutrition programs resulted in increased willingness to taste fruits and vegetables (18) or vegetables (spinach, carrots, peas, broccoli) (16); while one study with fourth graders reported no improvements in willingness to taste vegetables (15). This increased willingness to taste fruits and vegetables among the youngest children in kindergarten (18) and first grade (16) is encouraging, as it could potentially lead to developing increased fruit and vegetable preferences and fruit and vegetable intake as they grow older (29).

While the primary outcomes of interest in this review were fruit and vegetable intake, willingness to taste fruits and vegetables, and fruit and vegetable preferences, other nutrition-related outcomes are worth noting. Many of the studies also assessed changes in nutrition knowledge. Four studies reported that exposure to garden-based nutrition education was associated with increased nutrition knowledge (15,16,18,24), whereas two studies did not report improvements in nutrition knowledge following intervention programming (19,21). Measurement of knowledge ranged from the ability to identify food groups among younger children to the ability to recognize the benefits of fruits and vegetables and general nutrition knowledge among older children. While one study reported no increase (21) in self-efficacy to consume fruits and vegetables, another study reported improvements, but not whether these improvements were statistically significant (19). Other outcomes associated with exposure to garden-based nutrition education included increased intake of vitamin A, vitamin C, and fiber (14); increased likelihood to cook (23); and increased appreciation for other individuals and cultures (23).

Collectively, results from the studies in the current review provide some important insight into the feasibility and effectiveness of garden-based nutrition education; however, most involve limitations in evaluation methodology and study design. Investigators utilized different evaluation tools to measure fruit and vegetable intake, which may have influenced outcomes. One study utilized a single item question to assess vegetable intake, another used a combination of survey questions and 24-hour recall data, and two other studies reported the use of a validated 24-hour recall workbook to measure intake; however, the 24-hour recall validation process has not been published in a peer-reviewed journal. Studies were limited by small sample sizes, lack of long-term follow-up data, and lack of process survey data. In addition, some of the study descriptions would have been more complete with additional details about intervention design and information regarding the successes and challenges of study implementation. It is important that future studies include systematic process evaluation reports to inform future research interventions.

With regard to study design, investigators routinely relied on convenience samples involving youth who may or may not have had a prior interest in nutrition or gardening, thus biasing the results and limiting their generalizability. In addition, while studies provided pre-

Intervention Planning
- Include a formal needs assessment prior to implementing intervention
- Involve a variety of stakeholders (including youth) in the intervention planning process
- Use theory-based quantitative and qualitative investigation methods to guide intervention planning
- Consider principles in Community-Based Participatory Research

Study Design and Evaluation Methodology
- Convene a workgroup to determine research design and evaluation recommendations for school and community garden-based nutrition-education interventions
- Use previously validated tools, or pilot test and validate assessment tools prior to use
- Include sample sizes large enough to evaluate independent impacts of sex, age, and cultural group
- Evaluate independent effects of garden-based nutrition education and traditional nutrition education
- Evaluate which aspects of intervention design are most critical: program time, gardening time, gardening method, and season
- Use control groups and if resources allow, consider group randomized trials with a minimum of six groups per condition
- Conduct longitudinal research to track whether changes in intake and attitudes alter over time

Outcome Measures
- Evaluate changes in dietary intake among youth and their families as well as other physical and health-related outcomes
- Examine which aspects of the garden-based nutrition education are most critical: participation in garden planning, planting, maintenance, and harvest; food preparation; tasting; nutrition-education lessons

Program Sustainability
- Evaluate the facilitators and barriers to long-term sustainability of programming
- Include process survey data in evaluation, in a effort to inform future interventions
- Link school subjects and learning objectives to garden-based education and assess/monitor the outcomes

Figure 2. Considerations when implementing and evaluating garden-based youth nutrition-education programs.

and postintervention data, some did not include a control condition and most of the studies that included control and comparison groups assigned only one group per condition, which may have compromised the statistical outcomes due to possible clustering. Ignoring the clustering of observations within intact social groups (ie, students within one school) leads to underestimated standard errors, and thus the test of treatment differences is too sensitive giving *P* values that are too small. To ensure statistical rigor, future research may include quasi-experimental interventions with a minimum of six groups per condition in order to estimate appropriate standard errors (30). With the growing national interest in garden-based nutrition education, the need for well-designed studies is critical. It would be beneficial to convene a workgroup to address concerns inherent in these types of community-based projects and make recommendations for effective study designs and evaluation methodologies. Research considerations for implementing and evaluating garden-based youth nutrition-education programs are provided in Figure 2.

CONCLUSIONS AND IMPLICATIONS FOR FUTURE PRACTICE AND RESEARCH

There is a growing movement among educators to include gardens as a teaching tool within schools and communities, as evidenced by the number of youth participating in garden education programs (7,8). Schools throughout the country may consider integrating garden-based education into the curriculum as part of the school wellness policies required by the Child Nutrition Reauthorization Act of 2004, as research suggests garden-based education may lead to improved academic achievement (31-35). In addition, cooperative partnerships linking school, afterschool, and community garden programs could allow for continuity of programming and enhanced learning opportunities for youth, families, and community members throughout the year.

Based on the review of relevant but relatively limited literature, the evidence for the effectiveness of garden-based nutrition education is promising. Garden-based nutrition-education programs may have the potential to lead to improvements in fruit and vegetable intake, willingness to taste fruits and vegetables, and increased preferences among youth whose current preferences for fruits and vegetables are low. However, it is difficult to make conclusions based on the limited number of well-designed, methodologically peer-reviewed research studies available. Future research is needed to investigate whether garden-based nutrition-education programs positively impact dietary outcomes among youth. With high obesity rates among youth in the United States (36), it is imperative to investigate creative and effective healthful eating initiatives.

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