Implementation Science Communications

SYSTEMATIC REVIEW

Open Access

Implementation strategies used in policy, systems, and environmental interventions addressing obesity-related outcomes in early childhood education settings: a systematic review

Cody D. Neshteruk[1*], Courtney T. Luecking[2], Chelsea L. Kracht[3], Sarah Burkart[4], Emily M. Melnick[5], Robert E. Anderson III[6] and Hannah G. Lane[1]

Abstract

Background Policy, systems, and environmental (PSE) approaches, including those enacted in early childhood education (ECE) settings, can improve child health outcomes. The use of implementation strategies, or the ways in which these approaches are enacted across settings, may modify intervention impact. Therefore, the purpose of this review was to examine the implementation strategies used among interventions utilizing PSE approaches in the ECE setting.

Methods Seven databases including MEDLINE, PubMed, Web of Science, and EMBASE, were searched for interventions in ECE settings including children (0–6 years) that utilized ≥ 1 PSE approach. Eligible studies included either a child-level outcome (i.e., weight, physical activity, or diet) or an environmental outcome (i.e., nutrition and physical activity environment). Data extracted included study characteristics, description of the intervention, and description of the implementation of the intervention. Implementation strategies were coded using the School Implementation Strategies Translating ERIC Resources (SISTER) taxonomy. The Downs and Black checklist was completed to assess study quality.

Results One hundred and four studies representing 97 interventions were identified. Fourteen (14%) did not report any implementation strategies. Of the remaining 83 interventions reporting implementation strategies, the mean number of implementation strategies employed per intervention was 3.8 (± 2.3) (range 1–11). However, few interventions (5/83, 6%) clearly named and defined implementation strategies. Most implementation strategies came from the "train and educate stakeholders" SISTER domain (177/318, 56%), and the most frequently used implementation strategy was "conduct educational meetings (50/83, 60%). Most studies were classified as good (59/104, 57%) or fair (40/104, 38%) quality.

Conclusions In this review, many interventions appeared to use multiple implementation strategies to support ECE PSE interventions, though few explicitly documented or described those strategies. These findings suggest that more

*Correspondence:
Cody D. Neshteruk
cody.neshteruk@duke.edu
Full list of author information is available at the end of the article

precise documentation of implementation strategies is needed to enhance replication and scalability of ECE interventions.

Registration PROSPERO# CRD42022306670.

Keywords Early care and education, Child care, Physical activity, Nutrition, Obesity, Implementation science, Intervention, Policy, Environment

Contributions to the literature

- There are many effective healthy eating and physical activity interventions in early childhood education settings, yet little is known about implementation of interventions in these settings.
- While many interventions appeared to use multiple implementation strategies to support ECE interventions, few explicitly documented or described those strategies, limiting replicability or scalability potential.
- There is a clear research to practice translation gap among ECE interventions making it necessary for future interventions to explicitly identify implementation strategies and evaluate their use.

Background

In the United States, 12.7% of children between the ages of 2–5 years have obesity [1]. The development of obesity early in life is associated with poorer cardiovascular health, asthma, type II diabetes, increased anxiety and depression as well as later obesity and health complications [2–4]. Strategies for early life prevention of obesity are crucial, including the development of healthy eating behaviors and physical activity patterns that can track into adolescence and adulthood [5–8].

Roughly 87% of children 3–5 years old spend some time in early childhood education (ECE) settings, such as child care centers or family child care homes [9, 10]. This provides a unique opportunity to promote healthy eating and physical activity among the many children attending ECE [11]. Over the past nearly two decades, research into health promotion in ECE settings has proliferated. In particular, an increasing number of interventions are utilizing policy, system, and environmental (PSE) approaches for obesity prevention efforts [12, 13]. PSE approaches (e.g., center level policies, food service changes, modifications to the social or physical environment) intend to change the conduct, processes, and environments of ECE centers to be more conducive to healthy eating and physical activity. There is clear evidence that PSE interventions have beneficial impacts on the ECE nutrition and physical activity environment [14–17]. However, there is mixed, but promising, evidence on the effectiveness of ECE PSE interventions in changing child-level behaviors (e.g., weight status, fruit and vegetable intake, physical activity) [18].

The heterogeneity of ECE settings can lead to sporadic and inconsistent implementation of interventions in real-world conditions, potentially explaining the mixed effects of PSE interventions on children's behaviors. Greater attention to implementation strategies, which are strategic methods or techniques that seek to facilitate implementation of interventions across varied context by increasing acceptability, appropriateness, fidelity, penetration and other implementation outcomes, are likely needed for PSE interventions to be effective on a broad scale in ECE settings [17, 19–21]. Within the broader implementation science field, implementation scientists have systematically developed taxonomies of implementation strategies for a variety of types of interventions, with the intent to study their use across a variety of settings. While these taxonomies have allowed for more rigorous selection, tailoring and testing of implementation strategies more work is needed to understand the impact of implementation strategies on implementation and effectiveness outcomes, particularly within community settings, like ECE settings, that experience unique barriers to implementing evidence-based programs [20, 22–24]. This represents a critical gap in our ability to translate effective PSE intervention approaches into practice to improve obesity, diet, and physical activity outcomes at a population level. Greater knowledge of the implementation strategies provided in PSE ECE interventions is critical to facilitating intervention uptake and understanding the key mechanisms of action for future interventions [20].

Therefore, the aim of this systematic review was to characterize the implementation strategies used to support implementation of ECE interventions utilizing PSE approaches. Specifically, we sought to characterize the extent to which published studies report on implementations strategies, then use an existing taxonomy to describe the specific implementation strategies used. Findings from this review will identify priorities for future implementation-focused research in the ECE setting, highlight key directions for practitioners and policy makers, and ultimately work to close the gap in the translation of evidence-based interventions into practice

by addressing the varying contexts under which these approaches are being implemented.

Methods

Search strategy. The Preferred Reporting Items for Systematic Reviews and Meta-Analyses Checklist was used to prepare this review (Supplementary Table 1) [25]. This review was conducted as part of a systematic review examining the inclusion of priority populations (e.g., racial/ethnic minority, low-income, and rural populations) within obesity-related ECE interventions utilizing PSE approaches (PROSPERO# CRD42022306670) [18]. Specifically, the current review examined the implementation strategies used in the identified ECE PSE interventions. Therefore, the search strategy was not updated with additional terms, as the intention was not to identify studies with implementation strategies, but rather to understand the implementation strategies used in the current literature.

The original review examined peer-reviewed literature published between January 1, 2000 to February 2, 2022 among seven databases (i.e., MEDLINE OVID, PubMed, Web of Science, EMBASE, Education Resources Information Center, PsycInfo, and CINAHL). This range was chosen given the proliferation of obesity research in the ECE setting during this time [11]. The original search was replicated on October 6, 2022 for the current review. Supplemental search strategies included forward citation searching to identify subsequent process evaluation or implementation papers published after the primary outcome paper. Reference lists of included studies were also examined for relevant studies as well as protocol and intervention development papers that could provide additional context on the intervention implementation. Finally, experts in the field ($n=15$) were contacted to review the list of identified studies. The full search strategy is in Supplementary Table 2.

Eligibility criteria

Full inclusion and exclusion criteria are listed in Table 1. To be included, interventions must have targeted children between ages 0 to 6 years, had a focus on preventing obesity or improving a related outcome (i.e., diet, physical activity, sedentary behavior, or ECE environment) and included at least one PSE approach. Interventions could have included the PSE approach as the intervention itself, or in combination with other intervention components (e.g., educational or parent curriculum). Policy

Table 1 Inclusion and exclusion criteria

Component	Inclusion	Exclusion
Publication date	• January 1, 2000 – October 6, 2022	• Prior to 2000
Article Type	• Peer reviewed journal article • Published in English	• Conference abstracts • Dissertations • Clinical Trials registrations • Grey literature • Non-English publications
Population	• Children between ages 0–6 years or with a mean age < 6 years • Children without conditions that would affect physical activity	• Children above age of 6 years or mean age > 6 years or mainly conducted in children 7 + years • Children with acute or chronic conditions (e.g., asthma)
Setting	• ECE setting – settings that serve young children, have formal education component and are open during the weekdays (e.g., preschool, nursey, daycare, family child care home, child care, kindergarten)	• Home setting (i.e., with parents or other caregivers) • Clinical setting (i.e., delivered by healthcare provider)
Design	• Pre-post • Natural experiment • Pilot/feasibility study • Randomized controlled trial • Cluster randomized controlled trial	• Case study • Qualitative study • Cross sectional study • Commentary • Systematic review or meta-analysis • Study protocol[a]
Intervention	• Policy component and/or • System component and/or • Environmental component	• Only individual level intervention component • Curriculum only intervention
Outcome	• Obesity related (e.g., BMI, weight) • Diet (e.g., diet quality) • Physical activity (e.g., MVPA) • Motor skills • Sedentary behavior • ECE physical activity or nutrition environment	• Non-obesity focused health outcomes (e.g., dental caries, infectious diseases) • Provider level outcomes (e.g., teacher physical activity or dietary intake) • Parent-reported outcomes (e.g., physical activity or diet at home)

Abbreviations: early childhood education (ECE), body mass index (BMI), moderate to vigorous physical activity (MVPA)

[a] Forward citation searches were conducted on February 23, 2023 for all identified study protocols to determine if a subsequent outcomes paper was published

approaches were defined as written or formalized regulations (e.g., new policy on amount of outdoor playtime or the foods that could be served at meals) and could have been at the center, state, or federal level. System approaches were defined as a methodological change in processes, such as organizational or operational changes (e.g., changes to outdoor time schedule or modifications to food service) [26]. Environmental approaches were divided into social approaches, defined as provider-child interactions (e.g., interventions targeting provider feeding practices or teacher-led physical activity) and physical approaches, defined as observable or demonstrable changes to the environment (e.g., new playground equipment, installation of drinking stations to promote water intake). Interventions where providers were asked to teach a specific nutrition or physical activity curriculum were excluded, as these were not considered changes to the environment. Eligible study designs included pre-post studies, feasibility and pilot studies, quasi-experimental, natural experiments, and randomized control trials. Outcomes had to be collected in the ECE setting; studies with outcomes reported by caregivers or in non-ECE settings were excluded.

Study selection

As part of the original search, one author (CLK) completed title screening. Title screening can streamline the initial screening phase and has comparable return rates [27]. Prior to abstract screening and full-text review, all reviewers completed an initial pilot test of the screening process. Then, abstracts and full-text were screened in duplicate by members of the author team (CDN, CLK, and EM) using Covidence systematic review software (Veritas Health Innovation, Melbourne, Australia). CLK resolved conflicts at the abstract phase, and any full-text conflicts were resolved by discussion among the reviewers. For the updated search, the same process was used, apart from title screening. Given the relatively small number of identified abstracts ($n=1305$), title and abstract screening were conducted simultaneously by three authors (CDN, CLK, and SB). Supplemental search strategy techniques were employed with the final list of full-text articles.

Data extraction and risk of bias

Data were independently extracted by one reviewer using an extraction template and then checked by a second reviewer to verify accuracy. Extracted data regarding study characteristics included population, intervention type, study design, comparison group, PSE approaches, outcomes, and main findings. These data were extracted for newly identified studies only, as this information was already available for the studies included in the previous review. For all studies, additional extraction data included all text related to the intervention implementation, delivery, and components to identify implementation strategies. To reduce error in specifying the above components, extractors copied and pasted all text directly from the manuscript.

The School Implementation Strategies Translating ERIC Resources (SISTER) taxonomy was used to systematically code for implementation strategies in each identified study. The SISTER taxonomy is a set of 75 implementation strategies that are divided into nine different domains [28]. SISTER strategies were adapted for specific use in school settings from the widely-used Expert Recommendations for Implementation Change (ERIC) [29]. Given the close relationship of the ECE setting with school-based research, the SISTER strategies were used for this review. Extracted text related to implementation was reviewed by three members of the author team with expertise in implementation science (CDN, CTL, and HGL). These three authors reviewed the description of implementation, which was copied and pasted verbatim from the articles, then assigned strategies from the SISTER taxonomy. All articles were coded in duplicate and disagreements were iteratively discussed among the author team until a consensus was reached.

The Downs and Black checklist, a tool for assessing risk of bias for randomized and non-randomized intervention trials, was used to evaluate the quality of included articles [30]. The checklist includes 27 items on reporting (10-items), external validity (3-items), internal validity (13-items), and power (1-item). Similar to other reviews, the power item was modified to whether a power analysis was described (0 = not reported, 1 = reported) rather than the five-point scale [31]. The maximum possible score is 28 for randomized studies and 25 for non-randomized studies, with scores categorized by the following ranges: excellent (26–28), good (20–25), fair (15–19), and poor (≤ 14) [32]. The Downs and Black checklist was completed by one reviewer for each study, and examined by a second reviewer. If any data for extraction or risk of bias was missing, the reviewers examined protocol papers or marked as "not reported" in the extraction tool or "unable to determine" in the Downs and Black checklist. A certainty assessment of the evidence was not conducted due to the heterogeneity of comparators and outcomes.

Synthesis of results

Central tendencies were used to describe study characteristics that included PSE approaches, population, intervention/comparator design, outcomes assessed (i.e., obesity, physical activity, diet, sedentary behavior, environment), assessment methods (i.e., objective, observed, self/provider/caregiver reported), and methodological

quality. To describe the implementation strategies used in ECE interventions with PSE approaches, descriptive analyses summarized the frequency of specific implementation strategies and implementation strategy domains. Analyses to examine the effectiveness of specific strategies, groups of strategies, or level of implementation support on intervention outcomes were not conducted due to the heterogeneity in operationalization of individual implementation strategies and outcomes reported. Rather, directional effects for each outcome are presented in Supplementary Table 4.

Results

Search

After removal of 21,639 abstracts during title screening, 4,427 abstracts were screened in duplicate, 511 full-text articles were reviewed in duplicate (498 identified in the search and 13 from supplemental search strategies), and 407 were excluded based on the exclusion criteria, most commonly not using a PSE approach ($n=177$, Supplementary Table 3). In total, 104 articles were included in the review (Fig. 1). There were several instances where multiple articles reported on the same intervention: Toy Box ($n=4$) [33–36], FRESH ($n=2$) [37, 38]. Healthy Caregivers-Healthy Children ($n=2$) [39, 40], a state level policy ($n=2$) [41, 42], and a local accreditation policy ($n=2$) [43, 44]. Thus, there were 104 articles representing 97 unique interventions.

Study characteristics

Characteristics of the included interventions (n=97) are described in Table 2 and further information is provided in Supplementary Table 4. Most interventions were conducted in the United States (50/97, 52%), followed by Europe (23/97, 24%) and Australia (14/97, 14%). Many interventions (55/97, 57%) were conducted only in ECE settings. Interventions used a similar number of policy (51/97, 53%), system (53/97, 55%) and physical environment (54/97, 56%) PSE approaches. Social environment (39/97, 40%) approaches were the least utilized PSE approach. Nearly half of interventions used one PSE approach (42/97, 43%) and almost one third (28/97, 29%) used three or more PSE approaches. Slightly less than half of studies utilized a randomized controlled trial

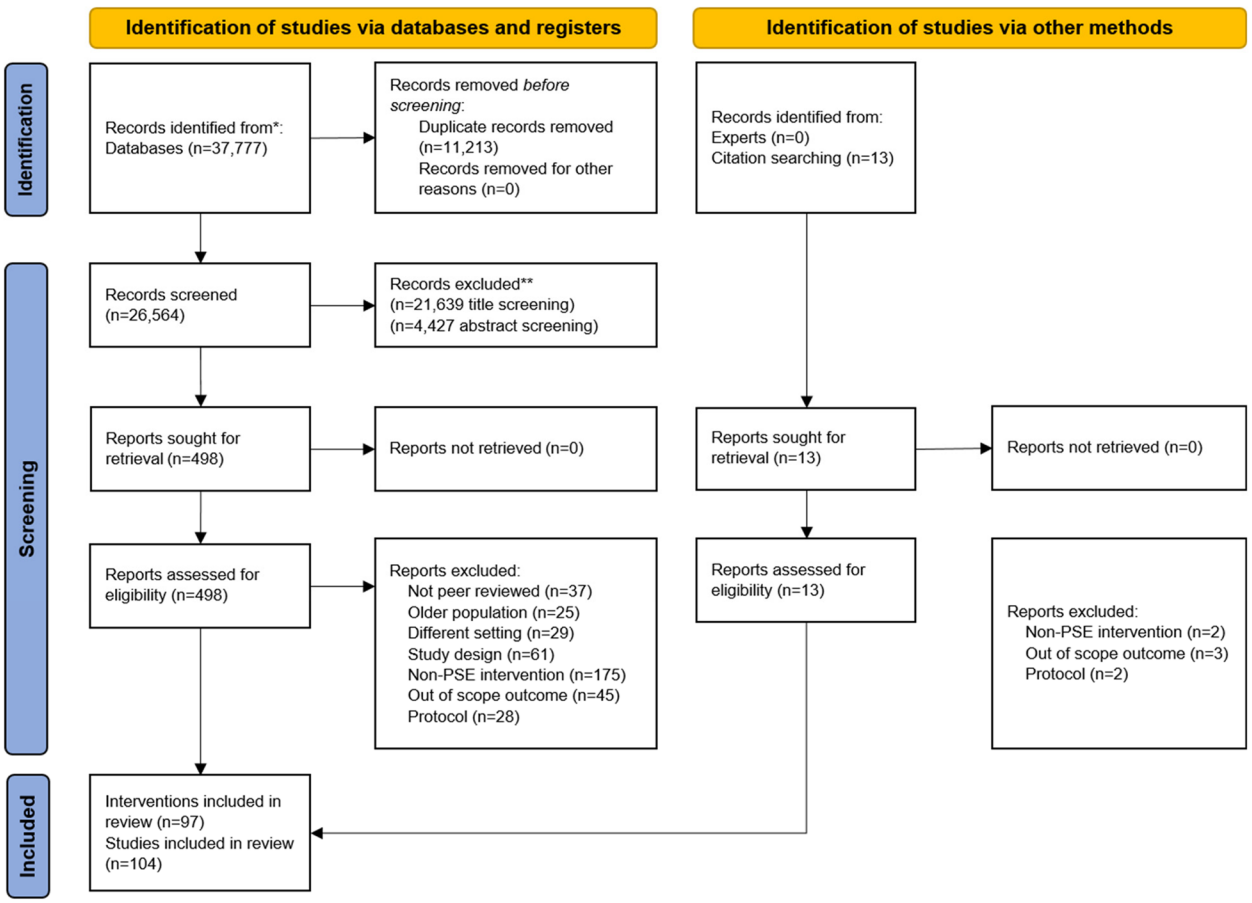

Fig. 1 PRISMA 2020 flow diagram for new systematic reviews that included searches of databases, registers, and other sources

Table 2 Summary characteristics of included interventions ($n = 97$)[a]

	n	%
Intervention setting		
ECE intervention with parent component	25	26
ECE intervention only	55	57
Multi-sector (ECE, parent, community)	9	9
Government regulation or policy	8	8
PSE approaches included [b]		
Policy	51	53
System	53	55
Social Environment	39	40
Physical Environment	54	56
Number of PSE approaches		
1	42	43
2	27	28
3	11	11
4	17	18
Study designs		
Randomized controlled trial	45	46
Pre-post study	21	22
Quasi-experimental	23	24
Other	8	8
Comparator		
No intervention	33	34
Delayed intervention	24	25
No comparator	25	26
Attention control	4	4
Other/not described	11	11
Outcomes assessed[b]		
BMI/weight	30	31
Diet	20	21
Physical activity	47	48
Sedentary behavior	24	25
Nutrition/physical activity environment	36	37

Abbreviations: early care and education (ECE); body mass index (BMI)

[a] Table reports on 97 studies as there were five interventions with multiple papers describing the same intervention

[b] Article could be included in multiple categories

design (45/97, 46%). One third of studies used a no intervention comparison (33/97, 34%), while one quarter used a delayed control (24/97, 25%) or no comparison (25/97, 26%). Child-level physical activity was the most frequently assessed outcome (47/97, 48%), followed by the nutrition and/or physical activity environment (36/97, 37%) and child weight status (30/97, 31%).

Implementation strategy reporting

Implementation strategy reporting for each intervention is shown in Supplementary Table 4. Of the 97 unique interventions, 14 (14%) did not specify what type of implementation strategies were used, either by explicitly stating strategies used or as identified through the coding process [45–58]. Among these interventions, most (86%, 12/14) used a single PSE approach, of which most were physical environment (50%, 6/12), followed by policy (25%, 3/12) and system (25%, 3/12) approaches. Physical activity was an outcome in most interventions not reporting implementation strategies (71%, 10/14).

Of the remaining 83 interventions, where at least one implementation strategy could be identified, only five (6%) specified the implementation strategies utilized by clearly naming, specifying and aligning the strategy with improved implementation and intervention outcomes [59–63]. Two of these five defined strategies using ERIC [60, 62], one used the Theoretical Domains Framework [63], one combined Theoretical Domains Framework and ERIC [61], and one used a combination of various frameworks to select and define implementation strategies [59]. Two of the five described the implementation strategies using Proctor et al.'s established guidance for identifying and reporting implementation strategies [21, 61, 62].

Table 3 Number of implementation strategies identified within each SISTER domain ($n = 318$)

SISTER Domain	# (%) of strategies
1. Use evaluative and iterative strategies	27 (8.5)
2. Provide interactive assistance	15 (4.7)
3. Adapt and tailor strategies	17 (5.3)
4. Develop stakeholder interrelationships	30 (9.4)
5. Train and educate stakeholders	177 (55.7)
6. Support educators	6 (1.9)
7. Engage consumers	9 (2.8)
8. Use financial incentives	25 (7.9)
9. Change infrastructure	12 (3.8)

Abbreviation: School Implementation Strategies Translating ERIC Resources (SISTER)

Implementation strategies used

Identified implementation strategies for each intervention are shown in Supplementary Table 4. The mean (standard deviation) number of implementation strategies among the 83 interventions demonstrating use of at least one implementation strategy was 3.8 (± 2.3) (range: 1–11). In total, 318 implementation strategies were coded, representing 44 (59%) out of a possible 75 implementation strategies from the SISTER taxonomy. All nine domains of the SISTER taxonomy were represented.

The distribution of implementation strategies across the nine SISTER domains is shown in Table 3. Most strategies (177/318, 56%) came from the "train and educate

stakeholders" domain. The next most frequently utilized domains were "develop stakeholder interrelationships" (30/318, 9.4%) and "use evaluative and iterative strategies" (27/318, 8.5%).

The number of studies that included each identified implementation strategy is shown in Table 4. "Conduct educational meetings" (50/83, 60%) was the most frequently identified implementation strategy. This strategy was often operationalized as a single training opportunity for ECE providers, directors, and staff prior to implementation. "Conduct ongoing training" (21/83, 25%) was operationalized as a series of trainings, often both before and throughout the intervention implementation. Over half of studies utilized the implementation strategy "distribute educational materials" (45/83, 54%), which typically involved the research team providing ECE providers with training and intervention materials. Many studies described providing implementation support from an individual with knowledge and expertise about the intervention: "provide ongoing consultation/coaching" (30/83, 36%) or "provide local technical assistance" (11/83, 13%). These strategies were distinctly operationalized based on who provided support: consultation/coaching was typically provided by a member of the research team or study interventionist, while technical assistance was delivered by local personnel (such state technical assistance agents) trained in delivering the intervention. Around one quarter (19/83, 23%), used "alter and provide individual and system-level incentives" from the "use financial incentives" domain, which included providing financial support (i.e., grant money) to fund the intervention or incentivizing individuals by providing continuing education credits or professional certifications. Beyond this strategy, implementation strategies from other domains outside the "train and educate stakeholder" domain were less frequently used.

Quality assessment

The quality of each included article ($n=104$) as assessed by the Downs and Black checklist is available in Supplementary Table 5. Most articles were classified as good (56/104, 54%) or fair (43/104, 41%). Two articles were classified as excellent, and three as poor. On average, many articles met reporting requirements (9.0/11 points), but met fewer external validity (1.7/3 points), bias (4.8/6 points), and confounding (4.1/6 points) criteria. Less than half (40/104, 38%) reported a power analysis. Few differences in reporting (9.1 randomized vs. 8.9 non-randomized) and external validity (1.7 randomized vs. 1.6 non-randomized) were found between differing study designs. However, randomized studies reported higher scores for bias (5.1 randomized vs. 4.6 non-randomized) and confounding (4.9 randomized vs. 3.1 non-randomized). More randomized studies reported a power analysis compared to non-randomized studies (64% vs. 8%). The majority of articles reported funding for the project and investigators (Supplementary Table 6).

Discussion

The goal of this systematic review was to examine the implementation strategies used in literature focused on PSE intervention approaches in ECE settings. Most interventions described using at least one implementation strategy, though those strategies were rarely defined as distinct from the intervention description. Studies mostly used implementation strategies designed to train and educate ECE professionals, with "conduct educational meetings" being the most frequently used strategy. With numerous PSE approaches and interventions available to support child nutrition and physical activity in the ECE setting, the lack of specified implementation strategies makes it difficult to understand the extent to which implementation outcomes (e.g., fidelity to intervention objectives) may influence effectiveness. Further, this limits the ability of practitioners and policy makers to recommend accompanying support strategies when initiating or mandating PSE approaches for childcare centers. This knowledge gap may be filled by improving reporting practices and exploring a variety of implementation strategies, to ultimately move PSE approaches into broad practice.

Only five studies clearly and explicitly defined the implementation strategies separately from intervention components. This is unsurprising, given that use of systematic language around implementation strategies as distinct from evidence-based intervention strategies is a relatively recent shift, particularly for community settings, as opposed to clinical settings, where much of the work to operationalize implementation strategies was initiated beginning around 2012 [21, 64, 65]. Other potential barriers to reporting may include the complexity of the setting and limited training in implementation science. In this review, the implementation strategies were often embedded within the "intervention description" section, requiring manual work from the authors to distinguish an implementation vs intervention strategy. This has important implications for dissemination of PSE approaches because providing ECE settings with not only the "what" but also the "how" is critical to the uptake and scalability. Furthermore, our efforts to distinguish implementation strategies from the interventions was further complicated by our specific focus on PSE approaches, as some of the ERIC and SISTER strategies could be considered interventions. For instance, the SISTER implementation strategies "change/alter environment" and "develop local policy that supports implementation" were defined

Table 4 Number of studies ($n = 97$) using each identified implementation strategy

SISTER Implementation Strategies (Domain)[a]	# of studies
37. Conduct educational meetings (5)	50
42. Distribute educational materials (5)	45
44. Provide ongoing consultation/coaching (5)	30
39. Conduct ongoing training (5)	21
61. Alter and provide individual and system-level incentives (8)	19
16. Promote adaptability (3)	12
15. Provide local technical assistance (2)	11
38. Conduct educational outreach visits (5)	9
2. Audit and provide feedback (1)	8
43. Make training dynamic (5)	7
35. Use advisory boards and workgroups (4)	6
41. Develop educational materials (5)	6
46. Use train-the-trainer strategies (5)	6
57. Involve students, family members, and other staff (7)	6
73. Mandate for change (9)	6
17. Tailor strategies (3)	5
21. Build partnerships (i.e., coalitions) to support implementation (4)	5
26. Identify and prepare champions (4)	5
5. Develop a detailed implementation plan or blueprint (1)	4
9. Monitor the progress of the implementation effort (1)	4
53. Remind school personnel (6)	4
12. Facilitation/problem solving (2)	3
23. Conduct local consensus discussions (4)	3
31. Obtain formal commitments (4)	3
68. Change/alter environment (9)	3
72. Develop local policy that supports implementation (9)	3
24. Develop academic partnerships (4)	2
29. Involve governing organizations (4)	2
33. Promote network weaving (4)	2
40. Create a professional learning collaborative (5)	2
59. Use mass media (7)	2
60. Access new funding (8)	2
63. Develop disincentives (8)	2
3. Conduct cyclical small tests of change (piloting or trialing the practice first) (1)	1
10. Stage implementation scale up (1)	1
11. Centralize technical assistance (2)	1
22. Capture and share local knowledge (4)	1
28. Inform local opinion leaders (4)	1
48. Create new practice teams (6)	1
51. Improve implementers' buy-in (6)	1
58. Prepare families and students to be active participants (7)	1
62. Alter student or school personnel obligations to enhance participation in or delivery of new practices, respectively (8)	1
64. Fund and contract for the new practices (8)	1

Abbreviation: School Implementation Strategies Translating ERIC Resources (SISTER)

[a] Domains are categorized as the following: (1) Use evaluative and iterative strategies, (2) Provide interactive assistance, (3) Adapt and tailor to context, (4) Develop stakeholder interrelationships, (5) Train and educate stakeholders, (6) Support educators, (7) Engage consumers, (8) Use financial incentives, (9) Change infrastructure

for our purposes as the intervention[28]. In order for evidence-based strategies to be effectively disseminated into practice, it is crucial to clearly distinguish these key aspects for future implementers [66, 67].

In terms of strategies identified, we found that over half of the identified implementation strategies were from the "train and educate stakeholders" domain, with four of the five most frequently used implementation strategies coming from this category. ECE teachers serve as key role models for children and are responsible for structuring the ECE classroom environment [68], so it is a logical step that training and educating ECE teachers in a particular intervention would support implementation. Indeed, a Cochrane review of 215 studies examining the effect of educational meetings (i.e., training) on practice and patient outcomes, found that educational meetings can improve practice and to a lesser extent patient level outcomes [69]. However, a reliance on ECE teachers as program implementers may not be a sustainable strategy. ECE teachers work long hours in highly demanding jobs, often have health problems of their own, and are among some of the lowest paid workers in the United States, resulting in a high degree of ECE staff turnover [70–72]. As such, the responsibility of implementing a PSE intervention may produce additional burden. Other implementation strategies, particularly those dispersed across staff and infrastructure of an entire child care facility, may be more effective [67, 73].

The large number of interventions and heterogeneity in both operationalization of implementation strategies and study outcomes precluded conclusions around effectiveness of specific implementation strategies, strategy domains, or level of implementation support (i.e. dose). For example, "conduct educational meetings" in one study was conceptualized as a 30-min intervention training session delivered by the intervention team [74], while in another it was a 9-h nutrition training from dietitians [75]. A prior systematic review examining implementation strategies in 21 ECE interventions targeting physical activity and healthy eating concluded that there is evidence that implementation strategies improve outcomes [17]. This suggests that implementation strategies can be effective, but additional work is needed to provide a more detailed evaluation of specific implementation strategies, focusing on specific elements such as dose, temporality, and actor [21].

Most studies in this review were rated as good or fair quality. Studies typically met many of the reporting requirements, but there was variability in the external validity, confounding, and bias subscale scores. This is likely the result of the community-based nature of these interventions compared to more tightly controlled clinical trials. This is further illustrated by the fact that only about half of studies utilized randomization, with child care centers as the unit of randomization. Several studies evaluated policies or naturally occurring interventions (e.g., pre-planned playground changes) or were pilot and feasibility trials, making randomization impractical. Additionally, by having child care centers as the unit of intervention, criteria like reporting of adverse events are likely not relevant. Finally, power analyses may not have been conducted due to the pilot/preliminary nature of the studies or because eligible samples were limited to specific communities.

Based on findings from this study, there are several actions for future obesity prevention and healthy eating/physical activity PSE interventions in the ECE setting. First, implementation must be considered from the start, even as early as grant proposals [76]. Future studies may consider the use of hybrid effectiveness implementation trial designs, which are designs that test both intervention effectiveness and success of the implementation framework [77]. Second, as evidenced by the current review, this field needs clear reporting of implementation strategies using consistent terminology. Studies by Swindle et al. and Yoong et al. in this review provide excellent examples of reporting implementation strategies by naming and defining the strategies based on existing taxonomies, specific actors, dose, and temporality for each strategy, and providing evidence for the use the particular strategies [61, 62]. Third, depending on the PSE intervention being implemented, researchers may consider co-developing implementation packages with providers or policy makers to ensure the feasibility and appropriateness of implementation strategies to support intervention uptake. This could also facilitate the adoption of additional implementation strategies that are uniquely positioned to promote intervention uptake in ECE settings. Finally, additional studies are needed to test the effectiveness of specific implementation strategies, or combinations of strategies, in the ECE setting.

Strengths and Limitations

This study had many strengths including: a comprehensive and systematic search strategy, ability to examine our research question over many studies describing various PSE approaches, the use of an expert defined list of implementation strategies that were designed specifically for education-based implementation research, and the inclusion of a quality assessment. However, there were also several limitations. First, by exclusively focusing on PSE approaches, this study did not account for the implementation of nutrition and physical activity curriculums, which can also support healthy behaviors. Second,

implementation strategy coding was subjective, despite expert coders, an expert defined list of implementation strategies specific to an education setting, and a rigorous training and coding process. This was driven by namely small excerpts of text to determine whether a particular strategy was part of the implementation of the intervention or the actual intervention. It is possible that some coded implementation strategies would not have been considered as such by the original authors and vice versa. Third, although the SISTER taxonomy was used, definitions of strategies did not always match the ECE context. Additionally, there were several instances where there were implementation strategies used that did not cleanly fit into a defined implementation strategy from the taxonomy. There is currently work underway to define implementation strategies for community contexts which may provide more relevant context to understand implementation strategies used.[78] Finally, while this is likely a product of changing publication priorities over the time frame of our review, the heterogeneity of implementation reporting and outcomes precluded formal analysis examining the effectiveness of identified implementation strategies on outcomes. It is possible since we conducted this review that additional ECE PSE studies have published on implementation strategies and outcomes.

Conclusion

PSE approaches have great potential for affecting population level change in children's weight status, dietary intake, and physical activity. An accurate depiction of the strategies that support implementation of these approaches is a key consideration in understanding how to scale and disseminate these approaches, but very few studies in this review explicitly identified implementation strategies used to support the implementation of these interventions. Furthermore, many of the implementation strategies identified focused on educating and training ECE providers, which could be one component of a comprehensive implementation package containing strategies within other domains rather than the sole approach. To advance the field of obesity prevention in the ECE setting, future studies must strategically select and specify implementation strategies and distinguish implementation and intervention strategies. Only then will we be able to effectively translate research into practice and improve the health and well-being of young children.

Abbreviations

ECE	Early childhood education
ERIC	Expert Recommendations for Implementation Change
PSE	Policy, systems, and environment
SISTER	School Implementation Strategies Translating ERIC Resources

Supplementary Information

The online version contains supplementary material available at https://doi.org/10.1186/s43058-025-00718-9.

Supplementary Material 1.
Supplementary Material 2.
Supplementary Material 3.
Supplementary Material 4.
Supplementary Material 4.
Supplementary Material 6.

Acknowledgements

We would like to thank Lori Steib for her assistance in developing the search strategy and conducting the literature search.

Authors' Contributions

CN conceptualized and designed the study, screened articles, extracted data, analyzed and interpreted the data, and drafted the initial manuscript. CLK, SB, and EM conceptualized and designed the study, screened articles, extracted data, interpreted the results, and provided critical feedback on the manuscript. REA extracted data and assisted with drafting the initial manuscript. CL and HGL conceptualized and designed the study, extracted data, interpreted the results, and provided critical feedback on the manuscript. All authors read and approved the final manuscript.

Funding

This paper was supported by Healthy Eating Research, a national program of the Robert Wood Johnson Foundation. The funder played no role in the conduct and interpretation of the review. Additionally, CN was supported by the National Institutes of Health (5K12HL138030-05), as was SB (F32HL154530), EM (1R01 HD 104708–01), and CLK (T32DK064584, U54GM104940, and K99HD107158). The content is solely the responsibility of the authors and does not necessarily represent the official views of the National Institutes of Health.

Data availability

Data extracted from studies can be found in supplementary tables or is available upon request.

Declarations

Ethics approval and consent to participate

Not applicable.

Consent for publication

Not applicable.

Competing interests

The authors declare that they have no competing interests.

Author details

[1]Department of Population Health Sciences, Duke University School of Medicine, 215 Morris Street, Suite 210, Durham, NC 27708, USA. [2]Department of Dietetics and Human Nutrition, Martin-Gatton College of Agriculture, Food and Environment, University of Kentucky, Lexington, KY, USA. [3]Division of Physical Activity and Weight Management, Department of Internal Medicine, University of Kansas Medical Center, Kansas City, KS, USA. [4]Department of Exercise Science, Arnold School of Public Health, University of South Carolina, Columbia, SC, USA. [5]College of Health Solutions, Arizona State University, Phoenix, AZ, USA. [6]Department of Nutrition, Gillings School of Global Public Health, University of North Carolina at Chapel Hill, Chapel Hill, NC, USA.

Received: 2 August 2024 Accepted: 16 March 2025
Published online: 31 March 2025

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