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Interventions to Prevent Obesity in Mexican Children and Adolescents: Systematic Review

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Abstract

The prevalence of overweight and obesity has been rising among Mexican children and adolescents in the last decades. To systematically review obesity prevention interventions delivered to Mexican children and adolescents. Thirteen databases and one search engine were searched for evidence from 1995 to 2021. Searches were done in English and Spanish to capture relevant information. Studies with experimental designs, delivered in any setting (e.g., schools or clinics) or digital domains (e.g., social media campaigns) targeting Mexican children or adolescents (≤ 18 years) and reporting weight outcomes, were included in this review. In addition, the risk of bias was appraised with the Effective Public Health Practice Project Quality Assessment Tool. Twenty-nine studies with 19,136 participants (3–17 years old) were included. The prevalence of overweight and obesity at baseline ranged from 21 to 69%. Most of the studies (89.6%) were delivered in school settings. The duration ranged from 2 days to 3 school years, and the number of sessions also varied from 2 to 200 sessions at different intensities. Overall, anthropometric changes varied across studies. Thus, the efficacy of the included studies is heterogeneous and inconclusive among studies. Current evidence is heterogeneous and inconclusive about the efficacy of interventions to prevent obesity in Mexican children and adolescents. Interventions should not be limited to educational activities and should include different components, such as multi-settings delivery, family inclusion, and longer-term implementations. Mixed-method evaluations (including robust quantitative and qualitative approaches) could provide a deeper understanding of the effectiveness and best practices.

Keywords Obesity · Prevention · Children · Adolescents · Mexico

Introduction

The prevalence of overweight and obesity is a major international public health problem and has nearly doubled in the last three decades, especially among children and adolescents (Global Obesity Observatory, 2019). Excess body fat in children and adolescents can lead to various clinical conditions and psychosocial disorders that might significantly reduce their quality of life. Moreover, children and adolescents with obesity are likely to maintain their weight status into adulthood, increasing their risk of developing chronic diseases, contributing to increased morbidity and premature mortality (WHO, 2012; Wang & Lim, 2012).

Mexico is an upper-middle-income Latin-American country where obesity levels have been increasing alarmingly in the last decades (Aceves-Martins et al., 2016a; Astudillo, 2014). Specifically, overweight and obesity rates have increased in the < 18 years old population. According to the latest results from the National Health and Nutrition Survey (ENSANUT, 2018), it is estimated that 8.2% of infants (0–4 years), 35.6% of school-age children (5–11 years), and almost 40% of adolescents (12–19 years) have overweight or obesity in Mexico. In addition, the Global Obesity Observatory (2019) suggests that Mexico has one of the highest prevalence of obesity among children and adolescents worldwide. Furthermore,

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according to the Organisation for Economic Co-operation and Development estimations, obesity rates will continue to rise in Mexico if no effective strategies are implemented (OECD, 2017). Likewise, some economic models have estimated that childhood obesity in Mexico's economic impact between 2006 and 2050 will be much higher than what the health care system can stand, jeopardising the general population's health care and wellbeing (Garduño-Espinosa et al., 2008; Ortega-Cortés, 2014).

Most of the published systematic reviews on childhood obesity prevention include only English publications (Ash et al., 2017; Liu et al., 2019; Tamayo et al., 2021; Ward et al., 2017) or evidence from high-income countries (Tamayo et al., 2021; Wang et al., 2015), excluding valuable evidence from non-English speaking low- or middle-income countries such as Mexico. The "Childhood and adolescent Obesity in MexicO: evidence, challenges and opportunities" (COMO) Project intend to synthesise and use data to comprehend the extent, nature, effects, and costs of childhood and adolescent obesity in Mexico (Aceves-Martins, 2021a, b, c). This systematic review is part of the COMO project, and it aims to identify and evaluate studies implemented in Mexico to prevent obesity among children and adolescents (< 18 years).

Methods

This project's systematic review is registered in The International Prospective Register of Systematic Reviews (Registration number CRD42019154132) (PROSPERO, 2021). In addition, this review is reported according to Preferred Reporting Items for Systematic Reviews and Meta-analyses guidelines (PRISMA, 2021). The research question and inclusion/exclusion criteria were established following the Population, Intervention, Comparison, Outcomes, Study design (PICOS) framework.

Electronic Searches

A sensitive search was developed to include index terms, free-text words, abbreviations, and synonyms to combine the key concepts for this review. Terms such as "overweight," "obesity," "child," "adolescent," "intervention," "program," and "Mexico" were included in the strategy with different term variation/synonyms and Boolean connectors to capture relevant publications. The databases searched included MEDLINE, EMBASE, the Cochrane Library, Global Health Library, LILACS, CINAHL, CAB abstracts, ERIC, PsycINFO, ScienceDirect, Scopus, AGRICOLA, and SciELO Citation Index. Also, the search engine Google Scholar was used to identify relevant studies. When possible, searches were also done in Spanish to capture relevant references. Conference abstracts and poster presentations were included if the inclusion criteria were met. Also, reference lists of the included studies were scrutinised for additional publications, and experts in the field were contacted for additional relevant reports. Searches were done in January 2020 and updated in January 2021.

Selection Criteria

Reports from 1995 onwards were included in this review to focus on information conducted under current epidemiological and environmental circumstances of child and adolescent obesity in Mexico. All searches were restricted to English, Spanish, or Portuguese language publications to capture reports from the most widespread languages spoken in the Americas. Following the PICOS framework, our inclusion/exclusion criteria were:

Population

Children and adolescents from zero to 18 years old (mean age at the start of the study) from any ethnicity or gender living in Mexico were included. Studies that involved parents, caregivers, or related stakeholders (e.g., teachers or health carers) were included only if the outcomes were measured in children or adolescents. Studies evaluating the treatment (i.e. only including participants with obesity) were excluded from this review. Mexican children living in different countries were excluded to better conceptualise the obesity problem within their sociodemographic characteristics, avoiding confounding information inherent to the migration phenomena. Likewise, studies that analysed children's severe conditions (e.g. HIV, cancer, down syndrome), premature babies and pregnant adolescents were excluded.

Intervention

Obesity prevention or lifestyles interventions delivered among Mexican children or adolescents were considered.

Outcomes

Since weight and weight-related measures are indispensable for the evaluation effectiveness of interventions related to child and adolescent overweight and obesity (Green et al., 2012), weight-related outcomes (i.e., weight, BMI, or BMI z-score change) were considered in this review as primary outcomes. Because of the studies' nature, any other outcome related to lifestyle changes (i.e., dietary, PA, behavioural outcomes) was also recorded as secondary outcomes.

Study Design

Any experimental or quasi-experimental studies designs were considered. In addition, interventions delivered in any setting

(e.g. home-based, school-based, clinic-based, community-based, leisure centres) or digital domains (e.g. social media interventions) were considered.

Data Extraction

Titles, abstracts, and relevant full-texts were screened by two reviewers (LL, MGB) and 100% checked by a third reviewer (MA-M). Two reviewers (MA-M and LLC) extracted data from intervention studies independently. In case of any disagreement, a third author was contacted (YG).

A data extraction form was created based on the Effective Public Health Practice Project Quality Assessment Tool (EPHPP, 2010) for quantitative studies and the PICOS framework. The template for intervention description and replication (TIDieR, 2021) checklist items were also included in the extraction form. Critical components of the interventions were extracted and categorised as a) Nutritional (i.e., studies including diet prescriptions or nutritional advice); b) PA (i.e., studies including PA practise or PA advice); c) behavioural or psychological (i.e., studies including counselling, or behavioural therapy); and d) environmental changes (i.e., environment changes to promote a weight change among participants). Any strategy or framework used in the design of the interventions was also recorded.

Quality and Risk of Bias Assessment

Following the Cochrane Handbook's recommendation about systematic reviews of health promotion interventions (Armstrong et al., 2011), the EPHPP (2010) Assessment Tool for Quantitative Studies was used. This tool produces an overall methodological rating (i.e., strong, moderate, or weak evidence) and comprises eight categories: selection bias; study design; confounders; blinding; data collection methods; withdrawals and drop-outs; intervention integrity; and analysis. According to the quality assessment tool's guidelines for each category, the scores were added, producing a global rating. In addition, the funding source and reported conflicts of interest were also extracted. Two reviewers (MA-M and LLC) evaluated each included study independently and then agreed. In case of any disagreement, a third author was contacted (YG).

Data Synthesis

A meta-analysis was not feasible because of the heterogeneity among the included studies and the lack of outstanding quality Randomised Controlled Trials [RCTs]. Hence, a narrative synthesis was conducted. The data obtained from the included studies were narratively synthesised, and relevant characteristics were tabulated. According to the type of study (i.e. studies including a control group and cohort studies without control groups), results were reported in the text. In addition, textual descriptions of studies and reported statistical significance were recorded and tabulated. Quality assessment was included in the synthesis.

Results

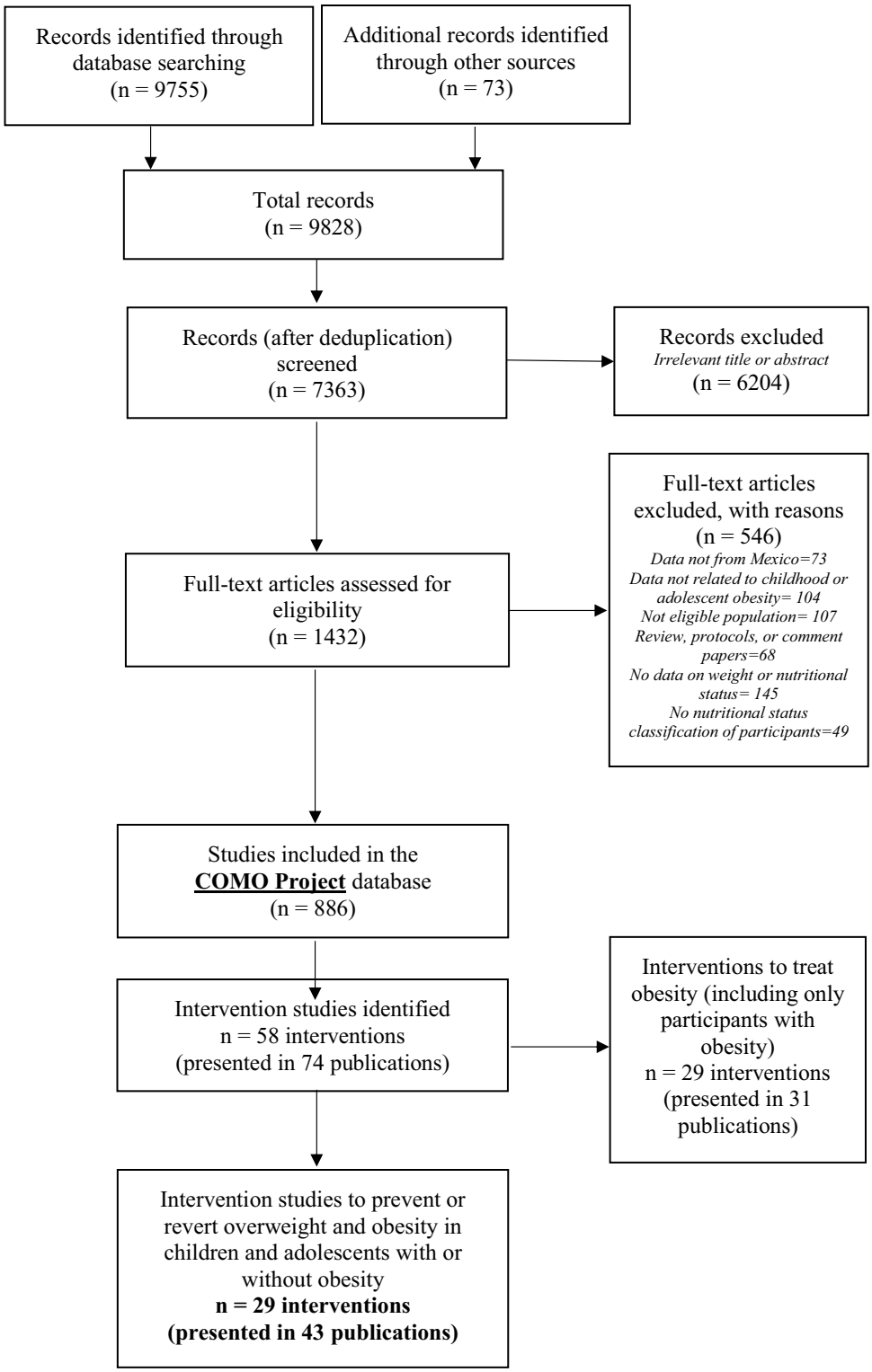
Our searches identified 9828 references, from which 1432 were retrieved for full-text review. Thus, overall, 886 references were included in the COMO database. From these, 58 studies (presented in 74 publications) were identified. From these, 29 studies (presented in 43 publications) met the inclusion criteria (Fig. 1). Nearly half of the studies (14/29) were published in Spanish, and the rest in English. Also, less than half (12/29) were published in Mexican journals.

From the 29 studies included, four (13.7%) (Levy et al., 2012a, b; Macias et al., 2014; Mejia et al., 2016; Morales-Ruán et al., 2014) were conference abstracts. Sixteen studies (55.2%) included control groups (seven [24.1%] were RCTs, one [3.4%] pilot RCT, eight [27.5%] were controlled trials), and 13 (44.8%) were cohorts (11 [37.9%] were single cohorts, and two [6.8%] were cohort analytic, including two intervention groups) (Table 1).

Overall, this systematic review includes data from 19,136 participants (from 3 to17 years old) recruited from 13 Mexican states (out of 32) (Fig. 2). Only Caballero-García et al. (2017) implemented a multi-site intervention that included pupils from different states across Mexico. The prevalence of overweight and obesity at baseline ranged from 21 to 69% across included studies. All the studies targeted and included both males and female participants. Most of the studies (89.6%) were delivered in school settings, two (Martínez-Andrade et al., 2014; Rodriguez-Ventura et al., 2018) in public clinics, and one (Zacarías et al., 2019) in a community setting. One study (Martinez-Andrade et al., 2014) was delivered among a preschool population, 22 studies among a school-age population (6–12 years), and six among adolescents (13–18 years). The principal characteristics of the included studies are presented in Table 1.

The design and implementation of the included studies varied widely. Some studies (13; 44.8%) included educational interventions, some others (5; 17.2%) included PA practise as an intervention, three (10.3%) included both educational intervention and PA practise, and one (3.4%) incorporated a school breakfast provision besides an educational intervention and PA practise. Elizondo-Montemayor et al. (2014) delivered a social media campaign plus a non-mandatory PA masterclass as part of the study. Ríos-Cortázar et al. (2013) used children's narratives to reconstruct the school's environment towards creating a healthier school atmosphere. Martínez-Andrade et al. (2014) and Salazar Vázquez et al.

Fig. 1 PRISMA flowchart



(2016) included solely motivational counselling. Rodriguez-Ventura et al. (2018) included a multidisciplinary clinical intervention. Zacarías et al. (2019) delivered a community intervention aiming to change children's weight but intervening mothers. However, this was not the only study including parents or other family members. Twelve studies (41.3%) included parents or siblings as active participants of the activities delivered to children (Table 1).

Overall, the components of the included studies also varied. Most of the studies (26; 89.6%) included a nutritional

Table 1 Principal characteristics of included studies

STUDY ID Study design	**Setting characteristics** (City or Town, Federal State, Setting, Year of implementation)	**Participant's characteristics**	**Intervention's key characteristics**	**Nutritional component**	**PA component**	**Behavioural component**	**Environmental changes**	**Weight reported outcomes**
Alvirde-Garcia et al. (2013) Randomised Control Trial	Tenango del Valle and Santa Cruz de Atizapan (State of Mexico) Two public schools from semi-rural communities 2007–2010	**Total initial sample:** 2682 **Female (%):** 50.2 **Mean (SD) age:** 9 (1.7) years **Baseline prevalence of OW + OB (%):** 38	**Duration:** 3 school years **Follow-up period:** NR **Intensity and Frequency:** 15 sessions **Delivered by:** Teachers (previously trained by the research staff) **Overall Scope:** Educational intervention to change lifestyles through didactic material and family-based activities (replication of Child and Adolescent Trial for Cardiovascular Health originally from the US)	☐	☐	NR	☐	After three years, the study resulted in a lower BMI increase but no significant weight change
Arroyo and Carrete (2018) Cohort (one group before and after)	Toluca (State of Mexico) Public schools from middle-SES neighbourhoods 2014	**Total initial sample:** 98 **Female (%):** 52 **Mean (SD) age:** 11.8 (0.5) years **Baseline prevalence of OW + OB (%):** 21.2	**Duration:** 3 months **Follow-up period:** NR **Intensity and Frequency:** 4 conferences + weekly homework + 2 optional conferences for parents **Delivered by:** Medical doctors and a nutritionist **Overall Scope:** Educational intervention intended to promote healthy eating practices	☐	NR	☐	NR	No weight or BMI changes were reported at the end of the study
Bacardi-Gascon and Jiménez-Cruz (2012) Randomised Control Trial	Tijuana (Baja California) Two public and two private schools from similar SES 2008–2010	**Total initial sample:** 532 **Female (%):** 48.9 **Mean (SD) age:** 8.4 (NR) years **Baseline prevalence of OW + OB (%):** 45.3	**Duration:** 6 months + 18 months **Follow-up period:** 18 months, but a follow-up program was continued during this time **Intensity and Frequency:** 3 sessions (60 min each) with school board and teachers + 8 sessions (30 min per week × 8 weeks) with children + 4 sessions (60 min per month × 4 months) with parents **Delivered by:** Nutrition (graduate students and professionals) and PA professionals **Overall Scope:** Educational intervention that implemented changes in the school curricula and included school board, teachers, and parents' involvement	☐	☐	NR	☐	At six months, there were significant BMI differences between the control and intervention groups

Table 1 (continued)

STUDY ID Study design	**Setting characteristics** (City or Town, Federal State, Setting, Year of implementation)	**Participant's characteristics**	**Intervention's key characteristics**	**Nutritional component**	**PA component**	**Behavioural component**	**Environmental changes**	**Weight reported outcomes**
Balas-Nakash et al. (2010) Cohort analytic (two groups before and after)	Toluca (State of Mexico), Two public schools serving middle-SES children and that had suitable playgrounds for activities 2008	**Total initial sample:** 319 **Female (%):** 59.6 **Mean (SD) age:** 10 (NR) years **Baseline prevalence of OW + O B (%):** 43.9	**Duration:** 3 months **Follow-up period:** NR **Intensity and Frequency:** 60 afterschool sessions (20 min for children in routine A and 40 min for children in routine B 5 days a week) **Delivered by:** Certified physical education trainer **Overall Scope:** PA practice, including two different routines at different intensities	NR	☐	NR	NR	Anthropometric measures (e.g., fat mass percentage, BMI) significantly decreased in routine B children. In addition, the prevalence of overweight and obesity decreased in both groups significantly
Benitez-Guerrero et al. (2016) Controlled trial	Tepic (Nayarit) Twelve public primary schools from an urban area Year of implementation NR	**Total initial sample:** 368 **Female (%):** 48.3 **Range age:** 9–11 years **Baseline prevalence of OW + OB (%):** 42.3	**Duration:** 3 months **Follow-up period:** NR **Intensity and Frequency:** NR **Delivered by:** NR **Overall Scope:** Educational intervention intended to promote healthy eating PA	☐	☐	NR	NR	Girls in the intervention group reduced underweight and overweight prevalence, reflecting a positive effect of the intervention. No effect was observed in boys
Caballero-Garcia et al. (2017) Cohort (one group before and after)	Chilpancingo (Guerrero) Puerto Vallarta (Jalisco), Coatetelco (Morelos) and Hermosillo (Sonora) Four public schools from medium- and low-SES. Some schools included indigenous and working children 2006–2008	**Total initial sample:** 1031 **Female (%):** 50.1 **Mean (SD) age:** 10 (NR) years **Baseline prevalence of OW + OB (%):** 27.6	**Duration:** 5 months **Follow-up period:** NR **Intensity and Frequency:** 20 educational sessions (60 min once a week) **Delivered by:** Education facilitator (external school staff, undergraduate/graduate) and research team **Overall Scope:** Educational intervention to promote healthy eating	☐	NR	NR	NR	Overall, the weight or BMI reduction varied across sites. There was a reduced prevalence of obesity in Sonora and a reduced prevalence of overweight in Morelos, Jalisco and Sonora

Table 1 (continued)

STUDY ID Study design	**Setting characteristics** (City or Town, Federal State, Setting, Year of implementation)	**Participant's characteristics**	**Intervention's key characteristics**	**Nutritional component**	**PA component**	**Behavioural component**	**Environmental changes**	**Weight reported outcomes**
Costa-Urrutia et al. (2019) Cohort analytic (two groups before and after)	Hermosillo, Punta Chueca and Bahía de Lobos (Sonora) Four general urban schools (from Hermosillo, the capital city) and two indigenous schools, Seris (from Punta Chueca) and Yaquis (from Bahía de Lobos) 2016	**Total initial sample:** 320 **Female (%):** 49 **Mean (SD) age:** 8.2 (2.3) years **Baseline prevalence of OW + OB (%):** 39.4	**Duration:** 3 months **Follow-up period:** NR **Intensity and Frequency:** 36 PA sessions (of 60 min) + 24 PA sessions (of 45 min) + 12 workshops (of 50 min) + 3 workshops for parents (length NR) **Delivered by:** Physical education teacher, nutritionist, and phycologists (previously trained), and teachers supported **Overall Scope:** PA practice, health education, parent involvement and school meals provision	☐	☐	☐	☐	BMI decreased significantly in children with overweight and obesity. Mestizos under group 1 (PA, health education and parent involvement components) increased BMI, whereas those in group 2 (group 1 intervention + school meals) decreased it. Seris increased BMI, Yaquis increased BMI significantly. Concerning ethnic groups, Mestizos and Seris decreased their BMI values, but not significantly. Yaquis increased their BMI values, and such an amount of increase decreases with age
Cruz-Bello et al. (2019) Cohort (one group before and after)	San Cristóbal Tecolit Municipality and Zinacantepec Municipality (State of Mexico) One public high school Year of implementation NR	**Total initial sample:** 32 **Female (%):** 43.4 **Mean (SD) age:** 15.6 (1.3) years **Baseline prevalence of OW + OB (%):** 43.7	**Duration:** 4 months **Follow-up period:** 3 months after the intervention **Intensity and Frequency:** 40 sessions (60 min each) **Delivered by:** Trained Nurses **Overall Scope:** Educational intervention aiming to promote healthy eating and PA open classes	☐	☐	☐	NR	No weight or BMI changes were reported at the end of the study
Elizondo-Montemayor et al. (2014) Cohort (one group before and after)	Monterrey (Nuevo Leon) Five private high schools in the urban area 2011–2012	**Total initial sample:** 554 **Female (%):** 48.1 **Range age:** 14–17 years **Baseline prevalence of OW + OB (%):** 25	**Duration:** 1 school year **Follow-up period:** NR **Intensity and Frequency:** Weekly updates on social media channels + 1 (optional) PA session **Delivered by:** Medical doctor, nutritionists, and medical and nutrition interns. Teachers continuously invited the students to go to these means to receive the counselling **Overall Scope:** Social media health promotion activities (weekly updates), conferences and PA open classes	☐	☐	NR	NR	No significant differences were found in the prevalence of obesity and overweight at the baseline and end of the study. However, there was a significant increase in BMI and fat percentage among female participants

Table 1 (continued)

STUDY ID Study design	**Setting characteristics** (City or Town, Federal State, Setting, Year of implementation)	**Participant's characteristics**	**Intervention's key characteristics**	**Nutritional component**	**PA component**	**Behavioural component**	**Environmental changes**	**Weight reported outcomes**
Gatica-Dominguez et al. (2019) Controlled trial	Tlaltizapan, Zacatepec and Galeana (Morelos) Four elementary public schools in Tlaltizapán town (intervention) and four primary schools in Galeana town (control) 2010–2013	**Total initial sample:** 214 **Female (%):** 48.6 **Range age:** 8–14 years **Baseline prevalence of OW + OB (%):** 35.6	**Duration:** 3 school years **Follow-up period:** NR **Intensity and Frequency:** NR **Delivered by:** NR **Overall Scope:** Intervention, including dietary, PA, and social participation components. However, the identified study only describes the PA component. Strategies targeted children, parents, teachers, educational authorities, community leaders and local government authorities	☐	☐	NR	NR	No weight or BMI changes were reported at the end of the study
Macias et al. (2014) (Abstract) Randomised Control Trial	Leon (Guanajuato) One elementary school Year of implementation NR	**Total initial sample:** 135 **Female (%):** NR **Mean (SD) age:** NR **Baseline prevalence of OW + OB (%):** 24.6	**Duration:** 6 months **Follow-up period:** 6 months **Intensity and Frequency:** 48 sessions (2 sessions per week) **Delivered by:** NR **Overall Scope:** Educational intervention designed for children about PA and nutrition in elementary schools based on theory to change habits	☐	☐	NR	NR	At one year of follow-up, more children with overweight and obesity were reported in the control group than the intervention group
Martinez-Andrade et al. (2014) Pilot—Randomised Control Trial	Mexico City (Mexico City) Four public primary healthcare clinics 2012 (Cespedeset al. 2012)	**Total initial sample:** 1406 **Female (%):** 47.4 **Mean (SD) age:** 3.4 (0.8) years **Baseline prevalence of OW + OB (%):** 55.9	**Duration:** 1.5 months **Follow-up period:** 6 months **Intensity and Frequency:** 6 sessions (120 min weekly sessions) + 1 educational session on PA (90 min) + 1 socialising session (30 min) **Delivered by:** Nutritionist, nurse and health educator **Overall Scope:** Intervention based on motivational counselling to change eating behaviours and PA was delivered. Mexican adapted version of the "High Five for Kids" intervention from the US	☐	☐	☐	NR	When using an intention to treat analysis, no BMI changes were found at either 3 or 6 months

Table 1 (continued)

STUDY ID Study design	**Setting characteristics** (City or Town, Federal State, Setting, Year of implementation)	**Participant's characteristics**	**Intervention's key characteristics**	**Nutritional component**	**PA component**	**Behavioural component**	**Environmental changes**	**Weight reported outcomes**
Mejia et al. (2016) (Abstract) Randomised Control Trial	Tamaulipas City, (Tamaulipas) Two elementary schools (no further information provided) Year of implementation NR	**Total initial sample:** NR **Female (%):** NR **Mean (SD) age:** NR **Baseline prevalence of OW + OB (%):** 56	**Duration:** 4 months **Follow-up period:** NR **Intensity and Frequency:** NR **Delivered by:** Unclear **Overall Scope:** Educational intervention named a culturally sensitive health education model to prevent child obesity targeting teachers, parents, and children	☐	☐	NR	☐	The upward trend of BMI was reversed among children with overweight/obesity in the intervention group, while the upward trend of the BMI in the control group continued to increase. However, these changes were not significant after four months
Padilla-Raygoza et al. (2013) Randomised Control Trial	Celaya (Guanajuato) Elementary public schools Year of implementation NR	**Total initial sample:** 301 **Female (%):** NR **Range age:** 6–13 years **Baseline prevalence of OW + OB (%):** 66	**Duration:** 4 months **Follow-up period:** NR **Intensity and Frequency:** 80 walking sessions (1 session 30 min 5 days a week for four months) + 8 sessions to mothers **Delivered by:** NR **Overall Scope:** The intervention included 30 min of daily PA and teaching in selecting and preparing meals for the children's mother	☐	☐	NR	NR	After the four months, there were non-significant differences in the prevalence of overweight or obesity among groups. However, weight and BMI were significantly lower in the intervention compared to the control group
Perichart-Perera et al. (2008) Cohort (one group before and after)	Santiago de Queretaro (Queretaro) Two public schools from urban areas Year of implementation NR	**Total initial sample:** 360 **Female (%):**53.1 **Range age:** 8–14 years **Baseline prevalence of OW + OB (%):** 42.2	**Duration:** 4 months **Follow-up period:** NR **Intensity and Frequency:** 80 sessions (20 min 5 days a week) + 16 sessions (minimum of 30 min per week of teacher's advice) **Delivered by:** Physical educator, teachers, nutritionists, and paediatric nurses **Overall Scope:** PA practice and food orientation intervention for schoolchildren promoted by teachers to increase PA in schoolchildren and provide messages that helped achieve a healthy balance	☐	☐	NR	NR	After the intervention, a non-significant reduction in waist circumference, BMI was reported. Children who had overweight and obesity at baseline had a higher risk score than those with normal BMI. However, this score did not decrease significantly after the intervention

Table 1 (continued)

STUDY ID Study design	**Setting characteristics** (City or Town, Federal State, Setting, Year of implementation)	**Participant's characteristics**	**Intervention's key characteristics**	**Nutritional component**	**PA component**	**Behavioural component**	**Environmental changes**	**Weight reported outcomes**
Polo-Oteyza et al. (2017) Cohort (one group before and after)	Toluca Valley, including Metepec, Ocoyoacac, Huixquilucan and Lerma (State of Mexico) 5 public schools from rural and urban areas 2013–2014 (Palacios-González et al. 2015)	**Total initial sample:** 1888 **Female (%):** NR **Range age:** 6–11 years **Baseline prevalence of OW + OB (%):** 31.9	**Duration:** 1 school year **Follow-up period:** NR **Intensity and Frequency:** 200 PA sessions (30-min routine to be performed five days a week) **Delivered by:** Teachers, PA teachers, a medical doctor, paediatric nurses, nutritionists, and research assistants **Overall Scope:** PA intervention designed and implemented by teachers in charge of the physical education activities in public schools	×	☐	NR	NR	No significant changes were found in BMI or waist circumference after the intervention, even after correcting children's growth
Ponce et al. (2016) Controlled trial	Mexicali (Baja California) Secondary schools (No further information provided) Year of implementation NR	**Total initial sample:** 418 **Female (%):** 54.3 **Range age:** 11–15 years **Baseline prevalence of OW + OB (%):** 40.6	**Duration:** 2 months **Follow-up period:** NR **Intensity and Frequency:** 6 sessions (totalling 28 h) **Delivered by:** NR **Overall Scope:** Educational intervention which promoted healthy dietary lifestyles	☐	NR	NR	NR	There was a significant decrease in weight and BMI in the intervention group compared to controls. However, the prevalence of overweight and obesity was higher in the control group and even higher in males from the control group
Radilla-Vazquez et al. (2019) Controlled trial	Mexico City (Mexico City) 16 public secondary schools Year of implementation NR	**Total initial sample:** 2368 **Female (%):** 49.7 **Mean (SD) age:** 11.8 (0.5) years **Baseline prevalence of OW + OB (%):** 39.2	**Duration:** 3 school years **Follow-up period:** NR **Intensity and Frequency:** NR **Delivered by:** Medical doctors and a provider of social nutrition service from the selected schools and one of the professional practices in psychology, with the support of a social worker for each school **Overall Scope:** Educational intervention using comic-type printed materials to promote healthy lifestyles and food choices	☐	NR	☐	NR	After the intervention, the prevalence of obesity and overweight decreased in the intervention group, while the control group remained similar

Table 1 (continued)

STUDY ID Study design	**Setting characteristics** (City or Town, Federal State, Setting, Year of implementation)	**Participant's characteristics**	**Intervention's key characteristics**	**Nutritional component**	**PA component**	**Behavioural component**	**Environmental changes**	**Weight reported outcomes**
Ramirez-Lopez et al. (2005) Controlled trial	24 communities from 17 municipalities (Sonora) Schools from considered communities, including both rural and urban 2002–2003	**Total initial sample:** 610 **Female (%):** NR **Mean (SD) age:** 8.5 (1.3) years **Baseline prevalence of OW + OB (%):** 41.1	**Duration:** 1 school year **Follow-up period:** NR **Intensity and Frequency:** 180 breakfasts (breakfast provision 5 days a week for 9 months) **Delivered by:** Social workers or teachers **Overall Scope:** School breakfast programme, plus and education and PA intervention	☐	NR	NR	NR	No significant differences were found between the two groups in height/age, BMI, and fat percentage. In addition, the prevalence of overweight or obesity did not change after the intervention
Rios-Cortazar et al. (2013) Cohort (one group before and after)	Mexico City (Mexico City) One public elementary school 2008–2011	**Total initial sample:** 232 **Female (%):** NR **Mean (SD) age:** NR **Baseline prevalence of OW + OB (%):** 34.4	**Duration:** 3 school years **Follow-up period:** NR **Intensity and Frequency:** NR **Delivered by:** NR **Overall Scope:** Health promotion intervention using children's narrative and actions to construct a school environment that promotes health	☐	☐	NR	NR	The prevalence of overweight decreased significantly
Vazquez et al. (2017) Cohort (one group before and after)	Cd. Victoria (Tamaulipas) Public secondary school Year of implementation NR	**Total initial sample:** 54 **Female (%):** 48.9 **Range age:** 11–14 years **Baseline prevalence of OW + OB (%):** 57.4	**Duration:** 2 days **Follow-up period:** NR **Intensity and Frequency:** 2 sessions (90 min each) **Delivered by:** Nurses **Overall Scope:** Educational nursing intervention following the Clinical Practice Guideline on Nursing Interventions to prevent overweight and obesity in children and adolescents in the first level of care	☐	NR	NR	NR	Baseline anthropometric data presented only. Weigh changes not reported at the end of the intervention
Rodriguez-Ventura et al. (2018) Pilot—Cohort (one group before and after)	Mexico City (Mexico City) Paediatrics department of a public hospital Year of implementation NR (Rodriguez-Ventura et al. 2014)	**Total initial sample:** 55 **Female (%):** 50 **Mean (SD) age:** 13.5 (NR) years **Baseline prevalence of OW + OB (%):** 55.6	**Duration:** 3–4 months **Follow-up period:** NR **Intensity and Frequency:** 3–4 sessions (single monthly visit) + 2 workshops **Delivered by:** Registered Dietitian, Paediatric Endocrinologist, Psychologists (if necessary) **Overall Scope:** Clinical and nutritional education intervention "*Sacbe*" (Mayan word that means "the white way") based on the Diabetes Prevention Programme (originally from the US)	☐	☐	☐	NR	Using an intention to treat analysis, obesity prevalence and BMI z-scores decreased significantly

Table 1 (continued)

STUDY ID Study design	**Setting characteristics** (City or Town, Federal State, Setting, Year of implementation)	**Participant's characteristics**	**Intervention's key characteristics**	**Nutritional component**	**PA component**	**Behavioural component**	**Environmental changes**	**Weight reported outcomes**
Safdie et al. (2013a, b) Randomised Control Trial	Mexico City (Mexico City) Forty public elementary schools from low-SES children receiving benefits from the Federal School Breakfast Program 2006–07 and 2007–08 school years (Aburto et al. 2011; Bonvecchio et al. 2014; Bonvecchio-Arenas et al. 2010; Safdie et al.2014)	**Total initial sample:** 886 **Female (%):** 50 **Mean (SD) age:** 9.7 (0.7) years **Baseline prevalence of OW + OB (%):** 43	**Duration:** 2 school years **Follow-up period:** NR **Intensity and Frequency:** Implementation of both interventions varied and depend on the willingness of principals, teachers, and school staff **Delivered by:** Physical Education teachers **Overall Scope:** Intervention focused on improving nutrition and PA norms at the schools and limited existing school infrastructure and resources. The "plus intervention" implemented all the primary intervention components and included additional financial investment and human resources	☐	☐	☐	☐	The prevalence of overweight and obesity in children changed across the evaluation period by type of intervention group. There was a BMI reduction in children in control schools from baseline to months 7, 11 and 18 and increased BMI in primary intervention schools from baseline to 7, 11 and 18 months. Overall, the interaction between intervention duration and type for BMI was significant. There was a significant difference in BMI between baseline and seven months, between 7 and 11 months, and between baseline vs 18 months
Salazar-Vazquez et al. (2016) Controlled trial	Durango City (Durango) One private school 2011	**Total initial sample:** 54 **Female (%):**43 **Mean (SD) age:** 12.5 (2) years **Baseline prevalence of OW + OB (%):** 35.4	**Duration:** 1 school year **Follow-up period:** NR **Intensity and Frequency:** 2 measurement sessions + adherence of each participant **Delivered by:** NR **Overall Scope:** Intervention designed to reduce the eating rate and foster awareness of the onset of the satiety reflex. Study participants received a 30-s-period portable hourglass used to pace bites' timing during meal consumption	☐	NR	☐	NR	Results are presented by adhering vs not adhering to groups. The BMI and BMI z scores significantly decreased after the first semester and second semester, the adhering group. In contrast, the BMI in the nonadherent and the control groups significantly increased after one year. In addition, the prevalence of participants with overweight and obesity adhering to the study decreased significantly at six months and 12 months

Table 1 (continued)

STUDY ID Study design	**Setting characteristics** (City or Town, Federal State, Setting, Year of implementation)	**Participant's characteristics**	**Intervention's key characteristics**	**Nutritional component**	**PA component**	**Behavioural component**	**Environmental changes**	**Weight reported outcomes**
Saucedo-Molina et al. (2018) Pilot—Cohort (one group before and after)	Hidalgo City (Hidalgo) Public high school from an urban area and pupils from various SES 2014	**Total initial sample:** 368 **Female (%):** 58.1 **Mean (SD) age:** 16.4 (NR) years **Baseline prevalence of OW + OB (%):** 50	**Duration:** 5 days **Follow-up period:** 6 months **Intensity and Frequency:** 4 sessions (1 h each) + 4 PA sessions (1 h each) + 1 final workshop (90-min) **Delivered by:** Undergraduate nutrition degree students **Overall Scope:** Educational prevention intervention comprising prevention of eating risky and sedentary behaviours based on The Body Project and the Eating, Aesthetic, Feminine Models and Media Programme, comprised five activity-based sessions, delivered on five consecutive days. Including enjoyable PA and three parallel workshops	☐	☐	☐	NR	A significant change in BMI distributions and a downwards trend was observed in students with overweight and obesity. In addition, the prevalence of overweight or obesity decreased among adhering participants compared with the non-adhering group
Levy et al. (2012a, b) Randomised Control Trial	125 municipalities (State of Mexico) 60 Public elementary schools were serving children that were beneficiaries of a school breakfast program 2010–2011 (Levy et al. 2011)	**Total initial sample:** 1019 **Female (%):** 50.6 **Range age:** 10–13 years **Baseline prevalence of OW + OB (%):** 35.4	**Duration:** 6 months **Follow-up period:** 6 months **Intensity and Frequency:** 6 sessions (workshops) + 4 sessions (once per week for four weeks puppet theatre) + approx. 48 sessions (PA twice per week sessions which gradually increased from 2 to 5 days) + 24 play activities at breaks + 2 sessions (workshops for teachers) + 1 session (1-h session for food store personnel) **Delivered by:** Nutritionists and health professionals (nurses and social workers previously trained), psychologists and educators and physical trainers and standardise health promoters **Overall Scope:** Multi-component intervention including a gradual decrease of the energy content of school breakfasts, a gradual regulation of food offered within the school, gradual adherence to the PA intervention and implementing an educational campaign	☐	☐	☐	☐	The probability of having obesity at the end of the intervention decreased in the intervention group while it increases in the control group. Thus, the intervention had a small but significant effect on reducing the probability of shifting from the overweight to the obesity category after six months of intervention. In addition, this study also documented a decreasing effect on the shift from the normal to the overweight categories during six months of intervention

Table 1 (continued)

STUDY ID Study design	**Setting characteristics** (City or Town, Federal State, Setting, Year of implementation)	**Participant's characteristics**	**Intervention's key characteristics**	**Nutritional component**	**PA component**	**Behavioural component**	**Environmental changes**	**Weight reported outcomes**
Vega et al. (2019) Controlled trial	Mexico City (Mexico City) 16 secondary schools Year of implementation NR	**Total initial sample:** 2368 **Female (%):** 49.7 **Mean (SD) age:** 12.1 (0.5) years **Baseline prevalence of OW + OB (%):** 39.1	**Duration:** 3 school years **Follow-up period:** NR **Intensity and Frequency:** NR **Delivered by:** School doctors, science, and physical education teachers **Overall Scope:** Educational intervention on Food orientation was provided to students and parents using educational materials	☐	NR	☐	NR	After the intervention, the prevalence of obesity decreased significantly in the intervention group
Vilchis-Gil et al. (2016) Controlled trial	Mexico City (Mexico City) Four elementary schools (two public and two private) from a middle SES area 2013–2014 (Vilchis-Gil et al. 2018)	**Total initial sample:** 407 **Female (%):** 46.9 **Mean (SD) age:** 8 (1.2) years **Baseline prevalence of OW + OB (%):** 49.2	Educational intervention for parents and children, including sessions to promote healthy eating habits and exercise. A website and text messages to reinforce the information were sent to parents' mobile phones, reinforcing the information. Also, workshops and visits to museums were part of the intervention	☐	☐	☐	NR	After the intervention, the intervention group decreased the BMI z-score, while the control group increased it
Zacarias et al. (2019) Cohort (one group before and after)	Montenegro (Queretaro) Low SES community 2016–2018	**Total initial sample:** 57 **Female (%):** NR **Mean (SD) age:** 8.1 (1.5) years **Baseline prevalence of OW + OB (%):** 69	**Duration:** 6 months **Follow-up period:** NR **Intensity and Frequency:** 6 sessions (1 monthly 90 min-session) **Delivered by:** Nutritionist **Overall Scope:** Intervention to improve the mother's knowledge and skills necessary to change children's food behaviour positively	☐	NR	☐	NR	After the intervention, children significantly reduced BMI z-score and waist circumference-height ratio

SD standard deviation; *OW* overweight; *OB* obesity; *SES* socioeconomic status; *min* minutes; *hr* hours; *PA* physical activity; *US* United States of America; *NR* not reported. ☐ = Component included × = Component not included. Intensity and Frequency were estimated from the reported data

Fig. 2 Map from the origin of the included interventions

or dietary component. Some studies (17; 58.6%) included a PA component, and less (13; 44.8%) included behavioural or physiological components. Few studies (6; 20.7%) considered environmental or setting changes (e.g., modifications to the school food stores or improving the school's infrastructure) (Table 1). Only Costa-Urrutia et al. (2019), Safdie et al. (2013a, b) and Levy et al. (2012a, b) included all the components considered in this review (i.e. considered in the studies a nutritional, PA, behavioural and an environmental change). The studies' duration varied, ranging from 2 days to 3 school years. The frequency and intensity of the interventions (calculated from the reported data) also varied from 2 to 200 sessions with different intensities (Table 1). Further details on the components and characteristics of each study are provided in Supplementary Information 1.

Some studies (9; 31.0%) reported using a framework or theory during the intervention's design and implementation: Bacardí-Gascon and Jiménez-Cruz (2012) used Bronfenbrenner's Ecological Model; Gatica-Domínguez et al. (2019) used the Booth's Eco-social Model; Safdie et al. (2013a, b) used the Ecological Principles summed to a Theory of Planned Behaviour, Social Cognitive Theory, and a Health Belief Model; Zacarías et al. (2019) used the Theory-Informed Model, Social Cognitive Theory and Interpersonal Models; Martínez-Andrade et al. (2014) used the Chronic Care Model with Family-Centred Approach; Rodriguez-Ventura et al. (2018) used the Sociocultural and Precede-Proceed Models; Arroyo and Carrete (2018) used the Protection Motivation Theory; and Mejia et al. (2016) used the Psycho-Pedagogical Theory (including Social Cognitive Theory and Positive Psychology). Macias et al. (2014) reported using a "theory to change habits," but no further detail was provided. Also, some studies reported using different delivery techniques. For instance, Costa-Urrutia et al. (2019), Saucedo-Molina et al. (2018) and Levy et al. (2012a, b) used participatory actions to deliver the activities or other psychoeducational strategies, such as peer-learning or empowerment, triggering technique and experience-based technique.

Changes in Anthropometric Outcomes

Results were heterogeneous among studies that included a control group ($n = 16$). No statistically significant ($p < 0.05$) BMI or obesity prevalence changes were reported in 4/16 of the studies across the evaluation period or between groups (Alvirde-García et al., 2013; Gatica-Domínguez et al., 2019; Martínez-Andrade et al., 2014; Ramírez-López et al., 2005). Macias et al. (2014) and Mejia et al. (2016) reported that the upward BMI trend was reversed among children with overweight/obesity in the intervention group, while the control group's upward BMI trend continued to increase. However, no statistical significance test was presented. Some studies (9/16) found a significant statistical ($p < 0.05$) change in either weight or BMI (Padilla-Raygoza et al., 2013; Ponce et al., 2016; Safdie et al., 2013a, b; Vilchis-Gil et al., 2016) or obesity prevalence (Bacardí-Gascon & Jiménez-Cruz, 2012; Perez-Morales et al., 2011; Radilla-Vazquez et al., 2019; Levy et al., 2012a, b; Vega et al., 2019) across the evaluation period and between groups. Benitez-Guerrero et al. (2016) reported only BMI effects among girls from the intervention group, but not in boys or the control group. Salazar-Vazquez et al. (2016) reported statistically significant ($p < 0.05$) BMI changes only in those participants from the intervention group that adhere to the intervention.

Results were also heterogeneous among cohort studies ($n = 13$). No statistically significant BMI or obesity prevalence changes were reported in 6/13 of the studies (Arroyo &

Carrete, 2018; Cruz-Bello et al., 2019; Elizondo-Montemayor et al., 2014; Perichart-Perera et al., 2008; Polo-Oteyza et al., 2017; Vazquez et al., 2017). But some studies (5/13) reported significant reductions in BMI (Rodriguez-Ventura et al., 2018; Saucedo-Molina et al., 2018; Zacarias et al., 2019) or obesity prevalence (Balas-Nakash et al., 2010; Rios-Cortazar et al., 2013). Caballero-Garcia et al. (2017) was the only multi-site study (carried out in four different states of Mexico) and found that anthropometric changes varied depending on the site. Also, Costa-Urrutia et al. (2019) found that BMI decreased significantly depending on participants' baseline nutritional status and ethnicity.

Heterogeneity and inconsistency of results were also present when considering the different life stages. Weight-related outcomes did not differ or were evident in preschool children, school-aged children, or adolescents.

Dietary Outcomes

Among the studies with a control group ($n = 16$), only nine measured dietary outcomes. Tools to measure dietary outcomes varied across studies, and not all were validated (Supplementary Information 2). In these studies, some dietary improvements were reported compared to the controls. For instance, some reported were fewer calories consumption (Alvirde-Garcia et al., 2013; Padilla-Raygoza et al., 2013), better-eating patterns (Ponce et al., 2016; Safdie et al., 2013a, b), increase in daily dairy consumption (Radilla-Vazquez et al., 2019) or reduce carbohydrates consumption (Alvirde-Garcia et al., 2013; Levy et al., 2012a, b) at the end of the study. Vega et al. (2019) reported a significant ($p < 0.05$) increase in fruit and vegetable consumption among the intervention group. However, this result varied according to their baseline nutritional status. Bacardi-Gascon and Jiménez-Cruz (2012) reported an increased vegetable intake and decreased consumption of snacks containing fat and salt among the intervention group. Still, there was also a significant increase in sugar-sweetened beverages consumption among the intervention group compared with the control. Martinez-Andrade et al. (2014) found at three months a significant increase ($p < 0.05$) in vegetable consumption, significant reductions ($p < 0.05$) in sweet snacks and sugar added to drinks in the intervention group. However, intervention effects were attenuated at six months.

Among cohort studies ($n = 13$), only 3/13 (23%) studies measured dietary outcomes. Overall, significant improvements in dietary lifestyles were reported in these studies. Rodriguez-Ventura et al. (2018) reported that the frequency of unhealthy dietary patterns decreased, but only some (e.g., eating more fruits and vegetables and breakfast consumption) were significant ($p < 0.05$). Elizondo-Montemayor et al. (2014) and Cruz-Bello et al. (2019) reported some significant ($p < 0.05$) dietary improvements (e.g., increase in the reported consumption of fruits and vegetables and decrease in soft drinks consumption). However, these studies also reported a decrease in the consumption of milk and water.

Physical Activity and Sedentary Behaviours Outcomes

Among the studies with a control group ($n = 16$), only 5/16 (31.2%) measured PA or sedentary outcomes. Tools to measure dietary outcomes varied across studies, and not all were reported as validated (Supplementary Information 2). Some studies reported statistically significant ($p < 0.05$) improvements compared to the controls, including a decrease in TV engagement (hr/day), sitting (hr/day), and an increased PA practice (Bacardi-Gascon & Jiménez-Cruz 2012; Gatica-Dominguez et al., 2019; Macias et al., 2014). Levy et al., (2012a, b) reported more children to be active compared to controls. However, this was not reported as statistically significant ($p > 0.05$). Safdie et al. (2013a, b) reported that PA's increase among intervention groups (two different studies provided) vs control group was not significant. However, the step count was higher in one of the intervention groups than the other intervention and control groups.

Among cohort studies ($n = 13$), only 4/13 (30.7%) measured PA or sedentary outcomes. Rodriguez-Ventura et al. (2018) reported only a statistically significant ($p < 0.05$) decrease in the time spent watching TV. Saucedo-Molina et al. (2018) reported a statistically significant ($p < 0.05$) increase in PA in the total sample. However, such an increase was higher among boys. Elizondo-Montemayor et al. (2014) reported no significant change in self-reported PA practice. Balas-Nakash et al. (2010), which implemented two different PA routines in two separate groups, reported that one group (routine B) registered higher PA levels; however, this result was not sustained six months follow-up.

Quality and Risk of Bias Appraisal

Only five (17.2%) of the studies had an overall strong quality, 12 (41.3%) a moderate quality, and 12 (41.3%) a poor quality (Table 2). Overall, 16 (55.2%) studies had a control group, and the study design was considered more robust than those without a control group. However, half of the studies with a control group (8/16) were randomised, and 2/8 RCTs were presented in an abstract. All except one were published in international journals or English language from the studies with the strongest quality. In most studies (79.8%), participants were considered somewhat likely to represent the target population. Some studies (44.8%) identified and controlled some analysis for relevant confounders. Because of the studies' nature, in most of the studies blinding was

Table 2 Quality assessment and risk of bias of included studies

STUDY ID	SELECTION BIAS	STUDY DESIGN	CONFOUNDERS	BLINDING	DATA COLLECTION METHODS	WITHDRAWALS AND DROP-OUTS	OVERALL RATING	Funding	COI
Alvirde-Garcia et al. (2013)	Moderate	Strong	Strong	Moderate	Strong	Weak	**MODERATE**	Funded by public national hospital and Metabolic Syndrome Institute	NR
Arroyo and Carrete (2018)	Moderate	Moderate	Weak	Moderate	Moderate	Weak	**WEAK**	No funding obtained	NR
Bacardi-Gascon and Jiménez-Cruz (2012)	Moderate	Strong	Weak	Moderate	Moderate	Strong	**MODERATE**	Funded by a public university	NR
Balas-Nakash et al. (2010)	Weak	Moderate	Strong	Moderate	Strong	Moderate	**MODERATE**	NR	Nothing to declare
Benitez-Guerrero et al. (2016)	Moderate	Strong	Weak	Moderate	Strong	Weak	**WEAK**	Funded by a public university	NR
Caballero-Garcia et al. (2017)	Moderate	Moderate	Strong	Moderate	Moderate	Weak	**MODERATE**	NR	NR
Costa-Urrutia et al. (2019)	Moderate	Moderate	Strong	Moderate	Strong	Weak	**MODERATE**	Funded by a local authority	Nothing to declare
Cruz-Bello et al. (2019)	Weak	Moderate	Weak	Moderate	Moderate	Weak	**WEAK**	NR	NR
Elizondo-Montemayor et al. (2014)	Weak	Moderate	Weak	Moderate	Moderate	Weak	**WEAK**	Funded by a private university	NR
Gatica-Dominguez et al. (2019)	Moderate	Strong	Weak	Moderate	Strong	Weak	**WEAK**	Funded by food industry (*Tresmontes lucchetti Mexico*)	NR
Macias et al. (2014) (Abstract)	Weak	Strong	Weak	Moderate	Moderate	Weak	**WEAK**	NR	NR
Martinez-Andrade et al. (2014)	Strong	Strong	Strong	Strong	Moderate	Moderate	**STRONG**	Funded by a public hospital	Nothing to declare
Mejia et al. (2016) (Abstract)	Weak	Strong	Weak	Moderate	Moderate	Weak	**WEAK**	Local health authorities	NR
Padilla-Raygoza et al. (2013)	Moderate	Strong	Moderate	Moderate	Moderate	Weak	**MODERATE**	National Ministry of Education	Nothing to declare
Perichart-Perera et al. (2008)	Moderate	Moderate	Strong	Moderate	Strong	Weak	**MODERATE**	Funded by food industry (*PepsiCo*)	NR
Polo-Oteyza et al. (2017)	Moderate	Moderate	Strong	Moderate	Strong	Weak	**MODERATE**	Funded by food industry (*Nestle*) and National public University	NR
Ponce et al. (2016)	Moderate	Strong	Weak	Moderate	Strong	Weak	**WEAK**	NR	NR
Radilla-Vazquez et al. (2019)	Moderate	Strong	Strong	Moderate	Strong	Moderate	**STRONG**	NR	NR

Table 2 (continued)

STUDY ID	SELECTION BIAS	STUDY DESIGN	CONFOUNDERS	BLINDING	DATA COLLECTION METHODS	WITHDRAWALS AND DROP-OUTS	OVERALL RATING	Funding	COI
Ramirez-Lopez et al. (2005)	Moderate	Strong	Weak	Moderate	Strong	Weak	**WEAK**	Local authorities funding	NR
Rios-Cortazar et al. (2013)	Weak	Moderate	Weak	Moderate	Strong	Weak	**WEAK**	NR	Nothing to declare
Vazquez et al. (2017)	Moderate	Moderate	Weak	Moderate	Moderate	Weak	**WEAK**	NR	NR
Rodriguez-Ventura et al. (2018)	Moderate	Moderate	Weak	Moderate	Moderate	Moderate	**MODERATE**	Science Mexican Council	Nothing to declare
Safdie et al. (2013a, b)	Strong	Strong	Moderate	Moderate	Strong	Strong	**STRONG**	Supported by the Pan American Health Organization, Program of The International Life Science Institute, Science Mexican Council, Health Ministry, and global health Research Initiative	Nothing to declare
Salazar-Vazquez et al. (2016)	Moderate	Strong	Strong	Moderate	Strong	Weak	**MODERATE**	National Funds	Nothing to declare
Saucedo-Molina et al. (2018)	Moderate	Moderate	Weak	Moderate	Strong	Weak	**WEAK**	Funded by two private foundations	NR
Levy et al. (2012a, b)	Strong	Strong	Strong	Strong	Strong	Strong	**STRONG**	Local authorities	Nothing to declare
Vega et al. (2019)	Moderate	Strong	Strong	Moderate	Strong	Weak	**MODERATE**	NR	NR
Vilchis-Gil et al. (2016)	Moderate	Strong	Strong	Moderate	Strong	Strong	**STRONG**	Public Paediatric Hospital	Nothing to declare
Zacarias et al. (2019)	Moderate	Moderate	Weak	Moderate	Strong	Strong	**MODERATE**	Science Mexican Council and public university	Nothing to declare

NR not reported, *COI* conflict of interest

not described or considered. However, two (6.8%) RCTs by Martinez-Andrade et al. (2014) and Levy et al. (2012a, b) described blinding as part of their methods. Data collection for anthropometric measurements did not raise any quality uncertainties since all the studies collected data according to international protocols. However, lifestyles outcome collection was very heterogeneous across studies. For instance, only 12 studies measured dietary lifestyles, and less than half of these were reported using validated tools (Supplementary Information 2). For studies measuring PA or sedentary lifestyles ($n=9$), only six reported using validated tools, with only one specifically validated in Mexican children. Most studies (20; 68.9%) had follow-up rates of less than 60%. Only five studies (17.2%) reported a follow-up rate of over 80%. Very few studies (4; 13.0%) reported using intention-to-treat in the analysis of their data. For details on each publication risk of bias assessment, see Table 2.

Concerning the studies' funding, nine (31.0%) did not report any funding, and only one (Arroyo et al., 2018) reported not receiving any funding for the study. Three studies (10.3%, Gatica-Dominguez et al., 2019; Perichart-Perera et al., 2008; Polo-Oteyza et al., 2017) reported receiving funding from the food industry, three more (10.3%; Costa-Urrutia et al., 2019; Ramirez-Lopez et al., 2005; Levy et al., 2012a, b) reported using funds from local authorities. Five studies (17.2%; Mejia et al., 2016; Padilla-Raygoza et al., 2013; Rodriguez-Ventura et al., 2018; Salazar-Vazquez et al., 2016; Zacarias et al., 2019) reported using public national funding, and five more (Alvirde-Garcia et al., 2013; Bacardi-Gascon & Jiménez-Cruz 2012; Benitez-Guerrero et al., 2016; Martinez-Andrade et al., 2014; Vilchis-Gil et al., 2016) received funding from public institutions (e.g., public hospitals or public universities). One study (Safdie et al., 2013a, b) reported being supported by local, national, and international organisations. Two (6.8%; Elizondo-Montemayor et al., 2014; Saucedo-Molina et al., 2018) reported receiving funding from private institutions (e.g. private universities, insurance companies' funds). The authors' conflict of interest was not reported in 18 studies (62.0%) (Table 2).

Discussion

This work systematically reviewed interventions to prevent obesity among children and adolescents in Mexico. Twenty-nine studies (presented in 43 publications) with various experimental designs, characteristics, duration, and intensities were identified after conducting a deep search across 13 databases and one search engine. Most studies (26; 89.6%) included a nutritional component, 19 (65.5%) a PA component, 12 (41.0%) a behavioural or psychological component, and only six (20.7%) included environmental changes to support obesity prevention and lifestyles improvement. Only three studies (10.3%; Costa-Urrutia et al., 2019; Safdie et al., 2013a, b; Levy et al., 2012a, b) included several components. However, only one (Safdie et al., 2013a, 2013b) was implemented for over 12 months. Overall, very few studies (17.2%) were considered to have a strong quality, and weight-related outcomes are heterogeneous across studies with or without a control group or age group. Some (12/29) measured dietary behaviours, with most showing dietary improvements. Fewer (9/29) measured and showed PA or sedentary lifestyle improvements.

The results shown in this review are like those presented in a recent systematic review of school-based obesity prevention interventions in Latin America (Chavez & Nam, 2020). Some characteristics of the studies reported as effective align with previous children and adolescent's obesity prevention evidence. Long term and sustained ($\geq$ 1-school year) studies with multi-component studies seem to be more effective since single-component or short-term interventions have weaker evidence on obesity prevention (Summerbell et al., 2005). All the identified studies were delivered in a single set, with most (26; 89.6%) delivered in schools. School-based studies have been reported as effective in preventing obesity and improving lifestyles (Aceves-Martins et al., 2016b; Wang et al., 2015) However, the importance of multi-setting interventions for childhood obesity prevention and treatment has also been acknowledged (Wang et al., 2015). Only six of the included studies in this review (20.7%) reported changing the environment to reinforce healthy lifestyles and prevent obesity among participants, which has been recognised as an essential factor prevent or revert childhood obesity effectively (Cauchi et al., 2016).

Children's food choices might be influenced by observing and imitating others' behaviour, specifically parents or siblings (Mura Paroche et al., 2017). Some of the included studies in this review (12; 41.3%) reported involving other family members in the intervention activities. Few studies (9; 31.0%) were designed in the light of a model or behavioural theory. Behavioural change may happen because of alterations in variables that mediate risk factors. These mediating variables are typically considered in theories or models used to understand behaviour (Baranowski et al., 2003). Using theories or models in the design of childhood obesity prevention studies could be helpful. Understanding the environment, triggers of risk behaviours, and including close relatives in the activities might determine the effectiveness of childhood obesity prevention (Aceves-Martins et al., 2019; Loveman et al., 2015; Mura Paroche et al., 2017). The interventions' design and method might also be critical in behavioural change and health outcomes improvement. Most of the identified evidence refers to educational interventions (e.g., teaching children benefits healthy lifestyles). Knowledge at some level is a prerequisite to the intentional performance of health-related behaviours (Baranowski et al.,

2003). However, knowledge might not be enough to produce a behavioural change that prevents weight gain in the long term. For this reason, studies aiming a weight gain prevention should not be limited to educational activities.

Developing strategies to tackle childhood obesity is a complex task for different reasons: it involves several stakeholders, multiple environments need to be considered, different health risk behaviours need to be shaped, health inequalities need to be addressed, there is still an open scientific debate on the best way to address childhood obesity, and the socio-political, cultural or economic context is a critical factor that might influence the effective management of obesity (Gortmaker et al., 2015; Knai & Mckee, 2010). Nevertheless, it is noteworthy that Mexico had led to implementing different nationwide strategies to tackle obesity among the general population. For instance, a couple of years ago, Mexico introduced a 1 peso per liter tax on sugar-sweetened beverages (Colchero et al., 2017; Mostert, 2017). More recently, a front-of-pack labelling law has also been introduced (Kaufer-Horwitz et al., 2018). Additionally, in 2017, the Caribbean Public Health Agency, the Pan American Health Organisation and the Caribbean Community brought together crucial stakeholders from Mexico and Chile to develop a roadmap to prevent childhood obesity (Caballero et al., 2017). Still, effective and targeted strategies are needed urgently to avoid and revert excess weight gain among children and adolescents.

A multi-component and multidisciplinary intervention that includes dietary modifications, physical activity practice, behavioural strategies, and active youth and parental involvement might help treat childhood obesity in Mexico (Aceves-Martins, 2021a, c, 2019). Indeed, these characteristics would also benefit prevention efforts. However, prevention would usually involve complex and multifaceted health promotion efforts at a community level, which cannot be expected to produce changes in outcomes within a short time frame, especially weight outcomes. Instead, a range of effects, including attitudes and health behaviours, can be achieved (Rosen et al., 2006), affecting weight outcomes in the long term. For this reason, longer-term measurements and follow-up of participants is needed.

Retrieved evidence arises from 13 (out of 32) states. As shown in Fig. 2, most evidence comes from Mexico's south-central area. Caballero-Garcia et al. (2017) was the only multi-site study (including children from four different states of Mexico) and reported variability of the results depending on the site. For instance, BMI reduction was different across sites. The results of such a study are discussed, considering various difficulties of running a multi-state intervention in Mexico. It is unclear the reason for such disparity of interventions identified across the different country regions. However, a considerable amount of evidence (13/29) was identified in Mexico City (the capital) and the State of Mexico, two of the most densely populated areas in the country and several universities, speciality clinical centres, and research centres can be found. Efforts to identify vulnerable populations nationwide and implementation barriers among different populations are needed as a national strategy. Also, implementing long term nationwide studies that consider and include vulnerable children or adolescents from all the regions of Mexico is essential to change the upward trends in obesity prevalence.

We found some limitations and challenges while conducting this systematic review. One of the major problems faced was the inadequate and insufficient description of methods across the included studies. Also, the lack of high-quality RCTs is noticeable. Only 7/29 (24.1%) studies were RCT and only three with strong quality. There is still a debate on the best ways to evaluate and assess the effectiveness of health promotion efforts (Rosen et al., 2006). No single method can be used to answer all relevant questions on health promotion or public health challenges (Armstrong et al., 2011). However, to evaluate the effectiveness of interventions, strong quantitative methods approaches are needed. Some suggest that randomised designs are appropriate for community-based health promotion research within the obesity prevention context (Rosen et al., 2006). Overall, the heterogeneity of the included studies, in terms of study design, sample size and characteristics, approach, follow-up length, analytical approach and overall quality of evidence, was also a limitation. The variability of these factors made not possible the effectiveness of cross-study comparison (i.e., meta-analysis), which is crucial for developing, evaluating, and improving studies, policies, practice, and research (Boaz & Davies, 2019). Also, we limited this review to those studies considering weight outcomes. By using this criterion, we might have foreseen relevant efforts to change other lifestyles that might affect long term obesity prevention.

This work's strengths include being the first systematic review of intervention to prevent obesity in Mexican children and adolescents. An exhaustive search for evidence was done across 13 various databases and one search engine, performed in two languages, which helped us capture relevant publications. In addition, an extensive search for grey literature was conducted as part of the COMO project, but no relevant studies or interventions were identified. The characteristics of the included studies and quality appraisal were considered in the synthesis.

This review is part of a broader project aiming to synthesise and use data to comprehend the extent, nature, effects and costs of childhood or adolescent obesity in Mexico (Aceves-Martins, 2021a, b). Because of the rising levels of childhood and adolescent obesity, every effort should be considered an experiment. Effects must be documented and evaluated to benefit every other initiative or strategy. Such efforts need to enhance their methodological quality, include various settings, stakeholders, and target different health risk behaviours.

Conclusion

Current evidence is heterogeneous and inconclusive about the efficacy of interventions to prevent obesity in Mexican children and adolescents. Overall, health promotion and prevention efforts need methodological improvement and should consider previous experiences to build evidence-based interventions. Such interventions should not be limited to educational activities and should include different components, such as multi-settings delivery, family inclusion, and longer-term implementations. Mixed-method evaluations (including strong quantitative and qualitative approaches) and follow up of participants after the intervention could provide a deeper understanding of the effectiveness and best practices.

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Declarations

Ethics Approval and Consent to Participate Since this is a systematic review of published data, no ethical approval or consent to participate was required.

Conflict of Interest MA-M, LL-C, MG-B, and CFMG have no conflict of interest to declare. YYGG received funding from Bonafont to present in a congress in 2016 and funding from Abbott's company to write two books' chapters in 2020.

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Appendix 1. Details on the interventions included in the Systematic Review.

STUDY ID	Nutritional component	PA component	Behavioural or psychological component	Environmental changes	Other relevant components	Material Provided	Control group activities
Alvirde-Garcia 2013	Changes in school curricula modification	Organised activities during recess + reinforcement of PE classes + Extracurricular actions (i.e., exercise with the family).	NR	Changes in the school canteen to change food availability and quality	Family activities included + Teachers also received a lifestyle intervention for themselves	Five adapted textbooks (one per academic year) and three working books	Received a talk on childhood obesity, but school curriculum or activities were not changed.
Arroyo 2018	Education on healthy eating, nutrition, and its relation to comorbidities. Discussions on risk cases with a nutritionist or teacher.	NR	Auto efficacy techniques.	NR	Parents were optionally involved.	NR	NA
Bacardi-Gascon 2012	Sessions encouraging healthy eating in children, children's dietary intake were assessed, and the child's nutritional report was sent to parents at baseline and end of the intervention.	Sessions to encourage children to enrol in sports and play activities and lower the number of hrs of TV viewing.	NR	Meetings with teachers and parents improved meals and snacks offered in the school and improved PA installations and activities during and after school hrs.	NR	NR	Unclear. However, after six months, the control group started receiving the intervention.
Balas-Nakash 2010	NR	Children in routine A received 20 mins of fewer intensity activities, and routine B received 40 mins of aerobic exercises. Both routines included an initial phase with warm-up exercises, a middle-phase with aerobic exercises and an ultimate phase for relaxation, following national guidelines including (30 min).	NR	NR	NR	NR	NA
Benitez-Guerrero 2016	Education sessions were delivered, including topics on nutrition.	Education sessions were delivered, including topics on PA.	NR	NR	NR	NR	There was a difference between the programmes provided for the intervention and the control group. However, the difference is unclear from the reported data.
Caballero-Garcia 2017	Ten educational sessions were delivered on healthy eating.	NR	NR	NR	Ten educational sessions were delivered on dental health and hygiene.	NR	NA

Costa-Urrutia 2019	Workshops on healthy eating. Three meals were provided: breakfast, a snack for mid-morning playtime, and lunch at school. Diet recommendation (fat intake of 25–35%, a carbohydrate intake of 45–65% and a protein intake of 10–30%), while total calories were adjusted according to age. Beverages comprised milk in the morning and water in the rest of the servings.	PA classes comprised moderate-vigorous activity, five days/wk. PA was divided into two types: (a) in the school backyard for 60 mins, three times/wk, and (b) in the classroom for 45 min (15 min three times/day), two days/wk. Strength, resistance, velocity, coordination, stability, and cardiovascular activity were included. Also, pre-sport games were included. The complexity of circuits was adjusted (according to the school year)	Workshops on self-monitoring.	Lunch provision in school and changes in PA environment.	Parents were involved in the intervention and were offered workshops.	Book for children with the four key topics addressed in this program. In addition, parents received a report of the program and a guideline book linked to that given to children.	NA
Cruz-Bello 2018	The themes of the sessions included healthy eating, concepts and differences between nutrition and food (7 sessions); feeding habits and schedules (4 sessions); Good Eating Dish, quantity, and quality (7 sessions); healthy snacks, theory, and practice (5 sessions); calorie level and quantity (5 sessions).	The session included the importance of PA (one session) and PA (3 open classes).	Eating disorders, concepts, and risk factors sessions were delivered (4 sessions); types of eating disorders, complications, and prevention (4 sessions).	NR	NR	NR	NA
Elizondo-Montemayor 2014	Information shared through social media, such as healthy diet information. Also, some conferences were provided with healthy lifestyles information.	Information shared through social media, such as PA tips. Some conferences were also provided with healthy lifestyles information, and an open class of Zumba and cardio dance were offered (but not mandatory).	NR	NR	Social media was used to promote healthy lifestyles.	NR	NA
Gatica-Dominguez 2019	Diet components included. However, there are not described in the paper.	Activities targeted to increase awareness among PA teachers of the quality of classes in terms of time spent on moderate or vigorous activity. Active workshops were delivered for children on the benefits of practising PA playfully.	NR	NR	Workshops with parents (parents performed exercises and recreational PA) + Trained personnel accompanied the school community daily to stimulate children, parents, and teachers to	Provision of recreational materials to practice PA (Unclear from the report what type of material).	No intervention and monitoring of significant changes in the control community were delivered. Likewise, while monitoring was carried out in the schools without intervention,

		Some workshops included parents. Also, this intervention established collaborative links between local authorities and PA teachers for community sports events. There was a summer course to promote the practice of PA during the school holidays.			supervise the correct implementation + holiday and extracurricular activities.		monitor the general conditions and record any critical changes that could influence the children's PA in the control community.
Macias 2014 (abstract)	Unclear	Unclear	NR	NR	NR	NR	Traditional education group received one session/wk.
Martinez-Andrade 2014	Educational sessions for parents and children on healthy dietary behaviours were delivered. In addition, socialising and building group rapport through activities like preparation and consumption of healthy foods on-site were offered.	Educational sessions for parents and children on PA were delivered. The nurse provided childcare and developed relevant games and activities for children while parents attended the workshops.	Educational sessions employed motivational interviewing and reflexive listening techniques to enhance self-efficacy.	NR	Parents and siblings were included in the intervention.	Illustrated manual and recipe book for parents, and a children's card game "memory" with pictures of foods were provided. In addition, transportation costs were reimbursed to participants.	The usual standard of care clinical practice guide within clinic guidelines, children, may be referred to a nutritionist if the physician considers it appropriate (but is not mandatory).
Mejia 2017 (Abstract)	Nutrition education was delivered (no further detail was provided).	Daily PA practice was delivered (no further detail was provided).	NR	Lunch provision in school.	Intervention targeting teachers and parents.	NR	Children in the control group had no intervention.
Padilla-Raygoza 2013	Teaching selection of healthy food and preparation of meals to the mother of the children was delivered.	30 mins of walk in the school from Monday to Friday was performed.	NR	NR	NR	NR	NR
Perichart-Perera 2007	Teachers provided food orientation and PA messages to all schoolchildren during their school hrs (min 30 mins/wk) to promote a correct energy balance.	A 20-minute exercise routine was designed, following the national guidelines. The routine included a warm-up phase (3-5 mins), a flexibility, strength, and balance phase (5-10 mins) and a relaxation phase (six mins). This routine was compulsory for all schoolchildren who attended schools before the morning start + Teachers provided food orientation and PA messages to all	NR	NR	NR	NR	NA

		schoolchildren during their school hrs (min 30 mins/wk) to promote a correct energy balance.					
Polo-Oteyza 2017	No	Teachers were trained. Activities allowed free exchange between peers and teachers. Two or three days per wk, brisk walking was substituted with play and games.	NR	NR	No attempt to modify other factors, such as diet or extracurricular activities, was made.	NR	NA
Ponce-y-Ponce-de-Leon 2016	Educational sessions included healthy diet sessions, healthy eating, and its relationship with a healthier life. Sessions briefly explained the topic to be discussed. With active individual and team participation, knowledge was built through various dynamics, finally getting the individual preparation of a healthy menu.	NR	NR	NR	NR	NR	NR
Radilla-Vazquez 2019	Nutritional orientation was given with multidisciplinary work and training of teachers and school doctors.	Unclear	Unclear. There was a psychology practitioner involved, and the intervention was multidisciplinary.	NR	Parents and teachers (School doctors, science, and physical education teachers) were trained.	Twenty-four printed comics were as educational materials.	Digital materials were used, 24 comics were available online. Also, nutritional counselling was given without multidisciplinary work.
Ramirez-Lopez 2005	Provision of breakfast from a governmental programme.	NR	NR	NR	Breakfast provision.	NR	No breakfast was provided.
Rios-Cortazar 2013	Collective production of children's stories, later reflected in a monthly school newspaper, collects, and reflects the experiences related to their diet, health, and nutrition.	Collective production of children's stories, later reflected in a monthly school newspaper, collects, and reflects the experiences related to their PA.	NR	NR	NR	The newspaper was created with views of children.	NA
Rivera-Vazquez 2016	The educational session, including a poster and delivery of diptychs using the active method, was delivered, allowing the understanding, debate,	NR	NR	NR	NR	Printed material with healthy lifestyles was provided.	NA

	and conclusions healthy lifestyle.						
Rodriguez-Ventura 2018	Workshops included guidance on food groups, portion sizes of each food group using replica models, healthy and unhealthy combinations of food groups, examples of healthy menus and meal plan explanations. In addition, all the participants received personalised dietary plans designed by a nutritionist.	All the patients received a pedometer and complimentary messages on healthy lifestyles during the workshops.	Strategies to improve lifestyle habits organising schedules, awareness, working as a family and empowering their individual decisions.	NR	Family active participation.	NR	NR
Safdie 2013	The nutrition intervention aimed to improve the prevailing food environment by increasing the availability of healthy food (fruits, vegetables, and non-fried dishes) and beverages (particularly water) by reducing energy-dense foods and sugary drinks.	The PA intervention aimed to enhance the prevailing PA environment by increasing PA resources' availability by improving infrastructure and enhancing aesthetics. In plus schools only, specialised physical education teachers were hired to teach one additional class per wk and offer 15 to 20 mins of moderate PA four days/wk.	The social cognitive theory was used to increase student and school staff awareness of program activities and develop positive PA and healthy eating attitudes at school planned behaviour.	Only the plus programme. The plus program implemented all the components incorporated in the primary program and included additional financial investment and human resources.	NR	NR	NR
Salazar-Vazquez 2016	Intervention not targeted to change dietary patterns. However, participants and parents were shown the weight by age, also promoted home-cooked meals. Recommendations such as: possibly avoiding sugary drinks; do not talk and eat at the same time; no repeated portions; no overfilling; no eating or snacking between meals; and no eating of the table was given.	NR	Behavioural counselling (specific to the eating process) Additional recommendations are given eat slowly, using the hourglass as a guideline.	NR	Participants were also instructed on the use of the 30-s hourglass to pace bites during meals. They received a guide with recommendations on how to follow the programme.	30-s hourglass.	The control group did not receive any instructions. The control group and their parents were fully informed of the programme on purpose and agreed to be measured according to the programme's schedule, at which time they received heath advice.

Saucedo-Molina 2018	Educational sessions and activities on healthy eating were delivered.	Four sessions included enjoyable PA. This hr of PA took place inside or outside the classroom, depending on the weather.	Critique session and discuss the body ideals promoted through advertising. Students were also invited to write a letter to dissuade a friend or family member who engages in certain risky behaviours.	NR	NR	NR	NR
Shamah-Levy 2012	Campaign to promote consuming one fruit and one vegetable, drinking pure water was implemented. There were nutrition workshops with recreational activities to handpick healthy foods. Parents received a recipe calendar with healthy recipes for school lunches.	A campaign to promote PA was implemented. There were PA workshops with recreational activities for children to gain knowledge and skills. Teaching resources were included. Parents received a recipe calendar with PA activities. There were organised activities involving motion games during the break (once per wk). Educational materials were provided for these activities, including posters with suggestions for team games and activities that involved moving during 30-mins breaks.	The workshop should reinforce and expand knowledge and foster self-assessment. Teaching resources were included. There was a puppet theatre based on the theory of peer learning.	The gradual regulation of food offered within the school was introduced through Mexico's technical council. Activities to change the school environment include selling fruits, vegetables, and pure water in the school's store cooperative. Spots were broadcast three times per wk during the break using the school's audio systems, and water bottles were delivered to children and teachers to encourage water consumption. In addition, a banner was hung that read, "This school promotes healthy breaks."	Teachers, parents, and personnel from school stores also received a comprehensive intervention.	Student booklets and a facilitator's guide; a school guide; a calendar for parents, as well as videos (or printed handouts for schools with no DVD players) and audio spots. Recipe calendars for parents.	No intervention.
Vega-y-Leon 2019	Food orientation educational sessions included topics such as healthy eating.	NR	Psychoeducational workshops were delivered (no further information).	NR	Parents and teachers were involved.	Printed educational materials were provided.	No nutritional guidance was given.
Vilchis-Gil 2016	Health promotion workshops and website material on nutritional status and healthy eating were provided.	Health promotion workshops and website material on PA and sedentary lifestyles were delivered.	Health promotion workshops and website material on self-monitoring, family behaviour and integration of all the intervention messages were delivered.	NR	Parents involved + website support + text messages to parents + visit to children and parents visited the Life in Balance room of the Science Museum + after each anthropometric measurement; children were handed a letter with the results of the	A website with materials was available. The artworks for this project, such as images of children eating healthy foods, were created by the designers who considered the age of the children culture of	NR

					nutritional status and tips to maintain or improve their health.	Mexico City. A paediatric nutrition expert edited the topic. Information posters were placed in strategic locations and frequently changed within the intervention schools. Various materials were developed for the children to take home.	
Zacarias 2019	Educational sessions to mothers, including healthy habits, healthy weight for children and healthy eating, were delivered.	NR	The Social Cognitive Therapy construct used in each specific session was provided.	NR	Mother included in the activities. In addition, a financial workshop for mothers was provided.	A booklet with graphical material of the sessions and recipes considering the cultural background was provided.	NR

PA= Physical Activity, wk=week, mins= minutes, hour=hr, NA=Not Applicable, NR= Not Reported

Appendix 2. Overview of relevant outcomes

STUDY ID	Diet-related outcomes	Validation	PA or sedentary behaviours related outcomes	Validation
Alvirde-Garcia 2013 Randomised Control Trial	Decrease in calorie intake during school hours and reduced sugar and fat consumption in the intervention group compared with the control group.	Unclear	NR	NA
Arroyo 2018 Cohort (one group before and after)	At the end of the intervention, a more significant percentage of teenagers perceived themselves as self-efficient to choose their food than baseline measurements.	No	NR	NA
Bacardi-Gascon 2012 Randomised Control Trial	At the end of the study, there was a significant increase in vegetable intake and decreased fat and salty snacks. However, there was also a significant increase in the consumption of sugar-sweetened beverages.	Unclear	TV engagement (hr/day) and sitting (hr/day) decreased significantly. Physical Education (hr/wk) and supervised sports or dance (hr/wk) increased significantly.	Yes, survey validated in Chile (INTA PA questionnaire)
Balas-Nakash 2010 Cohort analytic (two groups before and after)	NR	NA	More children in routine B achieved the aerobic exercise threshold of 120 beats/min and worked at a higher %HRmax. However, after six months of intervention, all children reported the same sedentary activity levels, and no differences were observed between groups.	Yes, a questionnaire validated in the Mexican population
Benitez-Guerrero 2016 Controlled trial	NR	NA	NR	NA
Caballero-Garcia 2017 Cohort (one group before and after)	Although measured, no effect or changes in the dietary pattern were reported in the publication.	Unclear	NR	NA
Costa-Urrutia 2019 Cohort analytic (two groups before and after)	NR	NA	NR	NA
Cruz-Bello 2018 Cohort (one group before and after)	Increase of the number of meals, reported water consumption, decreased the consumption of soda or flavoured water, reported fruit and vegetable consumption, cereals, and tubers and, to a lesser extent, consumption of food of animal origin.	Unclear	NR	NA
Elizondo-Montemayor 2014 Cohort (one group before and after)	There was a significant increase in the reported consumption of fruits and vegetables. Also, there was a decrease in the reported consumption of soft drinks, chips, milk, and water.	No	No change in self-reported PA practice was stated.	No
Gatica-Dominguez 2019 Controlled trial	NR	NA	An important limitation of this study is not having the baseline measurement of physical condition before the intervention. However, most PA measures (e.g., 6 mins walking test or 50 metres speed test) are reported to be better for the intervention group than the control group at the end of the intervention.	Yes, walk test in six mins & 50-meter flat test & pedometer adapted for children.
Macias 2014 (abstract) Randomised Control Trial	NR	NA	Mins/wk of PA practice were significantly increased in the intervention group compared to the control.	Unclear

Martinez-Andrade 2014 Pilot - Randomised Control Trial	At three months, the intervention group significantly increases vegetable consumption and reductions in sweet snacks and sugar added to drinks. However, at six months, these potential intervention effects were attenuated.	Yes, the Food Frequency Questionnaire (FFQ) adapted from the FFQ that assess dietary intake among 1-4-year-olds in the 2006 Mexican National Nutrition Survey	NR	No
Mejia 2017 (Abstract) Randomised Control Trial	NR	NA	NR	NA
Padilla-Raygoza 2013 Randomised Control Trial	After four months, the intervention group reported consuming fewer calories than the control group.	NA	NR	NA
Perichart-Perera 2007 Cohort (one group before and after)	NR	NA	NR	NA
Polo-Oteyza 2017 Cohort (one group before and after)	NR	NA	NR	NA
Ponce-y-Ponce-de-Leon 2016 Controlled trial	After the intervention, the intervention group reported better and healthier eating patterns than the control group.	Yes, Krece Plus nutrition test for the population aged 4 to 14 years to identify eating habits.	NR	NA
Radilla-Vazquez 2019 Controlled trial	There was an increase in the daily consumption of dairy in adolescents in the intervention group. In the intervention group, it was found that adolescents who never consume whole milk, fresh cow cheese and plain yoghurt have a higher prevalence of obesity than adolescents who consume them daily. In addition, a positive association was observed in the consumption of skim milk with nutritional status. However, this is because, at the end of the intervention, adolescents with overweight or obesity increased their consumption of this type of dairy more, with a highly significant difference. In the control group, it was also observed that the higher the consumption of dairy products, the lower the percentage of obesity.	Yes, 24-hour food recall and a frequency of food consumption questionnaire.	NR	NA
Ramirez-Lopez 2005 Controlled trial	NR	NA	NR	NA
Rios-Cortazar 2013 Cohort (one group before and after)	NR	NA	NR	NA
Rivera-Vazquez 2016 Cohort (one group before and after)	NR	NA	NR	NA
Rodriguez-Ventura 2018 Pilot - Cohort (one group before and after)	The frequency of unhealthy dietary habits decreased, but only some (e.g., eating more fruits and vegetables and breakfast consumption) were significant. Calorie's consumption was reported to be significantly lower at the end of the intervention.	Yes, 24-hour food recall and a frequency of food consumption questionnaire.	Reported time on watching TV was the only lifestyle that significantly was reduced.	Unclear

Safdie 2013 Randomised Control Trial	There were significant changes in the distribution of food available among the three categories of food over the two years of intervention characterised by an increase in the percentage of the highly recommended food and reduced the percentage of non-recommended food items in both interventions to control schools. In addition, potable drinking water was available to some of the intervention's schools by the end of the intervention. Overall, the children's food intake changes were notable across most of the assessments, but not all were significant.	Yes, food inventories.	Changes in moderate to vigorous PA in children during physical education classes and recess were not significant. Steps taken increased significantly only in the primary intervention group; however, the plus group showed an increasing tendency but was not significant, and the control group decreased the steps count.	Yes, SOFIT (System for Observing Fitness Instruction Time) + pedometer.
Salazar-Vazquez 2016 Controlled trial	NR	NA	NR	
Saucedo-Molina 2018 Pilot - Cohort (one group before and after)	NR	NA	There was a significant increase in PA in the total sample, which was higher in boys.	Yes, the International PA Questionnaire (IPAQ) using the version validated in Mexico.
Shamah-Levy 2012 Randomised Control Trial	The intervention group showed a lower risk of overweight associated with the combined interaction effect of the intervention and carbohydrates' consumption.	Yes, Food Frequency Questionnaire.	More children were active in the intervention group than in the control group; however, this was not significant.	Yes, the Youth activity questionnaire.
Vega-y-Leon 201 Controlled trial	After the intervention, there was a significant increase in fruit and vegetable consumption. However, this result varied on nutritional status.	Yes, the Food Frequency Questionnaire	NR	NA
Vilchis-Gil 2016 Controlled trial	NR	NA	NR	NA
Zacarias 2019 Cohort (one group before and after)	NR	Yes, Food Frequency Questionnaire.	NR	Yes, PA frequency.

NR=Not Reported, NA= Not applicable, min=minutes, hr=hours, PA=physical activity, BMI= Body Mass Index