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A Review of Garden-Based Youth Nutrition Intervention Programs 2009-2015

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This review of the scientific literature examines the effectiveness and impact of ten garden-based youth nutrition intervention programs conducted between 2008 and 2015. It also expands upon the research of Robison-OBrien and colleagues (Robinson-OBrien, Story & Heim, 2008). Their Considerations when implementing and evaluating garden based youth nutrition-education programs (Considerations) included: (1) intervention planning, (2) study design and evaluation methodology, (3) outcome measures, and (4) program sustainability. These components were reviewed for their inclusion by investigators in the 10 studies under review.

Robin-OBrien and colleagues (Robinson-OBrien ,Story & Heim ,2008) reviewed relevant articles published between 1999 and 2007(McAleese & Rankin, 2007 ;Morris & Zidenberg-Cherr, 2002;Morris,Neustadter & Zidenberg-Cherr,2001 ; Lineberger & Zajicek,2000; Cason, 1999; OBrien & Shoemaker, 2006; Hermann , Parker & Brown ,2005; Poston , Shoemaker & Dzewaltowski,2005; Lautenschlager & Smith, 2007(A);Lautenschlager, & Smith, 2007 (B); Koch, Waliczek & Zajicek,2006). Their findings suggested that garden-based nutrition intervention programs may have the potential to promote increased fruit and vegetable intake among youth and also to increase willingness to taste fruits and vegetables among younger children; however, empirical evidence in this area was relatively scant. The authors concluded that there is a need for well-designed, evidence based, peer-reviewed studies to determine program effectiveness and impact. With growing national attention on school-based gardens, including efforts of the White House (White House Task Force on Childhood Obesity, 2011), the need for well-designed studies is critical (Andersen, Bere, & Kolbjornsen, 2004).These types of school and community interventions could be of the anti-obesity efforts, as evidenced by the number of youth participating in gardening education programs (Ozer, 2007).

This current review of studies published between January 1, 2008 and December 31, 2015 were identified through a library search of data bases and an examination of reference lists of relevant publications. Articles were identified by searching PubMed, Agricola, ERIC and PsyINFO data bases. Search terms included school garden, garden-based education, obesity, nutrition, and evaluative research, with a combination of any and/or all of the preceding terms. Only articles published in peer reviewed journals in English were included

in this review. Ten studies were identified that met the review criteria (Christian, Evans, & Nykjaer.2014; Block, Gibbs & Staiger,2012; Evans, Ranjit & Rutledge, 2012 ; Jaeneke, Collins, & Morgan, 2012 ;Meinen, Friese, & Wright,2012 ; Parmer, Salisbury-Glennon & Shannon, 2009; Ratcliffe, Merrigan, & Rogers, 2009 ; Brouwer & Neelon, 2013 ; Heim, Stang & Ireland, 2009 ;Gatto, Martinez & Spruitt-Metz, 2015).

OVERVIEW OF STUDY CHARACTERISTICS

The 10 studies represent a variety of national(Evans, Ranjit & Rutledge, 2012;Meinen, Friese, & Wright,2012 ; Parmer, Salisbury-Glennon & Shannon, 2009; Ratcliffe, Merrigan, & Rogers, 2009;Brouwer & Neelon, 2013 ; Heim, Stang & Ireland, 2009 ; Gatto, Martinez & Spruitt-Metz, 2015)and international geographical regions (Christian, Evans, & Nykjaer,2014; Block, Gibbs & Staiger,2012 ; Jaeneke, Collins & Morgan,2012) . The 6 national studies included preschools ages (Meinen, Friese, & Wright,2012; Brouwer & Neelon, 2013), elementary schools ages (Christian, Evans, & Nykjaer,2014; Block, Gibbs & Staiger,2012 ;Jaeneke, Collins & Morgan, 2012; Parmer, Salisbury-Glennon & Shannon, 2009; Heim, Stang & Ireland, 2009 ; Gatto, Martinez & Spruitt-Metz, 2015) and middle school ages (Meinen, Friese, & Wright,2012; Brouwer & Neelon, 2013) .The 3 international studies (Christian, Evans, & Nykjaer, 2014; Block, Gibbs & Staiger, 2012; Jaeneke, Collins & Morgan, 2012) were all elementary school-aged students. Eight studies (Christian, Evans, & Nykjaer,2014; Block, Gibbs & Staiger,2012 ; Evans, Ranjit & Rutledge, 2012 ; Jaeneke, Collins, Morgan, 2012 ;Meinen, Friese, & Wright,2012 ; Parmer, Salisbury-Glennon & Shannon, 2009 ; Ratcliffe, Merrigan, & Rogers, 2009 ; Brouwer & Neelon, 2013) were within the classroom setting and 2 were implemented within the community setting (Heim, Stang & Ireland, 2009 ; Gatto, Martinez & Spruitt-Metz,2015). Nine studies were indicated as being integrated into curriculums (Christian, Evans, & Nykjaer,2014; Block, Gibbs & Staiger,2012; Evans, Ranjit & Rutledge, 2012 ; Jaeneke, Collins, Morgan, 2012 ; Meinen, Friese, & Wright,2012 ; Parmer, SalisburyGlennon & Shannon, 2009; Ratcliffe, Merrigan, & Rogers, 2009 ; Brouwer & Neelon, 2013; Heim, Stang & Ireland, 2009). One study looked at gender differences (Jaeneke, Collins, Morgan, 2012). Seven studies included intervention and control or comparison groups (Block, Gibbs & Staiger,2012; Evans, Ranjit & Rutledge, 2012 ; Jaeneke, Collins, Morgan, 2012 ; Meinen, Friese, & Wright,2012 ; Parmer, Salisbury-Glennon & Shannon, 2009; Brouwer & Neelon, 2013; Gatto, Martinez & Spruitt-Metz, 2015). Four studies utilized a comparison of garden- based nutrition and traditional nutrition education (Jaeneke, Collins, Morgan, 2012; Meinen, Friese, & Wright, 2012) or gardening vs no gardening (Parmer, Salisbury-Glennon & Shannon, 2009; Ratcliffe, Merrigan, & Rogers, 2009). Eight studies included pre /posttests within the same population (Christian, Evans, & Nykjaer,2014; Evans, Ranjit & Rutledge, 2012; Jaeneke, Collins, Morgan, 2012 ; Meinen, Friese, & Wright,2012; Parmer, SalisburyGlennon & Shannon, 2009; Brouwer & Neelon, 2013; Heim, Stang & Ireland, 2009 ; Gatto, Martinez & Spruitt-Metz,

2015). The majority of the investigators reported the use tools with known reliabilities and/or validated measures. One of the studies (Heim, Stang & Ireland, 2009) developed and pretested their instruments prior to its implementation. Evaluation tools included 24 hour food recall, food frequency, questionnaires, one-on one interviews, participant observations and focus groups. Outcome evaluated in this review include vegetable consumption only (Ratcliffe, Merrigan, & Rogers, 2009),fruit and vegetable consumption (Christian, Evans, & Nykjaer,2014; Evans, Ranjit & Rutledge, 2012 ; Jaeneke, Collins,& Morgan, 2012 ; Meinen, Friese, & Wright,2012; Parmer, Salisbury-Glennon & Shannon, 2009; Brouwer & Neelon, 2013 ; Heim, Stang & Ireland, 2009)motivation for eating fruits and vegetables, (Evans, Ranjit & Rutledge, 2012) fruit and vegetable preference (Evans, Ranjit & Rutledge, 2012 ; Jaeneke, Collins, & Morgan, 2012), taste rating (Jaeneke, Collins, & Morgan, 2012), likes/dislikes fruit and vegetables,(Meinen, Friese, & Wright,2012) , willingness to try fruits and vegetables (Meinen, Friese, & Wright,2012), asking behavior (Heim, Stang & Ireland, 2009), and home availability (Heim, Stang & Ireland, 2009). This review also includes knowledge of fruit and vegetables (Evans, Ranjit & Rutledge, 2012; Meinen, Friese, & Wright, 2012; Parmer, Salisbury-Glennon & Shannon, 2009) and self-efficacy for eating fruits and vegetables (Evans, Ranjit & Rutledge, 2012; Heim, Stang & Ireland, 2009). Findings from a program designed to reduce obesity and metabolic disease in Latino youth (Gatto, Martinez & Spruitt-Metz, 2015) are included in this review.

Overview of Studies

The following overview of the literature reviews works that present examples of alignment among research, teaching, and practice in the health promotion and public health fields. Table 1 represents the characteristics of each study reviewed, including study location, population, design, measurement tools utilized, and study outcomes.

In-School Garden-Based Nutrition Education Research

Christian and colleagues (Christian, Evans, & Nykjaer, 2014) evaluated the impact of a school garden intervention on childrens fruit and vegetable intake in a randomized control trial among elementary school children from 23 schools in the United Kingdom. These schools were randomized into two groups, one to receive the Royal Horticultural Society led interventions and the others to receive the less involved Teacher-led intervention. After adjusting for possible confounders there were no a significant differences (intervention effect:-40g, 95% CI:-88, 1; p=0.06.)

Block and Colleagues (Block, Gibbs & Staiger,2012) assessed a structured cooking and gardening program in Australian primary schools, focused on the programs impact on the social and learning environments of the schools. Results showed that some of the program attributes valued most highly by student participants included increased student engage-

ment and confidence, opportunities for experimental and integrated learning, teamwork, building social skills, and connections and links between schools and their communities.

Evans and Colleagues (Evans, Ranjit & Rutledge, 2012) explored a research aim that first measured the effects of different levels of exposure to a multi-component garden-based intervention on middle school students fruit and vegetable (FV) consumption and related variables and secondly determined the separate effects of each of their intervention componentson fruit and vegetable consumption. The outcome measures included fruit and vegetable (FV) consumption, motivation for eating FV, self-efficacy for eating FV, FV preference, and knowledge. Results indicated that compared with those students who were exposed to less than two intervention components, students who were exposed to two or more components scored significantly higher on FV intake, self-efficacy, and knowledge and lower on preferences for unhealthy food (p¡.05).

The research aim of Jaenke and colleague (Jaeneke, Collins, & Morgan, 2012) was to examine gender differences in the impact of a school garden and nutrition curriculum on fruit and vegetable intake, willingness to taste, and taste rating in children (11-14 years, 54% boys). Classes were assigned to wait-list control, nutrition education only (NE), or nutrition education plus gardening (NE+G) groups. Carrot taste rating was the only vegetable for which there was a significant gender difference, with girls rating it more highly (p=.04). There was no significant gender difference in fruit and vegetable consumption or willingness to taste scores for any other vegetables.

Meinen and colleagues (Meinen, Friese, & Wright, 2012) sought to identify the effect of gardens on student health behaviors using pre and posttest surveys on the predictors of and consumption of fruits and vegetables. A statewide school gardening initiative was developed through a partnership led by the University of Wisconsin (USA) Extension, along with the Wisconsin Department of Health Services. The survey results demonstrated statistically significant changes in (1) trying new fruit (P<05), (2) choosing fruit instead of chips/candy (P<.01), (3) choosing vegetables instead of chips/candy (P<.01), (4) trying new vegetables that were grown in the garden (P<.001), (5) tasting new vegetables (P<.01), and, most important, (6) increasing consumption of fruits and vegetables (P<.01).

Parmer and colleagues (Parmer, Salisbury-Glennon & Shannon, 2009) examined the effects of a school garden on childrens fruit and vegetable knowledge, preference, and consumption. Participants in the NE (Nutrition Education) +G (Gardening) and NE treatment groups exhibited significantly greater improvements in nutrition knowledge and taste ratings than did participants in the Control Group (CG). Moreover, the NE+G group was more likely to choose and consume vegetables in a lunchroom setting at post-assessment than either the NE or CG.

Ratcliffe and colleagues (Ratcliffe, Merrigan, & Rogers, 2009) assessed the effects of gardenbased education on childrens vegetable consumption. Students at both intervention sites participated in garden-based learning sessions that were integrated into their regularly scheduled science class. Results indicated that school gardening may affect childrens vegetable consumption, including improved recognition, attitudes toward, preferences for, and willingness to taste vegetables.

The research aim of Brouwer and colleagues (Brouwer & Neelon, 2013) was to assess the feasibility of gardening intervention to promote vegetable and fruit intake among preschoolers in a childcare center setting. For their pilot study, two intervention centers and two control centers were enrolled. The intervention included a fruit and vegetable garden, monthly curriculum, gardening support, and technical assistance. Post intervention, intervention and control centers served fewer vegetables (mean (standard deviation) difference of-0.18(0.63) in control), but intervention children consumed more than control children (+0.25(1.11) vs.- 0.18(0.52).

Afterschool and Community Garden Based Nutrition Education Research

Heim and colleagues (Heim, Stang & Ireland, 2009) evaluated a 12-week pilot intervention titled, Delicious and Nutritious Garden, designed to promote fruit and vegetable intake among 4th to 6th grade children attending a YMCA summer camp. The children participated in gardenbased activities twice per week. Weekly educational activities included fruit and vegetable taste tests, preparation of fruit and vegetable snacks, and family newsletters sent home to parents. Most children (97.8%) enjoyed taste testing fruits and vegetables. Children also liked preparing fruits and vegetables snacks (93.4%), working in their garden (95.6%), and learning about fruits and vegetables (91.3%). Impact data suggest that the intervention led to an increase in the number of fruits and vegetables ever eaten ($p<0.001$), vegetable preferences ($p<0.001$), and fruit and vegetable asking behavior at home ($P<0.002$). Investigators noted that, to their knowledge, this was the first garden based intervention that has examined fruit and vegetable asking behavior and home availability.

Gatton and colleagues (Gatto, Martinez & Spruitt-Metz, 2015; Martinez, Gatto & SpruittMetz,2015 ; Gatto, Ventura & Cook,2012) assessed the effects of a 12-week gardening, nutrition, and cooking intervention on dietary intake, obesity parameters, and metabolic disease risk among low-income, primarily Hispanic/Latino youth in Los Angeles. The randomized controlled trial involved four elementary schools [two schools randomized to intervention]. LA Sprouts participants had significantly greater reductions in BMI z-scores (0.1-vs. 0.04 point decrease, respectively; $P=0.01$) and WC (-1.2 cm vs, no change; $P<0.001$). Fewer LA Sprouts participants had syndrome (MetSyn) after the intervention than before, while the number of controls with MetSyn increased. LA Sprouts participants

had improvements in dietary fiberintake (+3.5% vs. -15.5%; P=0.04) and less decrease in vegetable intake (-3.6%vs. -26.4%; P=0.04).

SUMMARY OF OUTCOMES: A Review of Garden-Based Youth Nutrition

Intervention Programs 2009-2015

Fruit and /or vegetable intake was evaluated in six studies,(Christian, Evans, & Nykjaer,2014; Evans, Ranjit & Rutledge, 2012 ; Jaeneke, Collins, Morgan, 2012 ; Meinen, Friese, & Wright,2012 ; Parmer, Salisbury-Glennon & Shannon, 2009; Brouwer & Neelon, 2013). Results from two studies indicated an increase in both fruits and vegetables (Evans, Ranjit & Rutledge, 2012; Parmer, Salisbury-Glennon & Shannon, 2009) whereas only vegetables were shown to have increase for one study (Brouwer & Neelon, 2013). One study only evaluated vegetable intake (Ratcliffe, Merrigan, & Rogers, 2009) and the results indicated an increased vegetable consumption. Fruit and vegetable preferences were evaluated in four studies (Evans, Ranjit & Rutledge, 2012 ; Jaeneke, Collins, & Morgan, 2012; Parmer, Salisbury-Glennon & Shannon, 2009; Heim, Stang & Ireland, 2009).Two studies (Jaeneke, Collins, Morgan, 2012 ; Heim, Stang & Ireland, 2009)showed an increased fruit and vegetable preferences while two studies (Evans, Ranjit & Rutledge, 2012; Parmer, Salisbury-Glennon & Shannon, 2009)showed no improvement in the preference for fruits and vegetables. Motivation for eating fruits and vegetables was evaluated among middle schoolers (Evans, Ranjit & Rutledge, 2012) and indicated a higher fruit and vegetable intake. Two studies reported that exposure to garden-based education was associated with increased nutrition knowledge (Evans, Ranjit & Rutledge, 2012 ; Parmer, Salisbury-Glennon & Shannon, 2009)whereas one study did not show an increase in knowledge following the intervention programming (Evans, Ranjit & Rutledge, 2012).

The studies utilized a variety of intervention designs and measuring tools ranging in intensity and rigor. The studies differed in intervention design methodology and in the types of evaluation tools to evaluate outcomes. Three were scientifically rigor evaluations utilizing a random control study design (Christian, Evans, & Nykjaer,2014; Brouwer & Neelon, 2013 ; Gatto, Martinez & Spruitt-Metz, 2015) , two were quasi experimental, no randomization, (Jaeneke, Collins, Morgan, 2012 ; Meinen, Friese, & Wright,2012). The remaining 5 were less rigorous in their evaluation methodology. Investigators routinely relied on convenience samples and varied in intensity and duration.

SUMMARY OF OUTCOMES:

Research Considerations when implementing and evaluating garden-based youth nutrition-education programs are included in (Table 2) The 4 components of the Research Consid-

erations when implementing and evaluating garden-based youth nutrition-education program included: 1. Intervention Planning, 2.Study Design and Evaluation Methodology, 3. Outcome Measures, and 4.Program sustainability. This discussion only summarizes those studies with components above 50% inclusion criteria. Table 2 does provide all of the information compiled from the articles. The efforts were made to identify the specific details without omitting relevant information. Any oversights or commissions may be attributed to misinterpretation of authors work.

Component 1: Intervention and Planning

70% "Involved variety of stakeholders (including youth) in the intervention planning process". These included mostly teachers, parents, and other family members. **70%"Used theory based quantitative and qualitative investigation methods to guide intervention planning.** The majority of the studies utilized the Social Cognitive Theory (Bandura, 1986). It is believed that active engagement in gardening activities can reinforce healthy messages about eating, and increase childrens willingness to try fruits and vegetables (Bandura, 1986). One study (Block, Gibbs & Staiger,2012) utilized ecological theory (Bronfenbrenner, 1979 ; Hawe & Riley, 2005; McLaren & Hawe, 2003 ; World Health Organization, 1986)which recognizes the interdependence between individuals and their physical and social environment and principles of effective health promotion ,which require the combined elements of policy, environment, community, personal, and service elements to be addressed (World Health Organization, 1986).

Component 2: Study Design and Evaluation Methodology

90% "Used previously validated tools, or pilot test and validated tools prior to use". 70 % "Use of control groups, and if resources allow, consider group randomized trials with a minimum of 6 groups per condition. One study (Block, Gibbs & Staiger, 2012) included 6 groups per condition as recommended in the Considerations.

Component 3: Outcome Measures

70%"Examine which aspects of garden-based nutrition education are most critical". 70% of the studies identified food preparation as one of the activities utilized. This outcome is in-line with the recommendations of Hersch and Haas (Hersch, & Haas, 2014) on the benefits of getting children cooking.

Component 4: Program sustainability

90% "Linked school subjects and learning objectives to garden-based education and assess/monitor the outcomes"

Conclusion and Implications for Future Practice and Research

Garden Based nutrition education intervention research studies have been published in peer-reviewed journals throughout the first 2 decades of the 21st century. Our review of the most recent studies have indicated that garden-based learning can have a variety of positive and effective impacts including reduction in BMI z-scores, decreased waist circumference, increase in fruit and vegetable intake, and improvement in nutrition knowledge. The results of this review does continue to indicate progress since the post release of the studies conducted between 1999 and 2007 including being theory based, linked to school subjects , the use of control groups and utilization of a variety of stake holders. Less progress is evident in the form of a formal needs assessment, utilization of community participatory research, and the convening of work groups. Increased fruit and vegetables consumption does provide evidence that this is an effective treatment for obesity, ongoing efforts to support youth gardens should be an important public health goal toward combating obesity.

Author, Year	Location	Study Population (n)	Design (duration)	Measures	Measurement Tools	Outcomes
In-School						
Block and colleagues, 2012	Australia New South Wales	Elementary schools male/female (764) Intervention (475) Control (289)	Quasi-experimental Mixed Methods (2 yrs.) Process survey completed	Impact on broader social and earning environment of the school.	Interviews Focus Group Participant-observations	Increased student engagement; confidence opportunities for experimental and integrated learning, teamwork, building social skills; and connections and links between schools and their communities.
Brouwer and colleagues, 2013	USA NC	Preschoolers at Childcare Center male/female (760) Intervention (gardening) (2-centers) Control (no gardening) (1-Center)	RCT (5 mos.)	FV Intake	Structured dietary observation method by Registered Dietitian blinded to treatment condition.	Increased consumption of children in the intervention centers, on average, an additional 1/4 serving of vegetables, Children in control centers decreased their vegetable intake by 1/5 of serving.
Christian and colleagues, 2014	United Kingdom London	Primary schools male/female (641) No comparison groups	Cluster RCT (18 mos.) Process survey completed.	FV intake	24 hour food diary (baseline).	Very little evidence that school gardening alone can improve childrens daily FV intake. Follow-up dietary intake 18 mos. apart
Evans and colleagues, 2012	USA TX	Middle schools male/female (246) Intervention (5 schools) Control (1 school)	Pretest-posttest Nonequivalent Design; Final results were based on Unequal treatment-control posttest only (3mos.) Process survey completed	FV intake, Motivation, Self- efficacy Preference for eating FV and Knowledge.	Questionnaire	FV consumption increased by 0.352 servings for every additional component of intervention to which student was exposed ($p < .01$). Intervention students exposed to two or more components scored significantly higher on FV intake, self-efficacy and knowledge ($p < .05$)

Jaenke and colleagues, 2012	Australia/ Hunter Region/ NSW	Elementary schools male/female (127, 54% boys) NE only (35,49% boys) NE+G (35/59% boys) Wait -list/control (57/56% boys)	Quasi- experimental design Control- wait List (10 weeks)	FV: Preference, Intake. Taste rating	Preference (proxy measures of "willingness to taste" and "taste ratings") Questionnaire Two repeat 24 hour dietary recalls using three-pass method.	Carrot taste rating was the only vegetable for which there was a significant gender difference, with girls rating it more highly (p=.04).
Meinen and colleagues, 2012	USA WI	K-5 grades male/female Intervention (gardening) (217) Control (no gardening)(187)	Quasi-experimental prospective study (4 mos.)	FV: Willingness to try, Like/ dislikes, Intake. Knowledge	Pre/Post Tests Survey	Significant increase in the Intervention group's willingness to try a new kind of fruit at home (P<.05). Statically significant increase in intervention groups liking of vegetables related to what was grown in their garden (P<.01).
Parmer and colleagues, 2009	USA AL	2nd graders male/female NE+G (39) NE only (37) CG (39)	Pre/post-intervention/ control (28 weeks)	FV: Knowledge, Preference, Intake.	Self-reported questionnaire Interview-style taste and rate items Lunch room observations	Significantly greater improvements in nutrition knowledge and taste ratings among NE+G and NE groups than in the CG (P<.001).
Ratcliff and colleagues, 2008	USA MA	6th graders male/female (N=320) Intervention (gardening) (170) Control (no gardening) (150)	Pre/post panel design (4 mos. for total of 13 hrs.)	Vegetable Intake	Garden Vegetable Frequency Questionnaire Taste test	Intervention Groups: Increase in childrens vegetable consumption (p=.01). Gardening increased the variety of vegetables eaten ($p \leq .01$).

After School						
Gatto and colleagues, 2015	USA CA	3rd, 4th 5th graders male/female Intervention (172) Control (147)	Randomized Control trial (12 wks.)	Decrease in obesity and metabolic syndrome	Dietary Intake (FFQ) Anthropone- metric Measurements BMI WC Body Fat Fasting Blood Samples	Intervention participants had significantly greater reductions in BMI z-scores (0.1-vs. 0.04 point decrease, respectively; P=0.01) and WC (-1.2 cm vs, no change; P<0.001). Fewer intervention participants had syndrome (MetSyn) after the intervention than before, while the number of controls with MetSyn increased participants had improvements in dietary fiber intake (+3.5% vs. -15.5%; P=0.04) and less decrease in vegetable intake (-3.6%vs. 26.4%; P=0.04).
Helm and colleagues, 2009	USA MN	4-6 graders male/female (93) Intervention=43 Control=53	Pre/post, intervention/ control (12 weeks pilot) Process Evaluation completed	FV: Exposure Preferences, Self-efficacy. Asking Behavior Home availability	Self-administered survey adapted from existing measures	Intervention led to an increase in the number of fruits and vegetables ever eaten (P<0.001), vegetable preferences (P<0.001), and fruit and beverage asking behavior at home (P<0.002).

Table 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. FV= fruits and vegetable. (NE)Nutrition Education (NE) only or nutrition education plus gardening (NE+G), CG (Control Group) BMI=Body Mass Index. WC= waist circumference. MetSyn=metabolic syndrome**

Component:1 Intervention Planning	Authors
Included a Formal Needs Assess prior to implementing intervention	Christian, Evans, & Nykjaer,2014; Block, Gibbs & Staiger, 2012. (20%)
Involved variety of stakeholders (including youth) in the intervention planning process	Christian, Evans, & Nykjaer, 2014; Block, Gibbs & Staiger, 2012; Meinen, Friese, & Wright, 2012; Ratcliffe, Merrigan, & Rogers, 2009; Brouwer & Neelon, 2013; Heim, Stang & Ireland, 2009; Gatto, Martinez & Spruitt-Metz, 2015. (70%)
Used theory -based quantitative and qualitative investigation methods to guide intervention planning	Social Cognitive Theory (Christian, Evans, & Nykjaer, 2014; Evans, Ranjit & Rutledge, 2012; Jaeneke, Collins, Morgan, 2012; Ratcliffe, Merrigan, & Rogers, 2009; Heim, Stang & Ireland, 2009; Gatto, Martinez & Spruitt-Metz, 2015); Ecological Theory (Block, Gibbs & Staiger, 2012). (70%)
Consider principles in Community-Based Participatory Research	Block, Gibbs & Staiger, 2012; Ratcliffe, Merrigan, & Rogers, 2009; Brouwer & Neelon, 2013; Heim, Stang & Ireland, 2009. (40%)
Component 2: Study Design and Evaluation Methodology	
Convene work group to determine research design and evaluation recommendations for school and community garden-based nutrition-education intervention	None were reported among the 10 studies reviewed.
Used previously validated tools, or pilot test and validated assessment tools prior to use	Christian, Evans, & Nykjaer,2014; Block, Gibbs & Staiger,2012; Evans, Ranjit & Rutledge, 2012 ; Jaeneke, Collins, Morgan, 2012 ; Meinen, Friese, & Wright,2012 ; Parmer, Salisbury-Glennon & Shannon, 2009; Ratcliffe, Merrigan, & Rogers, 2009; Brouwer & Neelon, 2013 ; Gatto, Martinez & Spruitt-Metz, 2015. (90%)

Include sample sizes large enough to evaluate independent impacts of sex, age, and cultural groups.	1 study (Jaeneke, Collins, Morgan, 2012) looked at the impact of gender (10%)
Evaluated Independent effects garden-based nutrition and traditional nutrition education	Jaeneke, Collins, Morgan, 2012; Meinen, Friese, & Wright, 2012; Parmer, Salisbury-Glennon & Shannon, 2009; Ratcliffe, Merrigan, & Rogers, 2009 (40%)
Evaluate which aspects of intervention design are most critical: program time, gardening time, gardening method and season	Produce on menus/chosen for specific climate (Hermann, Parker & Brown, 2005). (10%)
Use control groups(CG), and if resources allow, consider group randomized trials with a minimum of 6 groups per condition,	Block, Gibbs & Staiger, 2012; Evans, Ranjit & Rutledge, 2012*; Jaeneke, Collins, Morgan, 2012; Meinen, Friese, & Wright, 2012; Parmer, Salisbury-Glennon & Shannon, 2009; Ratcliffe, Merrigan, & Rogers, 2009; Brouwer & Neelon, 2013; Gatto, Martinez & Spruitt-Metz, 2015. *used 6 CG (70%)
Conduct longitudinal research to track whether changes in in intake and attitudes over time.	Evaluative studies (Christian, Evans, & Nykjaer, 2014; Block, Gibbs & Staiger, 2012).
Component 3: Outcome Measures	
Evaluate changes in dietary intake among youth and their families as well as other physical and health-related outcomes.	None of studies indicated an expansion to family or wider community.
Examine which aspects of the garden-based nutrition education are most critical: participating in garden planning, planting, maintenance, and harvest; food preparation; tasting; nutrition education lessons.	Food preparation identified (Block, Gibbs & Staiger, 2012; Jaeneke, Collins, Morgan, 2012; Meinen, Friese, & Wright, 2012; Parmer, Salisbury-Glennon & Shannon, 2009; Ratcliffe, Merrigan, & Rogers, 2009; Heim, Stang & Ireland, 2009; Gatto, Martinez & Spruitt-Metz, 2015). (70%)
Component 4: Program Sustainability	
Evaluate the facilitators and barriers to long- term sustainability of programming.	Evaluative studies (Christian, Evans, & Nykjaer, 2014; Block, Gibbs & Staiger, 2012). (20%)

Include process survey data in evaluation, in an effort to inform future interventions.	Christian, Evans, & Nykjaer,2014; Block, Gibbs & Staiger,2012; Heim, Stang & Ireland, 2009. (30%)
Link to school subjects and learning objectives to garden-based education and assess/monitor the outcomes	Christian, Evans, & Nykjaer,2014; Block, Gibbs & Staiger,2012; Evans, Ranjit & Rutledge, 2012 ; Jaeneke, Collins, Morgan, 2012 ; Meinen, Friese, & Wright,2012 ; Parmer, Salisbury-Glennon & Shannon, 2009; Ratcliffe, Merrigan, & Rogers, 2009 ; Brouwer & Neelon, 2013 ; Heim, Stang & Ireland, 2009 (90%)

Table 2: **Considerations when implementing and evaluating garden based youth nutrition-education programs**

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