



Published in final edited form as:

J Acad Nutr Diet. 2016 August ; 116(8): 1295–1307.e6. doi:10.1016/j.jand.2016.04.015.

A systematic RE-AIM review to assess sugar-sweetened beverage interventions for children and adolescents across the socio-ecological model

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Abstract

Background—Sugar-sweetened beverage (SSB) consumption among children and adolescents is a determinant of childhood obesity. Many programs to reduce consumption across the socio-ecological model report significant positive results; however, the generalizability of the results, including whether reporting differences exist among socio-ecological strategy levels, is unknown.

Objectives—This systematic review aims to (1) examine the extent to which studies reported internal and external validity indicators defined by RE-AIM (reach, effectiveness, adoption, implementation, maintenance) and (2) assess reporting differences by socio-ecological level: intrapersonal/interpersonal (Level 1), environmental/policy (Level 2), multi-level (Combined Level).

Methods—Six major databases (PubMed, Web of Science, Cinahl, CAB Abstracts, ERIC, and Agricola) systematic literature review was conducted to identify studies from 2004–2015 meeting inclusion criteria (targeting children aged 3–12, adolescents 13–17, and young adults 18 years, experimental/quasi-experimental, substantial SSB component). Interventions were categorized by

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Conflict of Interest Statement

The authors of “Assessing the internal and external validity of sugar-sweetened beverage consumption interventions for children and adolescents: a systematic RE-AIM review using a socio-ecological approach” have no conflicts of interest to report.

socio-ecological level, and data were extracted using a validated RE-AIM protocol. A one-way ANOVA assessed differences between levels.

Results—There were 55 eligible studies (N) accepted, including 21 Level 1, 18 Level 2, and 16 Combined Level studies. Thirty-six (65%) were conducted in the USA, 19 (35%) internationally, and 39 (71%) were implemented in schools. Across levels, reporting averages were low for all RE-AIM dimensions (reach=29%, efficacy/effectiveness=45%, adoption=26%, implementation=27%, maintenance=14%). Level 2 studies had significantly lower reporting on reach and effectiveness (10% and 26%, respectively) compared to Level 1 (44%, 57%) or Combined Level studies (31%, 52%) ($p<0.001$). Adoption, implementation, and maintenance reporting did not vary among levels.

Conclusion—Interventions to reduce SSB in children and adolescents across the socio-ecological spectrum do not provide the necessary information for dissemination and implementation in community nutrition settings. Future interventions should address both internal and external validity to maximize population impact.

Keywords

beverages; youth; children and adolescents; review; systematic

INTRODUCTION

Over the past decade, the consumption of sugar-sweetened beverages (SSBs) has garnered attention as a correlate to childhood obesity.^{1,2} SSBs, including soft drinks, fruit drinks, and sports and energy drinks, contain few nutrients yet are a top energy source for children and adolescents. Based on a nationally representative sample, children and adolescents in the United States consume an average of 155 calories per day from SSBs, accounting for approximately 8% of their daily caloric intake.³

There is compelling evidence that a link exists between SSB consumption and weight status among children and adolescents and that reducing consumption has favorable effects on weight status.^{1,4-5} High levels of SSB consumption have also been linked to other adverse health conditions, such as dental decay, headaches, anxiety, and Type 2 diabetes mellitus.⁶⁻⁹ Furthermore, low-income children and adolescents and racial/ethnic minorities consume disproportionate amounts of SSBs and are at higher risk for developing obesity-related diseases, especially Type 2 diabetes.^{3,10-12}

Current interventions to reduce SSB intake use a variety of implementation strategies across levels of the socio-ecological model.¹³ The model considers the influence of intrapersonal, interpersonal, environmental, and organizational/policy factors on individual and population-level behavior change and is often used to develop childhood obesity initiatives.¹⁴⁻¹⁵ The socio-ecological model can be applied to SSB behaviors given that they are ubiquitous, i.e., readily and easily accessible, highly influenced by parental patterns, and pervasively marketed, particularly to Black and Hispanic children.¹⁶⁻²⁴ The Centers for Disease Control specifically recommends using this model when designing strategies to reduce SSB intake, particularly among at-risk populations.²⁵

Many promising studies demonstrate effective interventions to reduce SSB consumption among children and adolescents.^{1,4,5,26–29} However, all current published and planned systematic reviews of these studies focus almost exclusively on internal validity.^{1,4,5,26–29} More specifically, these reviews highlight efforts to test interventions under optimal conditions in order to determine the causal relationship between the intervention and participants' improved SSB outcomes.³⁰ This firmly established evidence regarding the negative impact of SSBs on child and adolescent weight^{1–2} has led to calls for health and nutrition professionals to promptly and widely facilitate this behavior change, particularly within at-risk groups.^{2,25} However, translation of research into practice-based recommendations that enhance public health impact requires a better understanding of the external validity across socio-ecological levels. This approach evaluates the degree to which an intervention's effects are generalizable to contexts outside controlled populations and environments.^{30–31} This is a gap in the current reporting approach, which provides limited understanding about the external validity. One proposed approach to better understand the potential impact of these interventions is use of Glasgow and colleagues' RE-AIM (reach, effectiveness, adoption, implementation, maintenance) framework.³¹

RE-AIM is a tool that assesses both internal and external validity elements of interventions and can be applied to various child and adolescent SSB interventions across socio-ecological levels.³² The framework provides criteria to evaluate the degree to which studies report both internal and external validity. Internal validity components are inclusion/exclusion criteria of participants and delivery agents (reach and adoption), attrition and imputation use (effectiveness, individual-level maintenance), and fidelity (implementation). Examples of external validity components include representativeness of the study sample or setting (reach and adoption), quality of life (effectiveness), and resource costs of implementing and sustaining an intervention in a given setting (implementation and site-level maintenance).^{31–32}

The RE-AIM framework has been frequently used to evaluate the validity of obesity-related interventions that utilize intra- and interpersonal strategies to change behavior and has been recommended TO EVALUATE environmental/policy strategies. However, it has not been used to examine intervention strategies that span the socio-ecological levels.^{33–42} The body of literature across different levels may differ widely in study design, reporting priorities, and quality. As one example, policy/environmental studies may focus more on setting-level indicators than individual/interpersonal studies. Therefore, assessing overall reporting quality by RE-AIM dimension and evaluating differences among socio-ecological levels will fully inform potential public health impact of available SSB interventions.⁴¹

The primary purpose of this systematic review of child and adolescent SSB intervention studies was to (1) examine the extent to which studies reported on RE-AIM indicators and (2) assess differences in reporting on RE-AIM indicators by socio-ecological level (intrapersonal, interpersonal, environmental, policy). Based on previous literature,^{33–41} our *a priori* hypotheses were (1) reporting quality would be highest for effectiveness and implementation, followed by reach, adoption, and maintenance and (2) when compared to intrapersonal/interpersonal studies, policy/environmental studies would report reach, efficacy/effectiveness, implementation, and individual-level maintenance indicators to a

lower degree and would report adoption and organizational maintenance at a similar or higher degree. A post-hoc exploratory aim was to explore differences in reporting by study design (RCT, quasi-experimental) and setting (school vs. non-school, US vs. non US). Contrary to previous reviews that focus exclusively on internal validity,^{1,4,5,26–29} findings from this review can identify the gaps in promoting translation of interventions to reduce SSB among children and adolescents into real world practice settings.

METHODS

This systematic review was conducted in June 2015. Eligible articles were those published in English between 2004–2015 and targeting children, adolescents, or young adults (ages 3–18). Study designs included experimental or quasi-experimental designs where pretest-posttest data were presented. Consumption, sales, and/or servings measures were eligible study outcomes across the socio-ecological levels. Articles were excluded if they were not peer-reviewed, were cross-sectional, only reported methods, were published prior to the seminal SSB intervention study in 2004, and did not identify an SSB outcome a priori. Articles that did not include a clear and substantial SSB reduction component (i.e., only assessed SSB as part of a general nutrition intervention or did not explicitly include SSB in policy guidelines) were also excluded.

Initial search terms in six databases (Figure 1) included *carbonated beverages, energy drinks, sugar sweetened beverage, SSB, sugary drinks, soda, soft drinks*, as well as *youth, adolescent, child, school* and *intervention, program, policy, environmental*. The search excluded articles pertaining to *university* or *college*. This search yielded 1,542 unique citations. Two authors (HL and JZ) reviewed titles and abstracts to determine whether they appeared to meet key inclusion criteria and then met to resolve discrepancies and reach consensus. Subsequent review of citation lists of recent systematic reviews^{1,4,5,26–29} and eligible studies also yielded 68 unique companion articles, which described additional aspects of eligible interventions. Figure 1 details the systematic process of identification of studies eligible for inclusion in this review.

Eligible articles were reviewed and coded by HL and KP using a previously validated 21-item RE-AIM extraction tool.^{43,44} The 21 items of the extraction tool represented indicators of the five RE-AIM domains:

- Reach: number, proportion, and representativeness of the participants in a study compared to eligible non-participants;
- Efficacy/Effectiveness: impact on primary study outcomes, quality of life, and unintended consequences;
- Adoption: number, proportion, and representativeness of settings and staff/intervention agents who agree to deliver or implement an intervention compared to non-deliverers;
- Implementation: degree to which intervention is delivered as intended and associated costs; and

- Maintenance: long-term individual change in primary outcomes and the extent to which intervention delivery or implementation is sustained over time.

Two authors coded five articles together to develop familiarity with the scoring protocol and met with the senior researchers for troubleshooting. All remaining articles were coded independently. Each reviewer coded a 1 (yes) or 0 (no) to indicate the presence or absence of each RE-AIM indicator and, where appropriate, noted specific details for indicators. Cohen's kappa was calculated for all independently coded articles to determine the tool's inter-rater reliability (mean=0.85). Coders met to resolve coding disagreements;⁴⁵ all authors discussed unresolved disagreements to gain consensus.

Proportions of each of the 21 items reported were derived by summing across all studies and dividing by the study total (n=55). The proportion of reporting was also calculated for each RE-AIM dimension. Results were reported as the mean proportion reported across studies by dimensions and specific indicators. Using established protocol, a "comprehensiveness of reporting" score was determined for each study: high quality (15–21 indicators reported), moderate quality (8–14), or low quality (<8).³³

The socio-ecological level of the interventions (i.e., intrapersonal, interpersonal, environmental, or policy) was also documented. The studies were classified into one of three levels derived from the socio-ecological model, as shown in Figure 2:

- Level 1: intrapersonal and/or interpersonal strategies;
- Level 2: environmental and/or policy strategies;
- Combined Level: multi-level strategies, including intrapersonal and/or interpersonal strategies AND environmental and/or policy strategies.

One-way ANOVAs and Tukey's post-hoc tests were conducted to examine reporting differences for each RE-AIM dimension among these three levels. Additionally, when data was provided, averages, counts, or proportions were calculated for various RE-AIM indicators (e.g., participation rate, adoption rate) across socio-ecological levels.

RESULTS

Overall Findings

The systematic search identified 88 articles representing 55 studies (Supplemental Table 1). Of these studies, 21 (38%) used intrapersonal and/or interpersonal strategies (Level 1)^{46–80}, 18 (33%) utilized environmental or policy strategies (Level 2)^{81–107}, and 16 (29%) used a combination of intrapersonal and/or interpersonal and environmental and/or policy strategies (Combined Level)^{108–132}. Across all levels, the total proportion of RE-AIM reporting was 29%. Level 1 (35%) and Combined Level studies (34%) had a significantly higher proportion of reporting than Level 2 studies (17%) ($p<.001$).

Description of Included Studies

About half of the 55 studies were randomized controlled trials^{46,49–55,57–63,65–71,73–75,77–80, 83–85, 96–98, 109–110, 112–118, 121–124, 127–129, 133} (29; 53%). The remaining studies utilized quasi-experimental designs, with either a two-group^{64,76,86–90,104,106,111,119–120,125,130–132} (11; 20%), or one-group pretest-posttest^{47–48,56,72,81–82,91–95,99–103,105,107–108,126} (15; 27%) design. In seven of the one-group designs, the pre- and post-tests were administered to different samples^{93–95,99–100,105, 107,126}. Nearly three-quarters of the interventions and policies (39; 71%) were implemented in schools or multiple settings including schools^{46, 49–55, 57–64, 70–72, 76, 80, 86–102, 104–108, 110–111, 114–133}. Additional settings included home^{66–67,109,112–113} (4; 7%), clinic^{47–48,56,65,68–69,73–75,77–79} (7; 13%), and community-based organizations^{81–85,103} (5; 9%). Twenty of 55 (36%) studies identified SSB as their sole focus^{56, 62–64, 70–72, 84–85, 90, 96, 98–99, 105–106, 109, 112–113, 120–125, 133}. Of the 55 studies, a third (19; 35%) were conducted internationally^{46, 49–54, 57–60, 62–64, 77–80, 100, 106, 109–110, 115–124, 127–129, 133}. Of these, 15 (79%) were conducted in countries similar in economic development to the U.S.^{46,49–54, 57–60,62–64,77–79,106,115–124,127–129,133}. Twenty-two reported using a behavioral theory during development (40%)^{46–54, 57–61, 64–68, 77–79, 82–83, 96–98, 110, 114–118, 121–124, 127–129, 133}. Finally, 21 (38%) reported focusing their programs or policies toward one or more at-risk groups: those of low socioeconomic status^{54,108,120–124,133} (5; 9%), racial and/or ethnic minorities⁴⁷ (1; 2%), those who are overweight or obese^{55,65,68,73–75,77–79,109,112,113} (8; 15%), those living in rural areas^{56,72,98} (3; 5%), or multiple at-risk groups^{66–67,81,84–85} (4; 19%). Supplemental Table 1 describes characteristics of the 55 individual studies, and Supplemental Table 2 summarizes these characteristics across all studies.

Comprehensiveness of Reporting

Table 2 details the quality of reporting across the 21 indicators of RE-AIM dimensions by strategy level. Reporting quality was low across studies, with no statistically significant differences by study design or setting (Figure 3). The mean number of indicators reported was 6.0 (SD=3.1), with a range of 1 to 14. Supplemental Table 1 details reporting quality of individual studies. None of the 55 studies were considered high quality, 21 (38%) were moderate quality, and 34 (62%) were low quality. About half of Level 1 and Combined studies (11/21 and 8/16, respectively) were moderate quality, compared to only two of 18 (11%) Level 2 studies.

Reach—Across the five reach indicators, the average reporting for all studies was 29%. Level 1 (44%) and Combined Level (31%) studies reported a significantly higher proportion of reach indicators compared to Level 2 (10%) studies ($p<.001$). Two Level 1 studies reported all reach indicators except representativeness. Reporting averages for each of the five reach indicators are described in Table 2.

Among those reporting participation rate (25 studies), the median number of participants per study was $675 \pm 1,331$, with an average participation rate of $66\% \pm 31\%$. Across Level 1 (13 studies), Level 2 (4 studies), and Combined Level (8 studies), the median number of

participants was 382 ± 497 , $705\pm 2,807$, and $919\pm 1,075$, respectively. Average participation rate ranged widely across Level 1 ($63\%\pm 26\%$), 2 ($78\%\pm 44\%$) and C ($78\%\pm 24\%$) interventions.

Efficacy/Effectiveness—The average reporting across all studies for the four efficacy/effectiveness indicators was 44%. On average, Level 1 (57%) and Combined Level (52%) studies reported significantly more efficacy/effectiveness indicators than Level 2 (26%) studies ($p<.001$). One Level 1 study reported all four effectiveness indicators while six Level 1 and five Combined Level studies reported three. Reporting averages for each of the efficacy/effectiveness indicators are described in Table 2.

About half (11/21; 52%) of Level 1 studies reported significant positive results; eight of these had a comparison group. Among Level 2 studies, 14 of 18 (78%) reported positive effects; six of these studies were comparison studies. One of these studies found a positive effect for servings but a null effect for consumption. Finally, over two-thirds of Combined Level studies (11/16; 69%) reported positive effects, including nine of the comparison studies. One of these studies found a positive effect for servings but a null effect for sales while another reported a negative consumption effect (i.e., increased SSB) but found a positive servings effect (i.e., decreased servings). Across all levels, the remaining studies reported either mixed (different within subcategories such as soda and fruit drinks) or null effects ($n=5$ and $n=14$, respectively).

Adoption—The average reporting across all studies for the six adoption indicators was 26%. The reporting was not significantly different across levels (25% for Level 1, 20% for Level 2, 31% for Combined Level). While no studies reported all adoption indicators, one Combined Level study reported all but representativeness. Additionally, one Level 1 and one Level 2 study reported four of six indicators. Reporting averages for each of the adoption indicators is described in Table 2.

Of studies reporting participation rate, 21 (38%) reported setting participation rate and two (4%) reported staff participation rate. The average number of settings per study was 40.4 ± 69.0 with an average participation rate of $49\%\pm 32\%$. Across Levels 1 ($n=5$), 2 ($n=7$), and Combined ($n=9$), the respective number of settings was 18.2 ± 13.5 , 27.8 ± 36.0 , and 67.1 ± 109.5 . For the two studies reporting staff participation, the Level 1 study reported participation of 132 staff (38% participation rate) and the Combined Level study reported participation of 140 staff (21% participation rate).

Implementation—The average reporting across all studies for the three implementation indicators was 27%, with differences in reporting across levels approaching significance ($p=.052$). Level 1, 2, and Combined studies averaged 30%, 15%, and 35% reporting, respectively. Two studies, one Level 1 and one Combined Level reported all three implementation indicators. Reporting averages for each of the implementation indicators is described in Table 2.

Across 12 studies reporting on the degree to which the intervention was implemented as intended, four followed closely with intended protocol, defined as reporting a fidelity $<75\%$,

including two of three Level 2 and two of seven Combined Level studies. The remaining eight studies reported fidelity rates between 50 and 75%. No studies reported <50% fidelity. As the few studies that reported implementation costs (n=10) did not use standardized metrics, it was not possible to compare across levels or determine an average implementation cost.

Maintenance—Across the three maintenance indicators, the average reporting among the 55 studies was 14%. There were no statistical differences between levels. The average reporting was 13%, 11%, and 21%, respectively, for Level 1, 2, and Combined studies. No studies reported all three indicators, but five of the 55 studies (representing all levels) reported at least two indicators. Reporting averages for each of the maintenance indicators is described in Table 2.

Of the 11 Level 1 and Combined Level studies reporting maintenance of individual outcomes, seven (64%) reported on maintenance of SSB outcomes as opposed to only weight-related outcomes. Three of these studies, two Level 1 and one Combined Level, reported a positive maintenance outcome, although one had a very brief follow-up period and another only saw maintenance in certain types of SSB. The other four reported either a return to baseline in the intervention group or no significant differences between control and intervention groups at the maintenance time point. Additionally, ten studies reported setting-level maintenance. One was discontinued, seven were sustained with adaptation, and two reported intervention maintenance but did not specify whether adaptation measures were taken.

DISCUSSION

The purpose of this review was to examine the extent to which child and adolescent SSB studies reported on RE-AIM indicators and to determine differences in reporting based on the targeted socio-ecological level. Findings partially support our two hypotheses. First, overall reporting quality was highest for effectiveness and lowest for maintenance, and reporting for reach, implementation, and adoption were relatively similar. Second, studies using environmental/policy strategies reported significantly fewer indicators for reach, efficacy/effectiveness, and individual level maintenance. These studies also were more likely to report on organizational level maintenance but not adoption. Compared to previous RE-AIM reviews, reporting across reach, effectiveness, and implementation dimensions appears to be lower for SSB interventions compared to other behavioral targets, including physical activity, nutrition, or tobacco control.^{32–35,44} However, SSB studies appear more likely to report adoption rates and setting-level maintenance.

Numerous primary studies and systematic reviews have detailed the promising effects of intervention and policy efforts at achieving reductions in SSB consumption among children and adolescents. However, the true public health impact of these interventions will only be realized if these interventions can be translated beyond research studies and into real-world settings. Simply knowing if an intervention is effective is insufficient. From a public health nutrition perspective, it is important to identify and enact those programs and policies that can reach the most children and adolescents, achieve the best effects, have high likelihood of

adoption and implementation by real-world settings, be able to maintain individual-level effects, and be sustained within local systems. Our review highlights that as a whole, key details are missing in these published reports. Without adequate information on all RE-AIM factors, researchers, practitioners, and decision makers lack adequate information to translate the current body of literature into practice and to maximize health impact of available effective interventions and policies to reduce SSB consumption among children and adolescents.

Compared to previous RE-AIM studies, reporting averages for Reach for Levels 1 and Combined appeared lower among SSB interventions than those seen in other behavioral studies.^{33–35,37,38} However, when compared to reviews of school-based intervention studies (as 39 of the 55 studies were school-based), more similarities emerge. For example, reporting of participation rate in Level 1 and Combined Level studies were similar (~62% and 50%, respectively) to the proportion of school-based nutrition, physical activity, and tobacco control studies (~59%).⁴⁴ The most pronounced difference arises when Level 2 studies are examined—only 22% of these studies reported participation rate. This is similar to the recent review by Brennan and colleagues that found only 10% of 146 obesity, nutrition, and physical activity policy and environmental interventions reported participation rate.⁴² The lack of reporting of participation rate typically arises due to undefined or unclear denominator, which is defined by the overall target population. Perhaps of even more concern is the lack of reporting of representativeness—only two Level 1 studies reported it—which is also corroborated by Brennan and colleagues, who reported representativeness in two of 32 studies.⁴² These gaps in reporting indicate a significant lack of understanding of the degree to which a representative population is exposed to interventions to reduce SSB consumption.

When compared to other RE-AIM reviews, our reporting of key efficacy/effectiveness indicators related to changes in quality of life and attrition are lower across SSB intervention studies, particularly Level 2 studies.^{32–35} However, when compared to other reviews focusing on children and adolescents or school-based interventions, the Level 1 and Combined Level interventions tend to report attrition with similar frequency and also similarly under-report on quality of life indicators.^{32,35} This suggests that quality of life may not be perceived as important to evaluate in children and adolescents regardless of the targeted behavior. It is promising, however, that most studies showed positive changes to the primary outcome. Furthermore, studies including both individual and environmental components had the highest proportion of effective trials.

Reporting of setting-level adoption and maintenance was considerably higher for SSB reduction studies compared to previous reviews. In particular, maintenance was not reported in any school-based studies of physical activity, nutrition, and tobacco control, or in a systematic review of policy and environmental changes related to childhood obesity.^{42,44} Studies reporting more on adoption and implementation, particularly adaptations necessary for sustainability, were more likely to include environmental/policy approaches. This suggests that more information is available to promote adoption of these interventions. Similar to reach, there was no data on representativeness of staff or settings where interventions were adopted, making conclusions about generalizability difficult.

Intervention duration, delivery as intended, and cost are key indicators for both internal and external validity. Reporting these factors is critical for replication in both research and practice settings. The lack of reporting on the extent the protocol was implemented as intended limits the internal validity of the findings, particularly among Level 1 and 2 studies. In contrast, the lack of reporting on cost limits the findings' external validity related to the resources necessary to implement the given intervention in typical practice or community settings. This low implementation reporting is consistent with previous RE-AIM reviews.^{32–37}

Findings also indicate differences in the reporting of specific RE-AIM dimensions between school and non-school studies as well as U.S. and non-U.S. studies. However, the difference in overall comprehensiveness of reporting was negligible (Figure 3cd).

Recommendations for Future Studies

While most of the studies in this review report indicators of internal validity, including SSB outcomes, none comprehensively reported key external validity indicators. This finding is consistent with other reviews that have primarily focused on individual-level behavioral approaches.^{33,36–38,42,44} Our findings indicate that studies utilizing environmental/policy strategies consistently had lower reporting across individual-level RE-AIM indicators, making it difficult to determine the impact of these intervention strategies at a population level. This finding reinforces the cautionary advice of Jilcott and colleagues, who warn against assuming adopted policies or environmental changes reach everyone within a setting.⁴⁰ Thus, environmental/policy studies, in particular, could benefit from a balanced reporting of internal and external validity factors across individual and setting level indicators. It is also important to assess any barriers that may prevent the most at-risk members from taking advantage of or being exposed to policy changes.⁴⁰

The observed gaps in reporting of adoption, implementation, and setting-level maintenance also exist for the individual-level strategies and are not surprising given that this information has been similarly elusive in previous obesity prevention reviews.^{134–136} As summarized in this systematic review, the current lack of reporting across RE-AIM dimensions impedes researchers and practitioners' ability to apply the body of child and adolescent SSB intervention literature to their decisions about appropriate interventions for their own setting and population. Without this information, evidence-based strategies are more difficult to replicate, and are unlikely to reach populations that can benefit most.

Potential challenges—Planning, implementing, and reporting this information may be challenging due to scarce resources, publication word limits, and a lack of knowledge on the importance of reporting both internal and external validity. While these challenges may be particularly prominent for small-scale pilot or feasibility studies, understanding factors beyond effectiveness and internal validity is of paramount importance among these studies. Thus, it is critical to plan, prioritize, and secure resources for a comprehensive evaluation prior to the start of the study. This prioritization needs to be accompanied by more efforts to educate researchers, peer-reviewers, and funding agencies about the importance of moving beyond the “efficacy-based” paradigm and providing opportunities to publish data other than

efficacy/effectiveness.^{31, 137} There is some evidence the paradigm is beginning to shift, such as a recent call to action for nutrition professionals to integrate translational research into their scope of work.¹³⁷ Based on our review, we have compiled a series of specific recommendations to enable researchers to overcome these challenges, improve reporting of internal and external validity, and subsequently promote the translation of effective intervention strategies into practice.

Recommendation 1—Report reach and representativeness of the study sample to increase transparency of potential generalizability. For strategies at all levels, identify and report characteristics of the study sample (i.e., demographic information), compare them with those of the broader target population, and report the participation rate based on the population. Studies testing environmental/policy approaches should include a measure of target population exposure (i.e., all students in a school district) with a clear description of how exposure is operationalized.

Recommendation 2—Examine the robustness of effects across high-risk groups within the target population and include and report on an indicator of child quality of life as an outcome. Studies at all levels should examine effects across subgroups to emphasize a continued focus on vulnerable children and adolescents. They should also report quality of life to discern whether positive intervention effects are at the expense of child perceptions of quality of life. A number of relatively brief measures of quality of life are available, such as the Peds-QL.¹³⁸

Additionally, environmental/policy change strategies should provide a logic model highlighting the potential impact on consumption and include brief behavioral assessment of SSB when possible. Although a number of environmental/policy change strategies measure individual-level outcome targets (i.e. sales or servings), these targets are somewhat distal to measurement of consumption.¹³⁹

Recommendation 3—Provide a description of the study setting and, when applicable, type of staff involved in implementation. For strategies at all levels, identify and report a denominator and characteristics of the target population of settings and staff (i.e., size, location, level of expertise). For studies examining environmental and policy approaches, report any aspects of the decision-making process by which the approach was initially adopted. Further, if the study is in a single setting, provide a detailed description of the setting, including resources available and audiences served.

Recommendation 4—Clearly define and report intervention strategies, content, duration, structure, and costs as well as the degree to which the strategies were implemented as intended. For strategies at all levels, report characteristics of the intervention, including timing and fidelity information, throughout implementation. In addition, include costs related to intervention start-up and ongoing implementation. For policy strategies, include information on the variability in compliance to and enforcement of the policy.⁴⁰ For environmental change strategies, report on activities related to assessment of any ongoing upkeep.⁴¹

Recommendation 5—Assess and report information on the degree to which the intervention is sustained within organizations beyond initial implementation, and whether it leads to sustained behavior change. For strategies at all levels, report outcomes over longer-term periods and include descriptions of adaptations made to ensure sustainability. For policy/environmental changes, include assessments of individual SSB changes for 12 months post-implementation, compliance, and enforcement of policies beyond the scope of research funding.

Limitations

Some limitations to the conclusions and recommendations should be noted. First, the data analyzed and discussed was only that which was reported and does not consider information that may have been collected but not included in the articles. However, companion articles were searched for in order to elicit as much information as possible. Second, the search for articles was limited to peer-reviewed articles, which may have eliminated valuable studies, particularly policy-related, that are published in other outlets. Third, the outcome measures and study designs varied widely and the number of studies per level was modest, which should be considered when interpreting the RE-AIM findings across the levels. Finally, this review focused exclusively on SSB outcomes; therefore, difference in reporting across the socio-ecological strategies may not be generalized to interventions targeting other dietary and health outcomes.

Conclusions

This RE-AIM review across socio-ecological strategy levels systematically documents that child and adolescent-focused SSB intervention studies are not providing enough information to determine best practices for nutrition and dietetics researchers, practitioners, and decision makers. Therefore, despite the quantity of studies as well as the available systematic reviews focused on internal validity,^{1,4,5,26–29} the potential public health impact of child and adolescent-focused SSB programs and policies remains unclear. To improve translation of evidence-based SSB interventions by nutrition and dietetic professionals in real world settings, future research and reviews should provide more information on all dimensions of the RE-AIM framework, including key elements of both internal and external validity.

Supplementary Material

Refer to Web version on PubMed Central for supplementary material.

Acknowledgments

Funding Statement

Support for this research, “Assessing the internal and external validity of sugar-sweetened beverage consumption interventions for children and adolescents: a systematic RE-AIM review using a socio-ecological approach” was provided, in part, by NIH/NCI 1R01CA154364-01 and the Virginia Tech Fralin Translation Obesity Research Center. The views expressed are solely those of the authors and do not reflect the official policy or position of the US government.

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Practice Implications

- What is the current knowledge on this topic?
Excess consumption of sugar-sweetened beverages (SSBs) among children and adolescents is causal to childhood obesity. Interventions using strategies across the socio-ecological model have reduced consumption among study samples.
- How does this research add to knowledge on this topic?
This review indicates a lack of reporting of reach, adoption, implementation, and maintenance indicators of these internally effective interventions and policies, limiting their external applicability within different contexts.
- How might this knowledge impact current dietetics practice?
This review implores SSB researchers to provide more information about external validity of their findings, to enable nutrition practitioners to establish best practices for reducing SSB consumption among children and adolescents.

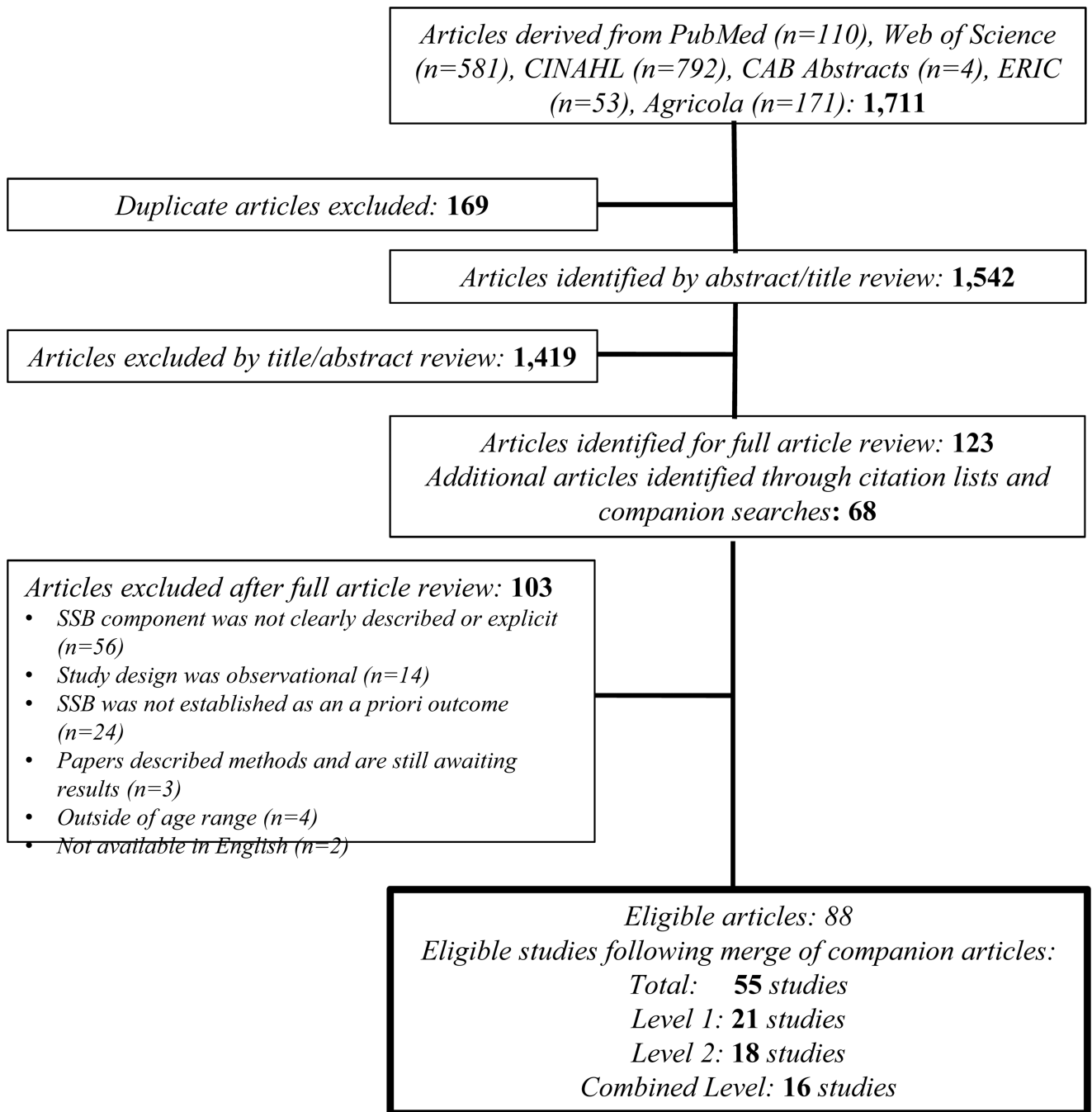


Figure 1. Research study selection criteria of experimental, and quasi-experimental SSB studies in children and adolescents.

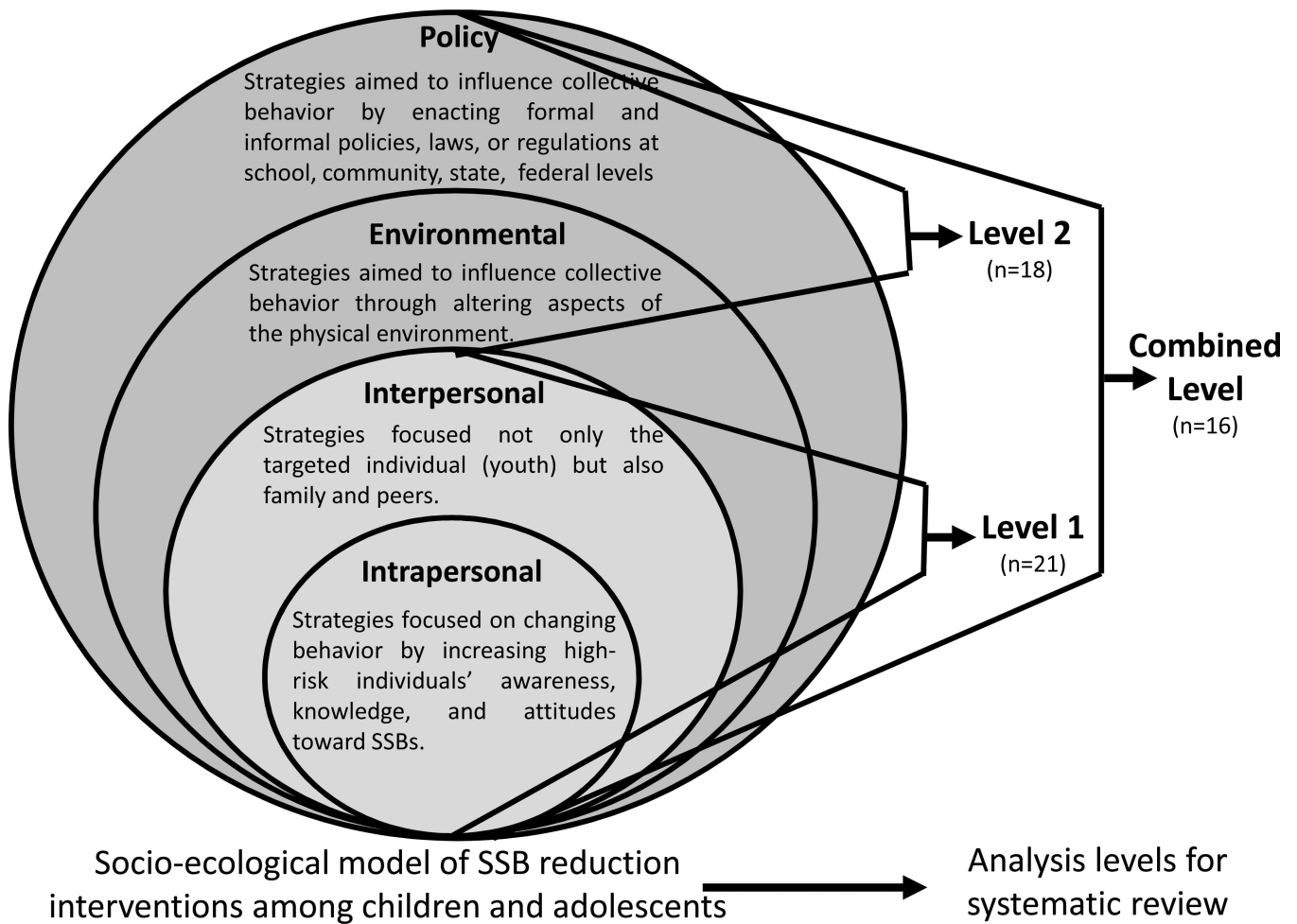


Figure 2. Evaluating socio-ecological strategy levels that address internal and external validity in child and adolescent (3–18 years) sugar-sweetened beverage consumption studies (n=55)

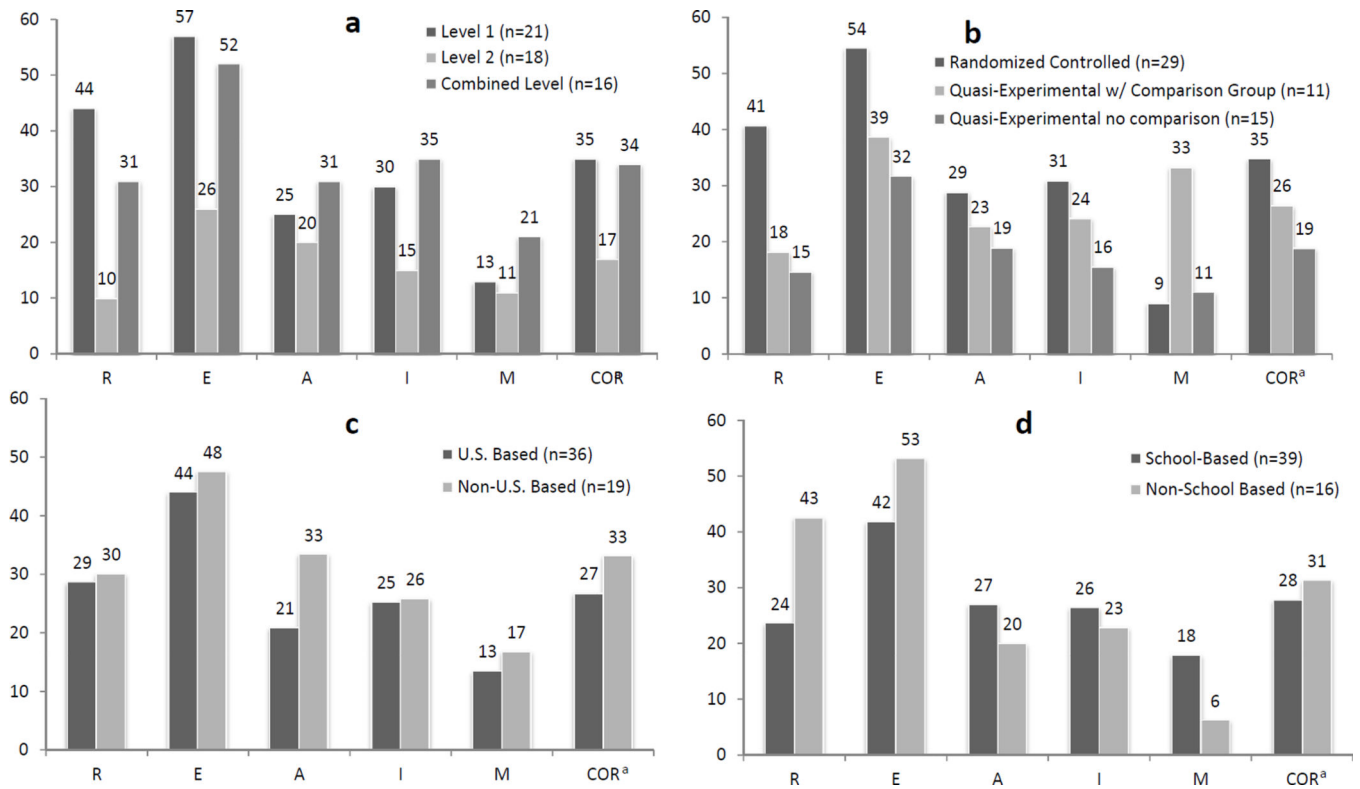


Figure 3.

Mean proportion reporting of RE-AIM indicators by study characteristics

a. Comprehensiveness of Reporting (COR) score: studies of “low” quality (L) had reported <33% of indicators, studies of “moderate” quality (M) reported between 33% and 67% of indicators, and studies considered “high” quality (H) reported >67%

Figure 3a: Socio-ecological level.; Figure 3b: Study-design; Figure 3c: Country; Figure 3d: Setting

Proportion of child, adolescent, and young adult-focused sugar-sweetened beverage (SSB) interventions and policies reporting RE-AIM item indicators by socio-ecological level

Table 1

RE-AIM Dimension Total Item Indicators Reported	Total Trials (%) N=55 Trials; 100%	Level 1 Individual/ Interpersonal n=21 (% of n)	Level 2 Policy/ Environmental n=18 (% of n)	Combined Levels Individual/ Interpersonal & Policy/ Environmental n=16 (% of n)	p-value
Average % Across all 21 RE-AIM Dimensions	29	35^a	17^b	34^a	<0.001
REACH					
1) Method to identify target population	38	62	11	37	<0.001
2) Inclusion criteria	36	48	17	44	
3) Exclusion criteria	22	38	0	25	
4) Participant rate	45	62	22	50	
5) Representativeness	4	10	0	0	
Average % across 5 Item Indicators	29	44^a	10^b	31^a	
EFFICACY/EFFECTIVENESS					
6) Intent to treat analysis	20	29	0	31	<0.001
7) Quality of life or unintended consequences	5	10	0	6	
8) Attrition rate	56	90	6	69	
9) Measures/Results from at least one follow-up	100	100	100	100	
Average % across 4 Item Indicators	45	57^a	26^b	52^a	
ADOPTION					
10) Site and/or staff participation rate	40	24	39	63	0.279
11) Setting description	33	29	39	31	
12) Method to identify staff or delivery agents	11	14	6	13	
13) Level of expertise or staff or delivery agents	40	67	NA	50	
14) Inclusion/Exclusion criteria of staff or setting	29	19	39	31	
15) Representativeness	0	0	0	0	
Average % across 6 Item Indicators	26	25	20	31	

	Total Trials (%) N=55 Trials; 100%	Level 1	Level 2	Combined Levels	p-value
IMPLEMENTATION					
16) Intervention duration	40	67	6	44	0.058
17) Extent protocol delivered as intended	22	10	17	44	
18) Measures of implementation costs	18	14	22	19	
Average % across 3 Item Indicators	27	30	15	35	
MAINTENANCE					
19) Measures/and/or results >6 months post-intervention	20	33	0	25	0.392
20) Measures of site-level maintenance	18	5	22	31	
21) Measures of maintenance costs	5	0	11	6	
Average % across 3 Item Indicators	14	13	11	21	