Systematic Review

Outcomes of Children's Cooking Programs: A Systematic Review of Intervention Studies

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ABSTRACT

Objective: To examine the factors that make such programs successful, this systematic review compared the outcomes of children's participation in cooking interventions based on intervention characteristics.

Design: Systematic review of randomized controlled trials of children's participation in cooking interventions published between 1998 and 2022 guided by the Preferred Reporting Items for Systematic Reviews and Meta-Analyses statement.

Setting: All settings

Participants: Children and parents.

Main Outcome Measures: Cooking skills, food acceptance and dietary behavior.

Analysis: Systematic search of 1,104 articles and review of 23 studies (42 articles) meeting inclusion criteria.

Results: Interventions varied in participant age, settings, cooking sessions, and program length. Knowledge of cooking skills, self-efficacy, and child cooking involvement were the most frequent positive outcomes; improvements in dietary intake were rarely achieved. Seven studies had a high rating for research quality.

Conclusion and Implications for Research and Practice: Lack of standardized assessment, large variability in program characteristics, and insufficient intervention description made it difficult to discern best practices for children's cooking programs. Improvements in intervention development and measurement instruments are needed. Interventions that include hands-on cooking lessons seem promising in improving knowledge and self-efficacy; however, further exploration is required on the factors that make cooking programs successful in the long term.

Key Words: cooking skills, intervention, systematic review, child nutrition (*J Nutr Educ Behav.* 2024;000:1−12.)

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INTRODUCTION

Cooking behaviors and proficiency in food preparation skills have been associated with healthful food choices and diet quality in adults and children. These behaviors are often mentioned as promising strategies to improve children's eating behaviors, attitudes, self-efficacy, and healthy dietary intake, indicated by increased vegetable and fruit intake and reduced fat intake.[1,2] It is argued that because of a decrease in time spent cooking,[3] coupled with an increase in convenience food consumption,[4] cooking skills may not be a priority. Lifestyles have become busier,[5−7] and cooking skills and abilities are declining. Because cooking skills are not often emphasized in current lifestyles, children have limited chances to develop them at home or through education. Consequently, children are at risk for unhealthy eating behaviors and, therefore, at significant risk for obesity and other diet-related diseases.[1]

Improving diet quality is a key strategy in the prevention of childhood obesity. Cooking interventions with children and adults are associated with improved preferences for healthful foods (eg, vegetables) and higher-quality diets in general. In

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addition, food safety strategies in cooking education (eg, handwashing before food preparation and keeping foods within safe temperature zones) diminish the risk of foodborne illness.[2,8,9] Publications on cooking interventions have increased in the literature and suggest a positive impact on nutrition intake and cooking self-efficacy.[10] Hersch et al[11] conducted a systematic review of cooking education programs that contained hands-on elements for children aged 5–12 years published between 2003 and 2014, finding that "cooking programs may positively influence children's food-related preferences, attitudes, and behaviors."[11] The review found a lack of standardization of study measures and operational definitions, and it was difficult to determine best program practices.[11] Other reviews elaborated on Hersch's work, such as the recent review of Charlton et al,[8] which focused on successful primary school-based experiential nutrition programs. Interventions included school gardens, food provision, taste testing, cooking classes, and multicomponent programs. Results showed that nutrition education (when combined with taste testing), cooking activities, and gardening interventions were most promising.[8] They noted similar limitations regarding the variation in quality, the short intervention duration, the lack of follow-up, and the quality of measurement instruments.[8]

Various other reviews in this domain have been published, all taking a slightly different approach. Some reviews focus on a specific setting, like interventions in school[11–14] or at home[15]; a specific target group, such as primary schoolchildren[16,17] or adolescents,[10] or on various outcomes such as eating behaviors[16,18] or health outcomes.[2] Despite the importance and ubiquity of cooking, many researchers have struggled to define cooking and cooking skills, and definitions have been limited in the literature.[19,20] In light of this, McGowan et al[6] systematically reviewed the literature to understand adult cooking and food skills, providing a framework for future measure facilitation.[6] Recent studies aimed to establish the concept and measurement of cooking skills among children.[21–23]

To enable systematic comparison of interventions based on their characteristics, as well as a broader definition of cooking skills and similar concepts such as self-efficacy of cooking, we summarized evidence from all interventions for children aged up to 18 years with a cooking component, not excluding settings, age groups or outcomes but improving on the gaps of existing reviews by analyzing only interventions including a control group.

Therefore, the objectives of this review were to examine the outcomes of children's participation in cooking interventions on their (1) cooking skills, knowledge, confidence, attitudes, and behavior; (2) food acceptance, willingness to taste, familiarity, and liking; (3) dietary habits, quality, and food intake; and (4) anthropometric and health measures. Furthermore, the quality of the scientific evidence regarding outcomes, particularly with respect to the definition, scope, and measures of children's cooking skills, should be evaluated.

METHODS

This review was conducted according to the Preferred Reporting Items for Systematic Reviews and Meta-Analyses guidelines.[24] The protocol was registered with the International Prospective Register of Systematic Reviews (PROSPERO registration ID: CRD42019139465).[25]

Eligibility Criteria

Using the population, intervention/exposure, comparator, outcomes, and study design categories for the formulation of our research objectives,[25,26] we included programs and interventions intended to promote cooking among children (aged <18 years) and that entailed at least 1 component or treatment explicitly to increase their cooking or food preparation skills. Programs and interventions could have included parents, but children were the primary targets for this review's purpose. Research designs must have (1) incorporated either a cluster randomized controlled, randomized controlled, or quasi-experimental trial, (2) included a control or comparison group, and (3) reported preintervention and postintervention cooking skills data (ie, through home food preparation, specific cooking skills, self-efficacy and/or attitudes) for all groups. Studies that did not have a cooking skills/food preparation component or a quantitative assessment of outcomes were cross-sectional or qualitative or were not written in English and were not eligible for inclusion.

Search Strategy

The search strategy was designed in consultation with colleagues with expertise in the topic area, systematic review and/or meta-analysis expertise, and with a research librarian. An existing review of reviews informed the inclusion of search terms and identified review articles with the potential of including children's cooking intervention studies.[27] This review of reviews included studies published between 1998 and 2017. Citations for individual study articles were identified from these reviews and are usually listed in results tables. When reviews included multiple tables of included studies, we only considered those that included information on children and cooking. The results of this search were saved to Excel. Two independent researchers reviewed the titles and abstracts of potentially relevant articles to confirm the program or intervention included children. If the study was clearly qualitative with no quantitative aspects or if a study clearly only included adults, it was excluded. The exclusion was done conservatively, and if there was any uncertainty for inclusion/exclusion, we analyzed the full-text. A systematic search was then conducted for records published between January 1, 2017, and June 30, 2019, and updated to include publications through March 7, 2022. The searches were conducted using Web of Science, COCHRANE, Medline, EBSCO, ProQuest, and the ProQuest Dissertations and Theses databases. Terms, words, and combinations of words searched in records'

titles, and abstracts were (cooking [MeSH Terms] OR cookery[MeSH Terms]) OR (snack[Title/Abstract] OR recipe[Title/Abstract] OR food[Title/Abstract] OR meal[Title/Abstract] AND prepar*[Title/Abstract])) AND (student[Title/Abstract] OR children [Title/Abstract] OR teen*[Title/Abstract] OR adolescent[Title/Abstract] OR youth[Title/Abstract])) AND (intervention[Title/Abstract] OR program[Title/Abstract] OR class [Title/Abstract] OR lesson[Title/Abstract] OR curriculum[Title/Abstract] OR activity[Title/Abstract] OR "hands-on"[Title/Abstract] OR session[Title/Abstract] OR demonstration[Title/Abstract])) AND ("2017/ 01/ 01"[PDat] : "2022/03/07"[PDat]). These searches used the same procedure as with the review articles to identify potentially eligible studies.

Study Selection

All records that met our inclusion criteria based on title and abstract content were moved to full-text review and coded by 2 independent researchers. A senior author confirmed inclusion or exclusion. To ensure that all relevant publications and data were considered, authors of articles that met the inclusion criteria were contacted for information on whether they had published other papers on their identified cooking program, and all additional published literature pertaining to the study was included for the next steps.

Quality Assessment

Full-text articles that met all inclusion criteria were assessed for methodological quality. Studies were given a quality rating of plus, minus, or neutral based on the Academy of Nutrition and Dietetics Evidence Analysis Library (EAL) quality criteria checklist for primary research.[28] This checklist includes 4 questions regarding relevance to practice and evaluates the validity of articles based on (1) clarity of research question, (2) presence of bias in selection of study subjects, (3) comparability of study groups, (4) methods for handling withdrawals, (5) use of blinding to mitigate bias, (6) description of the intervention, (7) validity and reliability of outcome measures, (8) appropriateness of statistical analysis, (9) whether conclusions were supported by the results, and (10) absence of bias in funding sources. Two researchers independently completed the checklist and assigned a rating for each study. Discrepancies were resolved by discussion and consensus by a third researcher.

Data Extraction, Synthesis, and Analysis

One reviewer extracted relevant data from all included articles into 2 tables, 1 for characterizing measures and results related to cooking skills and the other for dietary intake. Common content included project name, study purpose, research design, theoretical framework, participants, setting, and intervention details. This interim step allowed for the organization of content to more easily assess studies' outcomes related to the review's research questions. A second reviewer confirmed the content of these 2 tables and consolidated the information (Supplementary Data 1). Subsequently, the results were qualitatively summarized into each study's measured determinants of interest (ie, factors related to cooking skills, willingness to taste foods/food liking, and dietary intake) (Table). Discrepancies and questions regarding content were resolved by a third reviewer. Because of the heterogeneity across studies in study design, intervention characteristics, and outcomes of interest, it was not possible to combine study findings into a meta-analysis.

RESULTS

The review of reviews and database searches identified 1,104 unique articles. Twenty-three articles met the inclusion criteria for describing the main results of distinct interventions. Nineteen additional articles identified through literature search and communication with principal investigators of these studies gave more in-depth details on 12 of these 23 interventions (Supplementary Data 1). The Figure provides a detailed diagram of the search, selection process, and results. The next section includes references only for the main article of each intervention.

Cooking Interventions' Characteristics

Four articles were published before 2010.[29,43,47] Nine of the 23 studies used randomized controlled trial (RCT) designs for their outcome evaluation, with the remaining 14 using quasi-experimental designs. Sixteen of the 17 interventions reporting the use of theory applied Social Cognitive Theory in their development; the remaining 6 did not mention the use of any theory. The majority of studies took place in the US (n = 16). Two others occurred in England,[31,36] 1 in New Zealand[42] and 1 in Canada.[50] The most recent studies, all published in 2021, occurred in Spain,[44] Malaysia,[17] and Japan.[49] The detailed characteristics can be found in the Supplementary Data 1.

Many participants were in upper elementary/primary grades (aged 8−12 years; n = 17 studies), with 3 other groups in lower elementary/primary grades (aged 4−8 years) and 3 in middle school (aged 11−14 years). Five studies involved parent/child dyads,[17,37,38,40,48] and most school-based interventions sent reinforcement materials home (eg, newsletters, recipes). Sixteen studies were conducted in public schools, with the remainder in community centers or universities. Sample sizes ranged from 100−5,111 children in school-based settings, 44−228 in parent/child dyad studies, and 24−47 in single community settings. Only 1 was provided virtually,[30] others were in person. Three included a gardening component,[30,35,39] and 2 included sending home foods prepared during the lessons as reinforcement.[34,42] Two included a school lunch component.[43,51]

Seventeen interventions were led by study personnel/researchers, 4 by trained teachers,[33,34,43,51] and 2 by both.[32,34] Most mentioned support in lesson delivery from others, such as teachers, parents, and/or university students. The number of sessions, lesson duration, and intervention length varied across the studies. The greatest number of sessions was 24 in the Integrated Nutrition

Table. Key Findings for Studies Examining Children's Participation in Cooking Interventions on Cooking Skills, Food Acceptance, and Dietary Intake (n = 23)

	Cooking Skills				Food Acceptance			Dietary Intake			
References	**K**	**SE**	**AT**	**B**	**Willing to Taste**	**Familiarity**	**Liking**	**K**	**SE**	**Mo**	**B**
Auld et al, 1998[29]	–	+	–	–	–	–	–	+	+	–	M
Bell et al, 2018[30]	–	+	–	–	–	–	NS	–	+	M	NS
Caraher et al, 2013[31]	–	NR	–	–	–	–	–	–	NR	–	NR
Chen et al, 2014[32]	–	–	–	+	–	–	–	–	–	–	M
Cunningham-Sabo and Lohse, 2013[33]	–	+ (+ for noncookers)	+ (+ for noncookers and + for males)	–	–	–	+	–	–	–	–
Cunningham-Sabo and Lohse, 2014[34]	–	+ (+ for noncookers)	NS (+ for noncookers)	–	–	–	+ (+ treatment boys)	–	–	–	–
Davis et al, 2016[35]	–	NS	NS	–	NS	M	M	+	NS	NS	M
Ensaff et al, 2017[36]	–	–	+ (+ parent)	+ (+ parent)	NS (NR parent)	+ (+ parent)	–	–	–	–	–
Fulkerson et al, 2010[37]	–	+ (NS parent)	–	(+ parent)		–	–	–	–	–	M
Fulkerson et al, 2018[38]	–	NS	–	–	NS	–	NS	–	–	–	M
Gatto et al, 2012[39]	–	NS	NS	–	–	–	M (M for O/O and girls)	–	NS	+	M
Gunther et al, 2019[40]	–	–	–	+	–	–	–	–	–	–	NS
Harley et al, 2018[41]	–	NS	–	–	NS	–	M	+	NS		NS (readiness to change)
Kuroko et al, 2020[42]	–	+	+ (NS at FU)	M	–	–	+	–	–	–	+ (NS at FU)
Liquori et al, 1998[43]	+	+ (older children only)	–	–	–	–	+	–	–	–	+
Maiz et al, 2021[44]	–	NS	NS	–	+	–	M; NS for list of vegetables	–	–	–	M
Ng, 2021[17]; Kaur et al. 2020[45] (protocol)	+ for both	+	+	+	–	–	–	–	–	–	–
Oakley et al, 2017[46]	+ for both groups	NS peer (+ adult but not sustained at 3 and 6 months FU)	NS peer (+ adult but not sustained at 3 and 6 months FU)	–	–	–	–	–	–	–	–
Parris, 2006 (dissertation)	–	NS	–	–	–	–	–	+	–	–	–
Townsend et al, 2006[47]	+ (NS Black students)	–	–	–	–	–	–	+ (NS Black students)	–	–	M (+ for boys)
White et al, 2019[48]	–	+	–	NR	NS	–	–	–	–	–	M
Yoshii et al, 2021[49]	–	NS except for apple peeling	NS	+	–	–	–	–	–	–	–
Zahr and Sibeko, 2017[50]	–	M	–	M	+	–	M	–	–	–	–
Total	4+ (n = 4)	9+, 1M, 8NS, 1 NR (n = 19)	4+, 6NS (n = 10)	6+, 2M, 1 NR (n = 9)	2+, 5NS (n = 7)	1+, 1M, (n = 2)	4+, 5M, 2NS (n = 11)	5+ (n = 5)	2+, 3NS, 1NR (n = 6)	1+, 1M, 1NS (n = 3)	2+, 9M,3NS, 1NR (n = 15)

AT indicates attitude; B, behavior; FU, follow-up; K, knowledge; M, mixed results; Mo, motivation; NS, no significant differences between groups; NR, not reported despite being included in measurements; O/O, overweight/obesity; Parent, parent completed survey of their perception of child attribute; SE, self-efficacy.
Note: A positive sign (+) indicates a significant association reported.

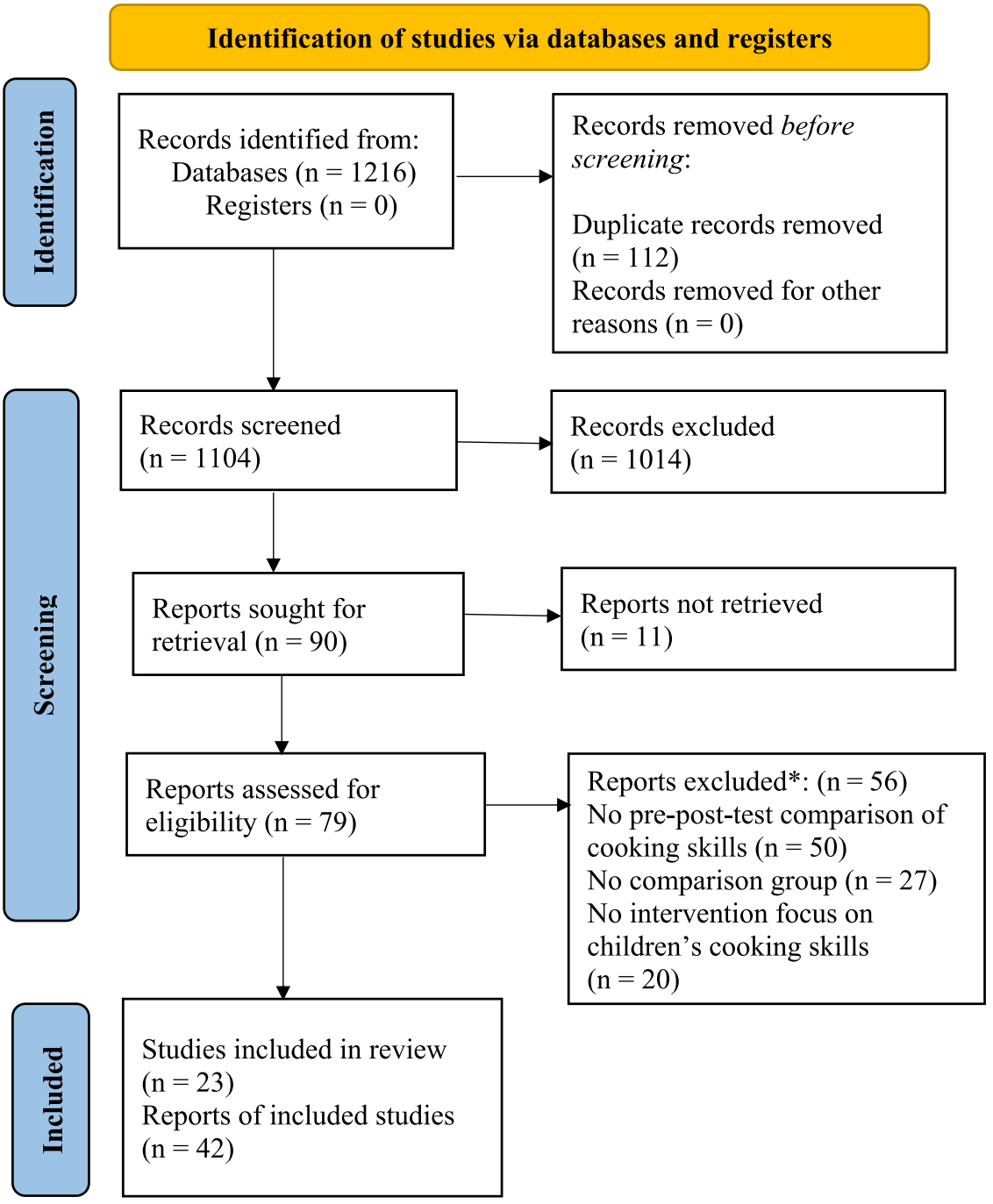

Figure. Flow diagram of the literature search and screening process for studies examining children's participation in cooking Interventions on cooking skills, food acceptance, and dietary intake, according to the Preferred Reporting Items for Systematic Reviews and Meta-Analyses guidelines. *31 had multiple reasons for exclusion.

Project,[51] and the fewest were 2 in the *Chefs Adopt a School*[31] and an unnamed program by Oakley et al.[46] The majority of sessions ranged from 5 to 10, with most cooking classes lasting 90 minutes to 2 hours.

Categories of outcome assessments included cooking skills, food acceptance, and dietary intake. Children were the only ones who completed measures in 15 of the 23 studies, and both children and parents completed measures for the remaining 8.[32,36–38,40,44,48] Data collection measures were most often in the form of self-report pre-post surveys and interview-conducted diet assessments; 3 studies

also included school lunch plate waste assessment.[43,44,51] Measures and protocols were unique to each intervention although some described use of previously validated tools.

Quality Assessment

The overall assessment of study quality is shown in detail in the Supplementary Data 2. Only 7 studies[17,29,34,37,38,44,46] were rated overall with a plus (according to the Academy of Nutrition and Dietetics EAL quality criteria checklist), 13 as neutral,[30,32,33,35,36,39–43,47–49] and 3 as a minus.[31,50] Four questions addressed the relevance to dietetic practice. All of these questions were answered in the affirmative, except that 1 study implemented a single cooking session.[31] We doubted it would be sufficient to improve cooking outcomes (relevance question 1). Another focus was on preparing a single fruit,[49] which may not be relevant for nutrition educators or dietitians because focusing on single foods may not improve overall cooking skills or dietary behavior (relevance question 3).

Ten questions addressed key considerations for the risk of bias and scientific validity of the studies. Supplementary Data 2 summarizes the results of the 10 validity questions for the 23 studies. Most adequately described the research question (Q1), which included identification of the target population and study outcomes (22 yes, 1 no) and assessment through valid measurements (Q7: 9 yes, 3 no, and 1 unclear). Group comparability (Q3), description of handling withdrawals (Q4), and appropriateness of statistical analysis (Q8) were assigned weak ratings, with the majority either assigned a no or unclear. Only 1 study[40] (parent/child study design) sufficiently applied intervention blinding techniques to data collectors (Q5). There were many instances in which specific aspects of the intervention, its implementation, and subsequent data analyses were insufficiently detailed and thus were assigned an unclear rating. Further patterns emerged when examining the validity ratings by research and intervention design. Of the 9 RCTs,[17,33,35,37,38,42,44,47,48] only the description of handling withdrawals (Q4) and blinding participants and data collectors (Q5) had more no and unclear ratings than yes. Four of these studies achieved an overall plus rating, with the remaining 5 rated as neutral. Compared with the group studies (eg, classrooms in schools), the 5 parent/child dyad studies[17,37,38,40,48] were strong in all 10 areas of validity, notably with study selection free from bias (Q2), thorough description of intervention procedures (Q6), outcomes clearly defined and measurements valid (Q7), and appropriate statistical analysis for study design, and outcome indicators (Q8). Three of these studies achieved an overall plus rating, with the remaining 2 as neutral. The specific relevance and validity ratings for each included study can be found in Supplementary Data 2.

Outcomes Measured and Results Reported for the Cooking Interventions

The key findings reported by the cooking interventions on cooking skills, food acceptance, and dietary intake are summarized in the Table.

Cooking Skills. All studies assessed changes in some aspect of cooking knowledge, self-efficacy, attitudes, and/or behavior. Cooking knowledge was measured in 4 studies, all of which showed significant improvement in the intervention children compared with the comparison group.[17,43,46,47] Cooking self-efficacy was by far the most frequent psychosocial construct measured, included in 19 of the 23 studies. However, the results were mixed in terms of intervention outcomes. Attitudes about cooking were assessed in 10 studies, with 4 demonstrating significant improvement.[17,33,36,42] Cooking behavior (eg, self- or parent-reported frequency of home food preparation) significantly increased in 6 of the 9 interventions measuring this behavior.

Food Acceptance. Twelve of the 23 studies measured some aspect of food acceptance, including willingness to taste intervention-targeted foods (mainly vegetables), familiarity with these foods, and liking of these foods. Only 2 of 7 studies measuring willingness to taste the foods emphasized in the cooking education program revealed significant improvement among intervention children.[44,50] The other 5 reported nonsignificant results. One of 2 studies measuring familiarity demonstrated improvement. Of the 11 interventions determining an intervention effect on liking specific foods, 4 documented improvements for the intervention children. The others either reported mixed results (n = 5) or nonsignificant results (n = 2).

Dietary knowledge and intake. Sixteen of the included studies measured ≥1 aspect of dietary intake, including knowledge (eg, about specific foods belonging to different food groups, nutrition label reading), self-efficacy toward eating foods emphasized in the program, motivation toward this goal, or actual dietary behavior. Five studies measured dietary/nutrition knowledge, and all demonstrated significant improvement in intervention participants compared with the comparison group. The 6 studies measuring dietary self-efficacy and the 3 measuring motivation showed no clear pattern of intervention effects. Dietary intake was the second-most frequent outcome measured (n = 15), with only 2 studies demonstrating significant target-specific improvements,[42,43] 9 showing mixed results, and 3 reporting nonsignificant results; 1 study did not report any results of this assessment.

Anthropometric and health measures. Eight studies measured ≥1 anthropometric assessment, including height and weight, to determine body mass index, waist circumference, percent body fat, and blood pressure. No significant effects were reported (data not shown).

DISCUSSION

Summary of Findings

Twenty-three articles described the main results of studies that met our inclusion criteria, supplemented by

19 articles augmenting the description and other results for 12 of them. Quasi-experimental designs were most common (n = 14), and of those reporting the use of behavior change theory (n = 17), all but 1 used Social Cognitive Theory. Most took place in the US (n = 16), although the 3 most recent ones occurred in other countries. Seventeen interventions involved children aged 8–12 years, and 16 took place in school classrooms or after-school programs. The number of participants varied widely across studies, and 5–10 sessions were the most common. Cooking lessons were usually 90–120 minutes. An important finding was that while interventions addressing 1 or more aspects of cooking skills were not successful in changing dietary intake or health indicators, they had mixed results on food acceptance, and positive associations were found for cooking knowledge, self-efficacy, and involvement of children in cooking in most studies reported these outcomes.

Quality Assessment

The EAL tool,[28] while useful, was not a perfect fit for assessing the research quality of complex cooking intervention studies with children. The tool addresses minimizing the risk of bias by study participant and group selection through randomization. However, it is challenging to randomize individuals or groups (eg, schools or classrooms) to cooking program treatment or a control group because it can hinder participation. Schools may not accept being randomized to a waiting list, and the risk of contamination increases if randomization has to be done within schools. This challenge can explain why 14 of the 23 included studies were quasi-experimental and used comparison rather than control groups. Of the 9 RCTs, 4 were parent/child dyad studies, which are less complex outside the school setting. The EAL tool also includes an emphasis on blinding participants and data collectors to the intervention to minimize reporting bias. The obviousness of the cooking interventions makes this aspect unlikely for participants and makes it difficult for data collectors to be truly unaware of their exposure to the intervention. Despite our team reviewing all publications related to an intervention program, many aspects of the EAL tool were insufficiently described and thus received an unclear rating. This was especially true relative to the appropriateness of the statistical analyses. Several systematic reviews have noted similar weaknesses in the research design, use of validated measurement tools, and limited descriptions of the underpinning of theory in both adult and child cooking interventions.[6,10,11,52,53]

Intervention Outcomes

Clear patterns could not be found when examining the intervention outcomes in more detail. Exploring the 5 studies using parent/child dyads, 3 studies reported positive results for cooking skills, whereas the other studies did not measure or report this outcome. This might highlight a tendency that even for school interventions, parental involvement in children's food behavior remains of key importance.

Cooking skills. Though this review documented improvements in knowledge, changes in self-efficacy (ie, belief in one's ability to perform specific cooking techniques and actions) were mixed. Self-efficacy was measured in 19 of the 23 studies (Table). Other reviews, such as Hasan et al,[2] found culinary interventions to be associated with improved attitudes, self-efficacy, and healthy intake in children.[2] An explanation for the lack of an effect in some studies may be that the children in the intervention group were taught the correct way of preparing foods and recipes during the lessons and thus may have developed a more accurate assessment of their gaps in abilities than the children in the control groups. This was the conclusion of researchers applying a validated cooking self-efficacy tool in an RCT cooking intervention with fourth-grade children.[54] Overestimation of abilities is a common occurrence with children, leading to response-shift bias.[55]

In our review findings, cooking skills were most often measured through a proxy, such as self-reported cooking knowledge, cooking self-efficacy, or past and current cooking frequency. In addition, cooking behavior assessments were most often reported by children or 1 of their parents/caregivers on the frequency of their involvement in home meal preparation.[17,32,36,37,40,42,48,49] No studies included an external assessment of cooking skills in view of cooking practice for both intervention and comparison groups preintervention and postintervention. Only the dissertation by Parris used observation to assess student cooking skills during practice, but this was only conducted by the research team to document the cooking skills of intervention students posttest. Harley et al[41] noted the following:

> *...no method for measuring actual cooking skills in youth has been validated other than through direct observation, which may be unfeasible depending on sample size and constraints of the classroom setting. Development of such a method would constitute a significant contribution to the literature in this domain because of limitations of using measures of perceived ability as a proxy for actual ability.*

There are several validated cooking behaviors and ability tools for adults[56,57]; however, none exist for children.

Only 2 *Cooking with Kids* studies[33,34] completed subanalyses on students' preintervention cooking experience. In the 2013 RCT, Cunningham-Sabo et al[33] noted significant improvements in cooking self-efficacy for both students who reported at baseline that they did not cook and for boys, whether they received the cooking lessons or not.[33] Similar results were seen with noncookers in a quasi-experimental study using the same cooking program.[34] This may be because of the effects of gender roles and maturation. Although we did not examine gender effects in our study, it is reported that girls are involved in cooking more than boys in much of the

world.[15,58] An explanation could be that girls report stronger baseline cooking self-efficacy and attitudes toward cooking,[15,54] or that there is a greater expectation for girls to help with home meal preparation than boys because food preparation is deemed a female responsibility in many cultures.[59] In an out-of-school cooking program, girls aged 9−10 years had significantly higher baseline cooking frequency than boys.[58] However, the most recent Cooking with Kids study found that more boys than girls in the cooking intervention group (but not the control group) newly identified themselves as cooks and reported more cooking with their families. This suggests that such interventions influence more boys to begin cooking, which warrants more effort in normalizing cooking as an activity that both genders could and should do.

Regarding age, children are generally given more opportunities to be involved in home food preparation as they grow older.[15,60] In addition, older children or adolescents have more autonomy to purchase and prepare foods and are more exposed to influential figures in the media or on social media that may drive their interest in food choice.[61] However, when it comes to meal preparation frequency, there was inconsistency between ages and grade levels in the review by Quelly,[15] suggesting a need for age-appropriate activities.

Food Acceptance. Our results indicated that only 2 of 7 studies reported significant increases in willingness to taste new foods.[44,50] Cooking programs often include a measure of preferences for specific foods or food groups (eg, liking) to assess whether increased exposure during the cooking experiences impacts such preferences, with the assumption that gains will lead to improved dietary choices. However, there is limited evidence for this.[2,18] Our review supports this weak link, with only 2 of the 15 studies that included an assessment of dietary behavior noting positive intervention effects on intake. The psychosocial measurement domain of preference/liking for specific foods presents an interpretation challenge because a few exposures to a new/unfamiliar food do not necessarily increase preference; personal tastes still prevail. The studies in our review showed mixed results. This may also be in part because of the limited exposure to new healthy foods during cooking lessons or through the school meals provided and the lack of significant home reinforcement through changes in foods available and prepared.

Dietary intake. Most of the 15 studies that documented dietary intake also included other constructs within this domain (ie, dietary knowledge, self-efficacy, and attitude). As with the cooking skills and knowledge gains, general dietary knowledge improved for intervention children in 5 of the studies measuring this construct.[29,35,41,47] Educating is a main task of schools, and even if it is well established that knowledge alone may not lead to behavior change,[62] children need to acquire the basic knowledge to have healthy behavior when they start to become responsible for food preparation. Eventhough knowledge and skills are appropriate for both cooking skills and dietary choices, interventions could also make a transfer to the home setting[42] to establish behavior change.

Unfortunately, the demonstration of dietary change postintervention was poor; only 2 of 15 studies reported significant improvements.[42,43] As mentioned above, without significant changes in reinforcement through family meals and home food availability, it is unlikely that cooking lessons will lead to changes in dietary patterns among children. Similar to other variables measured in these studies, the methods used to assess dietary intake should be critically evaluated and appropriate. Validated dietary intake and cooking measures can strengthen the evaluation of these interventions.[21,63,64] A review on cooking skill interventions in adults also concluded that evidence for changes in dietary intake was inconclusive.[5] However, other reviews conclude that culinary interventions were associated with improved dietary intake in adults and children.[2,13,15] It is worthwhile to note that further research on identifying the true factors of success for adults and children separately is warranted. For example, exposure to cooking interventions may be stronger with children as they typically associate a fun cooking activity with a positive attitude. In contrast, adults have to think about the time and money costs of the meal they are preparing, which could negatively impact the long-term influence of a cooking program. As already mentioned, cooking programs alone are not sufficient to induce significant effects; reinforcement through the support of schools, families, and communities is needed to improve dietary intake and meet nutrition recommendations better.

Critically reflecting on the difference between the studies of adults and children and this review, it must be mentioned that in our review, no observational studies were included, no narrative review was conducted, and only studies with a control group were reviewed. On the basis of this reflection, we conclude that from studies with the strongest study design, there is no evidence for an association with improved dietary intake. If a broader perspective is taken and interventions that focus only on hands-on activities and a multicomponent approach (including nutrition education, cooking, gardening, and taste lessons) are evaluated, cooking might support the positive findings that are reported in these interventions.[8,18]

In our review, only cooking knowledge, self-efficacy, behavior, and dietary knowledge measures demonstrated positive changes in intervention children compared with controls. Ng et al[17] concluded that hands-on meal preparation could be an approach to positive food perceptions, which can *potentially* improve children's diets. Recent reviews that also focus on quality aspects and methodology come to similar conclusions and highlight the need for methodological rigor to strengthen the evidence in this field.[65] One difficulty in improving the quality aspects is the plethora of outcomes on very different levels, ranging from attitudes and beliefs on tasting and

intake to even longer-term health and body weight. Efforts to standardize and improve measurements could be applied and used in future studies.[21] Regarding personnel for intervention implementation, the studies showed that culinary professionals implement cooking interventions with greater fidelity than (overburdened) teachers.[31,66,67]

In our review, we found no consistent relationship between program dosage and outcome. Thus, the dosage of cooking programs needs to be considered. As people are often short on time,[68] it is important to identify the right intensity delivered through an intervention that does not overburden teachers or other personnel, which still leads to sustainable outcomes.

Anthropometric and health measures. On a final note, we reviewed the impact of cooking interventions on anthropometric and health measures; however, the findings were inconclusive or minimal. Therefore, these results were not included in the main findings of this review. Modest improvements in body mass index were reported in 2 studies,[39,42] and another reported improvements only in the overweight/obese subgroup compared with the entire group of controls.[69] No improvements in waist circumference or percent body fat were reported. Blood pressure showed modest improvements only in the 2 *LA Sprouts* studies.[69,70] Thus, similar to other reviews,[2] we conclude that assessing physical body measures is not relevant for interventions that only focus on cooking. However, such measures could be important when interventions include other components in addition to cooking, such as physical activity.

The strengths of this systematic review include the comprehensive literature search, the duplicate process of selecting and appraising studies, and the attempt to evaluate outcomes quantitatively. The literature search was comprehensive (1998−2022, using multiple databases and search terms). However, a limitation of this systematic review is the initial reliance on a review of reviews[27] to identify potentially relevant publications between 1998 and 2017 rather than completing a systematic review for that period; this may have resulted in some missed records. This systematic review did not assess the heterogeneity, or lack thereof, regarding race and ethnicity or other sociodemographic factors of the studies' participants. These limitations may have introduced selection bias and reduced the generalizability of our findings. Regarding the interventions' characteristics, outcomes, and measures that we evaluate, the heterogeneity of these variables made it difficult to determine the extent to which outcomes were moderated by program frequency and duration, previous cooking experience, and parent participation. This difficulty was also compounded by the insufficient detail of statistical analyses performed to allow for replication and confirmation of reported results. Because of these limitations within the studies, an assessment of the strength of the effect of the results reported by the studies could not be done. The use of the EAL quality assessment tool to identify the risk of bias,[28] which is useful and well-accepted in this field, was not a perfect fit for multicomponent interventions randomization of participants group selection, and blinding is not always possible.

IMPLICATIONS FOR RESEARCH AND PRACTICE

Even though clear evidence is still lacking, interventions that include hands-on cooking lessons seem promising in improving knowledge and self-efficacy. Because of the plethora of outcomes (from attitudes and beliefs to tasting and intake) that were measured, it was difficult to compare studies. Outcomes sought from children's cooking interventions thus require further standardization, and we recommend valid and reliable measurement instruments be developed to enable such comparison. Future interventions may benefit from focusing outcome measures on the main aim; for example, if the intervention aims to improve cooking skills, then cooking skills could be measured as the main outcome. We also suggest future investigation into the extent to which outcomes are moderated by program frequency and duration, previous cooking experience, and parent participation. Other ways to improve interventions are the use of behavior change theories in the design of the interventions and applying participatory methods such as co-creation.[71]

Intervention implementation is another area for further improvement. For cooking programs to be more effective, creating a stronger link with school meals or other public nutrition programs can offer the reinforcement needed to allow families to apply what they learned during cooking lessons. Future research could seek whether there is a certain program intensity that can lead to success. To better cater to the time and resources of the people involved in interventions, future programs could consider being low-intensity, brief interventions while leveraging engagement[72] and being supported by the family, school, and community environments so they can lead to sustainable effects.

Distinguishing the factors, such as age, gender, and baseline cooking skills, that make cooking programs successful in the long term warrants further exploration. Considering the relative importance of different cooking skills children need to enable healthy eating is warranted. For example, prioritizing the importance of cooking skills in order of importance before commencing the intervention (ie, knife skills, grocery shopping, or assembly of a healthy meal) may lead to more efficient education. Furthermore, it will assess whether cooking skills are important or if cooking can be used to deliver nutrition education to children, as well as to increase familiarity with disliked or unknown food. If cooking skills are shown to be important, then the skills could be objectively evaluated in research and education using cameras and observation or in small group settings.

This review showed that interventions addressing 1 or more aspects of cooking skills were not successful in changing dietary intake or health indicators. Studies had mixed results on food acceptance, but positive

associations were found for cooking knowledge, self-efficacy, and cooking involvement. Cooking interventions are popular and frequently proposed as a part of child nutrition improvement. However, their cost-effectiveness needs to be evaluated. Therefore, to ensure funds continue to be given to cooking programs, future research on children's cooking programs could focus on quality and standardization. For example, intervention design, implementation, and outcome measurement could be carefully considered. In addition, future interventions could consider age-appropriate activities to enhance interest in cooking. For example, sensory activities can be used for younger children, and technology can be used for older children. In conclusion, we recommend that children's cooking programs be carefully planned and evaluated by nutrition educators and researchers to better understand the factors that make cooking programs successful.

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SUPPLEMENTARY DATA

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