

Review Article

Efficacy of school-based interventions aimed at decreasing sugar-sweetened beverage consumption among adolescents: a systematic review

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Abstract

Objective: To verify the efficacy of school-based interventions aimed at reducing sugar-sweetened beverage (SSB) consumption among adolescents in order to develop or improve public health interventions.

Design: Systematic review of interventions targeting adolescents and/or the school environment.

Setting: The following databases were investigated: MEDLINE/PubMed, PsycINFO, CINAHL and EMBASE. Proquest Dissertations and Theses was also investigated for unpublished trials.

Subjects: Adolescents were defined as individuals between the ages of 12 and 17 years.

Results: A total of thirty-six studies detailing thirty-six different interventions tested among independent samples (n 152 001) were included in the review. Twenty interventions were classified as educational/behavioural and ten were classified as legislative/environmental interventions. Only six interventions targeted both individuals and their environment. Over 70% of all interventions, regardless of whether they targeted individuals, their environment or both, were effective in decreasing SSB consumption. Legislative/environmental studies had the highest success rate (90.0%). Educational/behavioural interventions only and interventions that combined educational/behavioural and legislative/environmental approaches were almost equally effective in reducing SSB consumption with success rates of 65.0 and 66.7%, respectively. Among the interventions that had an educational/behavioural component, 61.5% were theory-based. The behaviour change techniques most frequently used in interventions were providing information about the health consequences of performing the behaviour (72.2%), restructuring the physical environment (47.2%), behavioural goal setting (36.1%), self-monitoring of behaviour (33.3%), threat to health (30.6%) and providing general social support (30.6%).

Conclusions: School-based interventions show promising results to reduce SSB consumption among adolescents. A number of recommendations are made to improve future studies.

Keywords

School-based interventions
Sugar-sweetened beverages
Adolescents
Systematic review

Obesity and overweight among children and youth is an important public health issue⁽¹⁾. In Europe, between 9.4 and 26.4% of boys and between 6.4 and 15.9% of girls aged 10–15 years are overweight or obese⁽²⁾. In the USA, among adolescents aged 12–19 years, 20.5% are obese

and obesity rates are slightly higher among females (21.0%) compared with males (20.1%)⁽³⁾. In Canada, 30.1% of adolescents aged 12–17 years are overweight or obese⁽⁴⁾, which predisposes them to future chronic diseases⁽⁵⁾. To address the obesity problem, the WHO

recently issued new recommendations encouraging populations of all ages to limit sugar intake, including sugar-sweetened beverages (SSB), to no more than 10% and possibly 5% of total energy intake⁽⁶⁾.

SSB consumption contributes to excessive intake of sugar among adolescents, which is related to many health problems such as heart diseases^(7–10), stroke⁽⁷⁾, obesity^(11–16), type 2 diabetes^(17–20), hypercholesterolaemia^(21,22), cancer⁽²³⁾ and tooth decay⁽²⁴⁾. Moreover, SSB offer no health benefits, increase total energy intake and may reduce the consumption of foods containing essential nutrients for optimal health, such as milk^(6,25). Unfortunately, adolescents are large consumers of SSB. SSB are the main source of energy from all beverages in adolescents aged 13–18 years in London, UK⁽²⁶⁾. They are also the main sources of added sugar in Mexico, representing 66.2% of added sugars for adolescents from 12 to 19 years of age⁽²⁷⁾. In the USA, adolescents aged 13–18 years drink an average of 606 ml of soda and fruit drinks daily⁽²⁸⁾. In Canada, boys aged 14–18 years drink a mean quantity of 574 g (which equates approximately the same in millilitres) of SSB daily and girls 354 g daily⁽²⁹⁾.

Since habits developed during adolescence tend to be preserved throughout life⁽¹⁾, it is essential to promote healthy behaviours among this population in a growing search for autonomy, especially in their food and drink choices^(30,31). Although the family environment is largely responsible for the development of healthy habits among children and youth, the responsibility of the school environment should not be underestimated given the time spent at school^(32,33). In fact, school is the ideal setting to develop and promote healthy eating habits among children and adolescents^(32,34–36). Additionally, schools offer the opportunity to easily reach young people, regardless of their age, socio-economic status (SES), cultural background and ethnicity^(32,37,38).

In the field of public health, ecological models are commonly used to design interventions aimed at changing health behaviours⁽³⁹⁾, such as decreasing SSB consumption among adolescents. One characteristic of these models is that they recommend targeting both individuals and their environment to increase the chances of successfully changing health behaviours⁽³⁹⁾. For example, an intervention could target adolescents by giving them information on the negative health consequences associated with consuming SSB and also target their environment by removing SSB from the vending machines and the cafeteria at their school.

Some authors recommend using theory to develop interventions that have a greater chance of changing health behaviours^(40–45). The theories most commonly used to develop public health interventions originate from social psychology (i.e. psychosocial theories) and include the Social Cognitive Theory (SCT)⁽⁴⁶⁾ and its predecessor by the same author, the Social Learning Theory (SLT)⁽⁴⁷⁾, the Theory of Planned Behaviour (TPB)⁽⁴⁸⁾, the Trans-theoretical Model (TTM)⁽⁴⁹⁾ and the Self-Determination

Theory (SDT)⁽⁵⁰⁾. Explaining each of these theories is beyond the scope of the present review. However, each theory gives indications on what needs to be changed in order to get individuals to intend or be motivated to change their behaviour. For example, the SCT/SLT both suggest that changing people's perception of their ability to change their behaviour – a notion known as self-efficacy – is one way to get them to change their behaviour. One advantage of the use of theory in designing public health interventions is that it can guide which techniques should be used to get participants to change their behaviour^(51,52). For example, the taxonomy of Cane *et al.*⁽⁵³⁾ contains eighty-seven different behaviour change techniques originating from diverse theories that can be used to change health behaviours. There is also recent work that aims to link these behaviour change techniques to their own mechanisms of action to facilitate the development and evaluation of behaviour change interventions⁽⁵⁴⁾.

In order to develop or improve school-based interventions aimed at decreasing SSB intake among adolescents, it is essential beforehand to review the scientific literature to identify which interventions and behaviour change techniques are effective at promoting this behaviour among this population. A number of reviews on various topics related to SSB and children or adolescents have already been conducted. The majority of previous reviews have focused on associations between SSB consumption and adverse health effects among children and adolescents⁽⁵⁵⁾, such as increased body weight^(56–59), and also on the methodological qualities of those reviews^(60,61). One study reviewed methods to assess intake of SSB in adults, adolescents and children⁽⁶²⁾. A few studies have reviewed the impact of policies⁽⁶³⁾ and additional taxes^(64,65) on children's and adolescents' consumption of SSB. Finally, there are a number of published reviews on interventions to reduce SSB consumption in children and adolescents^(66,67), including school-based interventions⁽⁶⁸⁾, or to prevent childhood and adolescent obesity⁽⁶⁹⁾. However, those existing reviews did not specifically target adolescents, and also included children^(66–69), and none of them assessed the behaviour change techniques used to decrease SSB consumption.

The aim of the present study was to fill this gap in the literature by performing a systematic review of school-based interventions aimed at reducing SSB consumption among adolescents aged 12–17 years. A second objective was to identify the behaviour change techniques most effective at decreasing SSB consumption using the taxonomy of Cane *et al.*⁽⁵³⁾ in order to inform future school-based interventions aimed at changing this behaviour among adolescents.

Methods

The study protocol was registered in PROSPERO (<https://www.crd.york.ac.uk/PROSPERO/>) by Do.B. in May 2015 (no. 42015023582).

Study eligibility criteria

Population

Adolescents were defined as individuals between the ages of 12 and 17 years. Studies including participants aged <12 years or >17 years were included only if $\geq 80\%$ of the participants were individuals between the ages of 12 and 17 years or if the mean age was between these ages.

Intervention

To be considered school-based, interventions had to be carried out in a school setting or the authors had to refer to their intervention as school-based. Studies evaluating the impact of school nutrition policies were included. Community-based interventions or those carried out outside schools were not included in the review.

Outcome

Articles had to report information on individual SSB consumption to be included in the review. There were no criteria on how individual consumption of SSB needed to be reported in the articles (e.g. millilitres or number of glasses per day or per week, percentage of individuals who reported consuming a given quantity of SSB, etc.). SSB included regular (non-diet) soft drinks, fruit drinks (excluding 100% pure fruit juices), energy drinks, sports drinks, sweetened tea and coffee (iced or hot) and other beverages with added sugar (e.g. slush)⁽⁷⁰⁾. There were also no criteria on how studies that included multiple types of beverages in their SSB definition needed to report this outcome; it could be reported separately (e.g. soft drinks, fruit drinks, etc.) or collectively (i.e. for all SSB). Studies whose definition of SSB included 100% pure fruit juices were not included in the review, except if this information was presented separately from other SSB. When unsure about whether or not SSB included 100% pure fruit juices, the authors of the articles were personally contacted by Do.B. Studies reporting information on SSB availability or SSB sales in schools were not included, since they are not measures of individual consumption of SSB.

Study designs

Types of study design included were randomised controlled trials (RCT), quasi-experimental studies and one-group pre–post studies.

Exclusion criteria

Articles written in languages other than English or French were excluded. Qualitative studies were also excluded given that the objective was to perform a meta-analysis of the results of interventions.

Search strategy

The following databases were investigated: MEDLINE/PubMed (1950+), PsycINFO (1806+), CINAHL (1982+) and EMBASE (1974+). Proquest Dissertations and Theses

(1861+) was also investigated for grey literature (i.e. unpublished trials). There was no restriction on the year of publication of the articles. The search was performed by L.-A.V.-I. on 2 July 2015 and was updated by the same author on 21 December 2016 to include articles published until 1 December 2016. In each database, the search strategy included terms related to three major themes: SSB, adolescents and school interventions (see the online supplementary material, Supplemental File 1, for the complete search strategy). The search was developed with an experienced librarian. Additional studies were included by checking the references of the articles included in the systematic review (i.e. secondary references).

Study selection and data extraction

All articles were first screened by L.-A.V.-I. for possible duplicates and then according to their title and abstract (see Fig. 1). Clearly irrelevant articles were excluded at this step. The remaining articles were fully retrieved (full text) and two authors (L.-A.V.-I. and Do.B.) independently assessed them for eligibility. A few studies reported results based on the same sample and/or the same intervention. To avoid duplication of results and attributing more weight to these studies, only the study that had the best methodological qualities (e.g. RCT with bigger sample size *v.* one-group pre–post pilot study) and that reported the most information (e.g. baseline, post-test and follow-up data *v.* baseline and post-test data only) was included for further analysis.

Data were extracted independently by two reviewers (L.-A.V.-I. and Do.B., A.B.-G., Da.B., C.S. or M.D.*) using a standardised data extraction form. Data extracted included information on the study population, intervention, types of SSB included in the study and their measure, use of theory, behaviour change techniques used and results of the intervention. Interventions were classified as educational/behavioural and/or legislative/environmental depending on whether they targeted individuals (e.g. nutritional education on SSB) or their environment (e.g. ban on SSB in schools) or both. The quality of studies was assessed using the Quality Assessment Tool for Quantitative Study of the Effective Public Health Practice Project (EPHPP)⁽⁷¹⁾. This tool, recommended by the Cochrane Collaboration⁽⁷²⁾, was selected because it can be used for different kinds of quantitative study design (RCT, one-group pre–post, etc.) and because it is especially formulated for public health studies. Briefly, the EPHPP tool evaluates the quality of studies using the following six criteria: (i) selection bias; (ii) study design; (iii) confounders; (iv) blinding; (v) data collection method; and (vi) withdrawals and dropouts. The rating for each of the six components is used to obtain a global rating of a study's

* L.-A.V.-I. extracted data (i.e. first data extraction) for all of the articles included in the review. Do.B., A.B.-G., Da.B., C.S. and M.D. shared the responsibility of performing the second data extraction and thus each extracted the data for a selection of articles.

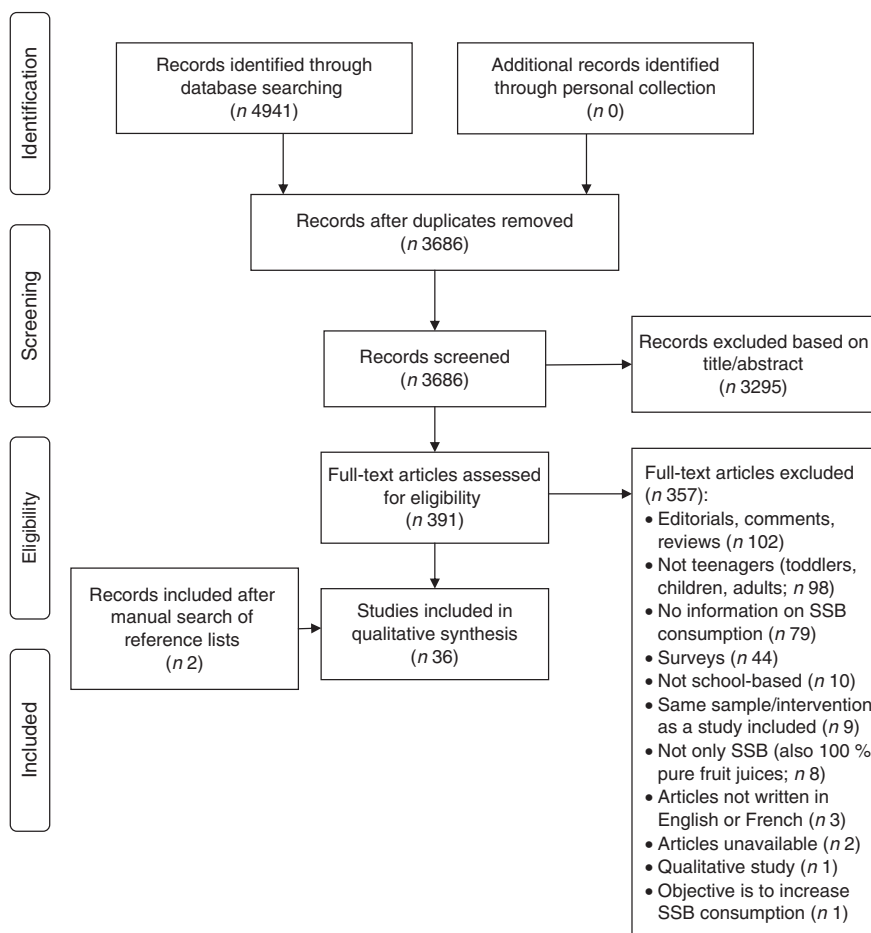


Fig. 1 PRISMA (Preferred Reporting Items for Systematic Reviews and Meta-Analyses) flowchart⁽¹³⁴⁾ showing selection of the studies included in the present systematic review (SSB, sugar-sweetened beverage)

quality. A strong global rating is obtained when there are no weak ratings to any of the six components of the EPHPP. A moderate global rating is obtained when there is one weak rating and a weak global rating when there are two or more weak ratings⁽⁷¹⁾. Behaviour change techniques used in interventions were classified according to the taxonomy of Cane *et al.*⁽⁵³⁾ which contains eighty-seven different behaviour change techniques (e.g. restructuring the physical environment, behavioural goal setting, self-monitoring of behaviour, etc; see online supplementary material, Supplemental File 2, for the complete list of behaviour change techniques). Disagreements at each step were resolved by discussion and when no consensus could be reached a third reviewer (Do.B. or A.B.-G., depending on who originally performed the second data extraction) helped resolve the discrepancy.

Results

The results of the search strategy and its update are presented in Fig. 1. A total of thirty-six studies detailing thirty-six independent interventions were included in the

present systematic review (see Table 1). This represented a total of 152 001 participants at baseline. Seventy-five per cent of studies were conducted in North America (USA: twenty-four studies^(38,73–95); Canada: three studies^(96–98)). Two studies were conducted in Australia^(99,100) and another two in Belgium^(101,102). Finally, one study was conducted in each of the following countries: Brazil⁽¹⁰³⁾, China⁽¹⁰⁴⁾, India⁽¹⁰⁵⁾, Korea⁽¹⁰⁶⁾ and The Netherlands⁽¹⁰⁷⁾. Given the important heterogeneity observed between the studies (i.e. differences in populations, study designs, types of intervention, behaviour change techniques used, behavioural measures and type of SSB included), no meta-analyses of the results were performed. In the rest of the text, the letter *k* will be used to represent the number of studies and the letter *n* to represent the number of participants.

Characteristics of interventions

Close to 60% of interventions (58.3%, *k* 21) included were aimed at reducing SSB consumption as part of a general objective: the promotion of healthy eating and physical activity combined (*k* 17)^(38,76–78,83,85,87,89,91,92,97,100–103,105,107)

Table 1 Summary of the studies included in the present systematic review

| Authors, year, reference & country | Objective of the study or intervention | Population | Study design & quality rating* | Baseline characteristics of sample | Type of intervention & theory used | Techniques used† | Behavioural measure & type of SSB included | Main results on SSB consumption |
|-----------------------------------------------------------------|-------------------------------------------------------------------|------------------------------------|-------------------------------------------------------|---------------------------------------------------------------------------------|--------------------------------------------------------------------------------------|-------------------------------------------------------------|--------------------------------------------------------------------------------------------------------------------------------------|--------------------------------------------------------------------------------------------------------------|
| Bae <i>et al.</i> (2012) ⁽¹⁰⁶⁾ Korea | Evaluate the impact of governmental nutrition policies on SSB | Healthy adolescents | Design: one-group pre-post Global rating: moderate | <i>n</i> 65 000 % ♂: NR M age: NR Middle & high schools | Educational/behavioural & legislative/ environmental Theory: N/A | Exp.: 5, 16 Cont.: N/A | Self-administered web-based survey SSB: carbonated beverages | Significant reduction in annual prevalence of SSB consumption ($P < 0.05$) |
| Bauhoff (2014) ⁽⁷³⁾ USA | Evaluate the impact of a nutrition policy on SSB | Healthy adolescents | Design: one-group pre-post Global rating: moderate | <i>n</i> 32 897 % ♂: 55.0 Age (range): 12–15 years Grades: 7 & 9 | Legislative/environmental Theory: N/A | Exp.: 5 Cont.: N/A | Self-administered 24 h recall SSB: soda | Only significant reduction in % of male adolescents consuming SSB ($P < 0.01$) |
| Blum <i>et al.</i> (2008) ⁽⁷⁴⁾ USA | Intervention aimed at reducing the availability of SSB in schools | Healthy adolescents | Design: quasi-experimental Global rating: weak | <i>n</i> 456 % ♂: 40.1 M age: 15.8 (SD 0.8) years Grades: 9–11 | Legislative/environmental Theory: N/A | Exp.: 5 Cont.: none | Validated self-administered FFQ SSB: soda, fruit drinks & iced tea | Significant time effect in SSB consumption for male & female adolescents ($P = 0.001$) |
| Bogart <i>et al.</i> (2001) ⁽⁷⁵⁾ USA | Healthy eating intervention | Healthy adolescents | Design: quasi-experimental Global rating: weak | <i>n</i> 425 % ♂: 50.0 M age: 13.0 (SD 0.5) years Grade: 7 | Educational/behavioural & legislative/ environmental Theory: SCT, TPB, EM, DIT | Exp.: 5, 16, 54, 77, 86 Cont.: none | Self-administered survey SSB: soda, fruit drinks & sports drinks | Significant time effect in % of students consuming sports/fruit drinks in peer advocates only ($P < 0.05$) |
| Cassaza (2006) ⁽⁷⁶⁾ USA | Healthy eating & physical activity intervention | Healthy adolescents | Design: RCT Global rating: weak | <i>n</i> 254 % ♂: 34.2 M age: 15.8 years Grades: 9–12 | Educational/behavioural Theory: SCT, TPB, TTM, PM, SM, ET | Exp.: 16, 20, 33, 46, 50, 51, 59, 66, 68, 80 Cont.: none | Interviewer-administered 24 h recall SSB: soda | Significant group × time effect for soda consumption ($P < 0.01$) |
| Collins <i>et al.</i> (2014) ⁽⁹⁹⁾ Australia | Healthy eating intervention | Low-SES adolescent girls | Design: cluster RCT Global rating: moderate | <i>n</i> 357 % ♂: 0 M age: 13.2 years Secondary schools | Educational/behavioural Theory: SCT | Exp.: 16, 51, 68 Cont.: none | Validated FFQ SSB: soda, fruit drinks & cordial concentrates | Significant time effect for cordial concentrate & total SSB consumption ($P < 0.05$) |
| Contento <i>et al.</i> (2010) ⁽⁷⁷⁾ USA | Healthy eating & physical activity intervention | Low-SES adolescents | Design: cluster RCT Global rating: moderate | <i>n</i> 1136 % ♂: 51.0 M age: 12.0 years Grade: 7 | Educational/behavioural Theory: SCT, SDT | Exp.: 2, 16, 33, 46, 48, 51, 59, 80 Cont.: none | Validated self-administered FFQ SSB: soft drinks, fruit drinks, sports drinks, iced tea & drink mixes | Significant reduction in frequency & quantity of SSB consumption at meals & with snacks ($P < 0.01$) |
| Cordeira (2012) ⁽⁷⁸⁾ USA | Healthy eating, physical activity & tobacco intervention | Healthy adolescents | Design: one-group pre-post Global rating: weak | <i>n</i> 38 % ♂: 32.0 Age (range): 13–18 years Grades: 9–12 | Educational/behavioural Theory: SCT | Exp.: 2, 16, 33, 46, 68, 77 Cont.: N/A | Self-administered survey SSB: soft drinks & fruit drinks | No significant reduction in SSB consumption |
| Cradock <i>et al.</i> (2011) ⁽⁷⁹⁾ USA | Evaluate the impact of a school district policy on SSB | Healthy adolescents | Design: quasi-experimental Global rating: moderate | <i>n</i> 2091 % ♂: 50.7 Age (range): 15–19 years Grades: 9–12 | Legislative/environmental Theory: N/A | Exp.: 5 Cont.: none | Interviewer-administered 24 h recall & 7 d recall SSB: soda & fruit drinks | Significant reduction in total SSB consumption ($P < 0.001$) |
| Cullen <i>et al.</i> (2008) ⁽⁸⁰⁾ USA | Evaluate the impact of a school nutrition policy on SSB | Healthy adolescents | Design: one-group pre-post Global rating: strong | <i>n</i> 2671 % ♂: NR Age: NR Grades: 6–8 | Legislative/environmental Theory: N/A | Exp.: 5 Cont.: N/A | Validated food records SSB: soft drinks & sweet beverages | Significant reduction in SSB consumption ($P < 0.005$) |
| da Silva Vargas <i>et al.</i> (2011) ⁽¹⁰³⁾ Brazil | Healthy eating & physical activity intervention | Normal & overweight adolescents | Design: quasi-experimental Global rating: weak | <i>n</i> 331 % ♂: NR M age: 13.1 years Grades: 5 & 6 | Educational/behavioural Theory: none | Exp.: 16, 33, 49, 57, 59, 65 Cont.: none | Self-administered questionnaire SSB: soda | No significant reduction in soda consumption in both groups |
| Davis <i>et al.</i> (2007) ⁽⁸¹⁾ USA | Healthy eating intervention | Overweight Latina adolescent girls | Design: RCT Global rating: moderate | <i>n</i> 30 % ♂: 0 M age: 14.7 years Grade: NR | Educational/behavioural Theory: none | Exp.: 2, 41, 46, 51, 54, 57, 59 Cont.: 46 | 3 d food record & validated interviewer-administered 24 h recalls SSB: soda, fruit drinks, sports drinks, sweetened tea or coffee | Significant reduction in SSB consumption in both groups ($P < 0.01$) |
| Dubuy <i>et al.</i> (2014) ⁽¹⁰¹⁾ Belgium | Healthy eating & physical activity intervention | Low-SES adolescent boys | Design: quasi-experimental Global rating: weak | <i>n</i> 414 % ♂: 100 M age: 12.3 years Elementary & secondary schools | Educational/behavioural Theory: ELM | Exp.: 16, 43, 63, 81 Cont.: none | Validated self-administered FFQ SSB: soft drinks | No significant reduction in soft drinks consumption |

Table 1 *Continued*

| Authors, year, reference & country | Objective of the study or intervention | Population | Study design & quality rating* | Baseline characteristics of sample | Type of intervention & theory used | Techniques used† | Behavioural measure & type of SSB included | Main results on SSB consumption |
|--------------------------------------------------------------|-------------------------------------------------------------------|----------------------------------------------------|-------------------------------------------------------|---------------------------------------------------------------------------|-------------------------------------------------------------------------|-------------------------------------------------------------------|--------------------------------------------------------------------------------------------------------------------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| Greece (2011) ⁽⁸²⁾ USA | Healthy eating intervention | Mainly low-SES adolescents | Design: quasi-experimental Global rating: moderate | <i>n</i> 294 % ♂: 45.6 M age: 12.7 (SD 0.9) years Grades: 6–8 | Legislative/environmental Theory: N/A | Exp.: 5, 16, 23 Cont.: none | Validated self-administered FFQ SSB: soft drinks & fruit drinks | Significant group × time effect on SSB consumption (<i>P</i> = 0.03) |
| Haerens <i>et al.</i> (2006) ⁽¹⁰²⁾ Belgium | Healthy eating & physical activity intervention | Healthy adolescents | Design: RCT Global rating: strong | <i>n</i> 2840 % ♂: 63.4 M age: 13.1 (SD 0.8) years Grades: 7 & 8 | Educational/behavioural & legislative/environmental Theory: TPB, TTM | Exp.: 5, 16, 68 Cont.: none | Validated self-administered FFQ SSB: soft drinks | No significant reduction in soft drinks consumption |
| Jones <i>et al.</i> (2014) ⁽³⁸⁾ USA | Healthy eating & physical activity intervention | Normal & overweight adolescents | Design: one-group pre–post Global rating: weak | <i>n</i> 336 % ♂: 40.5 M age: 14.3 years Grade: 9 | Educational/behavioural Theory: none | Exp.: 2, 16, 33, 41, 46, 49, 51, 52, 54, 59, 66, 68 Cont.: N/A | Self-administered survey SSB: soda | Significant increase in soda consumption among adolescents in the healthy habits track (<i>P</i> = 0.001) Significant decrease in soda consumption among adolescents in the weight management track (<i>P</i> = 0.002) |
| Lao (2011) ⁽⁸³⁾ USA | Healthy eating & physical activity intervention | Low-SES adolescents | Design: RCT Global rating: weak | <i>n</i> 192 % ♂: 55.7 M age: 14.9 years Grades: 9 & 10 | Educational/behavioural Theory: TTM | Exp.: 16, 33, 46, 54, 59, 65, 66, 68, 72 Cont.: none | Self-administered survey SSB: soda, fruit, sports & energy drinks | No significant reduction in SSB consumption |
| Lo <i>et al.</i> (2008) ⁽⁹⁶⁾ Canada | Intervention aimed at reducing SSB consumption | Healthy adolescents | Design: quasi-experimental Global rating: weak | <i>n</i> 101 % ♂: 61.4 M age: 14 years Grade: 9 | Educational/behavioural Theory: CTL | Exp.: 15, 16, 17, 59, 63 Cont.: 15, 16, 17, 59 | Self-administered questionnaire SSB: soft drinks, fruit drinks, sports drinks, iced tea, sweetened tea & coffee | Significant reduction in SSB consumption at the 3-month follow-up in the experimental group (<i>P</i> < 0.02) |
| Malbon (2012) ⁽⁹⁷⁾ Canada | Healthy eating & physical activity intervention | Healthy adolescents | Design: one-group pre–post Global rating: weak | <i>n</i> 44 % ♂: 48.0 Age: NR Grade: 10 | Educational/behavioural Theory: SDT | Exp.: 16, 21, 46, 51, 54, 66, 73, 80 Cont.: N/A | Self-administered questionnaire SSB: soft drinks, fruit drinks, energy drinks, iced tea & slush | No significant reduction in SSB consumption |
| McGoldrick (2006) ⁽⁹⁸⁾ Canada | Evaluate the impact of governmental nutrition policies on SSB | Healthy adolescents | Design: one-group pre–post Global rating: moderate | <i>n</i> 703 % ♂: 43.5 Age (range): 10–14 years Grades: 6–8 | Legislative/environmental Theory: N/A | Exp.: 5 Cont.: N/A | Validated web 24 h recall & self-administered FFQ SSB: soft drinks, fruit drinks, sports drinks & iced tea | Significant increase in volume of SSB consumed, significant reduction in frequency of cola consumption & significant increase in % of adolescents who consume SSB (<i>P</i> < 0.001) |
| Nanney <i>et al.</i> (2014) ⁽⁸⁴⁾ USA | Evaluate the impact of school policies on SSB | Healthy adolescents | Design: one-group pre–post Global rating: moderate | <i>n</i> 18 881 % ♂: NR Age: NR Grades: 9 & 12 | Legislative/environmental Theory: N/A | Exp.: 5 Cont.: N/A | Self-administered questionnaire SSB: soda & sports drinks | Significant reduction in SSB consumption (<i>P</i> = 0.04) |
| Nanney <i>et al.</i> (2016) ⁽⁹⁵⁾ USA | Evaluate the impact of school policies on SSB | Healthy adolescents | Design: one-group pre–post Global rating: moderate | <i>n</i> 7237 % ♂: NR Age: NR Grade: 9 | Legislative/environmental Theory: N/A | Exp.: 5 Cont.: N/A | Self-administered questionnaire SSB: soda & sports drinks | Significant reduction in soda consumption (<i>P</i> < 0.05) |
| Neumark-Sztainer <i>et al.</i> (2010) ⁽⁸⁵⁾ USA | Healthy eating & physical activity intervention | Low-SES normal & overweight/obese adolescent girls | Design: RCT Global rating: weak | <i>n</i> 356 % ♂: 0 M age: 15.8 years High schools | Educational/behavioural Theory: SCT, TTM | Exp.: 2, 16, 41, 46, 57, 59, 68 Cont.: none | Interviewer-administered 24 h recall SSB: soda, fruit drinks, sports drinks, sweetened tea & sweetened coffee | No significant reduction in SSB consumption at follow-up |
| Patel <i>et al.</i> (2011) ⁽⁸⁶⁾ USA | Intervention aimed at increasing water & reducing SSB consumption | Low-SES adolescents | Design: quasi-experimental Global rating: weak | <i>n</i> 876 % ♂: 45.0 M age: 12.9 years Grade: 7 | Educational/behavioural & legislative/environmental Theory: none | Exp.: 5, 15, 16, 23, 65 Cont.: none | Self-administered questionnaire SSB: soda & sports drinks | No significant reduction in SSB consumption |
| Pbert <i>et al.</i> (2013) ⁽⁸⁷⁾ USA | Healthy eating & physical activity intervention | Overweight & obese adolescents | Design: cluster RCT Global rating: moderate | <i>n</i> 82 % ♂: 30.5 M age: 15.8 years Grades: 9–11 | Educational/behavioural Theory: SCT | Exp.: 2, 16, 46, 47, 51, 66, 72 Cont.: 16 | Validated telephone-administered 24 h recall SSB: soda & sugary drinks | No significant reduction in SSB consumption |

Table 1 *Continued*

| Authors, year, reference & country | Objective of the study or intervention | Population | Study design & quality rating* | Baseline characteristics of sample | Type of intervention & theory used | Techniques used† | Behavioural measure & type of SSB included | Main results on SSB consumption |
|-------------------------------------------------------------------|---------------------------------------------------------------|---------------------------------------------------|---------------------------------------------------|-----------------------------------------------------------------------------|-------------------------------------------------------------------------------------------------------------------------------|------------------------------------------------------------------------------------------------------|---------------------------------------------------------------------------------------------------------------------------------------|-------------------------------------------------------------------------------------------------------------------------------|
| Singhal <i>et al.</i> (2010) ⁽¹⁰⁵⁾ India | Healthy eating & physical activity intervention | Healthy adolescents | Design: RCT Global rating: moderate | <i>n</i> 209 % ♂: 59.8 M age: 16.0 years Grade: 11 | Educational/behavioural Theory: none | Exp.: 2, 5, 16, 33, 48, 59 Cont.: none | Self-administered questionnaire SSB: soft drinks | Significant reduction in % of adolescents consuming soft drinks at least 3 times/week in the experimental group ($P=0.001$) |
| Smith <i>et al.</i> (2014) ⁽¹⁰⁰⁾ Australia | Healthy eating & physical activity intervention | Low-SES adolescent boys at risk for obesity | Design: cluster RCT Global rating: weak | <i>n</i> 361 % ♂: 100 M age: 12.7 (SD 0.5) years Secondary schools | Educational/behavioural Theory: SCT, SDT | Exp.: 2, 16, 33, 46, 51, 59, 63, 66, 68, 72, 77 Cont.: none | Self-administered questionnaire SSB: NR | Significant group × time effect on SSB consumption ($P=0.01$) |
| Smith & Holloman (2014) ⁽⁸⁸⁾ USA | Intervention aimed at reducing SSB consumption | Mainly low-SES adolescents | Design: one-group pre-post Global rating: weak | <i>n</i> 186 % ♂: 39.2 M age: 15.9 (SD 1.8) years Grades: 9–12 | Educational/behavioural Theory: none | Exp.: 16, 33, 65 Cont.: N/A | Self-administered questionnaire & food record SSB: soft drinks, fruit drinks, sports drinks, energy drinks, sweetened tea & coffee | Significant reduction in frequency & quantity of SSB consumed at 30 d follow-up ($P<0.05$) |
| Teufel & Ritenbaugh (1998) ⁽⁸⁹⁾ USA | Healthy eating & physical activity intervention | Native American adolescents | Design: one-group pre-post Global rating: weak | <i>n</i> 119 % ♂: 44.5 M age: 17.2 (SD 4.0) years Grades: 9–12 | Educational/behavioural & legislative/ environmental Theory: none | Exp.: 5, 16, 33, 68 Cont.: N/A | 24 h recall SSB: soft drinks & fruit drinks | Significant reduction in % of SSB consumed ($P<0.05$) |
| Thiele & Boushey (1989) ⁽⁹⁰⁾ USA | Intervention aimed at reducing SSB consumption | Eskimo adolescents | Design: quasi-experimental Global rating: weak | <i>n</i> 374 % ♂: NR Age: NR Grades: 7–12 | Educational/behavioural Theory: none | Exp.: 16 Cont.: none | Interviewer-administered 24 h recall SSB: soft drinks & fruit drinks | Significant reduction in SSB consumption in one of the two experimental groups ($P=0.001$) |
| Whittemore <i>et al.</i> (2013) ⁽⁹¹⁾ USA | Healthy eating & physical activity intervention | Healthy adolescents | Design: RCT Global rating: weak | <i>n</i> 384 % ♂: 38.0 M age: 15.3 (SD 0.7) years High schools | Educational/behavioural Theory: SLT, TIT | Exp.: 2, 16, 41, 46, 51, 54, 57, 63, 66, 68, 72, 82 Cont.: 16, 46, 51, 54, 57, 63, 66, 68, 72, 82 | Self-administered questionnaire SSB: soda & fruit drinks | Significant reduction in SSB consumption in both groups ($P<0.01$) |
| Winett <i>et al.</i> (1999) ⁽⁹²⁾ USA | Healthy eating & physical activity intervention | Adolescent girls from medically underserved areas | Design: quasi-experimental Global rating: weak | <i>n</i> 180 % ♂: 0 M age: 15.4 years Grades: 9 & 10 | Educational/behavioural Theory: SCT | Exp.: 16, 46, 47, 51, 54, 66, 71 Cont.: none | Self-administered 24 h recall & FFQ SSB: soda | Significant group × time effect on soda consumption ($P<0.05$) |
| Wing <i>et al.</i> (2015) ⁽¹⁰⁴⁾ China | Intervention aimed at promoting sleep | Healthy adolescents | Design: cluster RCT Global rating: weak | <i>n</i> 5219 % ♂: 39.0 M age: 14.7 years Grades: 7–11 | Educational/behavioural Theory: none | Exp.: 16, 33, 41, 50, 51 Cont.: none | Self-administered questionnaire SSB: energy drinks | Significant difference in incidence of energy drinks consumption in experimental v. control group ($P<0.05$) |
| Woodward-Lopez <i>et al.</i> (2010) ⁽⁹³⁾ USA | Evaluate the impact of school policies on SSB | Low-SES adolescents | Design: one-group pre-post Global rating: weak | <i>n</i> 3527 % ♂: NR Age: NR Grades: 7 & 9 | Legislative/environmental Theory: N/A | Exp.: 5 Cont.: N/A | Self-administered questionnaire SSB: soda & sports drinks | Significant reduction in % of adolescents consuming sodas at school ($P<0.01$) |
| Wordell <i>et al.</i> (2012) ⁽⁹⁴⁾ USA | Evaluate the impact of changes in the school food environment | Low-SES adolescents | Design: quasi-experimental Global rating: weak | <i>n</i> 2292 % ♂: 51.0 Age: NR Grades: 7 & 8 | Legislative/environmental Theory: N/A | Exp.: 5 Cont.: none | Self-administered FFQ SSB: energy drinks & sweet drinks | No significant reduction in SSB consumption |
| Yildirim <i>et al.</i> (2013) ⁽¹⁰⁷⁾ The Netherlands | Healthy eating & physical activity intervention | Low-educational-level adolescents | Design: RCT Global rating: weak | <i>n</i> 1108 % ♂: 46.7 M age: 12.8 years Grade: NR | Educational/behavioural & legislative/ environmental Theory: SRT, EnRG framework (DPT, ANGELO model, TPB, Habit theory) | Exp.: 2, 5, 16, 46, 48, 51, 54, 57, 63, 66, 68, 73 Cont.: none | Self-administered questionnaire SSB: soft drinks, lemonade, energy drinks & iced tea | Significant reduction in SSB consumption ($P<0.001$) |

SSB, sugar-sweetened beverage; SES, socio-economic status; RCT, randomised controlled trial; *n*, number of participants; ♂, male students; NR, not reported; M, mean; N/A, not applicable; SCT, Social Cognitive Theory; TPB, Theory of Planned Behaviour; EM, Ecological Model; DIT, Diffusion Innovation Theory; TTM, Transtheoretical Model; PM, Proactive Model; SM, Solution Model; ET, Empowerment Theory; SDT, Self-Determination Theory; ELM, Elaboration Likelihood Model; CTL, Constructivist Theory of Learning; SLT, Social Learning Theory; TIT, Theory of Interactive Technology; SRT, Self-Regulation Theory; EnRG, Environmental Research framework for weight Gain prevention; DPT, Dual-Process Theory; ANGELO, ANalysis Grid for Environments Linked to Obesity; Exp., experimental group; Cont., control group.

*Global rating of the quality of studies was performed using the Effective Public Health Practice Project (EPHPP) Quality Assessment Tool for Quantitative Studies⁽⁷¹⁾.

†The numbers refer to those used in the Behaviour Change Technique Taxonomy of Cane *et al.*⁽⁵³⁾ (listed in online supplementary material, Supplemental File 2) and in cases where there is an active control group, differencing techniques are presented in bold font.

or healthy eating alone (k 4)^(75,81,82,99). One study also included tobacco prevention⁽⁷⁸⁾. Ten interventions (27.8%) had the objective of evaluating the impact of nutrition policies in schools or changes in the school environment, such as reduced availability of SSB^(73,74,79,80,84,93–95,98,106). Only four interventions (11.1%) were specifically aimed at reducing SSB consumption and increasing water consumption^(86,88,90,96). Finally, one intervention was aimed at promoting sleep and included reducing energy drinks consumption as a means of achieving this goal⁽¹⁰⁴⁾.

Twenty interventions (55.6%) were classified as educational/behavioural^(38,76–78,81,83,85,87,88,90–92,96,97,99–101,103–105), while all the studies on school policies and environmental changes (k 10) were classified as legislative/environmental interventions^(38,73,74,79,80,84,93–95,98) (see Table 2). Only six interventions (16.7%) included both an educational/behavioural component and a legislative/environmental component^(75,86,89,102,106,107).

Characteristics of participants

About half of the interventions (47.2%, k 17) were conducted among healthy adolescents^(73–76,78–80,84,91,95–98,102,104–106). Thirteen studies (36.1%) targeted adolescents whose parents had a low SES^(38,77,82,85,86,88,93,94,99–101), who had a low educational level⁽¹⁰⁷⁾ or who were living in medically underserved areas⁽⁹²⁾. Four studies targeted adolescent girls only^(81,85,92,99) and two adolescent boys only^(100,101). Three studies targeted a mix of normal-weight and overweight adolescents^(38,85,103), two studies targeted overweight/obese adolescents^(81,87) and another targeted adolescents at risk for obesity⁽¹⁰⁰⁾. Finally, three studies targeted specific ethnic minorities in the USA, such as Latina girls⁽⁸¹⁾, Native Americans⁽⁸⁹⁾ and Inuits⁽⁹⁰⁾. It is worth noting that some studies targeted adolescents with multiple sociodemographic characteristics, such as overweight adolescents whose parents had a low SES, which explains why the number of studies in this section exceeds the number of studies included in the review.

Among the twenty-nine studies reporting information on the sex of participants^(38,73–79,81–83,85–89,91,92,94,96–102,104,105,107), 43.6% of samples were comprised of adolescent boys. The pooled mean age of the twenty-four studies reporting age was 14.3 years^(38,74–77,81–83,85–89,91,92,96,99–105,107). Finally, twenty-eight studies reported information on the level of education of their participants^(38,73–80,82–84,86–90,92–98,102–105). The range of education was from grades 6 to 12. Depending on the country where the study was conducted, this referred to either elementary, middle or high/secondary schools or a mix of these schools.

Behavioural measures of sugar-sweetened beverage consumption

Less than a third (27.8%) of studies (k 10) used a validated tool to measure SSB consumption^(74,77,80–82,87,98,99,101,102) and three out of four of the instruments (75.0%, k 27) were

Table 2 Efficacy of interventions included in the present systematic review according to their type

| Reference | SSB consumption | | |
|-------------------------------------------------------------------------------------------|-----------------------|--------------------------|----------------------|
| | Significant reduction | No significant reduction | Significant increase |
| Educational/behavioural studies (k 20) | | | |
| Cassaza ⁽⁷⁶⁾ | ✓ | | |
| Collins <i>et al.</i> ⁽⁹⁹⁾ | ✓ | | |
| Contento <i>et al.</i> ⁽⁷⁷⁾ | ✓ | | |
| Cordeira ⁽⁷⁸⁾ | | ✓ | |
| da Silva Vargas <i>et al.</i> ⁽¹⁰³⁾ | | ✓ | |
| Davis <i>et al.</i> ^{(81)*} | ✓ | | |
| Dubuy <i>et al.</i> ⁽¹⁰¹⁾ | | ✓ | |
| Jones <i>et al.</i> ^{(38)†} | ✓ | | ✓ |
| Lao ⁽⁸³⁾ | | ✓ | |
| Lo <i>et al.</i> ⁽⁹⁶⁾ | ✓ | | |
| Malbon ⁽⁹⁷⁾ | | ✓ | |
| Neumark-Sztainer <i>et al.</i> ⁽⁸⁵⁾ | | ✓ | |
| Pbert <i>et al.</i> ⁽⁸⁷⁾ | | ✓ | |
| Singhal <i>et al.</i> ⁽¹⁰⁵⁾ | ✓ | | |
| Smith <i>et al.</i> ⁽¹⁰⁰⁾ | ✓ | | |
| Smith & Holloman ⁽⁸⁸⁾ | ✓ | | |
| Thiele & Boushey ^{(90)‡} | ✓ | | |
| Whitemore <i>et al.</i> ^{(91)*} | ✓ | | |
| Winnet <i>et al.</i> ⁽⁹²⁾ | ✓ | | |
| Wing <i>et al.</i> ⁽¹⁰⁴⁾ | ✓ | | |
| Total | 13 | 7 | 1 |
| Legislative/environmental studies (k 10) | | | |
| Bauhoff ^{(73)‡} | ✓ | | |
| Blum <i>et al.</i> ^{(74)*} | ✓ | | |
| Cradock <i>et al.</i> ⁽⁷⁹⁾ | ✓ | | |
| Cullen <i>et al.</i> ⁽⁸⁰⁾ | ✓ | | |
| Greece ⁽⁸²⁾ | ✓ | | |
| McGoldrick ^{(98)§} | ✓ | | ✓ |
| Nanney <i>et al.</i> ⁽⁸⁴⁾ | ✓ | | |
| Nanney <i>et al.</i> ⁽⁹⁵⁾ | ✓ | | |
| Woodward-Lopez <i>et al.</i> ⁽⁹³⁾ | ✓ | | |
| Wordell <i>et al.</i> ⁽⁹⁴⁾ | | ✓ | |
| Total | 9 | 1 | 1 |
| Educational/behavioural & legislative/environmental studies (k 6) | | | |
| Bae <i>et al.</i> ⁽¹⁰⁶⁾ | ✓ | | |
| Bogart <i>et al.</i> ^{(75)*,‡} | ✓ | | |
| Haerens <i>et al.</i> ⁽¹⁰²⁾ | | ✓ | |
| Patel <i>et al.</i> ⁽⁸⁶⁾ | | ✓ | |
| Teufel & Ritenbaugh ⁽⁸⁹⁾ | ✓ | | |
| Yildirim <i>et al.</i> ⁽¹⁰⁷⁾ | ✓ | | |
| Total | 4 | 2 | 0 |

SSB, sugar-sweetened beverage; k , number of studies.

*Significant time effect only or significant reduction of SSB consumption in both the experimental and the control group.

†Significant reduction of SSB consumption in half of the experimental group (peer advocates) and significant increase of SSB consumption in the other half of the experimental group (non-peer advocates).

‡Significant reduction of SSB consumption in half of the experimental group and no significant reduction of SSB consumption in the other half of the experimental group.

§Significant reduction in frequency of cola consumption, but significant increases in volume of SSB consumed and in percentage of adolescents who consume SSB.

self-administered^(38,73–75,77,78,82–84,86,88,91–98,100–107). Among them, two studies used web-based questionnaires, such as a web-based survey⁽¹⁰⁶⁾ and a web 24 h recall⁽⁹⁸⁾. Three studies did not specify the mode of delivery of their behavioural measure^(80,89,99). The most common method for measuring SSB consumption was a survey or questionnaire (50.0%, *k* 18)^(38,75,78,83,84,86,88,91,93,95–97,100,103–107), followed by 24 h recalls (27.8%, *k* 10)^(73,76,79,81,84,86,88,89,91,97), an FFQ (25.0%, *k* 9)^(74,77,82,91,93,97,98,100,101) and food records (8.3%, *k* 3)^(80,81,88). Among the studies that used 24 h recalls, 60.0% (*k* 6) chose interviewer-administered^(76,79,81,85,90) or telephone-administered⁽⁸⁷⁾ 24 h recalls for assessing SSB consumption. Four studies (11.1%) used multiple self-reported tools, such as a 3 d food record and 24 h recalls⁽⁸¹⁾, a 24 h recall and an FFQ^(92,98), and a questionnaire and a food record⁽⁸⁸⁾.

More than 90% (91.7%) of studies (*k* 33) included soft drinks such as soda in their definition of SSB^(38,73–93,95–99,101–103,105–107). Among the studies that did not measure soft drinks, one did not specify the type of beverages included in its definition of SSB⁽¹⁰⁰⁾, another only considered energy drinks⁽¹⁰⁴⁾ and one included energy drinks and sweet drinks without specifying if soft drinks were included in the latter category of beverages⁽⁹⁶⁾. Seventeen studies (47.2%) included fruit drinks in their SSB definition^(74,75,77–79,81–83,85,88–91,96–99) and twelve studies (33.3%) sports drinks^(75,77,81,83–86,88,93,95,97,98). Nine studies (25.0%) included either iced tea or sweetened tea and coffee^(74,77,81,85,88,96–98,107). Six studies (16.7%) included energy drinks^(83,88,94,97,104,107) and four studies (11.1%) included other types of SSB such as cordial concentrates⁽⁹⁹⁾, drink mixes⁽⁷⁷⁾, slush⁽⁹⁷⁾ and lemonade⁽¹⁰⁷⁾. Finally, three studies (8.3%) had a general 'sweet drinks' category^(80,87,94).

Nine studies (25.0%) only measured the impact of their intervention on soft drinks consumption^(38,73,76,92,101–103,104,106). Slightly more than a third (36.1%) of studies included two types of SSB (*k* 13), generally soft drinks and fruit drinks^(78–80,82,84,86,87,89–91,93–95). Three studies (8.3%) included three types of SSB^(74,75,99) and six studies (16.7%) reported information on four categories of SSB^(81,83,85,96,98,107). Finally, three studies (8.3%) included five types of SSB^(77,88,97) and among them, only one study⁽⁸⁸⁾ included all of our five categories of SSB, namely soft drinks, fruit drinks, sports drinks, energy drinks and sweetened tea or coffee (iced or hot)⁽⁷⁰⁾.

Study designs and quality of studies

Thirteen interventions (36.1%) were RCT or cluster RCT^(76,77,81,83,85,87,91,99,100,102,104,105,107). A third of studies (33.3%, *k* 12) adopted a one-group pre–post study design, mainly those aimed at evaluating the impact of nutrition policies in schools (i.e. SSB consumption pre- and post-policy)^(38,73,78,80,84,88,89,93,95,97,98,106). Eleven interventions (30.6%) used quasi-experimental designs^(74,75,79,82,86,90,92,94,96,101,103).

Over 60% (61.1%) of studies (*k* 22) received a weak global rating for their quality according to the EPHPP

tool^(38,74–76,78,83,85,86,88–94,96,97,100,101,103,104,107). Over 80% (81.8%) of quasi-experimental studies (*k* 9) received a weak global rating^(74,75,86,90,92,94,96,101,103), followed by one-group pre–post studies (50.0%, *k* 6)^(38,78,88,89,93,97) and RCT (53.8%, *k* 7)^(76,83,85,91,100,104,107). The three most frequent reasons for a weak global rating were: (i) presence of a selection bias; (ii) no blinding; and (iii) the data collection tool was not valid or reliable. A third (33.3%) of studies (*k* 12) received a global rating of moderate quality^(73,77,79,81,82,84,87,95,98,99,105,106). Close to 40% (38.5%) of RCT (*k* 5) received a global moderate rating^(77,81,87,99,105), followed by one-group pre–post studies (33.3%, *k* 4)^(73,84,98,106) and quasi-experimental studies (18.2%, *k* 2)^(79,82). Finally, only two studies received a strong global rating according to the EPHPP tool. One was a one-group pre–post study that evaluated the impact of a school nutrition policy on SSB consumption using validated food records⁽⁸⁰⁾. The other was an RCT on healthy eating and physical activity which used a validated self-administered FFQ to assess SSB consumption⁽¹⁰²⁾.

Results of interventions

Over 70% (72.2%, *k* 26) of all interventions, regardless of whether they targeted individuals, their environment or both, were effective in decreasing SSB consumption^(38,73–77,79–82,84,88–93,95,96,98–100,104–107). Their efficacy, however, varied according to the type of intervention (see Table 2). The ten legislative/environmental studies had the highest success rate, with nine studies (90.0%) reporting a significant reduction in SSB consumption^(73,74,79,80,82,84,93,95,98) and only one study with no significant reduction in SSB consumption following changes in the school food environment⁽⁹⁴⁾. The twenty educational/behavioural interventions and the six legislative/environmental were almost equally effective in reducing SSB consumption, with success rates of 65.0% (*k* 13)^(38,76,77,81,88,90–92,96,99,100,104,105) and 66.7% (*k* 4)^(75,89,106,107), respectively. It is noteworthy that one legislative/environmental study⁽⁹⁸⁾ and one educational/behavioural intervention⁽³⁸⁾ reported significant increases in SSB consumption post-intervention.

Theory used in designing interventions

Among the twenty-six interventions that had an educational/behavioural component, over 60% (61.5%, *k* 16) of studies were based on behavioural theories^(75–78,83,85,87,91,92,96,97,99–102,107). The theory most frequently used to design this type of intervention was the SCT⁽⁴⁶⁾ and its predecessor the SLT⁽⁴⁷⁾ (*k* 10)^(75–78,85,86,91,92,99,100), followed by the TPB⁽⁴⁸⁾ (*k* 4)^(75,76,102,107), the TTM⁽⁴⁹⁾ (*k* 4)^(76,83,85,102) and the SDT⁽⁵⁰⁾ (*k* 3)^(77,97,100). It is worth noting that all of them are psychosocial theories (i.e. theories originating from social psychology) related to human motivation/intention.

Other theories were mentioned by only one study. More than half (56.3%, k 9) of theory-based interventions were effective in reducing SSB consumption^(75–77,91,92,96,99,100,107).

Behaviour change techniques used in interventions

As previously mentioned, the majority of interventions targeted the reduction of SSB consumption as part of a general objective to promote healthy eating and physical activity or healthy eating alone. Consequently, the majority of the behaviour change techniques were directed towards promoting the larger behaviours (healthy eating and/or physical activity). Nevertheless, an effort was made to code only the behaviour change techniques related to SSB consumption and not those related to healthy eating (e.g. fruit and vegetable consumption) and/or physical activity when possible. When this was not possible, only the behaviour change techniques related to healthy eating and not those related to physical activity were coded. However, in some studies, the curriculum of the intervention that specifically targeted SSB and/or healthy eating was not stated.

The behaviour change techniques that were the most frequently used in interventions were providing information about the health consequences of performing the behaviour (72.2%, k 26)^(38,75–78,82,83,85–92,96,97,99–107), followed by restructuring the physical environment (47.2%, k 17)^(73–75,79,80,82,84,86,89,93–95,98,102,105–107), behavioural goal setting (36.1%, k 13)^(38,76–78,81,83,85,87,91,92,97,100,107), self-monitoring of behaviour (33.3%, k 12)^(38,76,77,81,87,91,92,97,99,100,104,107), threat to health (30.6%, k 11)^(38,76–78,83,89,91,100,103–105) and providing general social support (30.6%, k 11)^(38,76,78,83,85,89,91,99,100,102,107). The other behaviour change techniques were mentioned in ten or fewer different studies. The majority of legislative/environmental studies used only one behaviour change technique (i.e. restructuring the physical environment) while the majority of interventions with an educational/behavioural component used multiple behaviour change techniques. Restructuring the physical environment was a frequently used behaviour change technique given that all legislative/environmental studies aimed at evaluating the impact of school nutrition policies implied some changes in the school environment, such as banning SSB or replacing SSB by healthier alternatives (e.g. water, milk, 100% pure fruit juices). The majority of educational/behavioural interventions explained to adolescents the negative health consequences of consuming SSB and they also sometimes included a component about threat to health when they further explained how chronic diseases related to SSB consumption, such as obesity and type 2 diabetes, can be detrimental to health. Behavioural goal setting (e.g. setting an objective to decrease one's own SSB consumption by one serving per day by next week), self-monitoring of behaviour (e.g. recording one's own daily consumption of SSB) and providing general social

support were other behaviour change techniques commonly part of interventions with an educational/behavioural component. Parents (72.7%, k 8)^(38,76,78,85,89,99,100,102) and/or friends (45.5%, k 5)^(76,78,83,85,107) were enlisted for social support and one study did not report from which specific persons social support was sought⁽⁹¹⁾. In some studies, parents received written material (newsletters, text messages, emails, post-cards)^(38,85,99,100,102) and/or were invited to school meetings^(89,102) to encourage them to support their adolescent to change his/her behaviour.

Finally, only four studies (11.1%) used a control group which received some kind of intervention (i.e. active control group)^(81,87,91,96). Among those studies, two had only one or two behaviour change techniques differentiating the experimental and the control group^(91,96) while the other two studies had six behaviour change techniques differentiating both groups^(81,87). Unfortunately, it was not possible to identify the most effective behaviour change technique given that studies with an educational/behavioural component often used a combination of different behaviour change techniques in their experimental group.

Discussion

The results of the present systematic review indicate that the majority of school-based interventions are effective at reducing SSB consumption among adolescents, although the overall rating of the interventions was frequently weak. This suggests that the school setting might represent a promising place to easily reach adolescents, regardless of their age, SES, cultural background and ethnicity^(32,37,38). For example, in the present systematic review, a few studies targeted adolescents whose parents had a low SES^(77,82,83,85,86,88,93,94,99–101) or specific ethnic minorities in the USA^(81,89,90). Given that parents' lower SES can be associated with SSB consumption among young children⁽¹⁰⁸⁾, schools – especially those in low-income neighbourhoods – could be a good place to reach adolescents at high risk for SSB consumption.

According to the present findings, legislative/environmental interventions were the most effective while educational/behavioural interventions and those targeting both individuals and their environment were less, but both equally effective, at decreasing SSB consumption among adolescents. Overall, this suggests that governmental efforts to reduce availability and/or eliminate SSB in schools should be pursued. However, governmental nutrition policies can also have unintended consequences. For example, one study conducted in Canada reported that while frequency of SSB consumption decreased following a ban on SSB in schools, the volume of SSB (in millilitres) consumed increased⁽⁹⁸⁾. In other words, adolescents might report consuming SSB less frequently

simply because they drink larger quantities each time they consume SSB. This could reflect a trend of the industry to continuously increase the size of the SBB it sells over the years⁽¹⁰⁹⁾. Another study in the USA observed that while the overall mean servings of SSB in school decreased following the implementation of a school nutrition policy, three times more adolescents mentioned bringing SBB from home post-policy⁽⁸⁰⁾. Similarly, the results of another study not included in the present review (the outcome was SSB sales) suggested that when there is a ban on SSB in schools, some adolescents instead buy SSB in stores located on their school commute⁽¹¹⁰⁾. One way of possibly avoiding these unintended consequences could be to provide educational/behavioural activities among adolescents and their parents about the negative consequences associated with consuming SSB as well as tips to promote drinking healthier alternatives and to overcome the barriers that could be encountered. This could help adolescents make healthy choices when they are outside school and parents could also support them by providing non-SSB at home, such as water and milk. In fact, substituting SBB with water and milk can have a positive effect on body fatness of adolescents⁽¹¹¹⁾. Yet, in the present review, only six interventions targeted both individuals and their environment as recommended by ecological models often used to design public health interventions⁽³⁹⁾ and by research specifically targeting obesity prevention and healthy eating among children and adolescents^(69,112,113).

Among studies including an educational/behavioural component, more than half were based on a psychosocial theory, such as the SCT/SLT, TPB, TTM and SDT, which are some of the most commonly used theories for developing public health interventions⁽¹¹⁴⁾. This is an interesting finding as over the years, a number of authors have advocated for the use of theory in designing public health interventions^(40–44,114,115). In fact, among the theory-based interventions included in the present review, more than half of them were effective in reducing SSB consumption among adolescents. While at first sight this might seem like a rather low success rate, current evidence regarding the efficacy of theory-based interventions is conflicting, with some studies reporting that theory-based interventions are more effective than those not theory-based^(114,116) while others report that both theory-based and non-theory-based interventions are equally effective in changing health behaviour⁽¹¹⁷⁾. Nevertheless, one advantage of using a theory is the potential to guide the choice of behaviour change techniques to use in interventions^(51,52).

It is interesting to note that while a majority of interventions report being based on the SCT/SLT, TPB, TTM and SDT, none of the most popular behaviour change techniques previously discussed – except providing information about health consequences, which is part of the SCT/SLT and the TPB – are recommended by any of these psychosocial theories⁽⁵²⁾. Unfortunately, it is rather common that behaviour change techniques used in

interventions are not necessarily related to the theory that interventions are supposed to be based on⁽¹¹⁷⁾, which is why some authors came up with the expression ‘theory-inspired’ instead of ‘theory-based’ to describe certain interventions⁽⁵⁴⁾. This could also explain the somewhat low success rate of theory-based interventions because using behaviour change techniques linked to the chosen theory should be more effective at changing behaviour than using theory-irrelevant behaviour change techniques⁽¹¹⁷⁾.

Finally, in the present review, providing information on the health consequences related to SSB consumption was the most frequently used behaviour change technique. While knowledge of the health benefits and risks of a particular behaviour is a requirement and one of the first steps for behaviour change, it is usually deemed not sufficient to engender behaviour change according to the author of the SCT/SLT⁽¹¹⁸⁾. Other behaviour change techniques need to be used in conjunction with this strategy. Self-monitoring of behaviour was another behaviour change technique often used in interventions aimed at decreasing SSB consumption among adolescents. In fact, according to previous reviews, self-monitoring is one of the most commonly used techniques to promote physical activity among overweight/obese adults⁽¹¹⁹⁾ and it is also consistently associated with behaviour change^(120,121) and with weight loss⁽¹²²⁾, which might explain its popularity. Behavioural goal setting was also a prevalent behaviour change technique to encourage adolescents to reduce their SSB consumption. Previous reviews found that goal setting is an effective strategy to promote health behaviour changes among overweight/obese adults⁽¹²³⁾ and people with type 2 diabetes⁽¹²⁴⁾. Providing general social support was another frequent component of interventions whose objective was to lower SSB consumption among adolescents. As previously mentioned, parents play an important role in encouraging their adolescents to develop healthy habits outside school. In the articles included in the present systematic review, they were the persons most frequently solicited for social support and some studies even targeted them in their interventions by sending them written material and/or inviting them to school meetings. In fact, according to ecological models used in public health⁽³⁹⁾ and supported by empirical work aimed at improving nutrition and preventing obesity among youth^(32,69,125), interventions that target different levels of social influences, such as adolescents, their parents and the school environment, should be more effective at changing health behaviours than those simply aimed at individuals.

Recommendations for future studies

More studies targeting individuals and their environment, as recommended by ecological models used in public health⁽³⁹⁾, are needed to avoid unintended consequences

associated with interventions only aimed at changing the school food environment. Ideally, theory-based interventions should choose behaviour change techniques relevant to their choice of theory. Authors whose interventions are aimed at multiple health behaviours, such as healthy eating (including SSB consumption) and physical activity, should clearly report which behaviour change techniques were used for each behaviour. This information would help distinguish which behaviour change techniques are the most effective for improving each specific behaviour. To facilitate replication, authors are encouraged to briefly explain how each behaviour change technique was used. In many of the included studies, authors simply reported using goal setting and self-monitoring without specifying how this was applied. This information is important given that there is evidence that increasing the level of specificity of certain behaviour change techniques increases the chances of successfully changing behaviour. For example, action planning is a behaviour change technique similar to goal setting, but that requires more detailed planning, such as specifying at least one of the following components: the context, frequency, intensity and duration of the behaviour⁽⁵³⁾. Recent studies found that adults who made more specific action plans had greater odds of attaining their goal concerning fruit or vegetable intake or physical activity⁽¹²⁶⁾ and experienced greater weight loss when they had high weight-loss goals⁽¹²⁷⁾. To improve the quality of their study and also facilitate comparison across studies, authors are also advised to use a valid and reliable measure of SSB consumption to obtain precise information on both frequency (e.g. times per day or per week) and quantity (e.g. in millilitres or fluid ounces) of SSB consumed. Finally, authors are encouraged to not just include soft drinks in their definition of SSB given that other types of SSB such as sports drinks and energy drinks are increasingly more popular among adolescents⁽¹²⁸⁾ and are equally detrimental to health^(55,129–131). There is also evidence that when only sodas are banned in schools, adolescents replace them by other SBB, such as sports drinks, energy drinks and sweetened coffee and tea⁽¹³²⁾. However, when including different types of SSB, authors are advised to report on types of SSB separately in case their intervention has a different effect on each drink included in their definition.

Limitations of the systematic review

Unfortunately, it was not possible to conduct a meta-analysis on the efficacy of interventions given the important heterogeneity observed between studies. Part of this heterogeneity could result from the inclusion of different individual measures of SSB consumption (e.g. millilitres or number of glasses per day or per week, percentage of individuals who reported consuming a given quantity of SSB, etc.) and also different measures of this outcome (e.g. different types of SSB reported separately or

collectively) in the present systematic review. This decision was made since there was no consensus on how to measure individual SSB consumption. In fact, a recent review of methods to assess intake of SSB among adults, adolescents and children concluded that there is a need for an agreed definition of SSB among instruments measuring this behaviour⁽⁶²⁾. At the same time, a strength of the present review was the inclusion of different types of intervention, such as educational/behavioural and legislative/environmental interventions, as both can inform the development of school-based interventions and are relevant for public health. The inclusion of different study designs was another strength⁽¹³³⁾, since including only RCT would have excluded studies reporting the efficacy of school nutrition policies. It was also not possible to verify the presence of a publication bias, which could explain why the majority of the studies reported a significant reduction of SSB consumption after their intervention. To lower the risk of encountering this bias, grey literature (i.e. unpublished trials) was included in the present review.

Conclusions

To our knowledge, the present study is the first to systematically review school-based interventions aimed at reducing SSB consumption among adolescents. It also applied the taxonomy of Cane *et al.*⁽⁵³⁾ to classify the behaviour change techniques used in interventions. Another novel aspect of the current review is the assessment of the quality of each study using the EPHPP tool⁽⁷¹⁾. As such, the present review contributes to identify gaps in knowledge and suggest new directions for people wishing to develop school-based interventions to effectively reduce SSB consumption among adolescents.

School-based interventions show promising results to reduce SSB consumption among adolescents and governmental efforts to reduce availability and/or eliminate SSB in schools should be pursued. More studies targeting individuals and their environment, as recommended by ecological models used in public health⁽³⁹⁾, are needed to avoid unintended consequences associated with interventions aimed only at changing the school food environment. Finally, it is hoped that these findings and the growing rates of obesity among adolescents will encourage public health authorities and researchers to pursue their efforts to encourage adolescents to adopt healthy drinking habits, such as replacing SSB by water or milk⁽¹¹¹⁾, which could be maintained throughout life.

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Supplementary material

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