The impact of greater consumption of unhealthy foods and beverages in children under 10 years on risk of malnutrition and diet-related non-communicable diseases: a systematic review and meta-analysis

FINAL REPORT

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Abstract

Background: Global shifts in diets have led to increased consumption of unhealthy foods and beverages among children worldwide. Infant and young child feeding guidelines therefore need to consider the impact of unhealthy as well as healthy food consumption on multiple forms of malnutrition including overweight and obesity, undernutrition and micronutrient deficiencies.

Objectives: To assess the impact of consumption of unhealthy foods and beverages on risk of critical and important outcomes relating to malnutrition and diet-related non-communicable diseases (NCDs).

Methods: We searched PubMed (Medline), Cochrane CENTRAL and Embase. Eligibility criteria were articles published from January 1971 onwards with no restriction on language or country setting. We included randomized controlled trials (RCTs); non-RCTs; prospective cohort studies; retrospective cohort studies and pre/post studies with a control. Participants were children aged 0 to ≤ 10.9 years at exposure. Unhealthy foods and beverages were defined using nutrient-based (i.e. those high in free sugars, artificial sweeteners; saturated or trans fats, or salt) and food-based (i.e. ultra-processed foods) approaches. Critical outcomes included child growth, overweight/obesity and body composition; diet-related NCD risk; displacement of healthy foods and dietary quality/diversity. Important outcomes included food/taste preferences in later life, dental health, micronutrient deficiencies and child development. Titles and abstracts, and then full texts of eligible studies were screened by two reviewers independently. For each included study, data were extracted and risk of bias assessed. Studies were synthesized based on exposure (unhealthy food and beverage items) and critical and important outcomes, stratified by age. Meta-analyses were performed where appropriate. Narrative synthesis was performed for all other outcomes. Certainty of evidence was assessed using GRADE.

Results: 26,544 unique citations were screened from the full search. 166 articles from 119 studies were included, five studies were RCTs and the remaining were observational cohort studies. No included studies examined effects of unhealthy foods and beverages among children in low-income countries. Approximately one-fifth of included studies were conducted in middle-income country settings, the remaining studies were from high-income country populations. Of the critical outcomes: 60 studies reported on growth, body

composition and overweight/obesity; seven reported on diet-related NCD indicators; three reported on displacement of healthy foods or breastmilk and four studies reported on dietary quality and diversity. Sugar-sweetened beverages (SSBs) were the most common unhealthy exposure examined in relation to growth and overweight/obesity (n = 45 studies), followed by unhealthy foods (n = 26 studies); 100% fruit juice (n = 17 studies) and artificially sweetened beverages (ASB) (n = 7). Meta-analyses were limited by the number of studies that could be harmonized but indicated a positive association between SSB intake and change in BMI (β = 0.01, 95% confidence intervals (CI) -0.00, 0.02; n = 3 studies), although heterogeneity was substantial, and percent body fat (β = 1.86, 95% CI 0.38, 3.34; n = 3 studies), but no association with BMI z-score (β = 0.10, 95% CI -0.11, 0.31; n = 3 studies). Meta-analysis of 100% fruit juice consumption on BMI showed an estimate of β=0.01 95% CI 0.00, 0.01 (n = 3 studies). However, results of meta-analyses should be interpreted with caution given the low number of studies that could be pooled.

Grade-evidence profiles were used to assess the certainty of evidence, disaggregated by age group where there were sufficient studies. For most outcomes, risk of bias across studies was judged as very serious due to non-randomization in observational studies leading to confounding and selection bias. Inconsistency was assessed as non-serious but it was noted that interventions and comparators differed widely across studies. Indirectness and imprecision were judged as not serious. The certainty of evidence was low or very low for all critical outcomes.

Conclusions: In children ≤ 10 years, consumption of SSBs and unhealthy foods may increase BMI/BMI z-score, percent fat or odds of overweight/obesity (low to very low certainty). ASBs and 100% fruit juice consumption may make little or no difference to BMI, percent fat or overweight/obesity outcomes (low to very low certainty). Unhealthy food and beverage consumption may worsen diet-related NCD indicators (low certainty); displacement of healthy foods (low certainty) and dietary quality and diversity (low certainty). Evidence synthesis was severely limited by the different interventions and comparators across studies. The review highlights important evidence gaps due to a lack of studies purposefully designed to assess the effects of unhealthy food consumption on child malnutrition. Further, evidence is lacking from low-income countries and there is substantially less evidence for children aged under 2 years than for children aged 2 - < 10 years.

Systematic review registration number: CRD42020218109

List of abbreviations

AOR	Adjusted odds ratio
ASB	Artificially sweetened beverage
ASQ-3	Ages and Stages questionnaire, Version 3
BF	Body fat
BAZ	BMI-for-age z-score
BMI	Body mass index
CI	Confidence interval
DAT	Dietary assessment tool
DBP	Diastolic blood pressure
defs	Number of teeth decayed with manifest caries, extracted and filled surfaces
dmfs	Number of decayed, missing or filled surfaces (for primary teeth)
DMFS	Number of decayed, missing or filled surfaces (for permanent teeth)
dmft	Number of decayed, missing or filled teeth (for primary teeth)
DMFT	Number of decayed, missing or filled teeth (for permanent teeth)
DR-NCD	Diet-related non-communicable disease
DQI	Diet quality index
DQI-I	Diet quality index international
DXA	Dual-energy X-ray absorptiometry
ECC	Early childhood caries
EDNP foods	Energy-dense, nutrient poor foods
EDNR	Energy-dense, nutrient rich foods
EI	Energy intake
EPL	Energy providing liquids
FFQ	Food frequency questionnaire
FMI	Fat mass index
GRADE	Grading of Recommendations Assessment, Development and Evaluation
Hb	Hemoglobin
HDL-C	HDL cholesterol
HDAS	Healthy dietary adherence score
HEI	Healthy eating index
HIC	High income country
HOMA-IR	Homeostatic model assessment of insulin resistance
IDDS	Individual Dietary Diversity Score
IRR	Incidence rate ratio
IYCF	Infant and young child feeding
KBIT-II	Kaufman Brief Intelligence Test, second edition
LDL	LDL cholesterol
LMIC	Low-income and middle-income countries
LNS	Lipid-based nutrient supplement
MAD	Minimal acceptable diet
MDD	Minimal dietary diversity
MIC	Middle income country
MMF	Minimum meal frequency
NCD	Non-communicable disease
NMES	Non-milk extrinsic sugars
NRSI	Non-randomized studies of interventions
OR	Odds ratio
OW/OB	Overweight or obesity
PICO	Systematic review framework referring to participants (P), intervention (I), comparator (C) and outcome (O)

PPVT-III	Peabody Picture Vocabulary Test, 3rd Edition
PWV	Pulse wave velocity
RCS	Retrospective cohort study
RCT	Randomized controlled trial
RoB	Risk of bias
RoB V2	Cochrane risk of bias assessment tool (version tool) for randomized trials
ROBINS-I	Risk of Bias for non-randomized studies of the effects of interventions
RR	Relative risk
SAMF	Sugar added to milk and/or fruit
SBP	Systolic blood pressure
SDQ	Strengths and Difficulties Questionnaire
SSB	Sugar sweetened beverage
SSF	Sum of skinfolds
TAG	Triacylglycerol
TC	Total cholesterol
tHcy	Total homocysteine
WC	Waist circumference
WHtR	Waist-to-height ratio
WRAML	Wide Range Assessment of Memory and Learning
WRAVMA	Wide Range Assessment of Visual Motor Abilities
% BF	Percent body fat
% EI	Percentage of energy intake

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Introduction

Children in many countries are experiencing multiple forms of malnutrition, including undernutrition and micronutrient deficiencies as well as overweight and obesity leading to increasing disparities in health globally (1–3). The Guiding Principles for the complementary feeding of the breastfed child (4) and for the non-breastfed child (5) provide a set of indicators for assessing infant and young child feeding practices and adherence to practices. However, previous complementary feeding guidelines were concerned primarily with the prevention of undernutrition, hence updated guidelines are needed to address concerns over increasing rates of childhood overweight/obesity and the development of non-communicable diseases (NCDs)(6). This is also reflected in newly developed indicators to assess consumption of unhealthy foods among infants and young children (7).

Infants and children are consuming increasing amounts of foods with added sugars, high in salt, and high in saturated or trans fats (8,9). Commercially prepared foods are more likely to be high in energy, low in nutrients (energy-dense, nutrient-poor) and ultra-processed (10,11). Globally, the consumption of sugary and savory snacks and refined foods has been increasing across all socio-economic groups (1). These foods may have direct consequences on health, as well as indirect consequences through displacement of healthy foods in the diet (6). Consumption of foods that are energy-dense, nutrient-poor is a particular risk for malnutrition among socio-economically disadvantaged groups, such as low income, urban communities in low-income and middle-income countries (LMICs) (12).

Previous systematic reviews have examined the impact of consuming certain unhealthy foods and beverages (i.e. fatty foods, sugar-sweetened beverages (SSBs) and fruit juice drinks (not exclusively 100% juice) among infants and young children aged 6-23 months in countries ranked high or very high on the Human Development Index (13) and among older children in high-income countries (14,15). In children under 23 months, limited evidence suggested that sugar-sweetened beverage consumption was associated with increased obesity risk in children, but not with other growth, size, or body composition indicators (13). A positive association between consumption of fruit juice and infant weight-for-length and child BMI z-scores was found, but this category included fruit drinks (with sugar) rather than 100% fruit juice and the evidence was limited (13).

A systematic review of 32 studies in children, adolescents and adults concluded that SSB consumption promotes weight gain (14). All included studies were in high-income countries. The meta-analysis for children and adolescents up to 18 years showed that BMI increased by 0.06 (95% CI: 0.02, 0.10) for each additional daily serving of 12 fluid ounces (approx. 354 ml) of SSBs over a 1-y period (14). A systematic review of longitudinal studies of fruit juice consumption reported that 100% fruit juice consumption was not associated with BMI z-score increase in children aged 7 to 18 years (15). Among children ages 1 to 6 years, a 1 serving increment was associated with a 0.087 (95% confidence interval: 0.008 to 0.167) unit increase in BMI z-score which was not considered to be of clinical significance. The review of 100% fruit juice consumption highlighted the lack of evidence on effects of fruit juice consumption among children under age 7 years (15). Significant positive associations were reported between ultra-processed food intake and greater percent body fat in children and adolescents in a systematic review, but this included both cross-sectional and longitudinal study designs (16).

The effects of consumption of unhealthy foods and beverages on child growth and body composition in LMIC settings is less well documented. A cross-sectional study found unhealthy snack food and beverage consumption was associated with lower dietary adequacy and child length (9). A review of the relationship between snack food, SSB consumption and child growth and dietary adequacy in LMICs found limited and inconclusive evidence, including both cross-sectional and longitudinal study designs (12). The review highlighted that high consumption of nutrient-poor foods may contribute to undernutrition as well as risk of overweight/obesity (12).

Systematic reviews have not examined the impact of unhealthy food and beverage consumption on nutritional status for children under 10 years, and far less consideration has been given to evidence from LMIC settings. The inclusion of cross-sectional and longitudinal data in evidence syntheses increases the possibility of reverse causality (12). Hence, there is a need to review the impact of unhealthy foods and beverages in all country settings and including evidence from only prospective cohort studies or randomized controlled trials. The aim of this systematic review was to examine, among children under 10 years, the risks of greater consumption of unhealthy foods and beverages compared to low or no consumption with specific reference to malnutrition and diet-related (NCDs).

Methods

We followed the PRISMA 2020 reporting guideline (17). For data synthesis without meta-analysis we followed the SWiM guideline (18).

Protocol and registration

The study protocol for the review was registered with Prospero (Registration number CRD42020218109) and is available at https://www.crd.york.ac.uk/prospero/display_record.php?RecordID=218109

Eligibility criteria

Study eligibility was based on the inclusion and exclusion criteria in Table 1 below in relation to participants; exposures; comparators; and outcomes. Reports published from January 1971 onwards were included. No restriction on language was applied. Non-English language reports were screened by native speakers with subject-specific knowledge in nutrition or health-related studies.

Table 1: Inclusion and exclusion criteria for the systematic review

	Inclusion criteria	**Exclusion criteria**
Participants/ population	Human studies including both males and females	Non-human studies
	Age at intervention or exposure: infants from birth to ≤10.9 years	Age at intervention or exposure >10.9 years
		Studies that exclusively enroll participants with a disease or with the health outcomes of interest (listed below)
		Studies using hospitalized patients; severely malnourished participants, or clinical populations
		Studies of exclusively pre-term babies (<37 weeks gestation) or exclusively babies that are low birth weight (<2500g) or small-for-gestational age
Independent variable (intervention or exposure)	Studies reporting (greater) consumption of unhealthy foods and beverages compared to no or low consumption	Studies not reporting consumption of unhealthy foods and beverages as per the protocol definition of consumption

	Unhealthy foods defined using i. nutrient-based approaches (foods high in added sugars, free sugars, artificial sweeteners, fats (e.g. saturated/trans), salt; and food-based approaches including ii. ultra-processed foods (based on NOVA classification, excluding formula and follow-on milks) iii. unhealthy foods & beverages listed in the WHO IYCF guide (2021). iv. Food items defined by authors using terms such as 'fast-food', 'convenience foods', 'non-core foods'.	Studies reporting only dietary patterns (i.e. data reduction techniques such as Principal Component Analysis) or eating practices (e.g. meals per day; snacking patterns; meal times and duration of eating episodes)
	Consumption defined as: i. quantities consumed (g/day, week or month); ii. portion sizes; iii. frequency of consumption (per week, month, year), or consumed/non-consumed.	
Comparator	Consumption of less or no unhealthy foods and beverages: no or low added sugar, free sugars, artificial sweeteners; less fat (or less of certain types of fat), less consumption of foods high in salt or ultra-processed/energy-dense, nutrient poor foods	
Study design	Randomized controlled trials	Cross-sectional studies
	Non-randomized controlled trials (including historically controlled studies)	Trials without a control group
	Prospective cohort studies (including interrupted time series analyses)	Narrative reviews, systematic reviews and meta-analyses
	Retrospective cohort studies	Case-control studies (i.e. cases with disease (e.g. diabetes) vs controls without disease.
	Pre/post studies with a control	Pre/post studies without a control
Dependent variable (outcome)	i. Growth and body composition: stunting; length-for-age or height-for-age; underweight or weight-for-age; wasting or weight -for-length/ weight-for-height; body mass index (BMI); BMI z-score waist circumference; prevalence of overweight or obesity; percent body fat	
	ii. Indicators of diet-related non-communicable disease risk: high blood pressure; type 2 diabetes; serum lipids	

	iii. Displacement of healthy foods/breast milk intake	
	iv. Dietary quality and diversity using standard international indicators (e.g. Minimum Acceptable Diet (MAD), Minimum Dietary Diversity (MDD), Minimum Meal Frequency (MMF); Individual Dietary Diversity Score (IDDS), or Healthy Eating Index/Diet Quality Index or Diet Quality Index International (DQI-I)	
	v. Food/taste preferences later in life	
	vi. Oral health (dental caries)	
	vii. Micronutrient deficiencies (iron, zinc, vitamin A, vitamin D, vitamin B complex and vitamin C)	
	viii. Child development (motor, cognitive, social)	
Country	All contexts (High, middle and low-income countries)	NA
Date range	Articles published from 1971 onwards	Articles published before 1971
Publication status	Reports published in peer-reviewed journals	Conference abstracts, conference proceedings, unpublished data, reports, letters, editorials
Language	All languages	NA

Participants

Inclusion criteria: We included human studies including both males and females where age at intervention or exposure was between birth and ≤10.9 years of age. Our protocol stated children less than 10 years of age, but we found many studies recruited children included ages equal to 10 years (e.g. 5-10 years) or did not define exact age (i.e. whether less than or equal to 10 years). We therefore defined our inclusion criteria to up to 10.9 years to reflect the age categories commonly applied in studies and to be more inclusive of the literature.

Exclusion criteria: We excluded non-human studies; studies with age at intervention or exposure greater than 10.9 years; studies that exclusively enrolled participants with a disease or studies that recruited only participants with the disease/outcome of interest. We excluded studies using hospitalized patients (not including birth and immediate post-partum

hospitalization of healthy babies); severely malnourished participants, or clinical populations were excluded. Studies of exclusively pre-term babies (<37 weeks gestation) or only babies with low birth weight (<2500g) were excluded.

Interventions/exposures

Inclusion criteria: We included studies reporting greater consumption of unhealthy foods and beverages compared to no or low consumption. For this review, unhealthy foods and beverages were defined using both nutrient-based and food-based approaches. The list included ultra-processed foods based on the NOVA classification; unhealthy foods and beverages defined in infant and young child feeding indicators (7); foods high in free sugars, artificial sweeteners, salt, and foods high in saturated or trans fats. The criteria for defining unhealthy foods and beverages are outlined below.

As there was no single classification system or criteria for unhealthy foods that covered all relevant exposures, we used four main measures of healthiness to classify foods and beverages as unhealthy. These measures were selected based on the Terms of Reference for the review and refined through consultation with experts and the relevant literature.

The first classification used was the NOVA classification system (19) which categorizes foods and beverages based on the nature, extent and purpose of industrial processing (i.e. the physical, biological and chemical processes) that food items and beverages undergo. The NOVA classification includes four groups (20): i. unprocessed or minimally processed foods, ii. processed culinary ingredients, iii. processed foods (i.e. food manufactured with the addition of salt or sugar to unprocessed or minimally processed foods (canned foods or breads/cheeses) and iv. ultra-processed foods. Of interest to this review is the fourth category, ultra-processed foods which are listed in Table 2, category A. These products are energy-dense and characterized by high levels of free sugar, total/saturated/trans fats, sodium and low levels of protein and fibers (21,22) and are known to be harmful to human health (23). One of the limitations of this classification is that it does not account for the presence of other beneficial/positive nutrients in foods, other than fiber. Formula and follow-on milk were excluded from the NOVA classification list as the effects of type of milk feeding during the complementary feeding period was examined in a separately commissioned systematic review.

The second classification used were the unhealthy indicators from the WHO guide to assess infant and young child feeding practices (7) (see Table 2 category B), namely: i. sweet beverages (i.e. commercially produced and packaged sweetened drinks, 100% fruit juice drinks and home-made drinks with sweeteners added) and ii. sentinel unhealthy foods (i.e. sweet foods and fried/salty foods).

The third and fourth categories were based on the nutrient content of foods and beverages (See Table 2 categories C and D). The nutrients of interest were saturated and trans fats and free sugars due to their known association with diet-related NCDs. Free sugars included "all added sugars in any form; all sugars naturally present in fruit and vegetable juices, purées and pastes and similar products in which the structure has been broken down; all sugars in drinks (except for dairy-based drinks); and lactose and galactose added as ingredients (24). Sugars naturally present in "milk and dairy products, fresh and most types of processed fruit and vegetables and in cereal grains, nuts and seeds" (24) were not included in the definition of free sugars. The basis for including all the sugars in drinks in the definition is that drinks are consumed in larger quantities and have therefore the potential to provide high amounts of sugar. In addition, they are known to have a lower satiety effect in comparison to solid foods (24).

In addition to the four classifications above, we included studies in which authors used terminologies denoting unhealthy foods namely: "junk food", "fast food", "snack food", "extra food", "non-core food", and "convenience food" (see Table 2 category E). While these are not precise definitions, they were considered to meet inclusion criteria based on the likelihood of containing either ultra-processed foods; sentinel unhealthy foods; high saturated fat or high free sugars.

Besides the unhealthy food and beverage items, we were also interested in "intermediate" or "borderline" items. These food items provide both positive and negative nutrients hence are neither strictly healthy or unhealthy, and are energy dense, nutrient rich. Intermediate foods were included in the review because they may have importance in providing positive nutrients but may also contribute to obesity and diet-related NCDs. These included dairy-alternative drinks (soya, rice, oat or nut-based drinks); cheese and unprocessed red meat (e.g. beef, lamb and mutton, pork, veal, goat) (see Table 2, section II). Hence, we were interested

in examining the evidence of consumption of such foods on child growth and body composition.

The compiled list of exposures considered as unhealthy foods and beverages and intermediate foods was shared with the technical staff at WHO for expert input. After incorporating feedback, the final list of food items for inclusion in the review was then applied for screening at title and abstract stage.

We included studies reporting exposures based on food consumption as grams/day, week or month, portion sizes/day; frequency of consumption (per week/month/year). Whilst the aim was to include studies with quantitative assessment of food intakes, we also included studies reporting food and drink consumption as a dichotomous variable (consumed/not-consumed), or above and below a median or specified value of intake.

Table 2: Classification used to define foods and beverages for inclusion in the review based on i: unhealthy ii: intermediate food items

I: List of unhealthy foods and beverages
A. Unhealthy foods and beverages (ultra-processed foods) defined as per the NOVA classification system †
Sugar-sweetened beverages (sweetened fruit and vegetable juices, soft drinks, fruit and vegetable concentrates, fruit-flavored drinks, fruit and vegetable smoothies, nectars, chocolate/cocoa drinks, milk/yoghurt drinks, energy drinks, sweetened/flavored water). These refer to packaged/commercially produced drinks.
Diet or light soft drinks (with non-caloric or artificial sweeteners)
Fruit/flavored/sweetened yoghurts
Chocolate
Candies/sweets
Ice cream
Sweet packaged snacks (e.g. sweetened popcorn, caramelized nuts)
Savory packaged snacks (e.g. crisps, salted popcorn, cheese puffs)
Margarine and other spreads
Biscuits
Pastries (e.g. croissant, pain au chocolat, brioche, doughnuts)
Energy bars
Cakes
Sweetened breakfast cereals
Instant noodles
Pizza
Pies
Processed meat or reconstituted meat products (e.g. sausages, ham, hot dogs, fried/battered chicken, poultry nuggets) and fish nuggets/battered fish

B. Unhealthy foods and beverages items defined in the WHO-UNICEF sentinel unhealthy food categorization⋆ (including only those items not already listed under A)
Fried potatoes/chips
100% fruit juices (i.e. unsweetened) whether made at home, by informal food vendors or packaged in cans, bottles, boxes, sachets and other sweet beverages that are home-made and to which any kind of sweeteners (e.g. sugar, honey, syrup, flavored powders) have been added.
C. Unhealthy items defined as high in saturated fat content (including only those items not already listed under A or B)
Butter, lard, ghee
D. Unhealthy items defined as high in free sugar content‡ (including only those items not already listed under A, B or C)
Table sugar
Jam, honey, syrups
Unsweetened, 100% fruit and vegetable juices, concentrates and smoothies
E. Other included terminologies used by study authors to refer to unhealthy items
Non-core food; extra food; convenience foods; junk food; fast food; snack foods
II: List of intermediate foods and beverages (i.e. those that provide both beneficial/positive and detrimental/negative nutrients)
Other dairy-alternative drinks (soya, rice, oat or nut-based drinks)
Cheese
Red meat (e.g. beef, lamb and mutton, pork, veal, goat)

† NOVA classification based on Monteiro et al. 2010 (19).
*based on WHO and UNICEF, 2021 (7).
‡ based on Swan et al. 2018 (24).

Exclusion criteria: We excluded studies that did not report consumption of unhealthy foods and beverages and studies reporting only dietary practices (e.g. number of meals per day; snacking patterns; who participants eat with and where; meal times and duration of eating episodes).

Comparator

Inclusion criteria: The comparator for included studies was low or no reported consumption of unhealthy foods and beverages: low or no free sugars, artificial sweeteners; less fat (or less of certain types of fat) or less consumption of foods high in salt or ultra-processed foods.

Outcomes

Critical outcomes of the review were:

i. Growth, body composition, obesity and longer-term outcomes including: stunting and/or length-for-age and height-for-age; wasting and/or weight-for-height;

weight-for-age, overweight/obesity and/or body mass index (BMI), percent body fat and waist circumference.

ii. Diet-related non-communicable disease indicators (blood pressure, glucose or insulin (type 2 diabetes risk) and blood lipids).

iii. Displacement of healthy foods or breast milk intake.

iv. Dietary quality and diversity assessed by standard international indicators such as Infant and Young Child Feeding (IYCF) indicators: Minimum Acceptable Diet (MAD), Minimum Dietary Diversity (MDD), Minimum Meal Frequency (MMF); Individual Dietary Diversity Score (IDDS), or Healthy Eating Index/Diet Quality Index either individually or combined (e.g. Diet Quality Index International (DQI-I)).

Important outcomes for the review were:

v. Food or taste preferences later in life.

vi. Oral health (dental caries).

vii. Micronutrient deficiencies relating to iron, zinc, vitamin A, vitamin D, vitamin B complex and vitamin C.

viii. Child development (motor, cognitive and social development).

If studies reported important outcomes but no critical outcomes these were still included in the review.

Types of study

Inclusion criteria: We included randomized controlled trials; non-randomized controlled trials (including historically controlled studies); prospective cohort studies (including interrupted time series analyses); retrospective cohort studies and pre/post studies with a control.

Exclusion criteria: We excluded cross-sectional studies; trials without a control group; pre-post studies without a control; narrative reviews; systematic reviews; meta-analyses.

Country context

Inclusion criteria: Studies conducted in all countries were included.

Information sources

Three electronic databases were used for the systematic literature searches: PubMed (Medline), Cochrane CENTRAL and Embase. Grey literature was not included in the systematic search due to the time limit for the review and budgetary constraints.

Search strategy

A literature search strategy was developed. Scoping searches were conducted to refine the search strategy and checked by an information specialist and WHO to ensure that relevant studies had been identified with the search syntax.

The search syntax was first developed for PubMed using database-specific indexing terms and then adapted to the two other database-specific search requirements. Citation alerts were set up in PubMed to flag new potentially relevant items published during the project.

The three searches were conducted from 17th – 23rd December 2020. The search results were imported into Covidence software which was employed for screening title, abstract and full text. Supplementary searches included hand searches of the list of references of included reports and hand searches of relevant published systematic reviews as well as consultation with subject experts for relevant published studies for records that had not been identified from database searches. Supplementary searches continued until April 2021. The search strategies for each database are included in Annex A.

Study selection

Duplicate records were identified automatically by Covidence software prior to screening. Covidence has a highly conservative threshold for removal of duplicate records. 50% of the duplicates identified in Covidence were checked to ensure that they were genuine duplicates. No incorrect duplicates were identified.

All reviewers underwent training by screening the same test sample of 25 records selected at random from the records retrieved. The results of the test screening were combined and discussed across the review team to check for any discrepancies in the interpretation of inclusion and exclusion criteria. Further guidance notes were added to the inclusion and exclusion criteria based on feedback from reviewers.

The list of unhealthy foods and beverages was applied during screening. As reports were screened, we updated and revised the list of unhealthy items to consider new terms or categories employed in reports or defined by study authors, adding 'non-core foods', 'extra foods' and 'convenience foods' (Table 3).

After completion of training, study selection started. Titles and abstracts were screened by two reviewers independently. Conflicting votes went into a folder and a third reviewer voted to include or exclude articles. If the third reviewer was unsure, the relevant report was considered by a fourth reviewer and discussed with the review team. Two random samples of 10% of the excluded studies at title and abstract stage were assessed for inclusion or exclusion by a third and fourth reviewer, each reviewed a different 10% sample.

Non-English language abstracts or full texts were screened by team members fluent in the language for French, Spanish and German. Chinese full text manuscripts were screened by one of the review team members working alongside a researcher in health sciences with native Chinese language.

All records included at the full text stage were retrieved and screened by two reviewers independently. After the first 50 had been screened, the review team discussed decisions and any examples of records where the decision to include or exclude was uncertain. Further details were added to inclusion and exclusion criteria based on decisions. All subsequent conflicts were resolved via discussion between a third or fourth reviewer to reach consensus. At the full text stage two different 10% random samples of excluded full text records were independently screened by two independent reviewers.

Reasons for exclusions at full text screening were recorded based on the first criteria that was not met using the following sequence of inclusion criteria: 1. Did not meet age group of ≤ 10.9 years; 2. Did not have longitudinal study design; 3. Did not meet health status criteria of participants; 4. No relevant unhealthy food/beverage exposures reported; 5. No relevant critical or important outcomes reported; 6. Did not meet report type criteria (i.e. Conference abstract, commentary/editorial; 7. Full text not available, and 8. 'Other'. In most cases, the reason for 'Other' was when the study met inclusion criteria but did not address the review question for example, the outcome and exposure were both reported, but only in relation to the effects of a specific behavioral or lifestyle intervention such as physical activity, healthy

eating, reduced television viewing. In all these cases, the study did not analyze the outcomes for this review in relation to unhealthy food consumption/ exposures. Other examples were when the study compared the effect of two items that were both on the list of unhealthy foods (sugar-sweetened beverages compared to artificially-sweetened or 'diet' beverages). Studies where fortified and unfortified food items were compared (e.g. vitamin fortified vs unfortified orange juice, or red meat vs iron and/or zinc-fortified cereals) were excluded unless there was an analysis of the unhealthy food group compared to control group (no/low consumption of the same food item). Studies that only reported intake of foods based on nutrient composition were excluded since unhealthy foods could not be identified using these data.

Studies that met all inclusion criteria but reported data for a wider age range (e.g. 8-13 years) were included. The review team emailed study investigators to request disaggregated data for participants below age 10.9 years or the raw data (emailed 3rd March 2021 with a request to reply by 12th March 2021). A follow-up email was sent to those who had not responded (18th March 2021 with a request to respond by 26th March 2021). Some authors provided contact details for another investigator who might have access to data whom we then emailed. One study author provided the disaggregated data for children <10.9 years (25). The remaining nine authors who responded to data requests stated that they were unable to provide original data, usually because the datafile was no longer accessible.

Data collection process and data items

A data extraction form was developed in Excel and piloted by all data extractors using a selection of six included articles covering different review outcomes. Following the first pilot, the form was modified and a second pilot data extraction was carried out with all reviewers extracting data from a single article and comparing notes. After further modification, the data extraction form was finalized. Data extracted from studies included: i. general information (study ID, title, authors, start and end date, study location (country, urban vs. rural), study design, study aim, aim of intervention (if applicable), study funding sources, conflicts of interest, ethical approval reported) and ii. study eligibility (participant selection and randomization process, sample size, participant characteristics (age, number of males and females), duration of intervention, exposure measures (food consumption data and dietary assessment methods used to collect dietary data) and critical and important review outcomes (details below), and the method of assessment of outcomes. Study protocols and

supplementary materials were searched for data extraction if the required data were not presented in the included reports of studies. Four articles were in Chinese language (26–29). For these reports, data extraction and risk of bias were conducted with one review team member working alongside a researcher with native Chinese language and expertise in health sciences.

One reviewer undertook data extraction for each report working independently. Any data extraction queries were discussed among the team. A second reviewer checked 50% of all records extracted for completeness and accuracy.

Data were extracted on all critical and important outcomes specified in the review protocol. If studies reported only important outcomes these were still included. We extracted data for baseline and follow up periods for all studies. Where multiple follow-up assessments were reported we extracted these data.

We recorded the variables that were adjusted for in analyses, such as education; socioeconomic status; sex; maternal age; race and/or ethnicity; other feeding practices (breast milk, infant formula, or both); birth size. These were taken into consideration as part of the risk of bias assessment for non-randomized studies of interventions (NRSI).

Food consumption data were extracted as the quantity consumed (e.g. g/day, g/week or g/month). We recorded methods of dietary assessment and the categories used to define high, low or other categories of exposure (e.g. tertiles or quartiles of intake). Frequency of consumption data were extracted in the format presented in studies, in some studies this was a continuous variable, in others it was categorical (dichotomous or multiple categories).

For studies reporting growth, body composition, overweight/obesity and diet-related non-communicable diseases we extracted data on all ages of follow up with no upper limit on age in order to assess longer term outcomes. We recorded methods of assessment for all outcome indicators. Where data were presented as z-scores or percentiles for BMI or other anthropometric indicators we recorded the growth reference or standard used.

Data were extracted from all the reports of a single study if they presented unique data, different outcomes or different exposures in order to cover all information comprehensively.

If two reports presented the same outcomes and exposures, we extracted data from the report that most directly addressed the systematic review question to avoid duplicate data.

Risk of bias assessment in individual studies

Risk of bias was assessed by two reviewers independently within the Covidence software which ensured blinding of the independent reviewers. Reviewers noted justifications for any domains that were assessed as serious, critical or no information against the rating. Assessments were made on the included reports of studies. Information was extracted from study protocols, clinical trial registers and supplementary files if not presented in the included reports. The two reviewers compared ratings, discussed discrepancies and reached consensus on each domain of the quality assessment tool. If agreement could not be reached, a third reviewer assessed risk of bias and a consensus was reached. Risk of bias was conducted at the outcome level.

Risk of Bias for non-randomized studies of the effects of interventions (prospective cohort studies)

The ROBINS-I tool was applied for non-randomized studies of interventions (NRSI) (30,31). Based on Cochrane and Grade definitions, observational studies are considered as non-randomized studies of interventions, hence ROBINS-I was selected as the most appropriate tool. ROBINS-I assesses seven domains: (1) bias due to confounding; (2) bias due to selection of study participants; (3) bias in classification of interventions; (4) bias due to deviations from intended interventions; (5) bias due to missing data; (6) bias in measurement of outcomes and (7) bias in selection of the reported result. For observational studies, ROBINS-I is conducted by comparing the study being assessed to a well-designed randomized controlled trial, even if such a trial is not ethically or logistically feasible in practice (32). Each domain in the risk of bias tool was given a rating of low, moderate, serious or critical risk of bias, or no information. We followed the signaling questions provided in the detailed guidance notes for each domain and also defined the major confounding variables to be considered for the intervention (i.e. exposure to (consumption of) unhealthy foods and beverages) under consideration in included studies (Domain 1) (30). We considered that all studies would be subject to some confounding in relation to the consumption of unhealthy foods and beverages (30). Following the detailed guidance, a study that controlled for all important confounding variables was judged as moderate risk of bias. Important confounding variables were baseline status for the outcome of interest

(anthropometric, NCD, dental, other); age, sex, socio-economic status and maternal/parental education. After completing consensus on the seven domains in the tool, the overall risk of bias for each study was assessed using the criteria in Table 3 (30).

Table 3: Overall risk of bias criteria for non-randomized studies of interventions

Overall risk of bias assessment for ROBINS-I*	**Criteria**
Low	Study is judged to be at low risk of bias for all domains
Moderate	Study is judged to be a low or moderate risk of bias for all domains
Serious	Study is judged to be a serious risk of bias in at least one domain-but not at critical risk of bias in any domain
Critical	The study is judged to be at critical risk of bias in at least one domain
No information	No indication that the study is a serious or critical risk of bias *and* there is a lack of information in one or more key domains of bias

* From Sterne et al 2016 (30)

Risk of Bias for Randomized Controlled Trials

Cochrane Risk of Bias (Version 2) (RoB 2.0) was used for randomized controlled trials (31,33). RoB 2.0 addresses five specific domains: (1) bias arising from the randomization process; (2) bias due to deviations from intended interventions; (3) bias due to missing outcome data; (4) bias in measurement of the outcome; and (5) bias in selection of the reported result. Each of the five domains was rated as low, some concerns, or high risk of bias, or no information independently by two reviewers. Supporting information and justifications for judgements in each domain were recorded. After reaching consensus on the five domains, the overall risk of bias was assessed using Cochrane guidance presented in Table 4 (31).

Table 4: Overall risk of bias criteria for randomized controlled trials

Overall risk-of-bias judgement*	**Criteria**
Low risk of bias	The trial is judged to be at low risk of bias for all domains for this result.

Some concerns	The trial is judged to raise some concerns in at least one domain for this result, but not to be at high risk of bias for any domain.
High risk of bias	The trial is judged to be at high risk of bias in at least one domain for this result. Or The trial is judged to have some concerns for multiple domains in a way that substantially lowers confidence in the result.
No information	Lack of information in one or more domains or no clear evidence of serious/critical risk of bias.

*From Higgins et al., 2019 (31) .

Some studies undertook a secondary analysis of data from a previous RCT to address a research question unrelated to the original trial (34–39). The trials had either reported no significant effects of the intervention from the original RCT and therefore pooled the intervention and control group whilst controlling for intervention arm or assessed the control group only. For these studies we assessed as NRSIs and applied the ROBINS-I tool since the study design was no longer a randomized controlled-trial. Risk of bias tables for individual studies and summary risk of bias tables for critical and important outcomes were produced using the R package 'robvis' (40).

Effect measures

We extracted the measures of intervention effect (odds ratio (ORs), beta coefficients, relative risks or general linear models with 95% confidence intervals or p value) for all studies providing data on the effect of exposure on the outcome of interest. We extracted data from fully adjusted models where available. If unadjusted effect measures only were reported, these were extracted. Unadjusted estimates were included without recalculations due to constraints on time and resources for the review. Prospective cohort studies most commonly reported ORs for categorical or dichotomous outcomes and beta coefficients for continuous outcomes. Included studies that were RCTs were more likely to present mean differences for intervention versus control groups.

Synthesis methods

We synthesized findings using the PICO framework, first grouping studies by outcome (four critical outcomes follow four important outcomes) and then by intervention/exposure. For

synthesis relating to participant characteristics, we stratified by age when there was a sufficient number of studies available. The following age groups were used in synthesis: 0 to < 2 years; 2 to <5 years and 5 to ≤10.9 years.

For each outcome, we tabulated measures of effect based on the availability and type of data. For completeness, we included all estimates in summary tables of results, including studies with critical risk of bias. In narrative synthesis, however, we did not report results from studies assessed as critical risk of bias in line with guidance (18,30).

Synthesis of growth, body composition and overweight/obesity outcomes

For the synthesis of growth, body composition and overweight/obesity outcomes, we prioritized studies that reported BMI, BMI-z-score, BMI change, BMI z-score change (or for children < 2 years, weight-for-length) or prevalence of overweight/obesity since these are the most widely applied indicators of growth and overweight or obesity at the population level. We then collated studies that reported effect estimates for percent body fat as this was a relatively homogeneous indicator across studies. For completeness, other indicators such as waist circumference, central adiposity, waist: height ratio and sums of skinfold thicknesses are included in summary tables but are not reported in detail in the narrative synthesis. These were often measured in conjunction with BMI or percent fat as additional measures (i.e. individual studies reported multiple indicators of body composition, overweight and obesity).

For other outcomes (critical and important), we synthesized results based on exposures, then age. Among these critical and important outcomes, multiple different indicators were assessed and reported to represent the outcome. For example, for early child development, there are large numbers of available tests to assess motor, cognitive and social development which meant that few studies reported the same indicator or measure for a given outcome.

Exposures were synthesized using three overarching groups of unhealthy food and beverages based on the need for requirements for evidence to make recommendations:

1. Unhealthy beverages. This was disaggregated into SSBs alone, artificially-sweetened beverages, and 100% fruit juice alone where studies specifically reported effects of these items separately. Any fruit drink that was not 100% fruit juice was included within the SSB category.

2. Intermediate foods or ‘borderline’ foods as listed in Table 2, for example, dairy-alternative drinks, cheese and red meat which are energy-dense, nutrient rich items.

3. Unhealthy foods listed in Table 2 (see rationale in the methods section).

The protocol planned to examine data by country income level (i.e. low- and middle-income countries versus high-income countries). The 20 included studies from middle-income countries were distributed across different outcomes domains and therefore the numbers within a single outcome were not sufficient for a separate synthesis. Instead of stratifying by country income level in the synthesis, we report the country in which studies took place where appropriate.

Preparation for synthesis

In line with our protocol for the quantitative synthesis, we explored sources of variability across studies to identify appropriate use of meta-analyses. There were many sources of variability across studies in the measurement of exposure, that is differences in the reporting of frequency of consumption or quantity consumed, different units of measurement and different time periods of assessment. Further, for each respective method, data reporting varied from dichotomous, multiple categories or continuous measures of consumption. For synthesis of each outcome, we examined studies reporting the same exposure group (either unhealthy beverages, intermediate foods or unhealthy foods). For those identified that reported exposures in the same way, we then harmonized for meta-analysis. We set a minimum requirement of two studies reporting the same outcomes to produce a forest plot.

Meta-analyses were conducted for studies that reported BMI, overweight/obesity or percent fat outcomes. For SSB consumption, there were studies that could be harmonized based on the reported portions, servings or quantity of intake (see details below). For unhealthy food consumption, we examined all studies to identify those which could be harmonized. Three studies reported odds ratios of overweight/obesity with unhealthy food consumption: Zulfiqar *et al*., (41) reported a dichotomous frequency of consumption with no indication of portion size; Wijga *et al*., (42) reported frequency of intake (continuous) without portion size, and Bel-Serrat *et al.*, (43) reported no portion size. Several other studies reported frequencies of intake without portions or servings indicated (44–46). Similarly, with continuous outcomes

(BMI, BMI z-scores), there were no two studies reporting intake as either portions/servings or g/day. Three studies (four articles) reported intake of foods as a percentage of total energy intake for an individual (two studies assessed ultra-processed food intake; one study assessed added sugar intake) (47–50). For these studies, percent energy intakes could not be converted to g/day because the denominator was the energy intake of the individual, not the mean energy intake of the sample (47–50). After interrogating data extracted from studies, we were unable to harmonize data on unhealthy food consumption from at least two studies which was the minimum criteria the review team specified for meta-analysis. We therefore performed narrative synthesis to explore overarching themes and identify similarities and differences between studies. Sources of study variability arose from different ages at baseline, duration of follow-up, and reporting of single or multiple points of follow-up.

Meta-analyses

Meta-analyses and corresponding forest plots were created to explore the combined effect of sugar sweetened beverage consumption, and separate effects of 100% fruit juice, on growth and body composition indicators including BMI, BMI change, BMI z-score, BMI z-score change and odds of overweight and obesity.

Studies that reported quantities of consumption, or number of servings were pooled. To harmonize data, we made all serving sizes equivalent so that the summary point estimate represented a unit change in daily serving of SSB, defined as 250ml for standardization. Serving sizes were reported as 12 oz (approx. 354 ml) for sodas (46), 8 oz (236.5 ml) for juice (46,51); three-quarters of a cup (184 ml) for juice (52); per 200 ml glass (53); per 100 ml (54); or per oz/day (per 29.6 ml/day) (55). If the serving size was not reported, we imputed a value of 250 ml per serving. Studies were excluded from meta-analyses if the intervention was reported as frequency of consumption where no portion or serving size was indicated, or as categories of consumption as these were not necessarily linear (56,57). Given the variability across studies in measurement of dietary intakes in studies (different recall periods, self-report versus weighed intakes, single vs repeated assessments) and the range of participant ages included in studies we avoided making further assumptions around linearity. Meta-regression, which could potentially have been used to convert categories of consumption to linear portions, is not recommended for fewer than 10 studies. A priori it was decided that meta-analyses and forest plots would only be created where there was a shared study design..

I^2 values were generated as indicators of heterogeneity, although these should be interpreted with caution when there are few studies in a meta-analysis. We adopted the indicative guide for interpretation of 0% to 40% indicating heterogeneity may not be important; 30% to 60% representing moderate heterogeneity; 50% to 90% representing substantial heterogeneity and 75% to 100% indicating considerable heterogeneity (31). For beta-coefficients, reported values and their standard errors were either multiplied or divided to achieve the common serving size estimate. Random effects models were performed as recommended where heterogeneity is likely. All analyses were undertaken using the meta command in Stata 16 (StataCorp. 2019. Stata Statistical Software: Release 16. College Station, TX: StataCorp LLC).

Reporting bias assessment

Funnel plots to explore potential publication bias in the meta-analysis were deemed inappropriate given the recommended number of at least 10 studies to produce funnel plots compared to the number of studies we were able to include in meta-analyses (31). Bias due to missing participants was considered within the risk of bias assessment using ROBINS-I for NRSIs.

Certainty of Evidence

We used GRADE (Grading of Recommendations Assessment, Development and Evaluation) criteria to assess the certainty of evidence for the effect of exposures on the critical outcomes. Grading of evidence was assessed by two reviewers independently and the individual ratings were agreed through discussion and consensus. The potential ratings for certainty of evidence were high, moderate, low and very low. Statements defining the certainty for each grade are provided below (Table 5).

Table 5: Quality of evidence Grade definitions

Grade	Definition
High	We are very confident that the true effect lies close to that of the estimate of the effect.
Moderate	We are moderately confident in the effect estimate: The true effect is likely to be close to the estimate of the effect, but there is a possibility that it is substantially different
Low	Our confidence in the effect estimate is limited: The true effect may be substantially different from the estimate of the effect.

Very Low	We have very little confidence in the effect estimate: The true effect is likely to be substantially different from the estimate of effect

Source: Schünemann et al., 2013 (58)

Within the grade profile for each outcome, we assessed the five domains namely: risk of bias; inconsistency; imprecision; indirectness and publication bias. Each domain was assessed as not serious, serious or very serious except risk of bias which had a fourth level of extremely serious when used in conjunction with ROBINS-I. As the risk of bias for all observational studies was assessed using ROBINS-I, studies were initially graded as high certainty of evidence in accordance with Cochrane guidance (31). The certainty of evidence was downrated by two levels if there was evidence of risk of bias due to non-randomization, namely due to the likelihood of confounding and selection bias. Specific guidance on the use of GRADE and ROBINS-I was followed for all evidence profiles (59). Directness was assessed based on whether studies addressed the review question in relation to similarity of populations, interventions (exposures) and comparators, using the PICO of this review. In general, this was not downrated because we assessed that studies had addressed the PICO of the review with the exception that no studies had been conducted in low income countries. For the assessment of inconsistency, we were not able to assess point estimates, overlap in confidence intervals or heterogeneity statistics, such as I^2 (58) because the data from all studies could not be meta-analyzed. Therefore, we did not downrate evidence for inconsistency, but noted that the interventions and comparators were different across studies. The rating of imprecision was assessed by considering the effect estimates and confidence intervals, or event rate for dichotomous outcomes or number of participants. We also referred to sample size calculations from included studies where available to support decisions where meta-analysis had not been conducted. Only two studies provided sample size estimates for critical outcomes. One study estimated a sample of n=42 required to assess the effect of consuming 10% of total energy from free sugars at 12 months on differences in weight status at 30 months (60). Another study estimated a sample of n=670 to detect a 5% different in rates of overweight/obesity by quartiles of exposure for fast food intake, with 90% power (61). Evidence profile tables were produced using GradePro software in conjunction with guidance in the handbook (58). The certainty of evidence was assessed for each critical outcome and disaggregated by age (< 2 years; 2 - < 5 years; 5 - ≤ 10 years) when there were sufficient numbers of studies. An evidence profile table was then produced for each critical outcome. Individual non-randomized studies of low, moderate and serious risk of bias were included in GRADE evidence profiles, but individual studies of critical risk of bias were

excluded from GRADE evidence profiles tables as the evidence was considered too unreliable.

Results

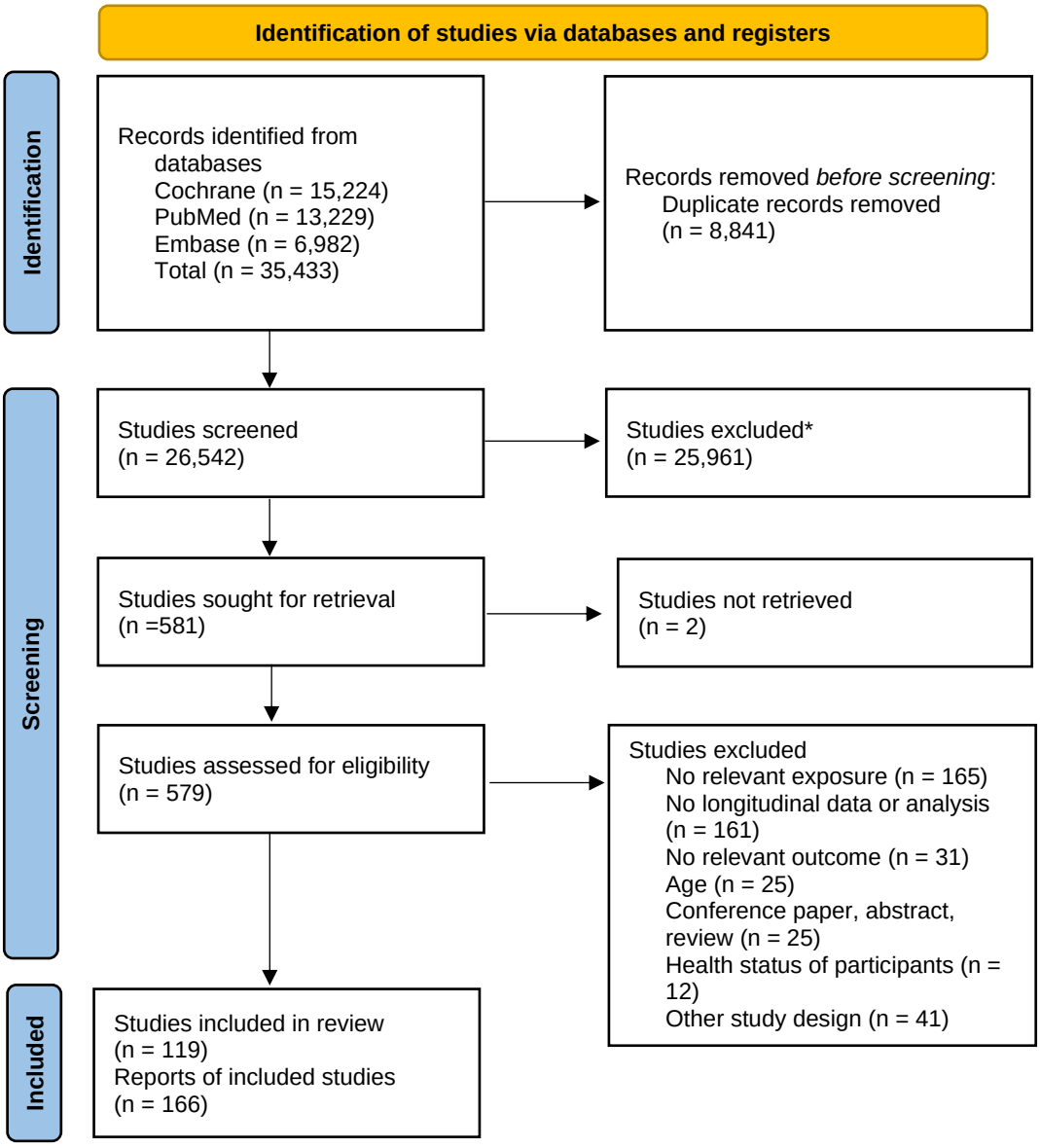
Study selection

The search retrieved 35,433 reports of which 8,841 duplicate records were detected by the software (Covidence) used. Figure 1 presents the number of reports retrieved from each database search. We screened 26,544 reports of which 583 were eligible for full text review. Of these, 581 records were assessed for eligibility as two reports could not be retrieved at full text stage (62,63). Four articles in Chinese language were included (26–29). All other included reports were in English language.

Reasons for exclusion at full text stage screening were: no reported data on unhealthy foods or beverages consumed (n=165); study design was not longitudinal (n=161); article did not report any of the review outcomes (n=31); the age group did not meet inclusion criteria (n=25); studies that exclusively recruited participants with the health outcome of interest (n=12); report was a conference paper, abstract, review or non-peer review article (n=25). For two articles, the full text could not be retrieved. Forty-one reports were excluded because the study design did not examine the exposure of interest against the outcome. These were typically multi-component interventions such as behavioral, educational or lifestyle modification that considered both unhealthy food consumption and growth/body composition as outcomes, rather than unhealthy foods as an exposure.

After full text screening, 166 articles from 119 studies were included. Of the included studies, data from 18 studies (21 articles) could not be extracted because the age range of participants extended beyond the age for inclusion (i.e. the sample included participants younger and older than 10.9 y (64,65,74–83,66,84,67–73). Characteristics of these studies are presented in Table 6. A further five articles could not be extracted due to pooled data for participants above and below age 10.9 years (85–89), but other reports from the same studies were available that met the age criteria. Characteristics of the five articles where data could not be extracted are shown in Table 6.

Figure 1: Flow chart of study search and selection



*No automation tools were used, all screened by review team.

Source: Page et al 2021 (90)

Study characteristics

Characteristics of the 99 included studies for which data were extracted are summarized in Tables 7-9, with the country, setting, study design, baseline age, exposure details and outcomes assessed. Sources of funding and conflicts of interests of authors for each of the included studies are listed in Tables S1-S3 (see supplementary materials). Year of publication of studies extended from 1984 to 2020. Nearly 80% (79 out of 99) of studies were conducted in high-income countries and 20% (20 out of 99) in middle-income countries based on the current Gross National Income per capita (91). Studies in middle-income countries were conducted in Peru, China, Brazil, Thailand, South Africa, Kenya, Ghana, Mexico, Columbia and Nepal. No studies were conducted in countries currently listed as low-income. Ninety-three were prospective cohort studies, one was a retrospective cohort study and five were randomized controlled trials (53,92–96). 47% (47 out of 99) of studies stated that participants were from urban settings; 13% (13 out of 99) recruited from both rural and urban areas, and only 9% (9 out of 99 studies) recruited from rural areas. Thirty studies did not specify the residence/location of participants. Sample size of included studies ranged from 70 to 32,000.

Across all outcomes, 65 studies reported on consumption of one or more unhealthy beverages, 50 studies reported on consumption of unhealthy food items, and 8 studies reported on intermediate food items according to the criteria described in the methods (see Table 2). Several studies reported effects of more than one unhealthy food or beverage items. For unhealthy beverages, we grouped all studies assessing any type of sugar-sweetened beverages (sodas, fruit-flavored drinks, cordials, powdered sweet drinks, juice with added sugar and caffeinated drinks with sugar added), referred to subsequently as SSBs. We grouped all studies that reported consumption of ASB only, and all studies that reported consumption of 100% fruit juice only in separate categories. Any juice consumption that was not specified as 100% fruit juice was placed within the SSB category. The specific unhealthy food items examined in each study are listed in Tables 7-9.

For critical outcomes, 60 studies reported on growth, body composition and overweight or obesity; seven reported on diet-related NCD indicators; three reported on displacement of healthy foods or breastmilk and four on dietary quality and diversity. Study characteristics are presented in Tables 7-8.

For important outcomes, seven studies reported food taste preference; 31 reported dental caries; three reported micronutrient deficiencies and five reported child development outcomes (Table 9).

Participants characteristics

Baseline age of participants ranged from one month to 10.8 years. Most studies included boys and girls. Three studies recruited female participants only (97–99). The oldest ages at follow-up were 20/21 years (98) and 21 years (100).

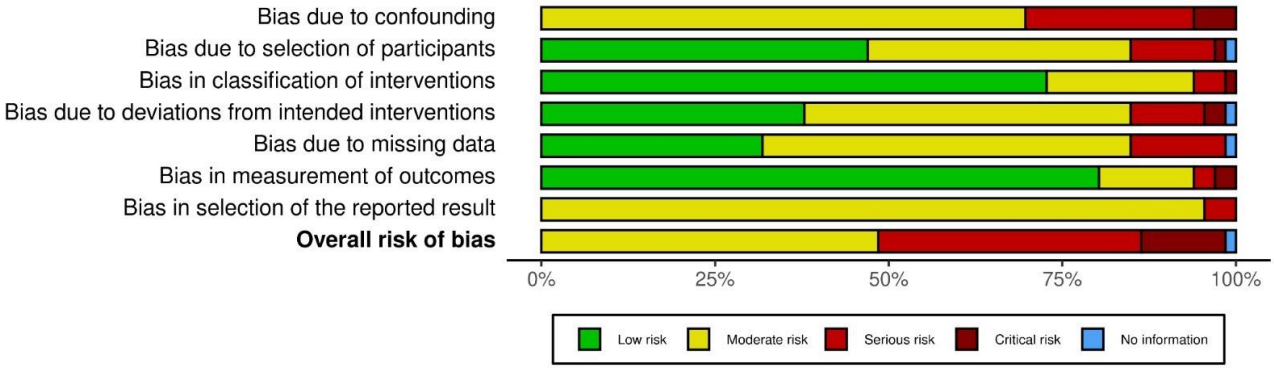
Risk of bias

Summary risk of bias assessments are presented for each of the critical and important outcomes in the review. Risk of bias summaries are presented in Figures 2 to 9. The individual risk of bias assessments for each study are presented in supplementary Figures S1 to S8.

Risk of bias assessment of studies reporting growth, body composition and overweight/obesity (critical outcomes)

67 articles from 60 studies reported on growth and body composition. One study was an RCT (53), and the remaining 59 studies (66 articles) were observational studies (NRSI). Of the 66 articles from observational studies (NRSIs) that reported on growth and body composition outcomes, we found none of the studies to have low risk of bias according to our pre-established criteria across the seven bias domains (D1 to D7) using ROBINS-I (32) (Figure S1a). Thirty-two articles (48.5%) had a moderate overall risk of bias (35,41,100–109,44,110–119,45,120,121,47,50,51,55,57,61), 25 articles (37.9%) had an overall serious risk of bias (26,42,122–131,43,132–136,46,48,49,52,54,56,97) and eight articles (12.1%) had an overall critical risk of bias (137–144). One article (1.6%) (60) was classed as having "no information" as information for criteria D2 (bias due to selection of participants) was missing. Full details of the risk of bias assessment for each study and domain are available in Figure S1. The relatively high risk of bias (50%) for studies reporting on body composition and growth outcomes arose primarily from biases due to confounding (D1), biases due to selection of participants (D2), biases due to deviations from intended interventions (D4) and biases due to missing data (D5) (Figure 2).

Figure 2: Summary risk of bias assessment of non-randomized studies reporting growth, body composition and overweight/obesity outcomes assessed using ROBINS-I

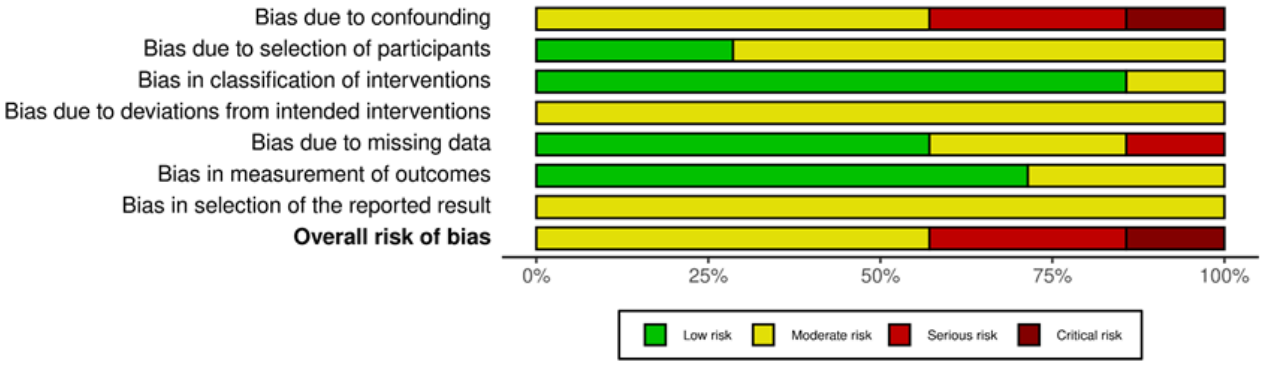


One RCT reported on diet-related NCD outcomes (53). This study was assessed as having some concerns according to our pre-established criteria (D1 to D5), specifically in relation to D3: risk of bias due to missing outcomes and D5: bias in selection of the reported result. Full details of the risk of bias assessment for the study for each domain are presented in Figure S1b.

Risk of bias assessment of studies reporting diet-related non-communicable disease indicators (critical outcome)

Seven included studies reporting on diet-related non-communicable disease indicators were non-randomized studies and were therefore assessed using ROBINS-I. Of the seven studies, we found none to have low risk of bias according to our pre-established criteria across the seven bias domains (D1 to D7) (Figure S2a). Four studies (57.1%) had a moderate overall risk of bias (47,113,145,146), two studies (28.6%) had a serious overall risk of bias (25,129) and one study (14.3%) had a critical overall risk of bias (147). Full details of the risk of bias assessment for each study and domain are presented in Figure S2a. The main contributors to the overall risk of bias across studies were biases due to confounding (D1) and biases due to missing data (D5) (Figure 3).

Figure 3: Summary risk of bias assessment of non-randomized studies reporting on diet-related non-communicable disease indicators



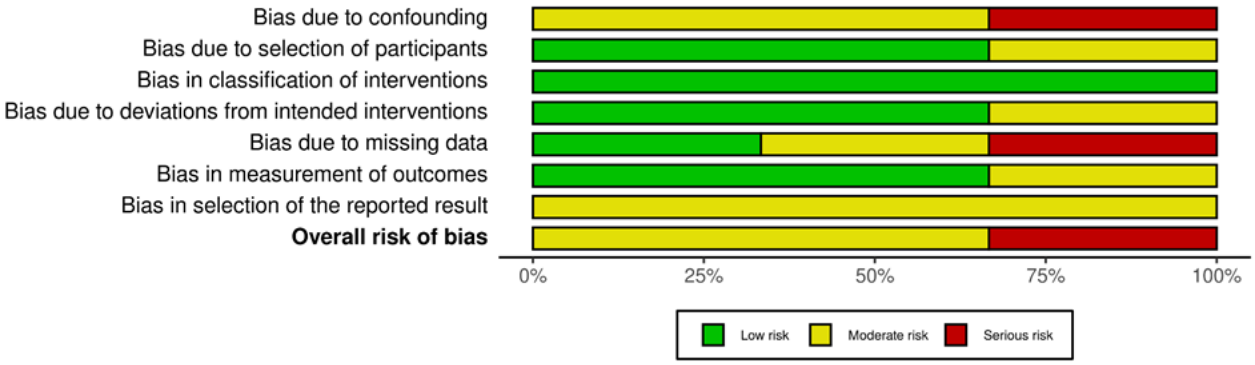
One RCT reported on diet-related NCD outcomes (94). This study was assessed as having some concerns according to our pre-established criteria (D1 to D5). Full details of the risk of bias assessment for the study for each domain are presented in Figure S2b.

Risk of bias assessment of studies reporting on displacement of healthy foods/breastmilk (critical outcome)

None of the included studies reporting on displacement of healthy foods or breastmilk were randomized controlled trials. All included studies therefore were non-randomized, observational studies assessed using ROBINS-I.

Of the three studies that reported on displacement of healthy foods/breastmilk, we found none of the studies to have low risk of bias according to our pre-established criteria across the seven bias domains (D1 to D7) (Figure S3). Two studies (66.7%) had a moderate overall risk of bias (103,148) whilst one study (33.3%) had a serious overall risk of bias (122). Full details of the risk of bias assessment for each study and domain are presented in Figure S3. Biases due to confounding (D1) and biases due to missing data (D5) were the main contributors to risk of bias (Figure 4).

Figure 4: Summary risk of bias assessment of non-randomized studies reporting on displacement of healthy foods/breastmilk

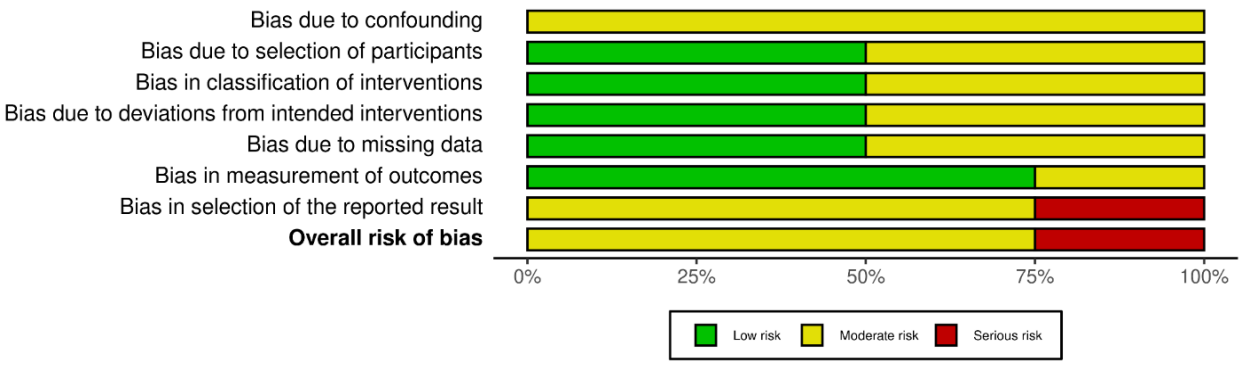


Risk of bias assessment of studies reporting on dietary quality and diversity (critical outcome)

None of the included studies reporting on dietary quality and diversity were randomized controlled trials. All included studies therefore were non-randomized, observational studies assessed using ROBINS-I.

Of the four studies that reported on dietary quality and diversity, we found none of the studies to have low risk of bias according to our pre-established criteria (D1 to D7) (Figure S4). Three studies (75.0%) had a moderate overall risk of bias (45,149,150) whilst one study (25.0%) had a serious overall risk of bias (135). Full details of the risk of bias assessment for each study and domain are available in Figure S4. Biases due to confounding (D1) and biases in the selection of reported results (D7) were the main contributors to risk of bias (Figure 5).

Figure 5: Summary risk of bias assessment of non-randomized studies reporting on dietary quality and diversity



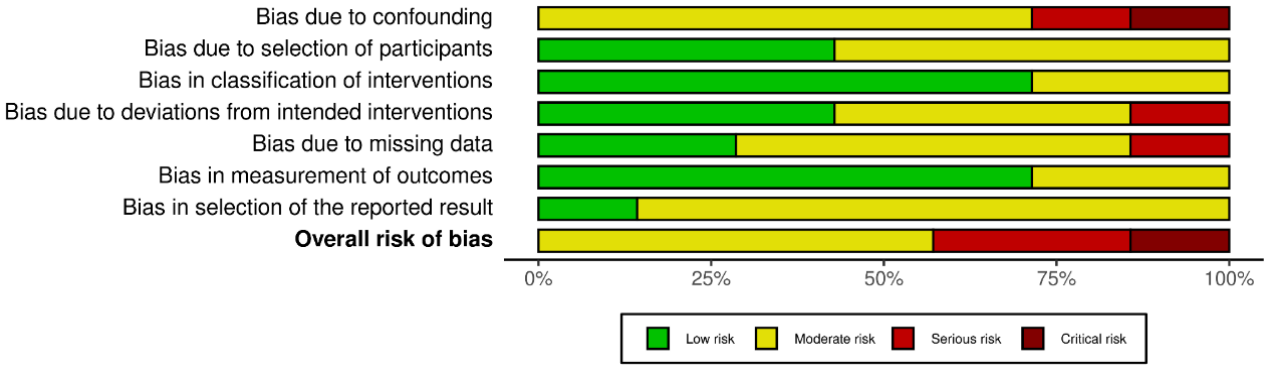
Important outcomes

Risk of bias assessment of studies reporting on food or taste preferences (important outcome)

None of the included studies reporting on food or taste preferences were randomized controlled trials. All included studies therefore were non-randomized, observational studies assessed using ROBINS-I.

Of the seven studies that reported on food taste preferences outcomes, we found none of the studies to have low risk of bias according to our pre-established criteria (D1 to D7) (Figure S5**)**. Four studies (57.1%) had a moderate overall risk of bias (34,99,151,152), two studies (28.6%) had a serious overall risk of bias (153,154) and one study (14.3%) was classed as having critical overall risk of bias (155). Full details of the risk of bias assessment for each study and domain are available in Figure S5. The main issues identified across studies were biases due to confounding (D1), biases due to deviations from intended interventions (D4) and biases due to missing data (D5) (Figure 6).

Figure 6: Summary risk of bias assessment of studies reporting on food or taste preferences

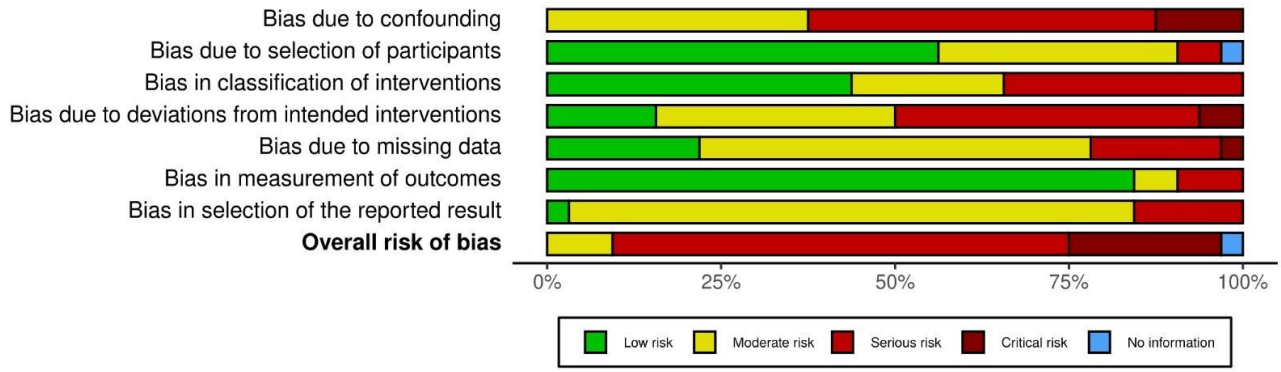


Risk of bias assessment of studies reporting on oral health (dental caries)(important outcomes)

None of the included studies reporting on oral health (dental outcomes) were randomized controlled trials. All included studies therefore were non-randomized, observational studies assessed using ROBINS-I.

Of the 32 articles (from 31 studies) that reported on dental caries outcomes, we found none had low risk of bias according to our pre-established criteria (D1 to D7) (Figure S6). The risk of bias was overall very high (84.4%) for articles reporting on oral health. Three articles (9.4%) had a moderate overall risk of bias (36,156,157), 21 articles (65.6%) had an overall serious risk of bias (28,37,165–174,39,158–164) and seven articles (21.9%) were classed as having critical risk of bias (175–181). One article (3.1%) (29) was classed as having "no information" as information for criteria D2 (bias due to selection of participants) was missing. Full details of the risk of bias assessment for each study and domain is presented in Figure S6. The main issues retrieved across studies were biases due to confounding (D1), biases in the classification of the intervention (D3), biases due to deviations from intended interventions (D4), biases due to missing data (D5) and biases in the selection of reported results (D7) (Figure 7).

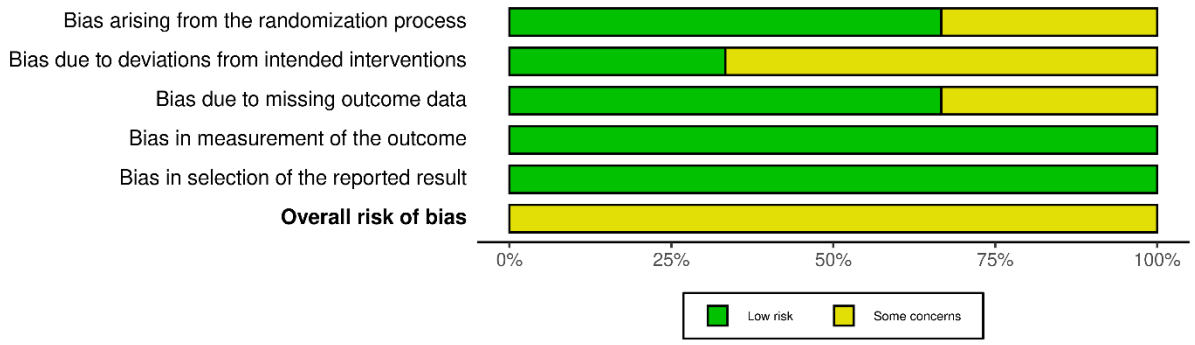
Figure 7: Summary risk of bias assessment of non-randomized studies reporting on oral health (dental caries)



Risk of bias assessment of studies reporting on micronutrient deficiencies (important outcome)

The three included studies reporting on micronutrient deficiencies were randomized controlled trials. All studies (100.0%) were deemed to have some level of concerns (93,96,182). Full details of the risk of bias assessment for each study and domain are available in Figure S7. None was found to have low risk of bias according to our pre-established criteria (D1 to D5) (Figure S7). The main issues identified were biases arising from the randomization process (D1), biases due to deviations from intended interventions (D2) and biases due to missing outcome data (D5) (Figure 8).

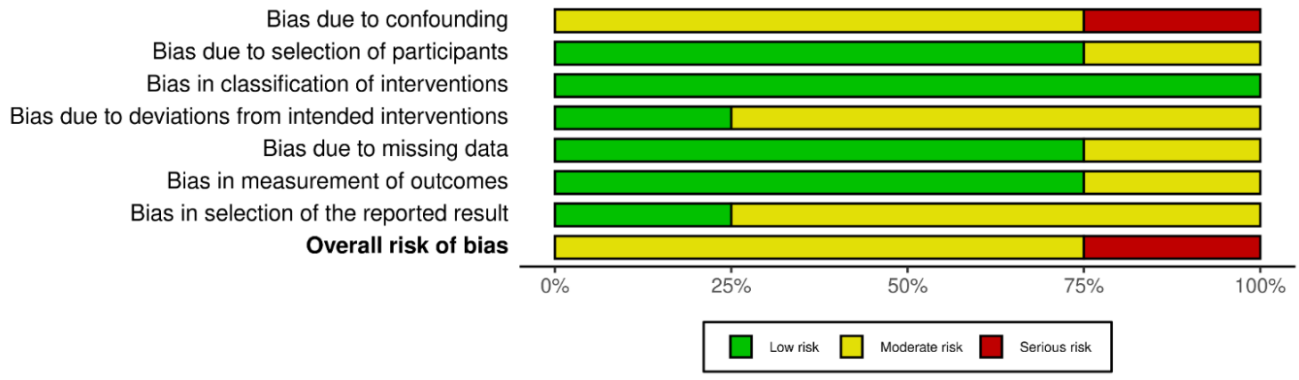
Figure 8: Summary risk of bias assessment of studies reporting on micronutrient deficiencies (all randomized controlled trials)



Risk of bias assessment of studies reporting on early child development (important outcome)

Of the five articles that reported on early child development outcomes, three studies (4 articles) were observational (NRSI). We found none of the studies to have low risk of bias according to our pre-established criteria (D1 to D7) **(**Figure S8a). Two studies (75.0%) had a moderate overall risk of bias (183–185) and one study (25.0%) had an overall serious risk of bias (186). Full details of the risk of bias assessment for each study and domain are presented in Figure S8a. The main issues retrieved across studies were biases due to confounding (D1), biases due to deviations from intended interventions (D4) and biases in the selection of reported results (D7) (Figure 8).

Figure 8: Summary risk of bias assessment of non-randomized studies reporting on early child development



One randomized controlled trial reported on early child development outcomes (92). This study was assessed as having some concerns according to our pre-established criteria (D1 to D5). Full details of the risk of bias assessment for the study for each domain are presented in Figure S8b.

Results of individual studies

Tables 10-14 present the summary statistics, effect estimates and confidence intervals for all included studies with data extracted (see end of report). Other study details include the methods of assessment of dietary intake, minimum analytic sample size and details of exposure (Tables 10-14). Results of studies reporting child growth, body composition and overweight/obesity outcomes are presented in Tables 10-12, results of other critical and important outcomes are presented in Table 13 and results for dental caries outcomes are presented in Table 14.

Synthesis of the results across studies

Critical outcomes: Growth, size, body composition and overweight/obesity

Sixty-seven articles from 60 studies reported on growth, body composition, overweight/obesity and longer-term outcomes. Summary statistics with effect estimates and confidence intervals for each study are shown in Table 10.

Unhealthy beverages and growth, body composition and overweight/obesity outcomes

Sugar-sweetened beverage (SSB) consumption

Narrative synthesis

Forty-five studies reported on SSB consumption and growth and body composition outcomes. We included all studies that reported consumption of sugar-sweetened beverages such as sodas, fruit drinks with sugar added, hot and cold beverages with added sugar. Studies examining consumption of 100% fruit juice only, or artificially sweetened beverages only were not included in this group, rather these are reported as separate categories in later sections. Some studies examined a range of different SSBs as a single category, while others assessed fewer types of SSBs (see Table 10). Some studies analyzed sodas, juice drinks or other sweetened beverages as separate categories and presented results for each exposure (98,110,116,140). Studies were predominantly conducted in high-income countries. Studies from middle-income countries were conducted in China, South Korea, Peru, Mexico and Belarus (26,101,111,124,129,130).

SSB consumption and BMI, overweight and obesity outcomes

Thirty-five of the 45 studies reported outcomes relating to BMI (raw values, percentiles or z-scores or change in raw/z-score values) and/or overweight/obesity prevalence (Table 10). In all tables and text, adjusted odds ratios and β values are presented for effect estimates.

Among children aged < 2 years at exposure, there were 10 studies; two were assessed as having critical risk of bias and are not reported on further (138,141). Of the remaining 8 studies, two reported a significant positive association. Cumulative consumption of SSBs in early life was associated with significantly higher odds of obesity aged 8-14 years (aOR = 2.99, 95% CI: 1.27, 7.00) (serious risk of bias) (124). Similarly, SSB consumption >1/week versus ≤1/week in infancy was associated with significantly greater odds of overweight and obesity at age 17 months (aOR = 1.6, CI = 1.04, 1.93, P < 0.01) (serious risk of bias) (26). Pan *et al*., (56) reported that SSB intake at 10-12 months was associated with significantly greater odds of obesity in the highest intake group (≥ 3 times/week) compared to no consumption, but not in the intermediate intake groups (< 1 or 1 - < 3 times/week) versus no consumption (serious risk of bias). The same study compared 'any' versus 'no' consumption of SSB from 1-12 months and observed a higher prevalence of obesity at 6 years in the group that consumed SSB (aOR = 1.71, 95% CI = 1.09, 2.68) (56). Three studies reported different effects based on either the time-point of assessment, or the assessed outcome. Flores & Lin (127) reported that consumption of SSB at age 2 years was not associated with severe obesity at 5 years, only consumption at 5 years was associated with severe obesity (aOR = 2.3, 95% CI 1.4, 3.7) (serious risk of bias). Quah *et al*., (54) reported that SSB intake at 18 months was not associated with BMI z-score or overweight/obesity at 6 years, but intake at 5 years was significantly associated with both outcomes (β = 0.34, 95% CI = 0.11, 0.58, P = 0.004; RR = 1.54, 95% CI = 1.03, 2.30, P = 0.033 respectively) (serious risk of bias). Leermakers *et al*., (187) found a significant association between SSB intake and BMI z-score among girls, but not boys (girls β = 0.11, 95% CI = 0.00, 0.23, p =0.04; boys: β = 0.05, 95% CI = −0.08, 0.18, p =0.42) at 6 y (moderate risk of bias). Two studies reported no significant associations between consumption of SSBs and growth or body composition outcomes, both assessed as serious risk of bias (42,136).

In children aged 2- < 5 years at baseline exposure, 11 studies reported on SSB intake and BMI or overweight/obesity. In one study results were not reported in an extractable format (125). Four of the 10 studies with included results reported a significant association. Among US children, SSB intakes among children aged 2-4.7 years at baseline and followed up at age

12.3-15 years were significantly positively associated with BMI z-score (β = 0.05, 95% CI = 0.022, 0.079, P = 0.001) (moderate risk of bias) (51). Among Australian children, each additional occurrence of SSB intake per day was significantly positively associated with BMI z-score (β = 0.017, 95% CI = 0.007, 0.027, P < 0.01) (moderate risk of bias) (44). Consuming SSBs above versus below the median intake (>65 ml/day vs <65 ml/day) at 18 and 30 months was associated with increased odds of overweight and obesity at 18 m follow-up (aOR = 1.92, 95% CI = 1.19, 3.11, P ≤ 0.01) and at 30 m follow up (aOR = 1.82, 95% CI = 1.11, 3.00, P ≤ 0.05 (126). In one study, total daily consumption of SSBs was not associated with obesity prevalence, but regular consumers of SSBs between meals versus those who did not consumed between meals at 2.5 years had greater odds of obesity at 4.5 years (aOR =2.36, 95% CI = 1.03, 5.39, P ≤ 0.05) (moderate risk of bias) (106). Five studies (6 articles) reported no association with BMI or overweight/obesity (all moderate risk of bias) (41,47,103,108,116,121). One study reported no association between SSBs consumption and odds of overweight and obesity combined, but significantly greater odds of obesity alone (obese: OR= 1.65, 95% CI = 1.12, 2.44, P = 0.01) (moderate risk of bias) (114).

In children aged 5- ≤ 10 years, 16 studies reported on SSBs and BMI or overweight/obesity, one study did not report effect estimates (122) and two had critical risk of bias (137,139). Of the remaining 13 studies with included results, there was one RCT and the remaining studies were observational. In a cluster RCT in Germany, SSBs intake among children was associated with significantly greater odds of obesity (aOR 1·22; 95% CI 1·04, 1·44, P= 0.014) but not overweight. There was also some association with BMI change (β = 0.02, 95% CI 0.00, 0.03). In this RCT, SSB intake was a secondary outcome of the intervention (risk of bias: some concerns) (53). Among observational studies, one study reported significant associations with BMI z-score changes such that SSB intake per 100ml/day at age 8 years was significantly associated with BMI change at 11.5 years (β = 0.10, SE = 0.03, P = 0.003) (serious risk of bias) (128). In Peru, daily versus no intake of SSB in the past 30 days was associated with greater BMI change (β =0·74 95% CI = 0·15, 1·33) and greater relative risk of overweight/obesity from age 8 years to age 12 years (aRR= 2·12, 95% CI 1·05, 4·28) (moderate risk of bias) (101). Among US children, SSB intake at 3-5 y was associated with significantly greater odds of odds of overweight/obesity at follow up (aOR = 1.04, 95% CI = 1.01, 1.07, P < 0.05) (moderate risk of bias) (55). One study reported different effects for different types of sugar-sweetened beverages (fruit drinks, non-100% fruit juice, sodas) with

only soda intake significantly associated with BMI (β = 0.011, SE = 0.005, P < 0.05) (serious risk of bias) (98). Eight studies reported no significant association between SSB intake and outcomes, five with moderate risk of bias (100,109,110,119,188) and three with serious risk of bias (46,97,129). Interventions, comparators and effect estimates are shown in Table 10.

SSB consumption and percent body fat outcomes

Seven studies examined SSBs consumption and percent body fat across all age groups (Table 11). Three out of seven studies reported a significant positive association. SSB intake of ≥ 2 servings/day compared to < 1 serving/day at age 5 years was positively associated with higher percentage body fat (group: P <0.01, age: P <0.01, group x age: p<0.01) (serious risk of bias) (97). High versus low SSB intake at 6.7 y was associated with higher percent body fat at 2 year follow up (β = 1.40, CI = 0.09, 2.72, P = 0.036) (serious risk of bias) (46). Zheng et al., (128) also reported a significant association between SSB intake at 9 years and percent body fat at 11.5 years (β = 1.04, SE = 0.32, P = 0.001) (serious risk of bias). Four studies reported no association between SSB consumption and percent body fat, three with moderate risk of bias (105,108,187) and one with serious risk of bias (129).

SSB consumption and other anthropometric and body composition outcomes

Sixteen studies reported effect estimates for other outcomes such as waist circumference, abdominal obesity, sums of skinfold thicknesses and adiposity rebound (Table 12). Two were assessed as having critical risk of bias (139,140). Of the 14 studies at moderate or serious risk of bias, 10 reported no significant association with anthropometric and body composition outcomes and four had mixed results. The associations between SSB consumption and these anthropometric and body composition indicators were not consistent, and the interventions and comparators were different across studies.

Certainty of evidence: SSB consumption

Grade evidence profiles for the effects of SSBs consumption and BMI/BMI z-scores, overweight/obesity and percent body fat are presented in Table 15. All studies except one were observational designs. For observational studies, risk of bias across studies for was assessed as very serious for most age groups due to non-randomization leading to a likelihood of confounding and selection bias. Inconsistency was judged as not serious, but it was noted that interventions and comparators were different across studies. Indirectness and imprecision were judged as not serious.

The certainty of evidence for observational studies of the effect of SSB consumption in children < 2 years was low for BMI/BMI z-score and very low for overweight/obesity prevalence. Evidence was down rated by one further level for overweight/obesity in children < 2 years because the included studies were all at serious risk of bias (Table 15). In children aged 2 - < 5 years, the certainty of evidence for effects of SSB consumption was low for BMI and low for overweight/obesity prevalence (Table 15). Among children aged 5- ≤ 10 years, the certainty of evidence for effects of SSB consumption was low for BMI/BMI z-score and low for overweight/obesity prevalence (Table 15). From the single randomized controlled trial, the certainty of evidence was low for BMI and low for overweight/obesity prevalence. The certainty of evidence for effects of SSB consumption on percent body fat in children aged 0- ≤ 10 years was low (Table 15).

In sum, across all age groups ≤ 10 years, the body of evidence indicates that SSB consumption may increase BMI, BMI z-score, percent body fat or the risk of overweight/obesity (low certainty).

Meta-analysis of sugar-sweetened beverage consumption and BMI, overweight and obesity outcomes

Figure 10 shows the descriptive effect estimates for the consumption of different beverages (per 250mL serving size) on BMI values in a single observational study (serious risk of bias) (98). Overall, there was no effect of sugar-sweetened beverage (SSB) consumption (diet soda, fruit juice, fruit drink) on BMI values at 0.5y follow-up (β=0.03 [-0.04, 0.09]; β=0.01 [-0.02, 0.05]; β=0.02 [-0.01, 0.06], respectively). There was stronger evidence for a small increase in BMI value per 250mL increase of regular soda consumption (β=0.03 [0.00, 0.05]).

Figure 10: Effect of consumption of different beverages (diet soda, regular soda, fruit juice and fruit drink) on BMI values within a single observational study

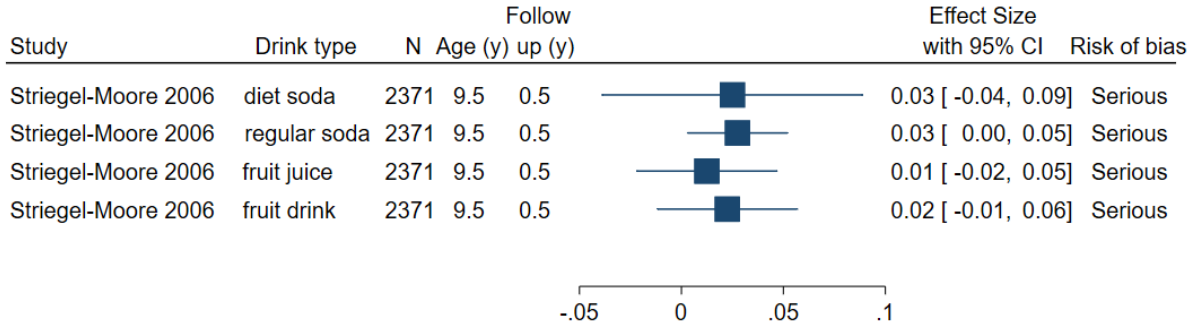


Figure 11 shows the effect estimates for the consumption of SSBs (per 250mL serving size) on BMI change over time (baseline to follow-up) for the individual studies (n=3) and overall. All three studies had moderate risk of bias (53,110,112,116). The pooled effect estimate showed a small positive association between SSB consumption and BMI change (β=0.01 [-0.00, 0.02]). However these findings should be interpreted with caution due to the small number of studies and the substantial heterogeneity across individual studies (I^2=73.7%) based on the recommended thresholds (31).

Figure 11: Effect of sugar-sweetened beverage consumption in children under 10 years on BMI change (baseline to follow-up)

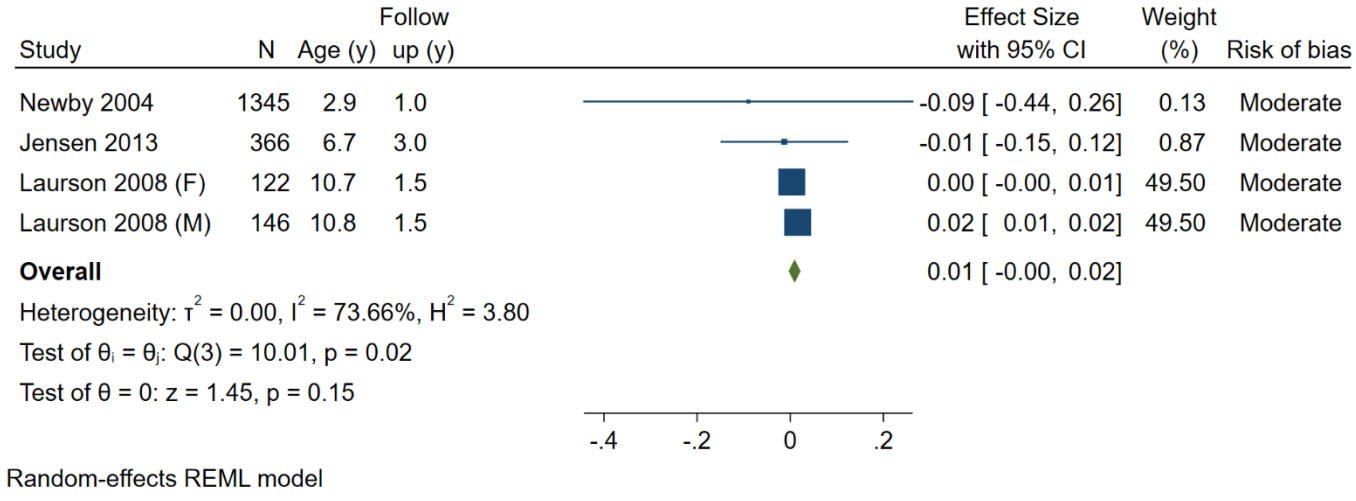


Figure 12 shows the effect estimates for the consumption of SSBs (per 250mL serving size) on BMI z-score values for the individual studies (n=3) and overall. One study (51) had moderate risk of bias whilst two studies (46,54) had serious risk of bias. The pooled effect estimate indicated that there was no association between consumption of SSBs and BMI z-score values at follow-up (β=0.10 [-0.11, 0.31]). There was no heterogeneity across individual studies (I^2=0.0%).

Figure 12: Effect of sugar-sweetened beverage consumption in children under 10 years on BMI z-score values

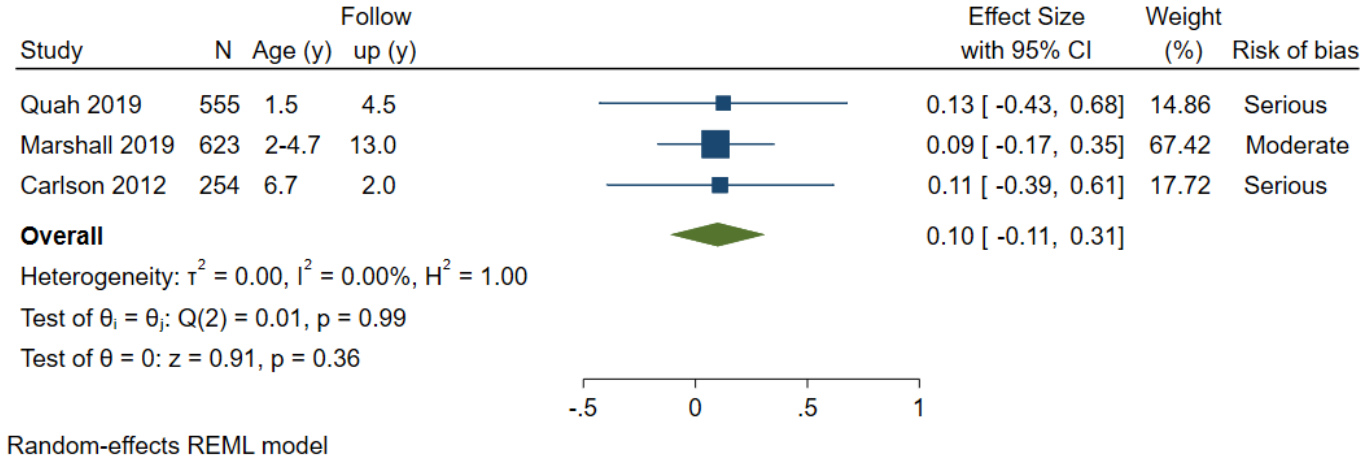
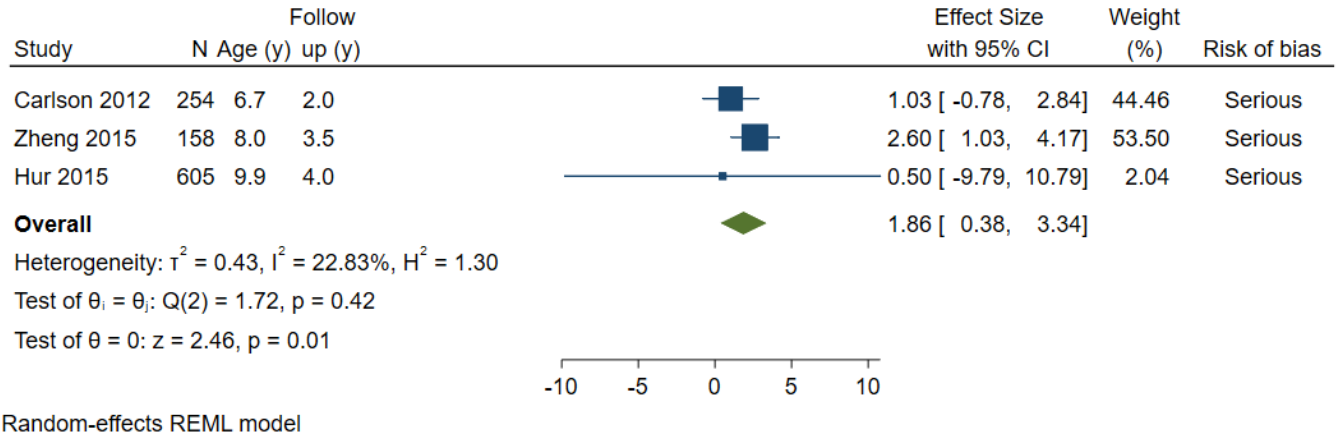


Figure 13 shows the effect estimates for the consumption of SSBs (per 250mL serving size) on percent body fat for the individual studies (n=3) and overall. All studies (46,128,129) had serious risk of bias. The pooled effect estimate indicated that there was a significant positive association between consumption of SSB and percent body fat at follow-up (β=1.86 [0.38, 3.34]). However, this should be interpreted with caution due to the low number of included studies, the three studies being assessed as at serious risk of bias. There was low heterogeneity across individual studies (I^2=22.8%).

Figure 13: Effect of sugar-sweetened beverage consumption on percent body fat in children under 10 years



Artificially sweetened beverage consumption

Narrative synthesis

Seven studies reported ASB consumption in relation to all child growth, body composition and overweight/obesity outcomes. four studies defined the exposure as diet-sodas (98,116,128,137), two used the term artificially-sweetened beverages (108,114) and one referred to reduced sugar, or sugar-free fruit squashes, cordials and diet sodas (105).

ASB consumption and BMI, overweight and obesity outcomes

Six studies examined ASB consumption and BMI or overweight/obesity (Table 10). One was assessed as critical risk of bias and is not reported on further (137). There were no included studies of ASB consumption among young children aged < 2 years. Of the five studies with included results, one observed a significant inverse association between ASB intake (g/day) and BMI z-score change (β = -0.20, SE = 0.07, P = 0.01) (serious risk of bias) (128). Three out of five studies reported no significant association between ASB intake and BMI, two with moderate risk of bias (108,116), one with serious risk of bias (98). One study reported no difference in odds of overweight/obesity with SSB high consumption (once per day) compared to low (< once per week or never) but significantly greater odds of obesity alone with high ASB consumption (aOR = 1.57, 95% CI = 1.05, 2.36, P = 0.03) (moderate risk of bias) (114).

ASB consumption and percent body fat outcomes

Three studies examined ASB intake in relation to body fat as an indicator of adiposity (Table 11). One reported a borderline negative association with percent body fat (serious risk of

bias) (β = -1.41, SE = 0.70, p = 0.046) (128). Two studies reported no significant associations, both moderate risk of bias (105,108).

Only one study examined ASB consumption in relation to other growth or body composition outcomes and reported no significant association with ASB consumption and annual weight gain (116) (Table 11).

Certainty of evidence: ASB consumption

There was no evidence on the effects of ASB consumption on children < 2 years. The certainty of evidence from observational studies for effects of ASB consumption in children aged 2 < 5 years was low for BMI/BMI z-score and low for overweight/obesity (Table 16). Among children aged 5 ≤ 10 years, the certainty of evidence was very low for BMI/BMI z-score. There were no included studies reporting overweight/obesity among children aged 5 ≤ 10 years. The certainty of evidence for effects of ASB consumption in children aged ≤ 10 years was low for percent body fat (Table 16). The effect estimates from studies indicated that there were no important harms from ASB consumption. Therefore, the body of evidence for all age groups ≤ 10 years indicates that ASB consumption may make little or no difference to increased BMI/BMI z-score, percent body fat or the risk of overweight/obesity (low certainty).

100% fruit juice consumption

Narrative synthesis

Seventeen studies reported effects of fruit juice consumption. In 16 studies, the exposure was specified as 100% juice, in one study the exposure was described as unsweetened fruit juice and small intakes of sweetened fruit and vegetable juice (108). This study was placed with 100% fruit juice for the synthesis as it matched most closely with this sub-category of unhealthy drinks. Three studies included children age < 2 years, nine studies included children 2 - <5 years and five studies included children aged 5 - ≤ 10 years. Two studies were judged as critical risk of bias and are not reported further (137,142).

100% fruit juice consumption and BMI, overweight and obesity outcomes

Ten studies across all ages assessed fruit juice consumption and BMI or overweight and obesity (Table 10). Nine of the 10 studies reported no significant association (5 moderate, 4

serious risk of bias) (46,51,57,108,116,121,123,128,189). One study reported mixed results, with fruit juice intake from 2- 4 years significantly associated with greater BMI z-score increase at 4 years (mean change 0.282, SE 0.028 vs 0.030, SE 0.037, P = 0.0003), but not with BMI increase from 4 to 5 years (mean change 0.034, SE 0.031 vs 0.020, SE 0.021 P = 0.6778) (moderate risk of bias) (118). In the same study, odds of overweight were not associated with juice intake among those of normal weight or those at risk of overweight at baseline. Odds were significantly higher for those overweight at baseline and follow up at 4 years but not at 5 years (moderate risk of bias) (118).

100% juice consumption and percent body fat outcomes

Four studies reported effects of 100% juice intake on whole body fat (Table 11). All four reported no significant association (two moderate, two serious risk of bias) (46,105,108,128).

100% juice consumption and other body composition outcomes

The effects of 100% juice consumption on other body composition outcomes were reported in six studies and are presented in Table 12. Five of the six studies reported no association between 100% juice intake and adiposity rebound, weight change, change in weight status category, weight for age or growth trajectory.

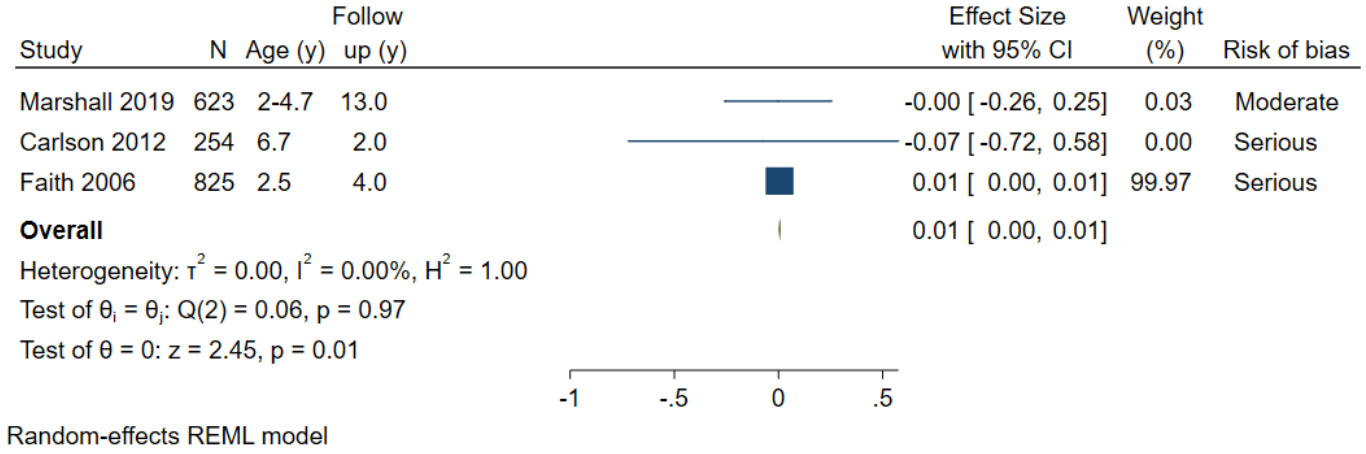
Certainty of evidence: 100% juice consumption

The certainty of evidence from observational studies for effects of 100% fruit juice consumption in children aged < 2 years was low for BMI/BMI z-score and very low for overweight/obesity (Table 17). Among children aged 2 - < 5 years, the certainty of evidence was low for BMI/BMI z-score and low for overweight/obesity (Table 17). Among children aged 5- ≤ 10 years, the certainty of evidence was very low for BMI/BMI z-scores. There were no included studies among children aged 5- ≤ 10 years and overweight/obesity. The certainty of evidence from observational studies for effects of 100% fruit juice consumption in children aged 0- ≤ 10 years and percent body fat was low (Table 17). The effect estimates from studies indicated that there were no important harms from 100% juice consumption. Therefore, the body of evidence for all age groups ≤ 10 years indicates that 100% juice consumption may make little or no difference to increased BMI/BMI z-score, percent body fat or the risk of overweight/obesity (low certainty).

Meta-analysis of 100% fruit juice beverage consumption and BMI, overweight and obesity outcomes

Figure 14 shows the effect estimates for the consumption of 100% fruit juice (per 250mL serving size) on BMI z-score values for the individual studies (n=3) and overall. One study (51) had moderate risk of bias whilst two studies (46,52) had serious risk of bias. The pooled effect estimate was positive (β=0.01 [0.00, 0.01]). Although statistically significant, this effect is unlikely to be clinically significant. There was no heterogeneity across individual studies (I^2=0.0%).

Figure 14: Effect of 100% juice consumption in children under 10 years on BMI z-score



Intermediate foods

Narrative synthesis

One study examined frequency of cheese intake in relation to prevalence of overweight/obesity at 5 years (138) (See Table 10). This study was assessed as being at critical risk of bias and therefore results are not reported on further.

Unhealthy food items

Narrative synthesis

Studies of consumption of unhealthy food items were included based on the nutrient-based and food-based approach outlined in the methods section and the pre-defined list of food

items (Table 2). This included ultra-processed foods based on the NOVA classification; unhealthy foods and beverages defined in infant and young child feeding indicators (7); foods high in free sugars, artificial sweeteners, salt, and foods high in saturated or trans fats. The list also included unhealthy foods described in studies as fast-foods, convenience foods or similar terms defined by authors.

Twenty-six studies reported effects of unhealthy food consumption on growth, body composition or overweight/obesity outcomes with a range of exposures. Consumption of high-fat foods was assessed in four studies (5 articles) (41,44,46,131,134). Six studies (7 articles) examined the intake of free sugars or added sugar or sweetened foods (45,48,49,60,129,136,139). Fast food consumption was examined in five studies (42,43,61,107,109). Three studies reported on ultra-processed food consumption (47,50,190). Some studies reported effects of different unhealthy foods separately (35,42,43,138). Other exposures included salty snacks (101), sweets (143), or combinations of both (115,126).

Studies were predominantly conducted in high-income countries. Studies from middle-income country settings were conducted in Brazil, South Korea and Peru (47,50,101,120,129,190). Four of the 26 studies were assessed as being at critical risk of bias and are not reported further (138,139,143,144).

Unhealthy foods and BMI, overweight and obesity outcomes

Of the included results of 22 studies examining unhealthy food consumption, 16 studies reported outcomes relating to BMI (raw values, z-scores or change in raw/z-score values) or overweight and obesity prevalence (Table 10).

Among children aged < 2 years at baseline, four studies examined unhealthy foods. Of these four studies, one observed a significant positive association between sweet foods consumption from 3-12 months, and weight-for-length z-scores at 3 years (ANOVA, $F=3.23$, $P = 0.03$), but no association with snack foods (moderate risk of bias) (115). The remaining three studies found no significant associations between ‘extra food’ consumption at 18 months and BMI at 6.5 years (moderate risk of bias) (35); fast food and snack consumption at in the first year of life and overweight/obesity between 7-8 years (serious risk of bias) (42) or

consumption of sweetened first foods in the first six months of life and BMI z-scores at 3 years (serious risk of bias) (136).

Among children aged 2 - < 5 years, seven studies (10 articles) examined the effects of unhealthy foods and BMI or overweight/obesity outcomes. Two studies reported a significant positive association with unhealthy food consumption and outcomes. Consumption of added sugar to milk and fruits was associated with significantly higher BMI in boys and girls aged 2 - < 6 years at baseline, but in older children (6 - < 10 years) the association was only significant in boys (no effect estimate available)(moderate risk of bias) (45). Frequency of fast food intake (high or low) was associated with significantly higher risk of change in BMI status (normal to overweight, or overweight to obese) among children aged 3-5 years followed up 1 year later (RR: 1.38, 95% CI 1.13, 1.67, P < 0.01) (moderate risk of bias) (61).

Three of the seven studies among children aged 2 - < 5 years presented results that differed by quantity consumed, outcome or time point (6 articles from 3 studies). In one study, high fat food consumption was associated with significantly higher BMI z-scores (44), but not with odds of overweight and obesity (moderate risk of bias) (41). In a study in Brazil, frequency of energy dense food consumption was not associated with BMI z-scores (120), but the percent energy intake from ultra-processed foods at age 4 years was significantly associated with BMI z-score at 7 years, whereas intake at 7 years was not (moderate risk of bias) (50). One study reported no effects of added sugar at age 2 years on change in BMI z-score at 5 and 6 years of age. A separate analysis from the same study found that consumption at age 1 years was not association with change in BMI z-score at 7 years, but change in intake from 1-7 years was significantly associated with change in BMI z-scores (serious risk of bias) (48,49).

The remaining two out of seven studies reported no significant association between unhealthy food consumption and BMI or overweight and obesity (one moderate, one serious risk of bias) (47,126).

Five studies examined effects of unhealthy food consumption among children aged 5- ≤ 10 years. One reported a significant association of salty, high-fat snack frequency with change in BMI from 8 years to 12 years ($\beta = 0.71$, 95% CI = 0.14, 1.28, $P < 0.05$) (moderate risk of bias)(101). Bel-Serrat *et al*., (43) found significantly lower odds of overweight/obesity with

savory snack intake some days/week (aOR = 0.48, 95% CI = 0.23, 0.99, P <0.05) or never (OR = 0.27, 95% CI = 0.10, 0.72, P < 0.01) compared with every day, but no association between fast food intake and overweight obesity (serious risk of bias). Three of the five studies among ages 5- ≤ 10 years reported no association between unhealthy food intake and BMI or overweight/obesity outcomes (one moderate, two serious risk of bias (46,109,129).

Unhealthy food consumption and percent body fat outcomes

Across all age groups, four studies (five articles) examined unhealthy food consumption in relation to body fat, three measured percent body fat (46,48,49,129)(48) and one assessed fat mass index (190) (Table 11). All three studies assessing percent fat reported no significant association with unhealthy foods (all serious risk of bias) (46,48,49,129). The study examining fat mass intake reported a significant association between annual consumption of ultra-processed foods (in g via 12 month recall) and higher fat mass index in children aged 6 years at baseline followed up for 5 years (β = 0.05, 95% CI = 0.04, 0.06, P < 0.001) (moderate risk of bias) (190).

Certainty of evidence: Unhealthy foods

Grade evidence profiles for the effects of unhealthy foods and BMI/BMI z-scores, overweight/obesity and percent body fat are presented in Table 18. All studies were observational. Risk of bias across studies for was assessed as very serious for most age groups due to non-randomization leading to a likelihood of confounding and selection bias. Inconsistency was judged as not serious, but it was noted that interventions and comparators were different across studies. Indirectness and imprecision were judged as not serious. The certainty of evidence for unhealthy food consumption in children aged 0- < 2 years was low for BMI and very low for overweight/obesity (see Table 18). The certainty of evidence for unhealthy food consumption in children aged 2 - < 5 years was low for BMI/BMI z-score and low for overweight/obesity (Table 18). The certainty of evidence for effects of unhealthy food consumption in children aged 5- ≤ 10 years was low for BMI/BMI z-score and low for overweight/obesity (Table 18). The certainty of evidence for effects of unhealthy food consumption in children aged ≤ 10 years on percent body fat was very low (Table 18). In sum, for all age groups ≤ 10 years, consumption of unhealthy foods may increase BMI/BMI z-score, percent body fat or risk of overweight/obesity (low to very low certainty).

Critical outcomes: Other diet-related non-communicable disease indicators

Narrative synthesis

Seven studies examined diet-related NCD indicators in relation to unhealthy or intermediate food and beverage consumption (Table 13). Three studies included children aged < 2 years at baseline (94,113,147); two included children aged 2 to < 5 years (145,146) and two studies recruited children aged 5 to ≤ 10 years (25,129). Six studies looked at unhealthy foods and beverages, and one study assessed an intermediate food item (red meat) (94). One study was assessed as at critical risk of bias and results are not presented further (147).

Across all age groups, four studies assessed the effects of SSB consumption (25,47,113,129); four assessed other unhealthy foods (47,129,145,146) and one study assessed red meat consumption (94).

Of the four studies examining SSB consumption, none reported a significant association between SSB consumption and diet-related NCD indicators (25,47,113,129). In children aged 12.9 months followed up for five years, no significant associations were observed in blood pressure (systolic and diastolic); pulse wave velocity; total to HDL cholesterol; triglycerides or insulin according to tertile of SSB consumption (high vs low and medium vs low tertile) (moderate risk of bias) (113). Among 4-year olds in Brazil, glucose, insulin and homeostatic model assessment of insulin resistance (HOMA-IR) were not associated with the percentage of total energy from SSB (moderate risk of bias) (47). Hur *et al*., (129) examined sugar from beverages in relation to a combined metabolic syndrome score (based on arterial blood pressure, fasting glucose, total cholesterol, HDL-cholesterol and triglycerides) among children aged 9.9 years. After a 4-year follow-up, no significant association was observed between the metabolic syndrome score and beverage sugar consumption (serious risk of bias).

In the fourth study, a subset of data from a larger study (25) for children aged ≤10.9 years only were analyzed by the review team. Mean SSB intake at baseline was not associated with changes in HDL cholesterol at 12 month follow-up. There was also no significant association between mean SSB intake and change in triglycerides in the subset of children ≤ 10.9 years which was the same as reported in the larger total study sample (serious risk of bias) (25).

Across all age groups, three studies (4 articles) examined the association between a range of unhealthy foods items and diet-related NCD indicators. Two studies reported significant associations (47,145,146) and one reported no significant associations (129). In a study of Brazilian children, greater consumption of ultra-processed foods was associated with a significantly increased total serum cholesterol at age 6 years (tertile 3 vs 1; β 0·22 mmol/l; 95% CI 0·04, 0·39) and higher mean triglyceride value of 0·11 mmol/l (95% CI 0·01, 0·20) than those in the lowest tertile (moderate risk of bias) (146). A second study in Brazil examined ultra-processed food consumption as a percent of total energy intake among children aged 3-4 years and followed-up at 7-8 years. Changes in total and LDL cholesterol were significantly associated with intake (β =0.430, 95% CI 0.008, 0.853, P = 0.046; β =0.369, 95% CI 0.005, 0.733 P = 0.047 respectively), but not HDL cholesterol or triglycerides (moderate risk of bias) (145). The same study found no significant associations between ultra-processed foods and glucose insulin or insulin resistance profiles (moderate risk of bias) (47). Consumption of sugar from confectionary and sweetened products in South Korean children was not associated with a metabolic syndrome score (serious risk of bias) (129).

Certainty of evidence: unhealthy foods and beverages and diet-related NCD indicators

Grade evidence profiles for the effects of unhealthy food and beverage consumption and NCD indicators are presented in Table 19. All studies were observational. Risk of bias across studies for was assessed as very serious for blood lipids and glucose or insulin indicators due to non-randomization leading to a likelihood of confounding and selection bias. Risk of bias across studies for metabolic syndrome was judged as extremely serious because there was only one included study which had an individual risk of bias of serious. Inconsistency was judged as not serious for all outcomes, but it was noted that interventions and comparators were different across studies. Indirectness and imprecision were judged as not serious. The certainty of evidence for observational studies of the effects of unhealthy food and beverage consumption in children aged ≤ 10 years and NCD outcomes was low for studies reporting blood lipid profiles; very low for studies reporting blood glucose or insulin indicators, and very low for metabolic syndrome (Table 19). Overall, the body of evidence indicates that unhealthy food and beverage consumption may be associated with worse diet-related NCD indicators (low to very low certainty).

One study examined the effect of consumption of red meat (beef) on diet-related NCD indicators among children aged 17 months in New Zealand. This was a secondary data analysis from an RCT conducted to assess the primary outcome of effect of red meat consumption on micronutrient status. There was no evidence of effects on serum lipids (total cholesterol; HDL cholesterol; total: HDL cholesterol) after the 5 month intervention (risk of bias: some concerns) (94).

Critical outcomes: Displacement of healthy foods or breastmilk intake

Narrative synthesis

Three studies examined displacement of healthy foods due to unhealthy food and beverage consumption, namely sweet beverages, energy-providing liquids, and high energy drinks as well as energy dense sweet deserts (103,122,148). Baseline ages of participants in each study were 1 month, 24 months and 6 years (Table 13). No included studies reported the effects of unhealthy foods on displacement of breastmilk.

Among children in Australia, intake of sweet beverages at age 2 years was not associated with displacement of fruit and vegetable intake at 5 years (moderate risk of bias) (103). There was a significant but weak inverse correlation between intake of sweet beverages and milk/alternatives at 2 years of age ($r = -0.11$, $P = 0.015$) and at 5 years ($r = -0.11$, $P = 0.012$) (103). A five-country European study reported children consuming energy providing liquids (EPL) versus not consuming had a significantly lower energy intake from infant formula at ages 2 to 5 months. At ages 4 and 5 months, children consuming EPL also consumed significantly more energy from solids than those without EPL but significantly less at 7, 9 and 12 months (effect estimate not extractable) (moderate risk of bias) (148).

A study in Germany examining longitudinal changes in fruit and vegetable consumption at age 6 and age 10 years reported no significant correlation between consuming high-caloric drinks and energy-dense sweets and deserts (cake, cookies, chocolate bars, ice cream) with change in fruit and vegetable consumption (serious risk of bias) (122).

Certainty of evidence: Displacement of healthy foods or breastmilk intake

In GRADE evidence profiles, all studies were observational and the risk of bias across studies was assessed as very serious due to non-randomization leading to a likelihood of confounding and selection bias. Inconsistency was judged as not serious, but it was noted that interventions and comparators were different across studies. Indirectness and imprecision were judged as not serious (Table 20). The certainty of evidence for effects of unhealthy food and beverage consumption on displacement of healthy foods was low (Table 20). No included studies examined the effects of unhealthy food consumption on displacement of breastmilk. The body of evidence therefore indicates that among children ≤10 years, unhealthy food and beverage consumption may increase displacement of healthy foods (low certainty).

Critical outcomes: Dietary quality and diversity

Narrative synthesis

Four studies reported dietary quality in relation to unhealthy food and beverage consumption (45,135,149,150). Mean baseline ages of participants in each study were 25 months, 3 years, 2-10 years and 3-6 years respectively (Table 13). Two examined unhealthy beverages (fruit juice; SSB) (135,150) and two examined unhealthy foods (added sugar, energy-dense foods) (45,149).

Fruit juice consumption was positively associated with the healthy eating index among children in the USA (serious risk of bias) (135). Healthy eating index total scores (HEI-2015) at follow-up (age 14–17 y) were almost 6 points higher among those with the highest compared to lowest preschool juice intakes (≥1.0 cups/day vs < 0.5 cups/day) at ages 3-6 years (ANOVA P = 0.004) (135).

Also in the USA, children not consuming soft drinks before age 3 years vs regular consumption between 24 and 36 months was associated with greater odds of being in higher diet quality trajectories (OR 2.7, 95% CI 1.6, 4.3 P < 0.0001) (moderate risk of bias) (150). In a European study across eight countries of children aged 2 to <6 years and 6 to <10 years, those consuming added-sugar with milk and fruit daily had a significantly lower healthy dietary pattern score at two-year follow-up (P < 0.001 for trend) in boys and girls for both age groups in adjusted analyses (moderate risk of bias) (45).

Among Portuguese children, weekly and daily consumption of energy-dense foods at 2 years of age was associated with a lower healthy eating score (below the median value) at 4 years of age (incidence rate ratio (IRR) = 0·75, 95% CI 0.58, 0.96; IRR = 0·56, 95% CI 0·41, 0·77, respectively) compared with consumption less than once per week (moderate risk of bias)(149).

Overall, included studies indicated that intake of soft drinks, energy dense foods and sugar-added to milk were associated with lower (poorer) dietary quality indicators, but fruit juice consumption was associated with higher diet quality scores.

In GRADE evidence profiles, all studies were observational and the risk of bias across studies was assessed as very serious due to non-randomization leading to a likelihood of confounding and selection bias. Inconsistency was judged as not serious, but it was noted that interventions and comparators were different across studies. Indirectness and imprecision were judged as not serious (Table 21).The certainty of evidence for effects of unhealthy food and beverage consumption on dietary quality and diversity was low (Table 21). For children under 10 years, therefore, the body of evidence indicates that unhealthy food and beverage consumption may worsen dietary diversity (low certainty).

Important outcomes: Food or taste preferences

Narrative synthesis

Seven studies examined food taste preference in relation to early exposure to unhealthy foods and beverages (34,99,151–153,155). Mean baseline ages of the study participants were less than or around 12 months (34,151,152,191) and 2 to 3 years, 5 years and 4-7 years (99,153,155) (Table 13). Three studies conducted taste preference tests (34,151,155), two used food liking scores (152,153) and two examined associations between food consumed early and later in life (99,154). One study was assessed as being at critical risk of bias and is not reported on further (155).

Five of the six studies with included results examined the effect of exposure to sweetened foods and beverages. Three studies reported a significant association and two reported no significant association. Children aged 24 months who received sugar water in the first 12 months of life consumed significantly more sucrose-solution in taste tests than infants who never received sweetened water in infancy ($p<0.05$, unadjusted ANOVA) (moderate risk of bias) (151). Consuming soft drinks, sweet biscuits or fruit drinks > once/week compared to <

once/week increased the odds of having a high liking of these foods at age 5 years (OR = 11.06, CI = 4.38, 27; OR = 4.84, CI = 1.80, 13.02; OR = 2.47, CI = 1.09, 5.59 respectively) however no significant association was observed for consumption of cake or lollies (candy/confectionary) (moderate risk of bias) (152).

SSB consumption compared to no consumption in the first year of life was significantly associated with greater likelihood of consuming SSBs more than once per day at age 6 years (serious risk of bias) (154). In a study of female children followed through to adolescence, consuming soda versus not consuming soda at age 5 years was significantly associated with soda intake at 15 years (repeated measures ANOVA, $P < 0.01$) (moderate risk of bias) (99). Consumption of SSBs at age 5 years, however, showed no significant association with 100% fruit juice intake at age 15 years (99).

One study looked at the effect of exposure to slightly sweetened lipid-based nutrient supplements in infants aged 6 months and found no difference in sweet taste preference among those who received a sweet-tasting supplement compared to a control group who received no supplement at follow-up age 5 years (moderate risk of bias) (34).

Preferences for foods other than sweetened foods and beverages were examined through a study of food choices among nursery children from their canteen (153). The selection of cheeses and sausages at 2-3 years of age was significantly associated with a preference for these foods in adolescence and adulthood (cheese $r^2=0.22$, early preference $F=82.4$ $P<0.001$; sausages $r^2= 0.18$ early preference $F=17.5$, $P<0.001$) (serious risk of bias) (153).

Important outcomes: Oral (dental) health

Narrative synthesis

Thirty-one studies reported the effects of unhealthy foods and beverages on child dental outcomes. Details of exposure, assessment methods and outcomes assessed are presented in Table 14. Fifteen studies considered unhealthy beverage consumption. These covered a variety of types of SSBs with or without juices. No studies examined ASB or 100% fruit juice alone. Twenty-three out of 31 studies examined unhealthy food exposures. Almost all studies examined foods high in sugar or candy/confectionary consumption. One of the 23 studies included takeaways and instant noodles as well as sweet foods (179). One of 23 studies examined savory high fat foods only (162).

Ten studies were conducted in middle-income settings from four countries: Brazil, China, Thailand, South Africa. Baseline age of participants across all studies ranged from 1 month to 6 years. More than half of the studies (17 out of 31) included children aged < 2 years at baseline. Seven studies were judged as being at critical risk of bias and are not reported on further (175–181).

Consumption of unhealthy beverages and dental outcomes

Eight studies examined unhealthy beverage consumption of children aged < 2 years, all eight studies were assessed as being at serious risk of bias. Five of the eight studies reported significant positive associations between SSB consumption and risk of dental caries (39,171,172,174,192) (Table 14). One study reported significant findings in an analysis from 1 year to aged 3-6 years at follow up) (39) but no significant effects were observed in a follow up at age 5 years (192). One study reported no significant associations between intake at 10-12 months and caries at 6 years (173), and one study reported borderline significance of juice drink intake and incident caries (164).

In children aged 2- < 5 years, five studies examined SSB consumption; all were assessed as being at serious risk of bias. Two of the five studies reported significantly greater odds of caries with greater SSB consumption (28,169). One study had borderline significance (160) and two studies reported inconsistent results (162,163).

There were no included studies of SSB intake and dental caries outcomes among children aged 5- ≤ 10 years at baseline, although some studies in the younger age category (2- < 5 years) included a proportion of participants greater than age 5 years.

Consumption of unhealthy food items and dental outcomes

Seventeen studies examined unhealthy food consumption and dental caries (Table 14). Among eight studies of children < 2 years, five reported significantly greater prevalence of caries among children with high versus low unhealthy food consumption (one moderate, four serious risk of bias) (36,159,166,168,171). Two studies reported different effects. Peres *at al*., (156) reported significantly higher dental caries prevalence and mean DMFT score among high sugar consumers (incident rate ratio (IRR) = 1.67, 95% CI = 1.23, 2.25) but not among those with increasing sugar consumption from baseline to end line (IRR = 1.22, 95%

CI = 0.94, 1.59)(moderate risk of bias). Chaffee *et al*., (37) reported significant differences in early childhood caries among high vs low tertile of a 'sweet index' at age 12 months, but not at age six months (serious risk of bias).

Of the 17 studies examining unhealthy food consumption, nine assessed children aged 2 -< 5 years. Eight of the nine studies reported a significant positive association between unhealthy foods and dental caries (1 moderate risk of bias, 8 serious risk of bias) (28,29,157,160–162,167,169). One study reported contrasting effects based on different time points and outcomes (serious risk of bias) (157).

There were no included studies of unhealthy food consumption and dental caries outcomes among children aged 5- ≤ 10 years at baseline, although some studies in the younger age category (2- < 5 years) included a proportion of participants greater than age 5 years.

Important outcome: micronutrient deficiencies

Narrative synthesis

No studies examined the effect of unhealthy food consumption on increased risk of micronutrient deficiency. However, three studies assessed the impact of red meat intake (pork or beef) on micronutrient deficiencies which was an intermediate food item, being energy-dense but nutrient rich, based on our classification (Table 13). All three studies were RCTs and were assessed by risk of bias as having 'some concerns'. Two studies examined hemoglobin concentration (93,95) and one examined vitamin B12 concentration (96). Regular supplementation with pork for 12 months among children aged 6 months living in a high poverty area in China was associated with significant increases in vitamin B12 ($P < 0.002$) and lower total homocysteine (tHcy) ($P=0.005$) compared to a group receiving local cereal only (risk of bias some concerns) (96). Red meat (beef) supplementation in infants ≥ 3 times/week from 10 to 12 months of age in Columbia led to significantly higher hemoglobin concentration ($P=0.016$) and hematocrit ($P = 0.03$) at 12 months of age compared to a control group (95). A trial in New Zealand found no effect of a red meat supplement intervention on young children aged 17 months on hemoglobin or serum transferrin receptor concentrations, but mean ferritin concentration was significantly higher in the red meat group compared to control at the end of the five month trial ($P = 0.03$) (93).

Important outcomes: Child Development

Narrative synthesis

Five studies (six articles) reported the effect of red meat (an energy dense, nutrient-rich food which was deemed intermediate in our scheme of unhealthy foods) or unhealthy foods and beverages and child development outcomes; two studies were conducted in high-income countries (183,185,186) and three in middle-income countries (92,96,184) (Table 13).

Two RCTs examined the effect of red meat on child development. In China, 50 g/day of red meat (pork) was administered at 6 months of age for 12 months. Significantly higher cognitive scores were observed in the meat vs control who received local cereal (P = 0.013) (risk of bias: some concerns) (96). There was no significant difference between groups in fine or gross motor function (96). In a school-based intervention in Kenya, children aged 7.1 y received snacks for two years. The intervention group received a daily mid-morning snack of a local plant-based stew (*githeri*) with added ground beef showed significant improvements in test scores compared with the control group receiving plain *githeri* (without meat) in six out of the seven subject tests and in the overall total test scores (moderate risk of bias) (92).

The association between consumption of noodles and biscuits (ultra-processed foods) and the ages and stages questionnaire was examined in children aged 14.9 months in Nepal. Higher consumption of processed foods over a 3-day period did not increase the odds of children being in the lowest 25% of child development at 23-38 m (moderate risk of bias) (184). In the Avon Longitudinal Study of UK infants, consumption of non-milk extrinsic sugars was examined in relation to the strengths and difficulties questionnaire at ages 6, 7 and 8 years (183,185). No association was observed between sugar intake and total difficulties at any of the ages assessed (moderate risk of bias) (183,185). In a US study, sugar-sweetened beverage, soda and fruit juice consumption was examined against a range of development tests in early and mid-childhood (see Table 13) (186). Out of nine tests conducted at two time periods of assessment only one significant association was observed between early childhood consumption of SSBs and lower mid-childhood KBIT-II verbal scores (–2.4 points per serving/day, 95% CI: –4.3, –0.5) (serious risk of bias) (186).

In sum, evidence from two studies on red meat consumption, as an intermediate food (energy-dense, nutrient rich), showed significant positive associations with improved cognitive development in young children and school age children. There were no studies showing an association between unhealthy foods and poorer child development outcomes.

Discussion

This review examined the evidence of effects of unhealthy food and beverage consumption on pre-defined critical and important outcomes based on the stated PICO and in accordance with our registered protocol. We defined unhealthy foods and beverages using both nutrient-based and food-based approaches since there is no single classification scheme or definition of unhealthy foods and beverages. We examined ultra-processed foods based on the NOVA classification; unhealthy foods and beverages defined in infant and young child feeding indicators (7); foods high in free sugars, artificial sweeteners, salt, and foods high in saturated or trans fats. We also include studies where authors defined unhealthy foods as fast-foods, convenience foods, junk foods or similar.

Summary of evidence

Using GRADE criteria, we assessed the evidence as having low and very low certainty for all outcomes. Low certainty means that the true effect may be substantially different from the estimate of the effect, and very low certainty means that there is little confidence in the effect estimate, with the true effect likely to be substantially different from the estimate of the effect.

Almost all evidence was from prospective observational studies. Following careful assessment of studies using Cochrane guidance, the evidence was down rated by two levels for risk of bias across studies because of non-randomization in observational studies leading to confounding and selection bias. Inconsistency was not down rated for most outcomes, but it is important to note that interventions and comparators differed widely across studies, leading to heterogeneity of findings.

Growth, body composition and overweight/obesity outcomes

Sugar-sweetened beverage consumption

The largest body of evidence in the review was on the effects of sugar-sweetened beverage consumption on BMI, overweight and obesity and percent body fat. For all age groups ≤ 10

years, the body of evidence indicates that SSB consumption may increase BMI, BMI z-score, percent body fat or the risk of overweight/obesity (low to very low certainty). Pooling of studies to calculate effect estimates was precluded by the differences in interventions and comparators across studies. We therefore conducted meta-analyses on sub-samples of the studies where SSB consumption was quantified in servings/day and data harmonization could be carried out for the units of measurement, outcomes and effect estimates.

Results of meta-analyses found a small positive association between SSB consumption and BMI change (β = 0.01, 95% CI -0.00, 0.02) (n = 3 studies), but substantial heterogeneity (I^2 = 73.6%) indicates uncertainty around these estimates. Meta-analysis of SSB consumption and BMI z-scores produced an overall effect estimate of β = 0.10, 95% CI -0.11, 0.31 (n = 3 studies) with low heterogeneity (I^2 = 0.0%). A positive association was also found with SSB consumption and percent body fat (β = 1.38 95% CI 0.38, 3.34, n = 3 studies) with low heterogeneity (I^2 = 22.8%) but all included studies had serious risk of bias. These results should be interpreted with caution due to the small number of studies included, the different baseline ages of participants and varying duration of follow-up across studies.

A previous systematic review estimated the effect of SSB intake in children and adolescents and reported that BMI increased by 0.07 (95% CI: 0.01, 0.12) for each additional daily 12-oz (approx. 354 ml) serving of SSBs using a random effects model, but heterogeneity was high (I^2 = 91.6%, P < 0.001) (14). In a systematic review of ultra-processed food consumption and body fat in children and adolescents, almost half of included studies assessed sugar-sweetened beverage consumption as the main exposure (12 out of 26) (16). While positive associations were reported, the review included both longitudinal and cross-sectional study designs and therefore causal associations are harder to identify (16). Some RCTs have examined the effects of SSB consumption by comparing to a group receiving artificially sweetened beverages (193–195). Such studies did not meet eligibility criteria for this review since they compared two of the unhealthy food items on the review list of exposures (SSBs and ASB) with no control group. One 18-month RCT reported lower BMI increase in children receiving ASBs compared to SSBs but on an intention-to-treat basis, there was no significant difference in BMI z-score increase between the two groups (0.06 SD in the sugar-free group versus 0.12 SD in the sugar group, P = 0.06) (193).

Artificially sweetened beverages consumption

Five studies reported results of ASB consumption and BMI or overweight/obesity outcomes. No studies reported the effects of ASB consumption among children < 2 years. Evidence indicated no important harms. Using GRADE, the body of evidence for ages 2 - ≤ 10 years indicates that ASB consumption may make little or no difference to increased BMI/BMI z-score, percent body fat or the risk of overweight/obesity (low to very low certainty). Reasons for the low certainty of evidence were the same as those listed above. Data synthesis was precluded by the different interventions and comparators across studies.

100% fruit juice consumption

Ten included studies examined 100% juice consumption and BMI. BMI z-score or overweight/obesity prevalence. Across all age groups ≤ 10 years, 100% fruit juice consumption may increase BMI/BMI z-score, percent body fat or risk of overweight/obesity (low to very low certainty). A meta-analysis of 100% fruit juice consumption on BMI z-score produced an effect size close to zero (β = 0.01, 95% CI 0.00, 0.01) (n= 3 studies). Whilst statistically significant, this is unlikely to be of clinical significance and the evidence indicated no important harms.

Our findings accord with a systematic review of longitudinal studies of fruit juice consumption among older children and adolescents (7 – 18 years) which found 100% fruit juice consumption was not associated with BMI z-score increase (15). Among children ages 1 to 6 years, a 1 serving increment was associated with a 0.087 (95% CI 0.008 to 0.167) unit increase in BMI z-score which was not considered to be of clinical significance (15). The review highlighted the lack of evidence on effects of fruit juice consumption among children under age 7 years (15).

Intermediate foods consumption

Only one study examined the effects of intermediate foods on growth, body composition, overweight and obesity, but this was assessed as being at critical risk of bias (138).

Unhealthy foods consumption

Studies reporting unhealthy food consumption assessed salty, high fat food consumption (41,43,44,101), ultra-processed foods (50,190), fast food or ‘extra foods’ (35,42,61) and added sugars or foods high in sugars (45,48,136). The interventions and comparators were too heterogeneous across studies for any meta-analyses to be carried out. Using GRADE,

among children ≤ 10 years, consumption of unhealthy foods may increase BMI/BMI z-score, percent body fat or risk of overweight/obesity (low to very low certainty).

Diet-related NCD outcomes

There were seven studies which reported on unhealthy food exposures and diet-related NCD indicators including blood lipids (25,113,145,146); glucose or insulin (47), and metabolic syndrome (129). The body of evidence for children ≤ 10 years indicates that unhealthy food and beverage consumption may increase BMI/BMI z-score, percent body fat or risk of overweight/obesity (low to very low certainty).

Displacement of healthy foods or breastmilk intake outcome

No included studies examined the effect of unhealthy food consumption on the displacement of breastmilk. Three studies examined the effect of unhealthy foods in displacing healthy foods with two studies reporting some associations, a weak negative inverse association between SSB and consumption of milk at age 2 year, but no association between SSB intake and fruit and vegetable intake (103), and children drinking more energy-providing liquids at 2-5 months having lower energy intake from infant formula at 2-5 months and greater energy intake from solids at 4-5 months (148). The body of evidence indicates that unhealthy food consumption may increase displacement of healthy foods (low certainty).

Dietary quality and diversity outcomes

Of four studies assessing associations between unhealthy food exposures and dietary diversity, three reported significantly poorer dietary quality or diversity with greater consumption of unhealthy foods or beverages. Children consuming sugar added to milk or fruit had lower HDAS (45); children who did not consume SSBs had significantly greater odds of being in a higher diet quality trajectory (150) and consumption of energy-dense foods was association with a lower healthy eating score (149). One study reported an inverse association in that greater preschool consumption of 100% fruit juice was associated with a significantly higher HEI at adolescence (135). The body of evidence indicates that greater consumption of unhealthy foods may worsen dietary quality and diversity (low certainty).

Important outcomes

Food taste preference outcomes

Three of the five studies reporting on sweet food exposures and food/taste preferences observed significant associations between greater consumption in early life and greater 'liking' or preference for sweetened foods (151,152,154). A study that assessed exposure to fruit juice in early life did not find an association with intake at 15 years (99). One study examined the effect of exposure to LNS (only slightly sweetened) in infancy and found no preference for sweet tastes in children followed up 4 years later (34). One study examined food/taste preferences for savory foods (cheese, processed meat) in early life was significantly associated with preferences for these foods in adolescence and adulthood (153).

Oral health (dental caries) outcomes

All the reported significant associations were in the direction of increased consumption of unhealthy beverages, mainly SSBs, or unhealthy foods (mainly free sugars or candy) leading to greater risk of dental caries. However, a high proportion of included studies were assessed as having serious risk of bias.

Micronutrient deficiency outcomes

No studies examined the effect of unhealthy food and beverage consumption on increased risk of micronutrient deficiency. Three studies examined the effects of red meat consumption, an intermediate food. Two studies reported significant improvements in micronutrient status (vitamin B12, hemoglobin), with increased meat consumption and one reported a smaller decline in iron status among supplemented children compared to those not receiving supplements.

Child development outcomes

Two studies examined intermediate foods (meat) in relation to cognitive performance, both reported significant improvements in infants (96) and in school age children (92) receiving red meat compared to control groups. No associations were observed between unhealthy food intake (instant noodles) in cognitive development in young children in Nepal (184), or non-milk extrinsic sugar consumption and development indicators among school age children (183,185). Consumption of sugar-sweetened beverages was not associated with developmental tests in early and mid-childhood in one study (186).

Limitations of the data at the study and outcome level

A major limitation of the evidence for critical outcomes was that all included studies, except one, were observational cohort studies. This concurs with other systematic reviews of complementary feeding that found insufficient evidence on effects of unhealthy foods and have highlighted the need for randomized controlled trials (13). In the present review, there was a lack of studies designed purposively to examine the effect of unhealthy food and beverage consumption on malnutrition. The interventions and comparators in included studies differed widely which meant that meta-analyses could be performed only on a small subset. Many studies did not specify the primary outcome or the smallest important difference for outcomes which would have aided assessment of the importance of effects. Most studies lacked an *a priori* analysis plan and performed multiple tests of exposures against outcomes leading to different findings within the same studies and further difficulties in interpretation.

In longitudinal cohorts, dietary assessments changed over time because of changes in instruments employed or the methods of administration. Other time-varying effects included the change from parental report to child (self-) report in some studies with increasing age of participants, both of which were subject to recall bias, social-desirability and effects of repeated assessments. Attrition of samples over time and effects of missing data were considered in the risk of bias assessment but are also likely to have contributed to residual confounding.

Studies employed a range of quantitative, semi-quantitative or qualitative assessments of dietary intakes. The heterogeneity of reporting of dietary intakes, and lack of quantitative estimates of servings or portion sizes limited the ability to conduct meta-analyses Retrospective or prospectively assessed periods of dietary intake varied from 24 hours, 3 days, 7 days, 28 days, 1 year or was sometimes unspecified. In general, wider adoption of the STROBE-NUT reporting guidelines would enhance evidence syntheses (196). Most of the outcomes were assessed objectively but did not necessarily have a clinical end-point.

Strengths and limitations of the review process

Strengths of the review are the inclusion of studies dating from 1971, with no restrictions on language or country. Other systematic reviews of unhealthy food consumption or malnutrition in young children have limited searches to countries classified as high on the Human Development Index (13,197) or English language only (13,197). The focus of this

review on children ≤ 10 years added valuable insights for this less-extensively studied age group. Study selection included longitudinal study designs to gain stronger evidence of potential causality rather than relying on associations in cross-sectional study designs. This review also examined the effects of all types of unhealthy foods and beverages using a comprehensive food-based and nutrient-based approach in addition to the use of food classifications such as NOVA.

Limitations of the study may arise from conducting one search in three electronic databases for a range of critical and important outcomes. By doing this, the completeness of the search may vary for the different included outcomes. Two full text articles were not retrieved for screening. Meta-analyses could only be performed for unhealthy beverage exposures on a subset of studies and these results should be interpreted with caution.

Conclusions

In children ≤ 10 years, consumption of SSBs and unhealthy foods may increase BMI/BMI z-score, percent fat or odds of overweight/obesity (low to very low certainty). ASBs and 100% fruit juice consumption may make little or no difference to BMI, percent fat or overweight/obesity outcomes (low to very low certainty). Unhealthy food and beverage consumption may worsen diet-related NCD indicators (low certainty); displacement of healthy foods (low certainty) and dietary quality and diversity (low certainty).

The review highlights important evidence gaps due to a lack of studies purposefully designed to assess the effects of unhealthy food consumption on child malnutrition. Evidence synthesis was severely limited by the different interventions and comparators across studies. There is a lack of evidence from low-income countries and there is substantially less evidence for children aged under 2 years than for children aged 2 - < 10 years.

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TABLE 6 Characteristics of included studies where data could not be extracted due to aggregate age range[1]

Study ID	Reference	Country	Setting (R/U)	Income level[2]	Recruitment method	Study design[3]
Growth and body composition						
Berkey 2004	Berkey et al., 2004 (77)	USA	Both	HIC	Mail	
Bisset 2007	Bisset et al., 2007 (78)	Canada	Both	HIC	School	
Cowin 2001	Dong et al., 2015 (89)	UK	NS	HIC	Clinic	
Field 2004	Field et al., 2004 (75)	USA	NS	HIC	Mail	
Jensen 2013 (2)	Jensen et al., 2013b (72)	Australia	NS	HIC	School	
Johnson 2012	Johnson et al., 2012 (73)	Australia	R	HIC	School	
Lee 2018	Lee et al., 2018 (74)	South Korea	U	HIC	School	
Libuda 2008	Alexy et al., 2011 (86)	Germany	U	HIC	Contacts, maternity wards, and clinics	
	Libuda et al., 2008 (87)	Germany	U	HIC		
Mrdjenovic 2003	Mrdjenovic et al., 2003 (67)	USA	U	HIC	Summer day camp	
Mundt 2006	Mundt et al., 2006 (68)	Canada	U	HIC	School	
Neumann 2007	Neumann et al., 2007 (69)	Kenya	NS	MIC	School	RCT
	Neumann et al., 2013 (198)	Kenya	NS	MIC		RCT
Nissinen 2009	Nissinen et al., 2009 (71)	Finland	Both	HIC	Clinic	
Phillips 2004	Phillips et al., 2004 (76)	USA	U	HIC	Schools, summer camps, friends, and family	
Seferidi 2018	Seferidi et al., 2018 (80)	UK	Both	HIC	NS	
Shroff 2014	Shroff et al., 2014 (65)	Colombia	U	MIC	School	
Xue 2016	Xue et al., 2016 (66)	China	NS	MIC	Household random cluster sampling	
Diet-related non-communicable disease indicators						
Asghari 2015	Asghari et al., 2015 (84)	Iran	U	MIC	Clinic	
	Asghari et al., 2016 (83)	Iran	U	MIC		
	Mirmiran et al., 2015 (64)	Iran	U	MIC		

Displacement of healthy foods/breastmilk						
Libuda 2008	Libuda et al., 2008 (88)	Germany	U	HIC	Personal contacts, maternity wards, and pediatric practices	
Dietary quality & diversity						
Libuda 2008	Alexy et al., 2011 (86)	Germany	U	HIC	Contacts, maternity wards, and clinics	
	Libuda et al., 2009 (85)	Germany	U	HIC		
Child development						
Busch 2002	Busch et al., 2002 (79)	NS	NS	NS	School	RCT
Littlecott 2016	Littlecott et al., 2016 (82)	UK	NS	HIC	School	RCT
Neumann 2007	Neumann et al., 2007 (69)	Kenya	NS	MIC	School	RCT
Wang 2020	Wang et al., 2020 (81)	Mexico	U	MIC	Clinic	

[1]HIC, high-income country; MIC, middle-income country; NS, not stated; R, rural; RCT, randomized controlled trial; U, urban; y, year.
[2]Calculated using the World Bank Atlas method for the 2021 fiscal year (based on gross national income per capita in 2019), https://datahelpdesk.worldbank.org/knowledgebase/articles/906519-world-bank-country-and-lending-groups
[3]Prospective cohort study, unless otherwise stated.

TABLE 7 Characteristics of included studies reporting on growth and body composition (critical outcomes)[1]

Study ID	Reference	Country	Setting (R/U)	Income level[2]	Recruitment method	Study design[3]	Exposure	Baseline age (mean or range)	Outcome assessed
Alviso-Orellana 2018	Alviso-Orellana et al., 2018 (101)	Peru	NS	MIC	Home		Snacks-salty and fatty foods; SSBs	8 y	BMI change; WC
Arcan 2013	Arcan et al., 2013 (102)	USA	R	HIC	School		100% fruit juice	5.8 y	BMI
Bayer 2014	Bayer et al., 2014 (122)	Germany	Both	HIC	School		High-caloric drinks; Energy dense sweets	6.0 y	BMI
Bel-Serrat 2019	Bel-Serrat et al., 2019 (43)	Republic of Ireland	Both	HIC	School		Fast food; Savory snacks	7.9 y	% OW/OB; Mean change in BAZ
Blum 2005	Blum et al., 2005 (137)	USA	R	HIC	School		100% juice; Diet soda; SSB	9.3 y	Normal weight/overweight assessed by BAZ
Budree 2017	Budree et al., 2017 (123)	South Africa	R	MIC	Clinic		Fruit juice	Birth	% OW/OB (BAZ >2)
Byrne 2018	Byrne et al., 2018 (103)	Australia	R	HIC	Clinic		Sweet beverages	24.1 mo	BAZ
Cantoral 2016	Cantoral et al., 2016 (124)	Mexico	U	MIC	Clinic		SSB	6 mo	% obese; % with abdominal obesity (WC >90th centile)
Carlson 2012	Carlson et al., 2012 (46)	USA	U	HIC	Phone, flyers, presentations		SSB; 100% fruit or vegetable juice; High-fat foods	6.7 y	BMI; %BF
Costa 2020	Costa et al., 2020 (190)	Brazil	U	MIC	Clinic		Ultra-processed foods	6–11 y	Fat Mass Index
Cowin 2001	Johnson et al., 2007 (105)	UK	NS	HIC			SSB; 100% fruit juice; Low energy drinks	5.2 y; 7.2 y	Change in fat mass (DXA)/serving
DeBoer 2013	DeBoer et al., 2013 (125)	USA	NS	HIC	"Complex sampling design"		SSB	2 y	BMI at 4 y and 5 y
DeCoen 2014	De Coen et al., 2014 (126)	Belgium	NS	HIC	School		Soft drinks; Sweet and savory snacks	4.95 y	BMI (overweight)
Dubois 2007	Dubois et al., 2007 (106)	Canada	U	HIC	Clinic		SSB between meals	2.5 y	OB (BMI >95th Percentile)

Emond 2020	Emond et al., 2020 (61)	USA	U	HIC	Clinic, childcare center, community and recreation events	Fast food	3–5 y	Change in BMI status (normal to overweight or overweight to obese)
Faith 2006	Faith et al., 2006 (52)	USA	U	HIC	Families participating in supplementary nutrition programme	Fruit juice	30.2 mo	BMI trajectory
Feldens 2010	Costa et al., 2019 (47)	Brazil	U	MIC	Clinic	Biscuits; Breakfast cereal; Powdered chocolate; Processed meat; Savory; Soft drink; Sugary milk beverages; Sweets; Others; Total ultraprocessed foods	4 y	BMI; WC; WHtR; SSF
Fiorito 2009	Fiorito et al., 2009 (97)	USA	NS	HIC	Flyers and newspaper advertisements	Sweetened beverage	5 y	Body fat; BMI
Flores 2013	Flores et al.,2013 (127)	USA	NS	HIC	NS	Sugary beverages	9 mo	BMI ≥ 99th percentile (severe obesity)
Garden 2011	Garden et al., 2011 (35)	Australia	U	HIC	Clinic	Extra foods; Dairy products	18 mo	BMI; WC; WHtR; SSF
	Garden et al., 2012 (199)	Australia	U	HIC		Extra foods; Dairy products	18 mo	BMI trajectory
	Zheng et al., 2015 (128)	Australia	U	HIC		100% fruit juices; Diet drinks; SSB	8 y	BAZ change; %BF
Guerrero 2016	Guerrero et al., 2016 (107)	USA	NS	HIC	NS	Soda; Juice; Fast food	9 mo	BMI trajectory
Hasnain 2014	Hasnain et al., 2014 (108)	USA	NS	HIC	NS	Fruit and vegetable juices; SSB; ASB	3–5 y	BMI; %BF
Hooley 2012	Millar et al., 2014 (44)	Australia	Both	HIC	Approached at home	SSB; High-fat foods	4.8 y	BAZ
	Wheaton et al., 2015 (200)	Australia	Both	HIC	Approached at home	SSB	4–5 y	Stability of weight status

	Zulfiqar et al., 2019 (41)	Australia	Both	HIC			SSB; High-fat foods	4.2 y	Boys: OW/OB v non-OW/OB; Girls: OW/OB vs non-OW/OB
Hur 2015	Hur et al., 2015 (129)	South Korea	U	HIC	School		Beverage sugar; Other sugar (total sugar minus that from fruit, milk, and beverages)	9.9 y	BAZ, body fat
Huus 2009	Huus et al., 2009 (138)	Sweden	NS	HIC	NS		SSB; Fried potato/French fries; Sausage; Cream/creme fraiche; chips; Cheese; Pastries; Chocolate; Candy; Lemonade; Ice-cream	Birth	BMI (OW/OB) at 5 y
Hwang 2020	Hwang et al., 2020 (130)	South Korea	NS	HIC	Clinic		SSB at 21 mo; SSB at 33 mo; SSB at 45 mo	5 mo	Adiposity rebound
Ismail 2008	Lim et al., 2009 (55)	USA	U	HIC	Home		All SSB	6.7 y	BMI ≥ 85th percentile
Jackson 2017	Jackson et al., 2017 (109)	USA	NS	HIC	School		SSB; Fast food	5.6 y	BMI
Jardi 2019	Jardi et al., 2019 (60)	Spain	U	HIC	Clinic		Free sugars	0 mo	Weight at 30 mo (excess or non-excess weight)
Jensen 2013 (1)	Jensen et al., 2013a (110)	Denmark	U	HIC	School	Pre/post study with a control	Sweet drinks; SSBs; Soft drinks only	6.7 y	BMI change
Kramer 2004	Kramer et al., 2004 (111)	Belarus	Both	MIC	Clinic		Juice or other liquids	1 mo	Weight-for-age at 1–3 mo; 3–6 mo; 6–9 mo and 9–12 mo
Laurson 2008	Laurson et al., 2008 (112)	USA	R	HIC	Community		SSB; Change in SSB consumption	Boys 10.8 y; Girls 10.7 y	BMI change
Leermakers 2015	Leermakers et al., 2015a (187)	Netherlands	U	HIC	Clinic		Sugar containing beverages	12.9 mo	BMI at 2 y; 3 y; 4 y; 6 y; %BF; Android/gynoid fat ratio

Libuda 2008	Alexy et al., 1999 (142)	Germany	U	HIC	Contacts, maternity wards, and clinics		Fruit juice	Boys 3 y; Girls 3 y	BMI
	Buyken et al., 2008 (48)	Germany	U	HIC			Added sugar	2 y	Change in body fat (SSF); Change in BMI
	Herbst et al., 2011 (49)	Germany	U	HIC			Total added sugars; Added sugar from beverages and sweets; Added sugar from other sources	1 y	Change in body fat (SSF); Change in BMI
Lissau 1993	Lissau et al., 1993 (143)	Denmark	U	HIC	School		Sweets/candies	9–10 y	BMI >90th percentile (overweight)
Macintyre 2018	Macintyre et al., 2018 (114)	UK	Both	HIC	NS		SSB; ASB	4–5 y	BMI (normal weight vs OW/OB); BMI (non obese vs obese)
Marshall 2003	Marshall et al., 2018 (201)	USA	NS	HIC	Clinic		Beverages	2–4.7 y	Height
	Marshall et al., 2019 (51)	USA	NS	HIC			100% juice; SSB	2–4.7 y	BMI
Moore 2019	Moore et al., 2019 (115)	USA	U	HIC	Clinic		Snack food; Sweets	3–12 mo	Weight-for-length
Muckelbauer 2016	Muckelbauer et al., 2016 (53)	Germany	U	HIC	School	RCT	Sugar containing beverages; Soft drinks; Juice	8.3 y	Mean change in BMI; % overweight and obesity
Newby 2004	Newby et al., 2003 (131)	USA	Both	HIC	Clinic		'Fat foods'	Boys 2.9 y; Girls 2.9 y	Weight change/y
	Newby et al., 2004 (116)	USA	Both	HIC			Fruit juice only; Juice drinks; Soda; Diet soda	2.9 y	Weight change; BMI change
Olafsdottir 2014	Olafsdottir et al., 2014 (117)	Belgium, Cyprus, Estonia, Germany, Hungary, Italy, Spain, and Sweden	Both	HIC	Schools and kindergartens		SSB	2–<6 y; 6–<10 y	% increase in BMI; % increase in WHtR
	Russo et al., 2018 (45)	Belgium, Cyprus, Estonia, Germany, Hungary, Italy, Spain, and Sweden	Both	HIC			Added sugars to milk and fruit	Boys 4.2 y; Girls 4.2 y; Boys 7.4 y; Girls 7.4 y	BMI; WC; SSF; %BF

Olsen 2012	Olsen et al., 2012 (139)	Denmark	U	HIC	School	Added sugar; Liquid sucrose; Solid sucrose	Boys 9.7 y; Girls 9.4 y (combined in analysis)	BMI; WC
Pan 2014	Pan et al., 2014 (56)	USA	NS	HIC	Mail	SSB, any from 1-12 mo; SSB mean weekly 10-12 mo	~1 mo	OB (BMI-for-age ≥ 95th percentile)
Quah 2019	Quah et al., 2019 (54)	Singapore	U	HIC	Clinic	SSB	18 mo	BMI; SSF; OW/OB
Santorelli 2014	Santorelli et al., 2014 (136)	UK	U	HIC	Clinic	SSB; sweetened first foods	6 mo	BMI-for-age z-score
Shefferly 2016	Shefferly et al., 2016 (118)	USA	NS	HIC	School	Fruit juice at 2-4 y; Fruit juice at 4-5 y	2 y	Height; Weight; BMI; Overweight BMI; Obese BMI
Skinner 1999	Skinner et al., 1999 (202)	USA	NS	HIC	Posters, referrals, and birth announcements	100% fruit juice	2–2.7 y	BMI and ponderal index
	Skinner et al., 2001 (132)	USA	NS	HIC		100% fruit juice	27 mo	BMI
Sonneville 2015	Sonneville et al., 2015 (57)	USA	U	HIC	Clinic	100% fruit juice	1 y	BAZ
Striegel-Moore 2006	Striegel-Moore et al., 2006 (98)	USA	NS	HIC	School	Diet soda; Regular soda; Fruit juice; Fruit drinks	9–10 y	BMI
Sugimori 2004	Sugimori et al., 2004 (144)	Japan	NS	HIC	NS	Juice; Noodles	3 y	BMI Status
Tam 2006	Tam et al., 2006 (140)	Australia	U	HIC	Clinic	Soft drinks/cordial; Fruit juice/fruit drinks	7.7 y	BMI gains/losses
Thurber 2017	Thurber et al., 2017 (134)	Australia	Both	HIC	Directly approached families and snowball	SSB; High-fat foods	0.5–2 y and 3–5 y; 0.5–2 y; 3–5 y	BMI
Traub 2018	Traub et al., 2018 (119)	Germany	NS	HIC	School	Soft drinks	7.08 y	BMI >90th age and gender specific percentile; BMI >97th age and gender specific percentile; WHtR
Vilela 2014	Durao et al., 2015 (120)	Portugal	U	HIC	Clinic	Energy-dense foods	2 y	BAZ

	Vedovato et al., 2020 (50)	Portugal	U	HIC			Ultra-processed foods	4 y	BMI at 4 y; BMI at 7 y
Wan 2020	Wan et al., 2020 (135)	USA	U	HIC	Original cohort members' descendants		100% fruit juice	3–6 y	BMI
Wang 2013	Wang et al., 2013 (26)	China	U	MIC	Clinic		Sweet drinks	1 mo	% OW/OB
Weijs 2011	Weijs et al., 2011 (141)	Netherlands	NS	HIC	Magazine publisher notice		Beverage sugar	8.7 mo	% overweight; BMI SD score
Welsh 2005	Welsh et al., 2005 (121)	USA	NS	HIC	Clinic	RCS	Sweet drinks; Fruit juices only	33.8 mo	BMI ≥ 95th percentile in those with BMI <85th percentile at baseline; BMI ≥ 95th percentile in those with BMI 85th-<95th percentile at baseline; BMI ≥ 95th percentile in those with ≥95th percentile at baseline
Wijga 2010	Wijga et al., 2010 (42)	Netherlands	NS	HIC	Clinic patients		Fast food; Snack; Soft drink	3–12 mo	% OW/OB
Zheng 2014	Zheng et al., 2014 (100)	Denmark	U	HIC	School		SSB	9.6 y	BMI; WC; SSF (4 sites)

[1]ASB, artificially-sweetened beverages; BAZ, BMI-for-age z score; DXA, dual-energy X-ray absorptiometry; HIC, high-income country; MIC, middle-income country; NS, not stated; OW/OB, overweight including obesity; OB, obesity only; R, rural; RCT, randomized controlled trial; RCS, retrospective cohort study; SSB, sugar-sweetened beverages; SSF, sum of skinfolds; U, urban; WC, waist circumference; WHtR, waist-to-height ratio; %BF, percentage body fat.
[2]Calculated using the World Bank Atlas method for the 2021 fiscal year (based on gross national income per capita in 2019), https://datahelpdesk.worldbank.org/knowledgebase/articles/906519-world-bank-country-and-lending-groups
[3]Prospective cohort study, unless otherwise stated.

TABLE 8 Characteristics of included studies reporting on diet-related non-communicable disease indicators, displacement of healthy foods/breastmilk or diet quality and diversity (critical outcomes)[1]

Study ID	Reference	Country	Setting (R/U)	Income level[2]	Recruitment method	Study design	Exposure	Baseline age (mean or range)	Outcome assessed
Diet-related non-communicable disease indicators									
Chaffee 2015	Leffa et al., 2020 (146)	Brazil	U	MIC	Clinic		Ultraprocessed food	3.2 y	TC; LDL-C; HDL-C; TAG
Cowin 2001	Cowin et al., 2001 (147)	UK	NS	HIC	Clinic		Biscuits; Chocolate; Butter Biscuits; Breakfast cereal; Powdered chocolate; Processed meat; Savory; Soft drink; Sugary milk beverages; Sweets; Others;	~18 mo	TC; HDL-C
Feldens 2010	Costa et al., 2019 (47)	Brazil	U	MIC	Clinic		Total ultraprocessed foods	4 y	Glucose; Insulin; HOMA-IR
	Rauber et al., 2015 (145)	Brazil	U	MIC	School		Processed products; Ultraprocessed products	3–4 y	TC; LDL-C; HDL-C; TAG
Hur 2015	Hur et al., 2015 (129)	South Korea	U	HIC	Clinic		Beverage sugar; Other sugar (total sugar minus that from fruit, milk, and beverages)	9.9 y	Mean arterial blood pressure; fasting blood glucose; TC; HDL-C; TAG
Leermakers 2015	Leermakers et al., 2015 (113)	Netherlands	U	HIC	Newspaper advertisement, direct mail		Sugar containing beverages	12.9 mo	SBP; DBP; Pulse wave velocity; TC:HDL-C ratio; TAG; insulin
Szymlek-Gay 2009	Szymlek-Gay et al., 2018 (94)	New Zealand	NS	HIC	School	RCT	Red meat	17.2 mo	TC; HDL-C; TC:HDL-C ratio
VanRompay 2015	VanRompay et al., 2015 (25)	USA	U	HIC	School		SSB	9.57 y	HDL-C; TAG
Displacement of healthy foods/breastmilk									

Bayer 2014	Bayer et al., 2014 (122)	Germany	Both	HIC	School	High-caloric drinks; Energy dense sweets	6.0 y	Change in fruit consumption; Change in vegetable consumption
Byrne 2018	Byrne et al., 2018 (103)	Australia	R	HIC	Clinic	SSB	24.1 mo	Fruit and vegetables intake; Milk/milk alternatives
Schiess 2010	Schiess et al., 2010 (148)	Belgium, Germany, Italy, Poland, and Spain	NS	HIC	Clinic	Energy providing liquids	1 mo	Formula milk intake; Solids intake
Dietary quality & diversity								
Olafsdottir 2014	Russo et al., 2018 (45)	Belgium, Cyprus, Estonia, Germany, Hungary, Italy, Spain, and Sweden	Both	HIC	Schools and kindergartens	Sugar added to milk and/or fruit	2–<6 y; 6–<10 y	HDAS
Vilela 2014	Vilela et al., 2014 (149)	Portugal	U	HIC	Clinic	Soft drinks; Salty snacks; Cakes; Sweets; Energy dense foods	25 mo	HEI at 4 y
Wan 2020	Wan et al., 2020 (135)	USA	U	HIC	Original cohort members' descendants	100% fruit juice	3–6 y	HEI–2015 at 14–17 y
Woo 2020	Woo et al., 2020 (150)	USA	U	HIC	NS	Soft drinks; Saturated fat	3 y	HEI–2005

[1]DBP, diastolic blood pressure; HDL-C, HDL cholesterol; HEI, healthy eating index; HIC, high-income country; HDAS, Healthy Dietary Adherence Score; HOMA-IR, homeostatic model assessment of insulin resistance; LDL-C, LDL cholesterol; MIC, middle-income country; NS, not stated; R, rural; RCT, randomized controlled trial; SBP, systolic blood pressure; SSB, sugar-sweetened beverages; TAG, triacylglycerol; TC, total cholesterol; U, urban.

[2]Calculated using the World Bank Atlas method for the 2021 fiscal year (based on gross national income per capita in 2019), https://datahelpdesk.worldbank.org/knowledgebase/articles/906519-world-bank-country-and-lending-groups

[3]Prospective cohort study, unless otherwise stated.

TABLE 9 Characteristics of included studies reporting on food taste preferences, oral health (dental caries), micronutrient deficiencies or child development (important outcomes)[1]

Study ID	Reference	Country	Setting (R/U)	Income level[2]	Recruitment method	Study design	Exposure	Baseline age (mean or range)	Outcome assessed
Food taste preferences									
Beauchamp 1984	Beauchamp et al., 1984 (151)	USA	U	HIC	Clinic		Sweetened water	6 mo	Sweet acceptability
Byrne 2018	Jackson et al., 2020 (152)	Australia	R	HIC	Clinic		Soft drinks; Sweet biscuits; Fruit drink; Cake; Lollies	13.7 mo	High liking of soft drinks; Sweet biscuits; Fruit juice; Cake; Lollies
Fiorito 2010	Fiorito et al., 2010 (99)	USA	NS	HIC	Flyers and newspaper advertisements		SSB	5 y	Fruit juice consumption at 15 y; Soda consumption at 15 y
Liem 2002	Liem et al., 2002 (155)	USA	NS	HIC	Newspaper advertisement	RCS	Habitually added sugar intake	4–7 y	Sweet taste preference
Nicklaus 2004	Nicklaus et al., 2004 (153)	France	U	HIC	Nursery		Cheese; Sausage	2–3 y	Change-from-baseline preference score for cheese and sausage
Okronipa 2019	Okronipa et al., 2019 (34)	Ghana	Semi-U	MIC	Phone	RCT	Slightly sweet LNS	6 mo	Sucrose solution most preferred (% wt/vol)
Pan 2014	Park et al., 2014 (154)	USA	NS	HIC	Mail		SSB	~3 wk	Daily SSB intake at 6 y
Oral health (Dental caries)									
Bankel 2011	Bankel et al., 2011 (175)	Sweden	U	HIC	Phone and clinic	RCS	Sugar-containing items	2 y	defs plus initial caries calculated
Bernabe 2020	Bernabe et al., 2020 (174)	Scotland	U	HIC	Clinic		SSB	12.8 mo	dmfs
Chaffee 2015	Chaffee et al., 2015 (37)	Brazil	U	MIC	Clinic		6 mo sweet index; 12 mo sweet index	6 mo	Severe ECC; dmft
deMelo 2019	deMelo et al., 2019 (158)	Brazil	U	MIC	Clinic		Sweets	30 mo	dmft index
Devenish 2020	Devenish et al., 2020 (159)	Australia	U	HIC	Clinic		Energy as free sugars	3 mo	Presence of ECC
Feldens 2010	Feldens et al., 2010 (36)	Brazil	U	MIC	Clinic		High density of sugar	6 mo	Severe EEC at 4 y

Grindefjord 1996	Grindefjord et al., 1996 (160)	Sweden	U	HIC	NS	Sugar-containing beverages; Candy	30 mo	Initial/manifest dental caries
Hao 2015	Hao et al., 2014 (27)	China	U	MIC	Clinic	Sweets/candies	3 y	dmfs
	Hao et al., 2015 (161)	China	U	MIC		Sweets/candies	3 y	dmfs
Holt 1991	Holt et al., 1991 (181)	UK	U	HIC	NS	Sweetened snacks or drinks	2 y	dmft
Hooley 2012	Hooley et al., 2012 (162)	Australia	Both	HIC	Home	Sweet drinks; High-fat foods	4.79 y	Dental caries (reported by primary caregiver) at 6–7 y and 8–9 y
Ismail 2008	Ismail et al., 2008 (163)	USA	U	HIC	Home	Soda beverages	0–5 y	ECC; Severe ECC
	Ismail et al., 2009 (203)	USA	U	HIC		Soda beverages	2.6 y	Caries increment
	Lim et al., 2015 (204)	USA	U	HIC		Soda beverages	0–5 y	dmfs
	Lim et al., 2019 (205)	USA	U	HIC		Soda beverages	0–5 y	Dental caries
Jordan 2020	Jordan et al., 2020 (164)	USA	R	HIC	Community centers	Juice	8–18 mo	dmfs
MacKeown 200	MacKeown et al., 2000 (176)	South Africa	U	MIC	NS	Added sugar	1 y	dmfs incidence
Marshall 2003	Chankanka et al., 2011 (206)	USA	NS	HIC	Clinic	Meals and snacks: beverages, fruit juices, soda, sports drinks, desserts, candy, added sugar, processed starch foods	5.0 y	New cavitated caries
	Chankanka et al., 2015 (207)	USA	NS	HIC		Sodas; juice drinks; 100% fruit juice	5.1 y	dmfs
	Curtis et al., 2018 (208)	USA	NS	HIC		SSB; 100% juice	7–9 y	dmfs
	Levy et al., 2003 (192)	USA	NS	HIC		Pop/sports drink consumption at 12-24 mo; Pop/sports drink consumption at 36-48 mo; Sugar beverages at 12-24 mo	6 wk	d_1 lesions; d_{2-3} lesions

	Marshall et al., 2003 (39)	USA	NS	HIC		Regular soda pop; Sugar-containing powdered beverages	1 y	d_1 lesions; d_{2-3} lesions
	Warren et al., 2002 (209)	USA	NS	HIC		Soft drinks; juice	4.7 y	Tooth wear
Mattila 2001	Mattila et al., 2001 (210)	Finland	Both	HIC	Clinic	Sweets	3 y	Dental caries: dmfs score
	Mattila et al., 2005 (165)	Finland	Both	HIC		Sweets; Daily sugar consumption	18 mo	dmft/DMFT score at 10 y
Meurman 2010	Meurman et al., 2010 (166)	Finland	U	HIC	Clinic	Added sugar; Sweet snacks	18 mo	dmfs
Pan 2014	Park et al., 2014 (154)	USA	NS	HIC	Mail	SSB	10–12 mo	Dental caries
Pang 2015	Pang et al., 2015 (28)	China	Both	MIC	School	Soda drinks; cookies and sweet breads	3–6 y	DMFT/dmft caries
Peltzer 2014	Peltzer et al., 2014 (177)	Thailand	NS	MIC	Clinic	Sweet candy	24 mo	dmft and dmfs
	Peltzer & Mongkolchati, 2015 (211)	Thailand	NS	MIC		Sweet food index	30 mo	Severe ECC
Peres 2016	Peres et al., 2016 (156)	Brazil	U	MIC	Clinic	Sugar intake	1 mo	dmft score
Rodrigues 2000	Rodrigues et al., 2000 (157)	Brazil	U	MIC	School	Sugary food	3 y	Change in dmfs
Ruottinen 2004	Karjalainen et al., 2001 (212)	Finland	U	HIC	Clinic	Sweet intake	37.4 mo	dmft
	Karjalainen et al., 2015 (167)	Finland	U	HIC		Added sucrose (sucrose and other free sugars)	3 y	dmft/DMFT
	Ruottinen 2004 (38)	Finland	U	HIC		Sucrose-containing foods	13 mo	dmft and DMFT
Sakuma 2007	Sakuma et al., 2007 (168)	Japan	NS	HIC	Clinic	SSB; Sweets	1.5 y	Change in caries
Skafida 2018	Skafida et al., 2018 (169)	UK	NS	HIC	Child Benefits Register (random sample)	Soft drinks; Sweets/chocolate	2 y	Dental decay (decayed, extracted or filled teeth)
Tamaki 2009	Tamaki et al., 2009 (178)	Japan	U	HIC	School	Sweet juice; Sweet snacks	5 or 6 y	Incident caries (baseline to follow-up)

Thornley 2020	Thornley et al., 2020 (179)	New Zealand	Both	HIC	Clinic	RCS	Sugary soft drinks; Fruit juice; Confectionary/cakes; Noodles/rice porridge; Ice-cream; Takeaways	2 y	dmft
Warren 2009	Warren et al., 2009 (170)	USA	NS	HIC	Clinic		SSB	6–24 mo	Cavitated and non-cavitated dental lesions
Watanabe 2014	Watanabe et al., 2014 (171)	Japan	NS	HIC	Clinic		SSB; Sweet snacks	1.5 y	Dental caries
Wigen 2015	Wigen et al., 2015 (172)	Norway	NS	HIC	Mail		SSB	1.5 y	sum of dmft
Winter 2015	Winter et al., 2015 (180)	Germany	NS	HIC	School		Sugar index	3.5 y	dmft increment
Wu 2020	Wu et al., 2020 (29)	China	Both	MIC	School		Candy	4.2 y	dmft rate
Micronutrient deficiencies									
Olaya 2013	Olaya et al., 2013 (95)	Colombia	U	MIC	Clinic	RCT	Red meat	6 mo	Hb; Hematocrit
Sheng 2019	Sheng et al., 2019 (96)	China	R	MIC	Clinic	RCT	Meat (pork)	6 mo	Serum vitamin B12 concentration; Serum tHcy concentration
Szymlek-Gay 2009	Szymlek-Gay et al., 2009 (93)	New Zealand	NS	HIC	Newspaper advertisement, direct mail	RCT	Red meat	17.1 mo	Hb; Serum ferritin; Serum transferrin receptor
Child development									
Cowin 2001	Mesirow et al 2017 (213)	UK	NS	HIC	NS		Processed foods	4 y	SDQ
	Peacock et al., 2011 (183)	UK	NS	HIC	NS		NMES intake at 81 mo	81 mo	SDQ; Total difficulties at 81 and 97 mo
	Wiles et al., 2009 (185)	UK	NS	HIC			NMES intake at 4.5 y	38 mo	SDQ; Total difficulties at 7 y
Hulett 2014	Hulett et al., 2014 (92)	Kenya	R	MIC	School	RCT	Red meat (ground beef)	7.1 y	Test scores English; Arithmetic; Kiswahili; Kiembu; Science; Geography; Arts; Total

Sheng 2019	Sheng et al., 2019 (96)	China	R	MIC	Clinic	RCT	Meat (pork)	6 mo	Cognitive function; Fine motor function; Gross motor function
Sonneville 2015	Cohen et al., 2018 (186)	USA	U	HIC	Clinic		SSB (regular soda and fruit drinks (but not 100% fruit juice)); Juice; Diet soda	3.3 y	PPVT-III; WRAVMA, Total early childhood; KBIT-II, verbal, mid-childhood; KBIT-II, non-verbal, mid-childhood; WRAVMA, Drawing, mid-childhood; WRAML, visual memory, mid-childhood
Thorne-Lyman 2019	Thorne-Lyman et al., 2019 (184)	Nepal	R	MIC	Village Development Committee	RCT	Processed food	14.9 mo	ASQ-3 total score; ASQ-3 communication; ASQ-3 gross motor; ASQ-3 fine motor; ASQ-3 problem solving; ASQ-3 personal-social

[1]ASQ-3, Ages and Stages questionnaire-version 3; defs, Decayed with manifest caries, extracted and filled surfaces; dmfs, decayed-missing-filled surfaces (for primary teeth); DMFS, decayed-missing-filled surfaces (for permanent teeth); dmft, decayed-missing-filled teeth (for primary teeth); DMFT, decay-missing-filled teeth (for permanent teeth); d1, non-cavitated lesions; d2-3, cavitated lesions; ECC, early childhood caries; HIC, high-income country; Hb, hemoglobin; KBIT-II, Kaufman Brief Intelligence Test, second edition; LNS, lipid-based nutrient supplement; MIC, middle-income country; NMES, Non-milk extrinsic sugars; NS, not stated; PPVT-III, Peabody Picture Vocabulary Test, 3rd Ed; R, rural; RCS, retrospective cohort study; RCT, randomized controlled trial; SDQ, Strengths and Difficulties Questionnaire; SSB, sugar-sweetened beverages; tHcy, total homocysteine; U, urban; WRAML, Wide Range Assessment of Memory and Learning; WRAVMA, Wide Range Assessment of Visual Motor Abilities.

[2]Calculated using the World Bank Atlas method for the 2021 fiscal year (based on gross national income per capita in 2019), https://datahelpdesk.worldbank.org/knowledgebase/articles/906519-world-bank-country-and-lending-groups

[3]Prospective cohort study, unless otherwise stated.

TABLE 10 Synthesis of results of effects of unhealthy foods and beverage consumption and body mass index and percentage overweight and obesity outcomes[1]

Study ID	Reference	Baseline age (mean or range)	Follow-up duration	N[2]	DAT	Exposure	Intake unit	Comparator	Outcomes	Estimate*	Overall RoB
SSB											
0–<2 y											
Cantoral 2016	Cantoral et al., 2016	12 mo	8–14 y	227	3-mo FFQ		Cumulative consumption in pre-school years	Third vs. first tertile SSB cumulative consumption	Obesity (%) (>2SD BMI z score, WHO 2006)	OR = 2.99, 95% CI: 1.27, 7.00.	Serious
Flores 2013	Flores et al.,2013	9 mo	~59 mo	6800	Caregiver questionnaire		Frequency in last wk	Usually consumed at age 2 y; consumed at age 5.7 y at least once/wk vs. none	Severe obesity (%) (BAZ >99th percentile, CDC 2000)	At 2 y P = NS; At 5 y OR = 2.3, 95% CI 1.4, 3.7.	Serious
Huus 2009	Huus et al., 2009	2.5 y	5 y	16058	7-d FFQ		Frequency/wk	Daily vs. <1 time/wk	OW/OB (%) at 5 y (Cole 2000)	OR = 1.14, 95% CI 0.90, 1.45, P = 0.270.	Critical
Leermakers 2015	Leermakers et al., 2015	12.9 mo	59 mo	1183 boys; 1188 girls	1-mo FFQ		Servings/wk	High (15 servings/wk) vs. low (3 servings/wk)	BAZ change (IOTF references) from 2-6 y	Boys: β = 0.05, 95% CI = −0.08, 0.18, p =0.42; girls β = 0.11, 95% CI = 0.00, 0.23, P = 0.04 at 6 y.	Moderate
Santorelli 2014	Santorelli et al., 2014	6 mo	2.5 y	743	Caregiver questionnaire		Consumed/not consumed <17 wk	Consumed vs. not consumed <17 wk	BMI-for-age z-score (WHO 2006)	Mean diff = -0.10, 95% CI = -0·36, 0·16.	Serious
Pan 2014	Pan et al., 2014	~1 mo	6 y	1189	7-d recall via postal questionnaire each month		Consumed/not consumed from 1-12 mo; Mean weekly consumption	Any: <1 time/wk; 1 to <3 times/wk; ≥ 3 times wk vs. none	OB (%) (BAZ ≥ 95th percentile, CDC 2000)	≥3 times/wk (OR = 2.00, 95% CI = 1.02, 3.90); 1-<3 times/wk (OR = 1.64, 95% CI = 0.65, 3.48); <1 times/wk (OR = 1.51, 95% CI = 0.65, 3.48) vs. none. High vs. low intake at 18 m and BMI z score at 6 y (β = 0.06, 95% CI = -0.20, 0.31, p = 0.676); % overweight/obesity (RR = 1.10, 95% CI = 0.67, 1.81, p = 0.204): High vs. low intake at 5 y and BMI z score at 6 y (β = 0.34, 95% CI = 0.11, 0.58, p = 0.004), % OW/OB (RR = 1.54, 95% CI = 1.03, 2.30, p = 0.033).	Serious
Quah 2019	Quah et al., 2019	18 mo	42 mo	767	Self administered FFQ		mL	High vs. low intake	BAZ; OW/OB (%) (WHO 2006)		Serious
Wang 2013	Wang et al., 2013	1 mo	17 mo	1956	Questionnaire administered parental report on monthly intake		Frequency/wk	> 1 x wk vs. ≤ 1 x wk	OW/OB (%) (BAZ ≥ 85th percentile, WHO 2006)	Unadjusted OR = 1.6, CI = 1.04, 1.93, p <0.01.	Serious

Weijs 2011	Weijs et al., 2011	8.7 mo	8 y	120	2-d food record parental recorded	g/d	Continuous	BAZ; OW/OB (%) (WHO BMI z score >+1) at 8 y	BMI: β= 0.044, 95% CI 0.008, 0.080, p = 0.016; OW/OB: OR = 1.13, 95% CI = 1.03, 1.24, P = 0.009	Critical
Wijga 2010	Wijga et al., 2010	3–12 mo	7 y 8 mo	1871	3-d weighed diet record completed by parents	kJ/wk	Frequency/mo (continuous)	OW/OB (%) (Cole 2000)	OR = 0.91, 95% CI = 0.44, 1.88	Serious
2–<5 y										
Byrne 2018	Byrne et al., 2018	24.1 mo	3 y; 3.7 y; 5 y	515 at 2 y; 405 at 5 y	Multiple pass 24-h dietary recall	Median (IQR) intake (g) of each beverage group and % of energy intake	Continuous	BAZ (WHO 2006)	P > 0.05	Moderate
DeBoer 2013	DeBoer et al., 2013	2 y	3 y	9600	Parent interviewed by trained assessors at 2, 4 and 5 y	Frequency/d	≥ 1 serving/d at 2 y vs. < 1 serving/d at 2 y	BAZ (CDC 2000) at 4 y and 5 y	No estimates reported for longitudinal analysis	Serious
DeCoen 2014	De Coen et al., 2014	4.95 y	30 mo	568 at 18 mo; 473 at 30 mo	Validated semi-quantitative 1-m FFQ	mL/d	>65 mL/d vs. <65 mL/d (median intake)	OW/OB (%) (Flemish references)	OR = 1.92, 95% CI = 1.19, 3.11, P ≤ 0.01 at 18 mo; OR = 1.82, 95% CI = 1.11, 3.00, P ≤ 0.05 at 30 mo	Serious
Dubois 2007	Dubois et al., 2007	2.5 y	2.5 y	1499	Self-administered FFQ at 2.5, 3.5, and 4.5 y & 24-hour recall at 4.5 y	Frequency/wk	Regular consumers at age 2.5, 3.5, and 4.5 y vs. Non-consumers; Between meal consumers vs. non-between meal consumers	OB (%) (> 95th percentile, CDC 2000)	Total daily consumption not significant; between meal consumption OR =2.356, 95% CI = 1.030, 5.390, P ≤ 0.05	Moderate
Feldens 2010	Costa et al., 2019	4 y	4 y	315	Two 24-h dietary recalls	%EI	Continuous	BAZ change (WHO 2006)	β -0.01, 95% CI -0.05 to 0.04, P = 0.852	Moderate
Hasnain 2014	Hasnain et al., 2014	3–5 y	12 y	98	3-d diet records	oz/d	Tertile 1 vs. 2; Tertile 1 vs. 3; Tertile 2 vs. 3	BMI (kg/m^2)	ANCOVA P = 0.0626	Moderate
Hooley 2012	Millar et al., 2014	4.8 y	6.1 y	4169	Parental reported 24-h recall, face to face interviews	Frequency/d	not at all; once/d; > once/d	BAZ (WHO 2006)	β = 0.017, 95% CI = 0.007, 0.027, P < 0.01	Moderate
	Zulfiqar et al., 2019	4.2 y	6 y	2163 boys; 2044 girls	Parental report up to 8–9 y, then children self-report (computer-based)	Frequency/d	≥ 1 vs. 0	OW/OB (%) (IOTF references): boys; girls	Boys: OR = 1.01, 95% CI = 0.8, 1.29; Girls: OR = 1.08, 95% CI = 0.87, 1.35	Moderate

Macintyre 2018	Macintyre et al., 2018	4–5 y	3 y	2986	Parent interview	Frequency/wk	1-6 times/wk; At least once/d; <once/wk	OW/OB (%) (85th and 95th percentile); Obesity (%) (UK references, Cole 1990)	Overweight/obesity: OR = 1.18, 95% CI 0.63, 1.15, P = 0.19; Obese: OR= 1.65, 95% CI = 1.12, 2.44, P = 0.01	Moderate
Marshall 2003	Marshall et al., 2019	2–4.7 y	12.3–15 y	454	7-d beverage frequency questionnaire	oz/d	Continuous	BAZ (CDC 2000)	β = 0.05, 95% CI = 0.022, 0.079, P = 0.001	Moderate
Newby 2004	Newby et al., 2004	2.9 y	8.4 mo	1345	1-mo FFQ	oz/d	Continuous	BMI/y	Fruit drinks: β = -0.01, SE = 0.00, P = 0.20; Soda: β = -0.01, SE = 0.02, P = 0.50	Moderate
Welsh 2005	Welsh et al., 2005	33.8 mo	~1 y	10904	Frequency Questionnaire (HFFQ)	Drinks/d	1≤2; 2≤3; ≥ 3 vs. 0≤1 times/d	Odds of OW/OB based on baseline BMI category status (CDC, 2000) ≥ 95th percentile in those with BMI <85th percentile at baseline; BMI ≥ 95th percentile in those with BMI 85th-<95th percentile at baseline; BMI ≥ 95th percentile in those with ≥95th percentile at baseline	OR = 1.3, 95% CI = 0.8, 2.1, ≥ 3/d vs. 0-<1/d among those normal weight at baseline	Moderate
5– 10 y										
Alviso-Orellana 2018	Alviso-Orellana et al., 2018	8 y	4 y	1414	30-d recall	Frequency per 2 wk/wk/d	up to every 2 wk; 2-6 times/wk; daily or never	BMI change (kg/m^2); OW/OB (%)	β = 0.74, 95% CI = 0.15, 1.33, daily vs. no intake; OW/OB aRR = 2·12, 95% CI 1·05, 4·28	Moderate
Bayer 2014	Bayer et al., 2014	6.0 y	4 y	1252	Self administered parental questionnaire	Servings/d	Continuous	Normal weight/overweight assessed by BMI z score	No estimates reported	Serious
Blum 2005	Blum et al., 2005	9.3 y	2 y	164	24-h dietary recall	oz/d	Continuous	Amount of SSB consumed according to BMI category (using CDC 2000)	ANOVA P > 0.05, unadjusted	Critical
Carlson 2012	Carlson et al., 2012	6.7 y	24 mo	254	Parent survey average consumption/d	Servings/d	Continuous	BAZ (CDC 2005)	Unstandardized β = 0.11, CI = -0.03, 0.25, P = 0.124	Serious

Fiorito 2009	Fiorito et al., 2009	5 y	10 mo	166	Three 24-h recalls	Servings/d	≥1 and <2 servings/d vs. <1 servings/d; ≥2 servings/d vs. <1 servings/d	BMI (kg/m^2)	ANOVA exposure group: P = NS; age: NS; group* age: NS)	Serious
Garden 2011	Zheng et al., 2015	8 y	3.5 y	158	Three 24-h recalls using multiple pass approach at age 9 y by telephone	g/d	per 100g/d	BAZ change (CDC 2000)	β = 0.10, SE = 0.03, P = 0.003	Serious
Hur 2015	Hur et al., 2015	9.9 y	4 y	605	3-d food record	g/d	Continuous	BAZ (Korean growth standards)	β = -0.02, SE = 0.03, P > 0.05	Serious
Ismail 2008	Lim et al., 2009	6.7 y	8.7 y	254	Quantitative FFQ	oz/d	Continuous	Overweight/obesity (%) (BMI ≥ 85th percentile (CDC 2000)	OR = 1.04, 95%CI = 1.01,1.07, P < 0.05	Moderate
Jackson 2017	Jackson et al., 2017	5.6 y	9 y	4938	1-wk FFQ	Servings/d	Times /d or times/wk (7 categories)	BAZ (CDC 2000)	P > 0.05 (parameter estimate from a cross-lagged autoregressive model)	Moderate
Jensen 2013 (1)	Jensen et al., 2013a	6.7 y	13.3 y	324	FFQ average of 5 and 7 y	kJ/d	Continuous	BMI change (kg/m^2)	Sweet drinks Intake at 6 y and BMI change 6–9 y (β = -0.014, 95% CI = -0.063, 0.035, P = 0.55), 6–13 y (β = -0.049, 95% CI = -0.1299, 0.024, P = 0.18) or 9–13 y (β = -0.036, 95% CI = -0.017, 0.088, P = 0.17). SSBs (soft drinks and squash only) intake at 6 y and BMI change 6–9 y (β = -0.005, 95% CI = -0.059, 0.049, P = 0.84); 6–13 y (β = -0.059, 95% CI = -0.145, 0.027, P = 0.17) or 9–13 y (β = 0.008, 95% CI = -0.098, 0.113, P = 0.88)	Moderate
Laurson 2008	Laurson et al., 2008	Boys 10.8 y; Girls 10.7 y	18 mo	146 boys; 122 girls	Questionnaire	Servings/wk	Continuous	BMI change (kg/m^2)	Baseline intake: boys β = 0.114, SE = 0.021, p = 0.184, girls β = 0.022, SE = 0.021, P = 0.821; Change in intake baseline to follow up: boys β = -0.037, SE = 0.019, P = 0.707, girls β = 0.086, SE = 0.027, P = 0.450	Moderate
Muckelbauer 2016	Muckelbauer et al., 2016	8.3 y	~10 mo	1987	Semi-quantitative 24-h recall	Glasses/d	Continuous	BMI change (kg/m^2); OW/OB (%)(Cole 2000)	% OB: OR 1·22; 95% CI 1·04, 1·44, P = 0.014; OW/OB P = 0.83; BMI change: β = 0.02, 95% CI 0.00, 0.03	Some concerns

Olsen 2012	Olsen et al., 2012	Boys 9.7 y; Girls 9.4 y	6 y	359	24-h recall interview, FFQ and a qualitative food record	per 10g intake	Continuous	Change in BAZ (Cole & Green 1992)	β = 0.024, SE = 0.017, P = 0.17 SSB: β = 0.011, SE = 0.005, P < 0.05; Fruit juice (not 100%): β = 0.005, SE = 0.007, P > 0.05; Fruit drinks (β = 0.009, SE = 0.007, P > 0.05	Critical
Striegel-Moore 2006	Striegel-Moore et al., 2006	9-10 y	10 y	2371	3-d food record	g/d	Continuous	BMI (kg/m^2)		Serious
Traub 2018	Traub et al., 2018	7.08 y	1 y	1250	Questionnaire completed by parents	Frequency/d; Frequency/wk	> 1 time/wk vs. <1 time/wk	Overweight only (%) BMI >90th percentile; obesity (%) BMI >97th percentile (German references)	Overweight only OR = 1.29, 95% CI = 0.84, 1.96, P = 0.246; obese only OR = 1.57, 95% CI = 0.82, 3.03, P = 0.177	Moderate
Zheng 2014	Zheng et al., 2014	9.6 y	12 y	171	24-h recall; face-to-face interview and qualitative food record	Servings/d	> 1 serving/d vs. ≤ 1 serving/d	BMI change (kg/m^2)	at 9 y > 1 serve β= 1.42, SE 0.68, P = 0.29; <= 1 serve β = 0.53 SE 0.55, P = 0.34; at 15 y > 1 serve β = 0.85, SE 0.54 P = 0.12, <= 1 serve: β = 0.58, SE 0.56 P = 0.30	Moderate
ASB										
Blum 2005	Blum et al., 2005	9.3 y	2 y	164	24-h dietary recall	oz/d	Continuous	BAZ (CDC 2000)	ANOVA P < 0.05	Critical
Garden 2011	Zheng et al., 2015	8 y	3.5 y	158	Three 24-h recalls using multiple pass approach at age 9 y by telephone	g/d	Intake per 100 g/d	BAZ change (CDC 2000)	β = -0.20, SE = 0.07, P = 0.01	Serious
Hasnain 2014	Hasnain et al., 2014	3–5 y	12 y	98	3-d diet records	oz/d	Tertile 1 vs. 2; Tertile 1 vs. 3; Tertile 2 vs. 3	BMI (kg/m^2)	ANCOVA P = 0.444‡	Moderate
Macintyre 2018	Macintyre et al., 2018	4–5 y	3 y	2986	Parent interview	Frequency/wk	At least once/d; 1 - 6 time/wk; <once/wk	OW/OB (%) (85th and 95th percentile); Obese (%)(Cole 1990)	OW/OB: OR = 0.85, 95% CI 0.63, 1.15 P = 0.85; obesity: OR = 1.57, 95% CI = 1.05, 2.36, P = 0.03	Moderate
Newby 2004	Newby et al., 2004	2.9 y	8.4 mo	1345	1-mo FFQ	oz/d	Continuous	BMI/y	β = 0.01, SE = 0.02, P = 0.83	Moderate
Striegel-Moore 2006	Striegel-Moore et al., 2006	9–10 y	10 y	2371	3-d food record	g/d	Continuous	BMI (kg/m^2)	β = 0.01, SE = 0.013, P > 0.05	Serious
100% fruit juice										

0–<2 y										
Budree 2017	Budree et al., 2017	Birth	12 mo	1076	FFQ items consumed on a daily, weekly, and monthly basis	Daily consumption	Daily vs. less than daily	OW/OB (%) (WHO 2006)	Unadjusted OR = 1.0, 95% CI = 0.5, 2.0, P = 0.916	Serious
Guerrero 2016	Guerrero et al., 2016	9 mo	63 mo	15418	Parent interview at 48, 60, and 72-mo	Intake vs. no intake in last 7 d	Any vs. none			Moderate
Sonneville 2015	Sonneville et al., 2015	1 y	median of 2.1 y and 6.7 y	1038	FFQ	oz/d	Large (≥16 oz/d) vs. none; Medium (8-15 oz/d) vs. none; Small (1-7oz/d) vs. none	BMI z score (US growth reference)	β=0.30, 95% CI = −0.01, 0.61 at 2.1 y; β=0. 0.27, 95% CI = −0.05, 0.59 at 6.7 y	Moderate
2–<5 y										
Hasnain 2014	Hasnain et al., 2014	3–5 y	12 y	98	3-day diet records	oz/d	Tertile 1 vs. 2; Tertile 1 vs. 3; Tertile 2 vs. 3	BMI (kg/m^2)	[3]ANCOVA P = 0.062	Moderate
Libuda 2008	Alexy et al., 1999	Boys 3 y; Girls 3 y	Boys 5 y; Girls 5.1 y	205	3-d weighed diet record by parents	g/d	Continuous	BMI (kg/m^2)	No estimates reported	Critical
Marshall 2003	Marshall et al., 2019	2–4.7 y	12.3-15 y	454	7-d beverage frequency questionnaire	oz/d	Continuous	BAZ (CDC 2000)	β = -0.001, 95% CI = -0.059, 0.057, P = 0.97	Moderate
Newby 2004	Newby et al., 2004	2.9 y	8.4 mo	1345	1-mo FFQ	oz/d	Continuous	BMI/y	β = 0.01 SE = 0.00, P = 0.20	Moderate
Shefferly 2016	Shefferly et al., 2016	2 y	2–3 y	6250	7 d recall frequency	Servings/d	≥ 1 serving/d vs. <1 serving/d	Change in BAZ; overweight (%); obese (%) (CDC 2000)	Mean BMI z score change 0.282 (SE 0.028) vs. 0.030 (SE 0.037), P = 0.0003 at 2–4 y, 0.034 (SE 0.031) 0.020 (SE 0.021) P = 0.6778 at 4–5 y; % OW/OB OR = 1.30, 95% CI = 1.06-1.59, P = 0.0129 at 2–4 y; OR = 0.80, 95% CI = 0.43-1.49, P= 0.473 at 4–5 y	Moderate
Skinner 1999	Skinner et al., 2001	27 mo	4 y	72	24-h recall and 2-d weighed food records	oz/d	Continuous	BMI (kg/m^2)	β = -0.057, P = 0.099 (SE not stated)	Serious
Wan 2020	Wan et al., 2020	3–6 y	10 y	100	Multiple sets of 3-day diet records	Cup equivalent/d	<0.5 cups; 0.5 ≤1.0 cups; ≥1.0 cups	BMI (kg/m^2)	No estimates reported	Serious
Welsh 2005	Welsh et al., 2005	33.8 mo	~1 y	10904	FFQ	Drinks/d	1-<2/d vs. 0-<1/d; 2-<3/d vs.	Odds of OW/OB based on baseline BMI category	Odds of overweight among those normal weight at baseline for intake 1-<2 /d	Moderate

								0-<1/d; ≥ 3/d vs. 0-<1/d	status (CDC, 2000) ≥ 95th percentile in those with BMI <85th percentile at baseline; BMI ≥ 95th percentile in those with BMI 85th-<95th percentile at baseline; BMI ≥ 95th percentile in those with ≥ 95th percentile at baseline	(OR = 1.1, 95% CI = 0.8, 1.5); 2-<3/d (OR = 1.0, 95% CI = 0.7, 1.4) or ≥ 3/d (OR = 1.2, 95% CI = 0.8, 1.7) compared to 0-<1/d. Odds of overweight for at risk for overweight at baseline 1-<2/d (OR = 1.1, 95% CI = 0.8, 1.6), 2-<3/d (OR = 1.0, 95% CI = 0.7, 1.4) or ≥ 3/d (OR = 0.8, 95% CI = 0.5, 1.1)	
5– 10 y											
Blum 2005	Blum et al., 2005	9.3 y	2 y	164	24-h dietary recall		oz/d	Continuous	BMI category based on BAZ (CDC 2000)	ANOVA P > 0.05	Critical
Carlson 2012	Carlson et al., 2012	6.7 y	24 mo	254	Parent survey average consumption/day		Servings/d	Continuous	BAZ (CDC 2005)	Unstandardized β = -0.04, CI = -0.21, 0.13, P = 0.631	Serious
Garden 2011	Zheng et al., 2015	8 y	3.5 y	158	Three 24-h recalls using multiple pass approach at age 9 y		g/d	Intake per 100g/d	BAZ change (CDC 2000)	β = 0.07, SE = 0.05, P = 0.12	Serious
Intermediate foods[4]											
2–<5 y											
Huus 2009	Huus et al., 2009	2.5 y	5 y	16058	7-d FFQ	Cheese	Frequency/wk	<1 time/wk vs. daily	OW/OB (%) at 5 y (Cole 2000)	Low vs. high intake at 2.5 y: OR = 0.7, 95% CI 0.55, 0.90, P = 0.005; at 5 y OR= 0.74, 95% CI 0.56, 0.98 P = 0.033	Critical
Unhealthy foods[5]											
0–<2 y											
Garden 2011	Garden et al., 2011	18 mo	6.5 y	362	3-d weighed food record	Extra foods (cookies, crackers, juice, cordial, fruit drinks and soft drinks, fats and oils, snack foods, sugar,	g/d	Quintiles of intake as g/d	BMI (kg/m^2)	Extra foods' β = -0.10, 95% CI = -0.30, 0.11, P = 0.36 for trend; dairy products β = -0.21, 95% CI = -0.41, 0.01, P = 0.04 for trend	Moderate

						confectionary, savory sauces, condiments, fried potatoes, ice-cream, and some miscellaneous foods); Dairy products (milk and milk products, including yoghurt, cheese, ice cream and custard)					
Huus 2009	Huus et al., 2009	2.5 y	5 y	16058	7-d FFQ	Fried potato/French fries; Sausage; Cream/creme fraiche; chips; Cheese; Pastries; Chocolate; Candy (non-chocolate); Ice-cream	Frequency/wk	Daily vs. <1 time/wk (1-2 times/wk vs. <1 time/wk for fried potato)	OW/OB (%) at 5 y (Cole 2000)	Fried potato/French fries consumption at 2.5 y OR = 0.75, 95% CI = 0.62, 0.92, P = 0.006) daily consumption at 5 y P > 0.05. Daily consumption of sausage, cream/crème fraiche, chips, cheese, chocolate and ice-cream consumption at either 2.5 or 5 y had no significant effect on the risk of OW/OB at 5 y (P > 0.05). Daily consumption of pastries and consumption of candy at 2.5 y (P > 0.05); 5 y (pastries OR = 0.46, 95% CI = 0.23, 0.90, P = 0.023; candy OR = 1.6, 95% CI = 1.22, 2.12, P = 0.001	Critical
Santorelli 2014	Santorelli et al., 2014	6 mo	2.5 y	743	Caregiver questionnaire	Sweetened first foods	Consumed/not consumed	Consumed vs. not consumed	BMI-for-age z-score (WHO 2006)	Mean difference = 0.03 95% CI = -0.12, 0.19	Serious
Thurber 2017	Thurber et al., 2017	0.5–2 y and 3–5 y; 0.5–2 y; 3–5 y		907	Caregiver report	High fat foods	Frequency/d	≥ 2 times/d in last 24 h vs. <2 times/d in last 24-h	BMI (kg/m^2)		Serious
Wijga 2010	Wijga et al., 2010	3–12 mo	7 y 8 mo	1871	3-d weighed diet record completed by parents	Fast food; Sweet and savory snacks	kJ/wk	Times/month (continuous)	OW/OB (%) (Cole 2000)	Fast foods: OR = 1.14, 95% CI = 0.77, 1.67; Snack consumption OR = 0.71, 95% CI = 0.52, 0.98	Serious
2–<5 y											
DeCoen 2014	De Coen et al., 2014	4.95 y	30 mo	568 at 18 mo; 473 at		Sweet and savory snack consumption	g/d	>54 g/d vs. <54 g/d (median intake)	OW/OB (%) (Flemish references)	OR = 0.76, 95% CI = 0.41, 1.40, P > 0.05	Serious

				30 mo							
Emond 2020	Emond et al., 2020	3–5 y	1 y	541	Parent reported usual frequency	Fast food	Frequency of consumption/wk	≥3.1 vs. >1.1 to 2.0 times/wk	Change in BMI status (normal to overweight or overweight to obese)	RR: 1.38, 95% CI 1.13, 1.67, P < 0.01	Moderate
Feldens 2010	Costa et al., 2019	4 y	4 y	315	12-mo FFQ	Ultraprocessed foods	%EI	Continuous	BMI change (kg/m^2)	β = 0.05, 95%CI = -0.04, 0.15, P = 0.282	Moderate
Hooley 2012	Millar et al., 2014	4.8 y	6.1 y	4169	Parental reported 24-h recall, face to face interviews	High fat foods (1) meat pie, hamburger, hotdog, sausage or sausage roll; (2) hot chips or French fries; (3) potato chips or savory snacks; 4) biscuits, doughnuts, cake, pie or chocolate)	Frequency/d	0 "not at all"; 1 "once/d"; 2 "more than once"/d	BMI z score	β = 0.021, 95% CI 0.014, 0.029 P < 0.001	Moderate
	Zulfiqar et al., 2019	4.2 y	6 y	2163 boys; 2044 girls	Parental report up to 8–9 y, then children self-reported (computer-based)	High fat foods	Frequency/d	>=1 vs. 0	OW/OB v non-OW/OB in boys and girls	Boys: OR = 0.85, 95% CI = 0.6, 1.19; Girls: OR = 0.97, 95% CI = 0.7, 1.35	Moderate
Libuda 2008	Buyken et al., 2008	2 y	5 y; 6 y	380	3-d weighed dietary record	Added sugar (white sugar, brown sugar, raw sugar, corn syrup, corn-syrup solids, high-fructose corn syrup, malt syrup, maple syrup, fruit syrup, pancake syrup, fructose sweetener, liquid fructose, honey, molasses, anhydrous dextrose, and crystal dextrose)	%EI	Continuous	Change in BAZ (German references)	β = -0.001, SE = 0.010, P = 0.9	Serious
	Herbst et al., 2011	1 y	6 y	216	3-d weighed dietary record	Total added sugars (added sugar from beverages (regular and diet soft	%EI	Continuous	Change in BAZ (German references)	Intake at 1 y: β = -0.116, SE = 0.057, P = 0.04 at 7 y. Change in intake 1-2 y: β = 0.074, SE = 0.043, P = 0.09) at 7 y	Serious

						drinks, fruit juices) + sweets (candy, chocolate jam and ice cream) + other sources (BF cereals, pastries, milk and milk products)) : Added sugar from beverages and sweets : Added sugar from other sources (BF cereals, pastries, milk and milk products)					
Olafsdottir 2014	Russo et al., 2018	Boys 4.2 and 7.4 y; Girls 4.2 and 7.4 y	2 y	6929	FFQ via Children's Eating Habits Questionnaire	Added sugars to milk and fruit Energy-dense foods (salty snacks, soft drinks, cakes, and sweets)	Daily/weekly/rarely	Daily (once or more times/d) vs. Rarely (never/less than once a wk); Weekly (<1/d) vs. Rarely (never/less than once a wk)	BMI (kg/m^2)	2 < 6 y: boys P = 0.005, girls P = 0.03; 6 < 10 y: boys P = 0.001, Girls P > 0.05	Moderate
Vilela 2014	Durao et al., 2015	2 y	2 y	589	FFQ and 3-d food diaries		Frequency/d	Continuous	BMI z score (Cole 2000)	β = -0.051, 95% CI = -0.135, 0.034	Moderate
	Vedovato et al., 2020	4 y	6 y	1175	2-d or 3-d food diaries including quantities	Ultraprocessed foods	%EI	Continuous per 100 kcal intake	BMI z score (WHO 2006)	β = 0·028; 95% CI = 0.006, 0.051 intake at 4 y; β=0·014; 95%CI = -0.007, 0.036 intake at 7 y	Moderate
5– 10 y											
Alviso-Orellana 2018	Alviso-Orellana et al., 2018	8 y	4 y	1414	30-d recall	Snacks-salty and fatty foods (crisps, fried snacks)	Frequency/2 wk/wk/d	Up to every 2 wk; 2-6 times/wk; daily or never	BMI change (kg/m^2), OW/OB (%)	Everyday vs never β = 0.71, 95% CI = 0.14, 1.28; relative risk=1.43 CI= 0.78, 2.69	Moderate
Bayer 2014	Bayer et al., 2014	6.0 y	4 y	1252	Self administered parental questionnaire	Energy dense sweets	Servings/d	Continuous		No estimates reported	Serious
Bel-Serrat 2019	Bel-Serrat et al., 2019	7.9 y	4 y	2755	7-d recall	Fast food (Pizza, fries, hamburger etc.); savory	'never/< once a wk', 'some days (1–3 d)', 'most	Everyday vs. never	OW/OB (%) (Cole 2000)	Savory snack intake some days/wk (OR = 0.48, 95% CI = 0.23, 0.99, P < 0.05),	Serious

						snacks (crisps, popcorn, peanuts etc.)	days (4–6 d)', 'every day'.			never (OR = 0.27, 95% CI = 0.10, 0.72, P < 0.01) vs. everyday. Fast food intake some days/week (OR = 0.88, 95% CI = 0.27, 2.83, P > 0.05), never (OR = 0.91, 95% CI = 0.19, 4.31, P > 0.05) vs. everyday	
Carlson 2012	Carlson et al., 2012	6.7 y	24 mo	254	Parent survey average consumption/d	High fat foods (fried chicken, pizza, whole or 2% milk, French fries, tater tots, onion rings)	Servings/d	Continuous	BAZ (CDC 2005)	Unstandardized β = -0.02, CI = -0.06, 0.03, P = 0.409	Serious
Hur 2015	Hur et al., 2015	9.9 y	4 y	605	3-d food record	Other sugar (sweets, sweetened grains, sweetened dairy products, sugars, syrup and natural sugar from vegetables and grains).	g/d	Continuous	BAZ (Korean growth standards)	β = 0.16, SE = 0.10, P > 0.05	Serious
Jackson 2017	Jackson et al., 2017	5.6 y	9 y	4938	1-wk FFQ	Fast food	Servings/d	Frequency/d or /wk (7 categories)	BAZ (CDC 2000)	P > 0.05 (parameter estimate from a cross-lagged autoregressive model)	Moderate
Lissau 1993	Lissau et al., 1993	9–10 y	11 y	512	Postal survey to parents	Candy	Frequency/d	Frequent vs. infrequent consumption	Overweight (%) (BMI >90th percentile, internal z scores)	OR = 0.5, CI = 0.1, 1.4, P > 0.05	Critical
Olsen 2012	Olsen et al., 2012	Boys 9.7 y; Girls 9.4 y (combined in analysis)	6 y	359	24-h recall interview, FFQ and a qualitative food record	Added sugar; Solid sucrose (added sugar/sucrose + liquid sucrose)	per 10g intake	Continuous	Change in BAZ (Cole & Green 1992)	Added sugar intake: β = 0.012, SE = 0.011, P = 0.26; Solid sugar intake: β = 0.000, SE = 0.0016, P = 0.99	Critical

*Estimate shows adjusted odds ratios unless stated otherwise

[1]ASB, artificially-sweetened beverages; BF, body fat; BIA, bioelectrical impedance; BAZ, BMI-for-age z score; DAT, dietary assessment tool; DXA, dual x-ray absorptiometry; FMI, fat mass index; FFQ, food-frequency questionnaire; NS, not stated; OW/OB, overweight including obesity; OB, obesity only; RoB, risk of bias; SSB, sugar-sweetened beverages; SSF, sum of skinfolds; WC, waist circumference; WHtR, waist-to-height ratio; %BF, percentage body fat; %EI, percentage of energy intake.

[2]Minimum analytical sample size.

[3]Defined as unsweetened fruit juice and small intakes of sweetened fruit and vegetable juices.

[4]Defined as energy-dense, nutrient rich foods.

[5]Includes energy-dense, nutrient poor and ultra-processed foods.

[6]Fat mass index was calculated by dividing fat mass (kg) by height (m2).

[7]Body fat was assessed via air displacement plethysmography.

TABLE 11 Synthesis of results of unhealthy food and beverage consumption and body fat outcomes[1]

Study ID	Reference	Baseline age (mean or range)	Follow-up duration	N[2]	DAT	Exposure	Intake unit	Comparator	Outcomes	Estimate*	Overall RoB
SSB											
0–<2 y											
Leermakers 2015	Leermakers et al., 2015	12.9 mo	59 mo	1183 boys; 1188 girls	1-m FFQ		Servings/wk	High (15 servings/wk) vs. low (3 servings/wk)	%BF (DXA)	Boys β= 0.05, 95% CI = -0.11, 0.20, P = 0.53; girls β = 0.09, 95% CI = -0.06, 0.23, P = 0.25 high vs. low intake	Moderate
2–<5 y											
Hasnain 2014	Hasnain et al., 2014	3–5 y	12 y	98	3-d diet records		oz/d	Tertile 1 vs. 2; Tertile 1 vs. 3; Tertile 2 vs. 3	%BF (DXA)	ANCOVA P = 0.929	Moderate
5– 10 y											
Carlson 2012	Carlson et al., 2012	6.7 y	24 mo	254	Parent survey average consumption/d		Servings/d	Continuous	%BF (BIA)	Unstandardized β = 1.40, CI = 0.09, 2.72, P = 0.036	Serious
Cowin 2001	Johnson et al., 2007	5.2 y; 7.2 y	~4 y	362	3-d unweighed diet diaries		g/d; serving/d (1 serving = 180g)	Continuous	Change in fat mass (kg) (DXA) per serving	β = -0.15, 95% CI = -0.54, 0.24, P = 0.45	Moderate
Fiorito 2009	Fiorito et al., 2009	5 y	10 mo	166	Three 24-h recalls		Servings/d	≥1 and <2 servings/d vs. <1 servings/d; ≥2 servings/d vs. <1 servings/d	%BF (SSF)	ANOVA group P < 0.01, age P < 0.01, group x age P < 0.01	Serious
Garden 2011	Zheng et al., 2015	8 y	3.5 y	158	Three 24-h recalls using multiple pass approach at age 9 y by telephone		g/d	per 100g/d	%BF (BIA)	β = 1.04, SE = 0.32, P = 0.001	Serious
Hur 2015	Hur et al., 2015	9.9 y	4 y	605	3-d food record		g/d	Continuous	%BF (BIA)	β = 0.02, SE = 0.21, P > 0.05	Serious
ASB											
2–<5 y											
Cowin 2001	Johnson et al., 2007	5.2 y; 7.2 y	~4 y	362	3-d unweighed diet diaries		g/d; serving/d (1 serving = 180g)	Continuous	Change in fat mass (kg) (DXA) per serving	β = 0.26, 95%CI = -0.004, 0.52, P = 0.05	Moderate

Garden 2011	Zheng et al., 2015	8 y	3.5 y	158	Three 24-h recalls using multiple pass approach at age 9 y by telephone		g/d	Intake per 100 g/d	%BF (BIA)	β = -1.41, SE = 0.70, P = 0.046	Serious
Hasnain 2014	Hasnain et al., 2014	3–5 y	12 y	98	3-d diet records		oz/d	Tertile 1 vs. 2; Tertile 1 vs. 3; Tertile 2 vs. 3	%BF (DXA)	ANCOVA P = 0.584	Moderate
100% fruit juice											
2–<5 y											
Hasnain 2014	Hasnain et al., 2014	3–5 y	12 y	98	3-day diet records		oz/d	Tertile 1 vs. 2; Tertile 1 vs. 3; Tertile 2 vs. 3	%BF (DXA)	ANCOVA P = 0.119	Moderate
5–<10 y											
Carlson 2012	Carlson et al., 2012	6.7 y	24 mo	254	Parent survey average consumption/day		Servings/d	Continuous	%BF (BIA)	Unstandardized β= -1.06, CI = -2.70, 0.57, P = 0.202	Serious
Cowin 2001	Johnson et al., 2007	5.2 y; 7.2 y	~4 y	362	3-d unweighed diet diaries		g/d + serving/d (1 serving = 180g)	Continuous	Change in fat mass (kg) (DXA)/serving	β = -0.11, 95% CI = -0.61, -0.38, P = 0.66	Moderate
Garden 2011	Zheng et al., 2015	8 y	3.5 y	158	Three 24-h recalls using multiple pass approach at age 9 y		g/d	Intake per 100g/d	%BF (BIA)	β = -0.05, SE = 0.44, P = 0.91	Serious
Intermediate foods[3]											
2–<5 y											
Huus 2009	Huus et al., 2009	2.5 y	5 y	16058	7-d FFQ	Cheese	Frequency/wk	<1 time/wk vs. daily			Critical
Unhealthy foods[4]											
2–<5 y											
Libuda 2008	Buyken et al., 2008	2 y	5 y; 6 y	380	3-d weighed dietary record	Added sugar (white sugar, brown sugar, raw sugar, corn syrup, corn-syrup solids, high-fructose corn syrup, malt syrup, maple syrup, fruit syrup, pancake syrup, fructose sweetener, liquid fructose, honey, molasses, anhydrous dextrose, and crystal dextrose.)	%EI	Continuous	Change in %BF (SSF)	β = 0.048, SE = 0.046, P = 0.3	Serious
	Herbst et al., 2011	1 y	6 y	216	3-d weighed dietary record	Total added sugars (added sugar from beverages (regular	%EI	Continuous	Change in %BF (SSF)	Intake at 1 y: β = -0.014, SE = 0.015,	Serious

						and diet soft drinks, fruit juices) + sweets (candy, chocolate jam and ice cream) + other sources (BF cereals, pastries, milk, and milk products)): Added sugar from beverages and sweets: Added sugar from other sources (BF cereals, pastries, milk and milk products)				P = 0.4 at 7 y; Change in intake 1-2 y: β = 0.002, SE = 0.012, P = 0.8	
Olafsdottir 2014	Russo et al., 2018	Boys 4.2 and 7.4 y; Girls 4.2 and 7.4 y	2 y	6929	FFQ via Children's Eating Habits Questionnaire	Added sugars to milk and fruit	Daily/weekly/rarely	Daily (once or more times/d) vs. Rarely (never/less than once a wk); Weekly (<1/d) vs. Rarely (never/less than once a wk)	%BF (SSF)	2< 6 y boys P = 0.009; girls P > 0.05: 6 < 10 y, boys P = 0.001, girls P > 0.05	Moderate
5– 10 y											
Carlson 2012	Carlson et al., 2012	6.7 y	24 mo	254	Parent survey average consumption/d	High fat foods (fried chicken, pizza, whole or 2% milk, French fries, tater tots, onion rings)	Servings/d	Continuous	%BF (BIA)	unstandardized β = -0.38, CI = -0.81, 0.05, P = 0.081	Serious
Costa 2020	Costa et al., 2020	6 y	5 y	3514	12-mo retrospective FFQ	Ultraprocessed foods	Annual consumption in g at 6 y and 11 y	Continuous	FMI[5,6]	β = 0.05, 95% CI = 0.04, 0.06, P < 0.001	Moderate
Hur 2015	Hur et al., 2015	9.9 y	4 y	605	3-d food record	Other sugar, sweetened grains, sweetened dairy products, sugars, syrup and natural sugar from vegetables and grains.	g/d	Continuous	%BF (BIA)	β = 0.83, SE = 0.72, P > 0.05	Serious

*Estimate shows adjusted odds ratios unless stated otherwise

[1]ASB, artificially-sweetened beverages; BF, body fat; BIA, bioelectrical impedance; DAT, dietary assessment tool; DXA, dual x-ray absorptiometry; FMI, fat mass index; FFQ, food-frequency questionnaire; NS, not stated; OW/OB, overweight including obesity; OB, obesity only; RoB, risk of bias; SSB, sugar-sweetened beverages; SSF, sum of skinfolds; %BF, percentage body fat; %EI, percentage of energy intake

[2]Minimum analytical sample size.

[3]Defined as energy-dense, nutrient rich foods.

[4]Includes energy-dense, nutrient poor and ultra-processed foods.

[5]Fat mass index was calculated by dividing fat mass (kg) by height (m^2).

[6]Body fat was assessed via air displacement plethysmography.

TABLE 12 Synthesis of results of unhealthy food and beverage consumption and other growth and body composition outcomes[1]

Study ID	Reference	Baseline age (mean or range)	Follow-up duration	N[2]	DAT	Exposure	Intake unit	Comparator	Outcomes	Estimate*	Overall RoB
SSB											
0–<2 y											
Cantoral 2016	Cantoral et al., 2016	Birth	8–14 y	227	3-m FFQ		Cumulative consumption in pre-school years	Third vs. first tertile SSB cumulative consumption	Abdominal obesity (%) (WC >90th centile)	High vs. low: OR = 2.70, 95% CI: 1.03, 7.03, mid vs. low = P > 0.05	Serious
Guerrero 2016	Guerrero et al., 2016	9 mo	63 mo	15418	Parent interview at 48, 60, and 72-mo		Intake vs. no intake in last 7 d	Any vs. none in last 7 d	BMI trajectory	β = 0.138, SE = 0.037, P < 0.01	Moderate
Hwang 2020	Hwang et al., 2020	5 mo	69 mo	12777	Diet questionnaire		cc/d	≥ 200 cc/d vs. <200 cc/d	Adiposity rebound	Difference at 21 mo P = 0.02; at 33 m P = 0.71; at 45 mo P = 0.71	Serious
Kramer 2004	Kramer et al., 2004	1 mo	11 mo	16491	NS		Yes/No	Consumed vs. not-consumed	Weight-for-age	9-12 mo (Point estimate = 0.026, 95% CI = -0.016, 0.069, P > 0.05)	Moderate
Leermakers 2015	Leermakers et al., 2015	12.9 mo	59 mo	1183 boys; 1188 girls	1-m FFQ		Servings/wk	High (15 servings/wk) vs. low (3 servings/wk)	Android/gynoid fat ratio	boys, β = 0.02, 95% CI = -0.14, 0.18, P = 0.77; girls, β= 0.14, 95% CI = -0.02, 0.29, P = 0.09	Moderate
Quah 2019	Quah et al., 2019	18 mo	42 mo	767	Self administered FFQ		mL	High vs. low intake	SSF (mm)	Intake at 18 mo and outcome at 5 y OR = -0.46, 95% CI = -3.27, 2.34, P = 0.850; at 6 y OR = 2.2, 95% CI = -0.38, 4.78, P = 0.0096	Serious
Thurber 2017	Thurber et al., 2017	0.5–2 y and 3–5 y; 0.5–2 y; 3–5 y		907	Caregiver report		Frequency/day	≥ 2 times/d vs. <2 times/d in last 24 h	BMI trajectory in those normal weight at baseline	Difference in intercept from reference -20.20; 95% CI: 20.39 to 20.01	Serious
2–<5 y											
Feldens 2010	Costa et al., 2019	4 y	4 y	315	Two 24-h dietary recalls		%EI	Continuous	WC (cm); WHtR (cm); SSF (mm)	Change in WC: β = 0.01, 95% CI -0.22 to 0.19 P= 0.892; change in WHtR β =0.00, 95% CI -0.00 to 0.00; Change in SSF β =- 0.04, 95% CI 0.34 to 0.27	Moderate
Newby 2004	Newby et al., 2004	2.9 y	8.4 mo	1345	1-mo FFQ		oz/d	Continuous	Weight change (lb)/y	Fruit drinks: β = -0.03, SE = 0.02, P = 0.42; Soda β = -0.01, SE = 0.04, P = 0.81	Moderate
Olafsdottir 2014	Olafsdottir et al., 2014	2–<6 y; 6–<10 y	2 y	32283	28-d recall FFQ		Frequency/wk	Continuous	% increase in BMI; % increase in WHtR	2-<6 y: % increase in BMI (OR = 1.01, 95%CI = 0.99, 1.03, P > 0.05) or waist to hip ratio (OR = 1.00, 95%CI = 0.98, 1.03, P >0.05); 6-	Moderate

									<10 y: % increase in BMI (OR = 1.00, 95% CI = 0.99, 1.02, P > 0.05) or waist to hip ratio (OR = 1.01, 95% CI = 0.999, 1.03, P > 0.05)	
Sugimori 2004	Sugimori et al., 2004	3 y	3 y	4176 boys; 3994 girls	Questionnaire	Not stated	Continuous	Proportion consuming juice drink by weight status change from 3 y to 6 y normal weight vs. obese status (normal/normal, normal to obese, obese to normal, obese/obese)	No significant differences in proportion consuming juice drinks, unadjusted analysis	Critical
5– 10 y										
Alviso-Orellana 2018	Alviso-Orellana et al., 2018	8 y	4 y	1414	30-d recall 24-h recall interview, FFQ and a qualitative food record	Frequency per 2 wk/wk/d	up to every 2 wk; 2-6 times/wk; daily or never	WC (cm); WHtR (cm); SSF (mm)	β = 1.43, 95% CI= -0.41, 3.27, P > 0.05	Moderate
Olsen 2012	Olsen et al., 2012	Boys 9.7 y; Girls 9.4 y	6 y	359		per 10g intake	Continuous	Change in WC (cm)	β = 0.220, SE = 0.138, P = 0.11	Critical
Tam 2006	Tam et al., 2006	7.7 y	5.4 y	281	3-d food record at baseline	g/d	Continuous	BMI gains/losses	Comparison of acceptable BMI (Mean = 20, SD = 0–71 g/d), BMI gainers (Mean = 29, SD = 0-91 g/d), BMI losers (Mean = 6.5, SD = 0-170 g/d) from 7–13 y had significantly lower intakes of soft drink/cordial consumption vs. overweight/obese (Mean = 30, SD = 0-108 g/d) at both time points (Kruskall Wallis tests, P < 0.005) : Comparison of acceptable BMI (Mean = 14, SD = 0–48 g/d), BMI gainers (Mean = 8.6, SD = 0–59 g/d), BMI losers (Mean = 13, SD = 0-41.4 g/d) from 7–13 y had no significantly differences in juice/juice drink consumption (continuous variable) compared to those who were OW/OB at both	Critical

									time points (Mean = 14, SD = 0–44 g/day) (ANOVA, P > 0.05)	
Traub 2018	Traub et al., 2018	7.08 y	1 y	1250	Questionnaire completed by parents	Frequency/d; Frequency/wk	> 1 time/wk vs. <1 time/wk	Abdominal obesity (%) WHtR ≥ 0.5	No significant difference in the odds of abdominal obesity by intake	Moderate
Zheng 2014	Zheng et al., 2014	9.6 y	12 y	171	24-h recall; face-to-face interview and qualitative food record	Servings/d	> 1 serving/d vs. ≤ 1 serving/d	Change in WC (cm); Change in SSF (mm)	Intake at 9 y and WC at 21 y P > 0.05. Change in intake from 9–15 y and change in WC from 15–21 y P > 0.05. No change vs. increased SSB intake 9–15 y WC (b = 2.72, P = 0.04), but SSF P > 0.05	Moderate
ASB										
2–<5 y										
Newby 2004	Newby et al., 2004	2.9 y	8.4 mo	1345	1-mo FFQ	oz/d	Continuous	Weight change (lb)/y	β = 0.01, SE = 0.02, P = 0.92	Moderate
100% fruit juice										
0–<2 y										
Guerrero 2016	Guerrero et al., 2016	9 mo	63 mo	15418	Parent interview at 48, 60, and 72-mo	Intake vs. no intake in last 7 d	Any vs. none	BMI trajectory	Est = -0.101, SE = 0.053, P > 0.05	Moderate
2–<5 y										
Faith 2006	Faith et al., 2006	30.2 mo	48 mo	971	Self administered questionnaire	Servings/d	Continuous	BAZ trajectory (slope)	β = 0.05, SE = 0.002, P < 0.01	Serious
Newby 2004	Newby et al., 2004	2.9 y	8.4 mo	1345	1-mo FFQ	oz/d	Continuous	Weight change (lb)/y	β = 0.01 SE = 0.01, P = 0.23	Moderate
Shefferly 2016	Shefferly et al., 2016	2 y	2–3 y	6250	7 d recall frequency	Servings/d	≥ 1 serving/d vs. <1 serving/d	Weight-for-age	<1/ wk vs. ≥ 1 at 2–4 y (0.371 (0.032) vs. 0.432 (0.024), P = 0.055) or 4–5 y (0.042 (0.016) vs. 0.029 (0.012), P = 0.4553)	Moderate
Wan 2020	Wan et al., 2020	3–6 y	10 y	100	Multiple sets of 3-day diet records	Cup equivalent/d	<0.5 cups; 0.5 ≤1.0 cups; ≥1.0 cups	Adiposity rebound	(No estimates) Longitudinal juice intake was not significantly associated with child height, weight, or BMI.	Serious
5– 10 y										
Arcan 2013	Arcan et al., 2013	5.8 y	15 mo	424	Food consumption questionnaire	Frequency/d	Continuous	Normal weight, overweight or obese (based on BMI) at follow up grouped by	No significant association with 100% juice consumption.	Moderate

									baseline weight status category		
Unhealthy foods[3]											
0–<2 y											
Garden 2011	Garden et al., 2011	18 mo	6.5 y	362	3-d weighed food record	Extra foods (cookies, crackers, juice, cordial, fruit drinks and soft drinks, fats and oils, snack foods, sugar, confectionary, savory sauces, condiments, fried potatoes, ice-cream, and some miscellaneous foods); Dairy products (milk and milk products, including yoghurt, cheese, ice cream and custard)	g/d	Quintiles of intake as g/d	WC (cm)	Extra foods β = -0.31, 95%CI = -0.85, 0.23, P = 0.26 for trend; dairy products β = -0.45, 95%CI = -0.99, 0.08, P = 0.10 for trend	Moderate
Guerrero 2016	Guerrero et al., 2016	9 mo	63 mo	15418	Parent interview at 48, 60, and 72-mo	Fast food	Intake vs. no intake in last 7 d	Any vs. none	BMI trajectory in those normal weight at baseline	β = 0.103, SE = 0.035, P < 0.05	Moderate
Jardi 2019	Jardi et al., 2019	0 mo	30 mo	81	24-h dietary recall at 12 mo	Free sugars (sweetened dairy desserts, sugary drinks, sweetened cereals, chocolate, sugar, and honey	%EI	Continuous	Excess vs. non-excess weight (present/absent)	OR: 1.130, 95% CI = 1.032, 1.238, P = 0.008	No information
Moore 2019	Moore et al., 2019	3–12 mo	3 y	666	3-mo FFQ	Snack food (biscuits, puffs, melts); Sweets (cookies, cakes, or candy)	Frequency/d	Consumed often vs. never	Weight-for-length z score	ANOVA sweets (F = 3.23, P = 0.03); sweets * time interaction (F = 2.44, P = 0.04)	Moderate
Thurber 2017	Thurber et al., 2017	0.5–2 y and 3–5 y; 0.5–2 y; 3–5 y		907	Caregiver report	High fat foods	Frequency/d	≥ 2 times/d in last 24 h vs. <2 times/d in last 24-h	BMI trajectory in those normal weight at baseline	Difference in intercept from reference -0.15; 95% CI: -0.34, 0.04	Serious
2–<5 y											

Feldens 2010	Costa et al., 2019	4 y	4 y	315	12-mo FFQ	Ultraprocessed foods	%EI	Continuous	WC (cm); WHtR (cm); SSF (mm)	6<10 y WC z score: boys (P = 0.05), girls (P = 0.05), SSF: boys (P = 0.05), girls (P = 0.02)	Moderate
Newby 2004	Newby et al., 2003	Boys 2.9 y; Girls 2.9 y	6–12 mo	1379	Semi-quantitative FFQ	'Fat foods' (includes ice-cream, mayonnaise, potato chips, cookies, cakes, pie, chocolate, hot dogs, bologna, butter, margarine, fried chicken, fried fish, sausage, bacon, donuts, sweet rolls, and French fries)	Frequency/d	Continuous	Weight change (kg)/y	β = 0.05, SE = 0.02, P = 0.03	Serious
Olafsdottir 2014	Russo et al., 2018	Boys 4.2 and 7.4 y; Girls 4.2 and 7.4 y	2 y	6929	FFQ via Children's Eating Habits Questionnaire	Added sugars to milk and fruit	Daily/weekly/rarely	Daily (once or more times/d) vs. Rarely (never/less than once a wk); Weekly (<1/d) vs. Rarely (never/less than once a wk)	WC z score; SSF (mm)	2<6 y: WC z score boys (P = 0.001), girls (P = 0.01); SSF boys (P = 0.05), girls (P = 0.02)	Moderate
Sugimori 2004	Sugirmori et al., 2004	3 y	3 y	3994 girls	Questionnaire	Instant noodles	Frequency/wk	Continuous	Normal weight at 3y and 6 y, obese/normal at 3/6 y; normal/obese at 3/6 y or obese/obese at 3/6 y	P > 0.05 for all comparisons (unadjusted)	Critical
5– 10 y											
Alviso-Orellana 2018	Alviso-Orellana et al., 2018	8 y	4 y	1414	30-d recall	Snacks-salty and fatty foods (crisps, fried snacks)	Frequency/2 wk/wk/d	Up to every 2 wk; 2-6 times/wk; daily or never	WC (cm)	β = 0.85, 95% CI= -0.89, 2.6, P > 0.05	Moderate
Olsen 2012	Olsen et al., 2012	Boys 9.7 y; Girls 9.4 y (combined in analysis)	6 y	359	24-h recall interview, FFQ and a qualitative food record	Added sugar; Solid sucrose (added sugar/sucrose + liquid sucrose)	per 10g intake	Continuous	Change in WC (cm)	Added sugar: β = 0.148, SE = 0.083, P = 0.08; Solid sugar: β = 0.063, SE = 0.122, P = 0.6	Critical

*Estimate shows adjusted odds ratios unless stated otherwise

[1]ASB, artificially-sweetened beverages; BAZ, BMI-for-age z score; DAT, dietary assessment tool; DXA, dual x-ray absorptiometry; FMI, fat mass index; FFQ, food-frequency questionnaire; NS, not stated; OW/OB, overweight including obesity; OB, obesity only; RoB, risk of bias; SSB, sugar-sweetened beverages; SSF, sum of skinfolds; WC, waist circumference; WHtR, waist-to-height ratio; %EI, percentage of energy intake.
[2]Minimum analytical sample size.
[3]Includes energy-dense, nutrient poor and ultra-processed foods.

TABLE 13 Synthesis of results of unhealthy food and beverage consumption and other critical and important outcomes[1]

Study ID	Reference	Baseline age (mean or range)	Follow-up duration	N[2]	DAT	Exposure	Intake unit	Comparator	Outcome indicator	Unit	Result * (relevant outcomes)	Overall RoB
Critical outcomes												
Diet-related non-communicable disease indicators												
SSB												
0–<2 y												
Leermakers 2015	Leermakers et al., 2015	12.9 mo	59 mo	2045	1-m FFQ	Sugar containing beverages (fruit juices, fruit concentrates, lemonades, soft drinks, and sports drinks)	Servings/wk	High tertile vs. low tertile; Medium tertile vs. low tertile	SBP; DBP; PWV; TC:HDL-ratio; TAG; insulin	mmHg; mmHg; m/s; mmol/L; mmol/L; pmol/l	No significant association between the consumption of sugar containing beverage intake at age 13 mo and SBP, DBP, PWV, blood lipids or insulin at age 6 y.	Moderate
2–<5 y												
Feldens 2010	Costa et al., 2019	4 y	4 y	315	Two 24-h dietary recalls	Soft drink (soda, sweetened juice, and sport drinks)	%EI	Continuous	Glucose; Insulin; HOMA-IR	mmol/L; µU/ml; N/A	No significant associations between SSB consumption and glucose profiles.	
5– 10 y												
VanRompay 2015	Van Rompay et al., 2015	9.57 y	12 mo	127	FFQ	SSB (regular sodas, non-100% fruit juices/drinks, and other beverages such as sweetened teas)	Times/wk	>0 & <2 servings/wk (approx. once weekly) vs. zero reported SSB intake; ≥ 2 & < 7 servings/wk (approx. every other day) vs. zero 2 reported SSB intake; ≥ 7 servings/wk (daily consumption) vs. zero reported SSB intake	HDL-C; TAG	mg/dL; mg/dL	No significant association between mean SSB intake and changes in HDL-C or TAG changes (data from <10 y).	Serious
Hur 2015	Hur et al., 2015	9.9 y	4 y	605	Modified 3-d food record	Beverage sugar (fruit juice, fruit and vegetable drinks, carbonated beverages, sports drinks, coffee, sweet tea, soy	g/d	Continuous	Metabolic syndrome score (based on mean arterial blood pressure; fasting blood glucose; TC; HDL-C; TAG)	Composite score	No significant associations between beverage sugar and metabolic syndrome score.	Serious

						milk, energy drinks and other beverages)						
Intermediate foods												
0–<2 y												
Szymlek-Gay 2009	Szymlek-Gay et al., 2018	17.2 mo	5 mo	180	3-d weighed food records	Lean red meat	g/d	Red meat vs. control	TC; HDL-C; TC:HDL-C ratio	mmol/L; mmol/L; N/A	No significant difference in serum lipids between intervention and control group.	Some concerns
Unhealthy foods												
0–<2 y												
Cowin 2001	Cowin et al., 2001	~18 mo	~13 mo	~370	3-d unweighed dietary record	Biscuits; Chocolate; Butter	g/d; consumed/not-consumed last 24-h (only for biscuits exposure)	Consumed vs. not consumed (biscuits, chocolate, or butter)	Total cholesterol; HDL cholesterol	mmol/L	Biscuit, chocolate, and butter had no association with TC or HDL-C among girls. Among boys, children who ate biscuits or chocolate had a significantly higher TC level than those who did not. For biscuits, TC =4.19 (0.63) vs. 3.86 (0.67) P = 0.011 (unadjusted); Chocolate, TC= 4.22 (0.67) 3.99 (0.57) P = 0.012 (unadjusted analysis). For butter consumption among boys, there was borderline significant difference in HDL-C value consumers and non-consumers (0.91 (0.26) vs. 0.83 (0.19) respectively, P = 0.047).	Critical
2–<5 y												
Chaffee 2015	Leffa et al., 2020	3.2 y	~3 y	308	Two multiple-pass 24-h dietary recalls	Ultra-processed food	%EI	Tertile 2 vs Tertile 1 : Tertile 3 vs Tertile 1	Total cholesterol; LDL-cholesterol; HDL-cholesterol; TAG	mmol/l; mmol/l; mmol/l; mmol/l	Higher UPF intake was associated with increased total serum cholesterol at age 6 years (tertile 3 v tertile 1; β 0·22 mmol/l; 95% CI 0·04, 0·39) and TAG (tertile 3 vs tertile 1 0·11 mmol/l (95% CI 0·01, 0·20).	Moderate

Feldens 2010	Rauber et al., 2015	3-4 y	4 y	305	Two 24-h dietary recalls	Processed products (Cheese and canned dishes) Ultraprocessed products (included bread, savory and biscuits, sweets, soft drinks, processed meat, mayo, dressing and sauces)	%EI	Continuous	TC; LDL-C; HDL-C; TAG	mg/dL	No significant association between consumption of processed products and lipid concentrations. In adjusted linear regressions, consumption of ultraprocessed products at preschool age was a significant predictor of increase in TC and LDL-C concentrations from preschool to 7-9 y. For every 1% increase in EI from ultraprocessed products, change in TC increased by 0.430 mg/dL and LDL-C increased by 0.369 mg/dL after adjusting for sex, group status in the early phase, birth weight, family income, maternal schooling; and BMI z score and total EI at age 7-8 y.	Moderate
Feldens 2010	Costa et al., 2019	4 y	4 y	315	Two 24-h dietary recalls	Total ultraprocessed foods including biscuits (crackers and cookies); breakfast cereal; powdered chocolate; processed meats; savory (chips and salty snacks); sugary milk beverages; sweets (candy, chocolate and ice cream); others (instant noodle, dehydrated soup, mayo, dressing and sauces	%EI	Continuous	Glucose; Insulin; HOMA-IR	mmol/L; µU/ml; N/A	No significant associations between ultraprocessed food consumption and glucose profiles.	Moderate
Hur 2015	Hur et al., 2015	9.9 y	4 y	605	Modified 3-d food record	Other sugar (sweets (candies, chocolate, gum, jellies,	g/d	Continuous	Metabolic syndrome score (based on mean arterial blood	Composite score	No association between other sugars and metabolic syndrome score.	Serious

						caramels), sweetened grains, sweetened dairy products, sugars, syrup and natural sugar from vegetables and grains			pressure; fasting blood glucose; TC; HDL-C; TAG)			
Displacement of healthy foods/breastmilk												
SSB												
0–<2 y												
Schiess 2010	Schiess et al., 2010	1 mo	11 mo	875	Parental recorded 3-d weighed food diary every month at 1-9 mo and 12 mo	EPL	kcal/d	EPL vs. no EPL	Formula milk intake; Solids intake	kcal/d	EPL intake associated with significantly lower EI from formula (2 - 5 mo). At 4 and 5 mo EPL consumers vs non-consumers significantly more energy from solids but significantly less at 7, 9 and 12 mo (statistical tests not extractable).	Moderate
2–<5 y												
Byrne 2018	Byrne et al., 2018	24.1 mo	3 y	515	24-h recall questionnaire with mother of child conducted by dietician	SSB (flavored milks, 100% juice, dilute juice, fruit drink/cordial and soft drink)	%EI	SSB = continuous variable	Fruit and vegetables intake; Milk/milk alternatives	Proportion of estimated EI	No significant relationship between intake of sweet beverages and fruit and vegetable consumption at any time point; There was a weak inverse correlation between intake of sweet beverages and milk/alternatives at age 2 y ($r = -0.11$, $P = 0.015$) and at 5 y ($r = -0.11$, $P = 0.012$).	Moderate
5– 10 y												
Bayer 2014	Bayer et al., 2014	6.0 y	4 y	1252	Self administered parental questionnaire	High-caloric drinks	Servings/d	Continuous variable	Change in fruit consumption; Change in vegetable consumption	serving size/d	Change in high-caloric drink consumption was not significantly correlated with change in fruit or change in vegetable consumption.	Serious

Unhealthy foods												
5– 10 y												
Bayer 2014	Bayer et al., 2014	6.0 y	4 y	1252	Self administered parental questionnaire	Energy dense sweets	Servings/d	Continuous variable	Change in fruit consumption; Change in vegetable consumption	serving size/d	Changes in energy dense sweet consumption was not associated with change in fruit consumption/vegetable consumption.	Serious
Dietary quality & diversity												
SSB												
2– 10 y												
Woo 2020	Woo et al., 2020	3 y	4 y	349	Parental recorded 3-d diet diary at 0 to 3 mo, 4 to 6 mo, 7 to 12 mo, 12 to 24 mo, or 24 to 36 mo	Soft drinks (powdered drink mixes, sport drinks or soda pop)	Consumed daily/not consumed daily	Regularly consumed vs. Not regularly consumed	HEI–2005	NA	Multivariable multinomial logistic regression analysis identified that not regularly consuming soft drinks before age 3 y vs. regular consumption between 24 and 36 mo was associated with a greater odds of having a higher diet quality trajectory (OR 2.7, 95% CI 1.6 to 4.3, P < 0.001) .	Moderate
Wan 2020	Wan et al., 2020	3-6 y	11 y	100	3-d diet record completed by caregiver instructed by nutritionist at 3-6 y	100% fruit juice	Cups/d	0.5 to < 1 cup vs. < 0.5 cups/d; ≥ 1 cup vs. < 0.5 cups/d	HEI–2015 at 14–17 y	Score	At the end of follow-up (14–17 y), HEI total scores for those with the highest preschool juice intakes (≥1.0 cups/d) were almost 6 points higher than those with the lowest preschool fruit juice intakes (3-6 y) (< 0.5 cups/d) (P = 0.004).	Serious
Unhealthy foods 0–<2 y												
Vilela 2014	Vilela et al., 2014	25 mo	24 mo	708	FFQ answered by main carer in face to face interview	Energy dense foods	Times/wk	≥ Median vs. < Median	HEI at 4 y	Score	Weekly and daily intake at 2 y vs < once/wk associated with greater likelihood of a lower HEI score (below the median value) at 4 y (IRR = 0·75, 95% CI 0.58, 0.96; IRR =	Moderate

											0·56, 95% CI 0·41, 0·77, respectively)	
2– 10 y												
Olafsdottir 2014	Russo et al., 2018	2-<6 y; 6-<10	2 y	2- <6 y: Boys: 1648; Girls: 1556; 6-<10y Boys: 1834; Girls: 1891	FFQ (Children's Eating Habits Questionnaire)	SAMF	Times/wk	Boys: Sugar added to milk and/or fruit index at baseline, weekly vs. Sugar added to milk and/or fruit index at baseline, rarely; Sugar added to milk and/or fruit index at baseline, Daily vs. Sugar added to milk and/or fruit index at baseline, rarely. Girls: Sugar added to milk and/or fruit index at baseline, weekly vs. Sugar added to milk and/or fruit index at baseline, rarely; Sugar added to milk and/or fruit index at baseline, Daily vs. Sugar added to milk and/or fruit index at baseline, rarely.	HDAS	Change in score	Daily intake significantly lower HDAS than weekly or rarely intake at 2 y follow up (adjusted analysis, P < 0.001 for trend in boys and girls and for 2-6 y and 6-≤10 y).	Moderate
Important outcomes												
Food taste preferences												
SSB												
0–<2 y												
Park 2014	Park et al., 2014	~3 wk	6 y	1333	Postal questionnaires to parents	SSB (juice drinks,soft drinks, soda, sweet tea, Kool-Aid,etc)	Consumed/not-consumed last month	Any SSB during infancy vs. No SSB during infancy	Daily SSB intake at 6 y	times/d	Consuming SSBs at age 6 y ≥1 time/d vs. no consumption was significantly associated with any SSB intake during infancy (AOR, 2.22 95% CI 1.59, 3.10); mean SSB intake during age 10-12 mo (AOR, 2.72 95% CI 1.57-4.72) for 1	Serious

											to <3 times/wk and 2.57 95% CI 1.56-4.23 for ≥3 times/wk vs. none).	
Beauchamp 1984	Beauchamp et al., 1984	6 mo	18.3 mo	63	7-d diet history completed by mothers with standardized measures	Sweetened water (water with table sugar, Karo or honey)	Whether or not consumed ever/for > 6 m or for <= 6 m	Consuming > 6 mo vs. never fed; Consuming ≤ 6 mo vs. never fed	Sweet acceptability	NA	Significant main effect of tastant [F(2, 120) = 10.75, P < 0.001] and tastant by group interaction [F(4, 120)=3.15, P < 0.02], groups fed sugar water in infancy vs never fed consumed more (P <0.05) sucrose solution	Moderate
Byrne 2018	Jackson et al., 2020	13.7 mo	46.3 mo	211	Questionnaire completed by mother	Soft drinks, sweet biscuits, fruit drinks	Number of times/wk	>1/wk vs. <1/wk - for all exposures	High liking of soft drinks; Sweet biscuits; Fruit juice; Cake; Lollies	6 point scale	Consuming soft drinks, sweet biscuits and fruit drinks >1/wk compared to <1/wk increased the odds of having a high liking of these foods at age 5 y (OR = 11.06, 95%CI = 4.38, 27; OR = 4.84, 95%CI = 1.80, 13.02; OR = 2.47, 95%CI = 1.09, 5.59).	Moderate
5– 10 y												
Fiorito 2010	Fiorito et al., 2010	5 y	10 y	166	24-h recall	Soda (SSB)	Consumed or not-consumed over a period of 2-3 weeks	Consumed at 5 y vs. not consumed at 5 y	Fruit juice consumption at 15 y : Soda consumption at 15 y :	fl oz; fl oz	No association between soda consumed or not-consumed at 5 y and juice intake at 15 y. Significant association between soda consumed or not-consumed at 5 y and soda intake at 15 y (P < 0.01).	Moderate
Unhealthy foods												
0–<2 y												
Byrne 2018	Jackson et al., 2020	13.7 mo	46.3 mo	211	Questionnaire completed by mother	Cake; Candy (lollies)	Number of times/wk	>1/wk vs. <1/wk - for all exposures	High liking of soft drinks; Sweet biscuits; Fruit juice; Cake; Lollies	6-point scale	Consuming cake or candy >1/wk compared to <1/wk did not increase child liking of these foods at age 5 y (OR = 1.75, CI = 0.7, 4.37; OR = 1.57, CI = 0.68, 3.61).	
Okronipa 2019	Okronipa et al., 2019	6 mo	54 mo	624	Supplement feeding provided daily	Slightly sweet LNS	g/d	Supplementary feeding vs. no feeding	Sucrose solution most preferred (% wt/vol)	NA	Children in the LNS group did not have a higher sweet taste preference than children in the non-LNS group.	Moderate

2– 10 y												
Liem 2002	Liem et al., 2002	4-7 y	NA	70	Maternal report	Habitually added sugar to the child's diet	NA	Frequently vs. never	Sweet taste preference	No times child preferred apple juices with added sugar in a taste test	Children whose mothers reported adding sugar to their child's foods on a routine basis were significantly more likely to prefer apple juices with added sugar, 9.6, SEM +- 0.32 vs. 8.4, SEM +- 0.47 times F(1, 78)=4.68, P < 0.05 compared to those who did not report adding sugar.	Critical
Nicklaus 2004	Nicklaus et al., 2004	2-3 y	2-20 y	341	Based on the foods selected for lunch by 2-3 y olds at nursery canteen	Preference for cheese at 2-3 y Preference for sausage at 2-3 y	NA	NA	Change-from-baseline preference score for cheese and sausage	RPrefi = MPrefi/(Sum MPrefi for the i categories); RPrefi = MPrefi/(Sum MPrefi for the i categories)	Preference for cheese at age 2-3 y was significantly associated with preference in childhood, teenage and adult periods (P < 0.001). Preference for sausage at age 2-3 y was significantly associated with preference in childhood, teenage and adult periods (P < 0.001).	Serious
Micronutrient deficiencies												
Intermediate foods												
0–<2 y												
Szymlek-Gay 2009	Szymlek-Gay et al., 2009	17.1 mo	5 mo	135	3-d weighed food records	Lean red meat	g/d	Red meat vs. milk	Hb; Serum ferritin; Serum transferrin receptor	g/L; ug/L; mg/L	Adjusted serum ferritin concentration was 68% (95% CI: 27, 124%) greater in the fortified milk group than in the control group (P , 0.001) and 29% (95% CI: 2, 63%) greater in the red meat group than in the control group (P = 0.033). There was no evidence of intervention effects on Hb or serum transferrin receptor concentrations.	Some concerns
Olaya 2013	Olaya et al., 2013	6 mo	6 mo	110	24-h maternal recall conducted by dietician	Red meat	Times/wk	≥ 3 times/wk between 10-12 mo vs. < 3 times/wk between 10-12 mo;	Hb; Hematocrit	ng/mL	Infants with red meat consumption ≥ 3 times/wk from 10-12 mo had higher Hb (P = 0.016)	Some concerns

								High frequency of consumption from 6 to 12 mo of age vs. Low frequency of consumption from 6 to 12 mo of age - same for all outcomes			and hematocrit (P = 0.03) concentrations at age 12 mo.	
Sheng 2019	Sheng et al., 2019	6 mo	12 mo	879	Supplement feeding provided by community doctor	Lean red meat (pork)	g/d	Meat (pork) vs. local cereal	Serum vitamin B12 concentration; Serum tHcy concentration	pg/ml; µmol	Meat group had significantly higher vitamin B12 (p = 0.002) and lower tHcy concentrations (p = 0.005) than the local cereal group.	Some concerns
Child development												
SSB												
2–<5 y												
Sonneville 2015	Cohen et al., 2018	3.3 y	4.4 y	1234	Semi-quantitative FFQ completed by mothers	SSB (regular soda and fruit drinks (but not 100% fruit juice)); Juice; Diet soda	Serving size/d	SSB = continuous variable; Juice = continuous variable; Diet soda = continuous variable	PPVT-III; WRAVMA, Total early childhood; KBIT-II, verbal, mid-childhood; KBIT-II, non-verbal, mid-childhood; WRAVMA, Drawing, mid-childhood; WRAML, visual memory, mid-childhood	Score	Early childhood consumption of SSBs was inversely associated with mid-childhood KBIT-II verbal scores (–2.4 points per serving/d, 95% CI: –4.3, –0.5).	Serious
Intermediate foods												
0–<2 y												
Sheng 2019	Sheng et al., 2019	6 mo	12 mo	879	Food provided by researchers	Lean red meat (pork)	50 g/d	Meat (pork) vs. local cereal	Cognitive function; Fine motor function; Gross motor function	Score	Meat group had significantly higher cognitive function than local cereal group (P = 0.013). No significant difference between groups in fine or gross motor function.	Some concerns

5– 10 y												
Hulett 2014	Hulett et al., 2014	7.1 y	2 y	360	Supplement feeding at school	Lean red meat (ground beef)	g/wk	Red meat vs. control (no supplementation of diet)	Test scores English; Arithmetic; Kiswahili; Kiembu; Science; Geography; Arts; Total	Score	Meat group showed significant improvements in test scores vs. control group in six of the seven subjects (Arithmetic, English, Kiembu, Kiswahili, Geography and Arts) and in the overal total test scores.	Some concerns
Unhealthy foods												
0–<2 y												
Thorne-Lyman 2019	Thorne-Lyman et al., 2019	14.9 mo	16 mo	307	24-h recall questionnaire completed by parents	Processed food (biscuits and noodles)	Times/wk	Processed food = Continuous variable	ASQ-3 total score; ASQ-3 communication; ASQ-3 gross motor; ASQ-3 fine motor; ASQ-3 problem solving; ASQ-3 personal-social	Score	Higher consumption of processed foods over a 3-d period did not increase the odds of children being in the lowest 25% of child development at 23-38 m.	Moderate
2–<5 y												
Cowin 2001	Wiles et al., 2009	38 mo	43 mo	12783	FFQ completed by child's main carer	NMES intake at 4.5 y	Times/wk	NMES intake per 100 g at age 4.5 y = Continuous variable	SDQ; Total difficulties at 7 y	Score	No evidence for an association between sugar intake and total difficulties.	Moderate
5– 10 y												
Cowin 2001	Peacock et al., 2011	81 mo	16 mo	7727	FFQ completed by child's main carer	NMES intake at 81 mo	Times/wk	NMES at 81 mo = continuous variable	SDQ; Total difficulties at 81 and 97 mo	Score	No association between NMES intake and behavioural problems at 81 and 97 mo.	Moderate

*Results present adjusted odds ratios unless otherwise stated

[1]AOR, adjusted OR; ASQ-3, Ages and Stages questionnaire-version 3; DAT, dietary assessment tool; DBP, diastolic blood pressure; EI, energy intake; EPL, energy-providing liquids; FFQ, food-frequency questionnaire; Hb, hemoglobin; HDAS, Healthy Dietary Adherence Score; HDL-C, HDL cholesterol; HEI, healthy eating index; HOMA-IR, homeostatic model assessment of insulin resistance; KBIT-II, Kaufman Brief Intelligence Test, second edition; LDL-C, LDL cholesterol; LNS, lipid-based nutrient supplement; NMES, non-milk extrinsic sugars; NS, not stated; OW/OB, overweight including obesity; OB, obesity only; PPVT-III, Peabody Picture Vocabulary Test, 3rd Ed; RoB, risk of bias; PWV, pulse wave velocity; SAMF, sugar added to milk and/or fruit; SBP, systolic blood pressure; SDQ, Strengths and Difficulties Questionnaire; SSB, sugar-sweetened beverages; SSF, sum of skinfolds; TAG, triacylglycerol; TC, total cholesterol; tHcy, total homocysteine; WRAML, Wide Range Assessment of Memory and Learning; WRAVMA, Wide Range Assessment of Visual Motor Abilities; %EI, percentage of energy intake.

[2]Minimum analytical sample size.

TABLE 14 Synthesis of results of unhealthy food and beverage consumption and **o**ral health (dental caries) outcomes[1]

Study ID	Reference	Baseline age (mean or range)	Follow-up duration	N[2]	DAT	Exposure	Intake unit	Comparator	Indicator	Outcome unit	Estimate*	Overall RoB
SSB												
0–<2 y												
Bernabe 2020	Bernabe et al., 2020	12.8 mo	36 mo	1111	FFQ		Frequency/d	Initial intake (continuous); Deviations from initial intake (continuous)	dmfs	Dental caries trajectory	Baseline intake: β = -0.1 95% CI = -0.17,-0.03, P = 0.006; Change in intake: β = 0.14, 95% CI = -0.22, -0.05, P = 0.001	Serious
Jordan 2020	Jordan et al., 2020	8-18 mo	5 y	93	FFQ		Frequency/d	Consumed vs. not consumed	dmfs	Incident caries dichotomized outcome of caries-free (incidence = 0) versus caries (incidence >0)	OR = 2, 95% CI: 1.0, 4.2	Serious
Marshall 2003	Levy et al., 2003	6 wk	5 y	291	3-d diet diaries at 1, 2, 3, 4, 5 y		g/d	Pop/sports drink consumption 12-24 mo; Pop/sports drink and 36-48 mo; Sugar beverages at 12-24 mo	d_1 lesions; d_{2-3} lesions	Caries at 12-36 mo	12-36 mo: OR = 1.34, p = 0.12; 36-48 mo: OR = 1.33, P = 0.12	Serious
	Marshall et al., 2003	1 y	3-6 y	396	3-d diet diaries at 1, 2, 3, 4, 5 y		g/d	Continuous	d_1 lesions; d_{2-3} lesions	Caries at 4 and 7 y	OR = 1.26, P = 0.21 Soda pop: OR = 2.2, 95% CI = 1.4, 3.6, P < 0.05; Drinks from powder: OR = 2.0, 95% CI = 1.2, 3.4, P < 0.05	Serious
Pan 2014	Park et al., 2015	10-12 mo	62 mo	1269	7-d recall questionnaire		Frequency/d	SSB <1 times/wk vs. none; SSB 1-<3 times/wk vs. none, SSB ≥ 3	Number of reported caries	Caries number at 6 y	OR = 1.15, 95% CI = 0.61, 2.18	Serious

								times/wk compared vs. none				
Sakuma 2007	Sakuma et al., 2007	1.5 y	1.5 y	5107	FFQ	Frequency/d	Continuous	Change in caries	Number of teeth with caries	Four cities/districts: β = 0.34, OR = 1.4, CI 1.2,1.7, P < 0.001; β = 0.39, OR = 1.5, CI 1.3, 1.7, P < 0001; β = 0.19, OR = 1.2, CI 1.0, 1.4, P < 0.05; Other β = 0.28, OR = 1.3, CI 1.2, 1.5, P < 0.001	Serious
Warren 2009	Warren et al., 2009	6-24 mo	18 mo	128	Questionnaire completed by study coordinator	Consumed/not consumed in a week	Regular consumption vs. not consumed	Cavitated and non-cavitated dental lesions	Cavitated ($_{d2-3}$) and non cavitated ($_{d1}$ lesions)	OR = 5.20, 95% CI = 2.0, 13.3, P = 0.00	Serious
Watanabe 2014	Watanabe et al., 2014	1.5 y	~21 mo	3120 2	FFQ	Frequency/d	Daily consumed vs. not consumed	Dental caries present or absent	Dichotomous (0, 1)	OR 1.56 95% CI: 1.46, 1.65; P < 0.001	Serious
Wigen 2015	Wigen et al., 2015	1.5 y	3.5 y	1095	FFQ	Frequency/wk	≥ once/week vs.< once/week	Sum of dmft	Dichotomous (0, 1)	OR = 1.9, 95% CI 1.2-2.9	Serious
2–<5 y												
Hooley 2012	Hooley et al., 2012	4.79 y	2.05 y	4149	24-h dietary recall	Frequency/d	Continuous	Dental caries (reported by primary caregiver) at 6-7 y and 8-9 y	Yes or No to occurrence of cavities, extractions or fillings since last survey	2 y: OR = 1.02, SE = 0.03, P = 0.56; 4 y OR 1.10, SE 0.04, P = 0.01	Serious
Ismail 2008	Grindefjord et al., 1996	30 mo	12 mo	692	Questionnaire completed by parents at 1, 2.5 and 3.5 y	Frequency/d	≥2 vs.<2/d	Initial/manifest dental caries	Present or absent	OR = 1.79, CI = 1.00, 3.15, P = 0.045	Serious
	Ismail et al., 2008	0-5 y	2 y	788	FFQ	Frequency/wk	Continuous	ECC; Severe ECC	Present or absent	Caries: OR = 1.27, SD = 0.20, P = 0.14; Severe caries OR = 0.13, SD = 0.13, P = 0.04	Serious
Pang 2015	Pang et al., 2015	3-6 y	2 y	887	Questionnaire completed by parents	Frequency/d	≥ 1/d vs.< 1/d; ≥ 1/d vs.< 1/d	DMFT/dmft caries	New cases of caries	OR = 3.73, 95% = 1.55, 8.97	Serious

Skafida 2018	Skafida et al., 2018	2 y	3 y	3770	FFQ		Frequency/mo	Several times/mo vs.< once/mo or never	Decayed, extracted or filled teeth	Dichotomous (0, 1)	OR = 1.26, 95% CI = 1.01, 1.55, P < 0.05	Serious
Tamaki 2009	Tamaki et al., 2009	5 or 6 y	2.5 y	500	FFQ		Frequency/d	Continuous	Incident caries	Change from baseline to follow up	OR = 1.355, 95% CI = 0.963, 1.908, P = 0.08	Critical
Thornley 2020	Thornley et al., 2020	2 y	5 y	4111	FFQ		Frequency/mo	Four groups	dmft	Category based on dmft score	Univariate analysis: P < 0.001	Critical
Unhealthy foods												
0–<2 y												
Chaffee 2015	Chaffee et al., 2015	6 mo	32 mo	458	Parent interview on age of introduction of child foods	6 mo sweet index; 12 mo sweet index	Time of introduction	6 mo sweet index Tertile 3 vs.1; 12 mo sweet index Tertile 3 vs. Tertile 1	Severe ECC; dmft	≥1 affected maxillary anterior teeth or ≥4 decayed, missing due to caries, or restored tooth surfaces	Upper vs. lowest tertile at 6 mo: RR = 1.46; 95% CI: 0.97, 2.04; at 12 mo RR = 1.55; 95% CI: 1.17, 2.23 (cumulative incidence ratio)	Serious
Devenish 2020	Devenish et al., 2020	3 mo	26 mo	965	24-h recall, 2-d food diary at 1 y; FFQ at 2 y	Energy as free sugars	%EI	> 10%EI free sugar vs. <5%EI free sugar at 1 and 2 y; > 10%EI as free sugar at 1 or 2 y (not both) vs.<5%EI free sugar at 1 and 2 y; <10%EI free sugar on at 1 and 2 y, but >5 % at least at 1 or 2 y vs.<5%EI free sugar at 1 and 2 y	Presence of ECC	Present or absent	PR = 1.97, 95% CI: 1.13, 3.44	Serious
Feldens 2010	Feldens et al. 2010	6 mo	44.5 mo	340	Face-to-face structured interviews	High density of sugar	Consumed or not consumed	Consumed vs. not consumed	Severe ECC at 4 y	dmfs	RR = 1.43, 95% CI = 1.08, 1.89, P = 0.005	Moderate
MacKeown 2000	MacKeown et al., 2000	1 y	4 y	259	semi-quantitative FFQ	Added sugar	g/d (continuous)	Continuous	dmfs incidence	dmfs score change from age 1 y to 5 y	Not significant	Critical
Mattila 2001	Mattila et al., 2005	18 mo	8.5 y	413	Semi structured questionnaire	Sweets/candy	Frequency/wk	Daily or a couple of times a week vs. more seldom;	dmft/DMFT score at 10 y	Score at 10 y	Daily/two times/wk (OR = 5.5, 95% CI = 1.9, 15.8);	Serious

								Once/week vs. more seldom			once/wk (OR = 2.4, 95% CI = 0.8, 7.6)	
Meurman 2010	Meurman et al., 2010	18 mo	24 mo	366	Dietary recall questionnaire	Added sugar	Frequency/wk	Added sugar vs. never	dmfs	Caries increment (dichotomous) 18 mo to 5 y	OR = 2.2, 95% CI = 1.1, 4.5, P = 0.024	Serious
						Sweet snacks		Sweet snacks vs. never/seldom			OR = 1.7, 95% CI = 0.8, 3.9, P = 0.169	
Peres 2016	Peres et al., 2016	1 mo	18 y	302	FFQ	Sugar intake	Frequency/d	High sugar intake vs. low intake (≥2 of ages 4, 15, and 18 y have been measured low intake); Upward sugar intake vs. low intake (≥2 of ages 4, 15, and 18 y have been measured low intake)	dmft score	Prevalence and mean dmft score	High: IRR = 1.67, 95% CI = 1.23, 2.25: upward: IRR =1.22, 95% CI = 0.94, 1.59	Moderate
Sakuma 2007	Sakuma et al., 2007	1.5 y	1.5 y	5107	FFQ	Sweets/candy	Frequency/d	Continuous	Change in caries	Change in number of teeth with caries	Four cities/districts: β = 0.31, OR = 1.4, CI 1.2,1.5, P < 0.001; β = 0.33, OR = 1.4, CI 1.1, 1.7, P < 0.1; β = 0.5, OR = 1.6, CI 1.3, 2.1, P < 0.001; β = 0.37, OR = 1.5, CI 1.3, 1.7, P < 0.001	Serious
Watanabe 2014	Watanabe et al., 2014	1.5 y	~21 mo	31202	FFQ	Sweet snacks	Frequency/d	Daily consumption vs. not consumed: 1 d/wk vs.0 d/wk; 2 d/wk vs.0 d/wk; 3 d/wk vs.0 d/wk	Dental caries present or absent	Dichotomous (0, 1)	Once/d (AOR: 2.0; 95% CI: 1.46, 2.74, P < 0.001); twice/d (AOR: 3.21; 95% CI: 2.34, 4.40) 3 times/d (AOR: 3.90; 95% CI: 2.79, 5.45) vs. none at 1.5 y	Serious

2–<5 y												
deMelo 2019	de Melo et al., 2019	30 mo	-	469	Questionnaire	Sweets/candy	Never, sometimes, daily	Sweets daily vs. never; Sweets sometimes vs. never	dmft index	Increase index from 18-36 mo	Daily: RR = 1.53, 95% CI 1.09,2.14, p = 0.014; sometimes: RR = 1.12 95% CI = 0.79, 1.58, P = 0.527	Serious
Grindefjord 1996	Grindefjord et al., 1996	30 mo	12 mo	692	Questionnaire completed by parents at 1, 2.5 and 3.5 y	Candy	Times/d	≥1 vs. <1/wk	Initial/manifest dental caries	Present or absent	OR = 1.63, CI = 1.04, 2.55, P = 0.032	Serious
Hao 2015	Hao et al., 2015	3 y	12 mo	130	FFQ	Sweets/candy	Frequency/d	Sweets ≥2 times/d vs.< 2 times/d	dmfs at 6 mo; dmfs at 12 mo	Present or absent	P < 0.01	Serious
Holt 1991	Holt et al., 1991	2 y	3 y	2139	Questionnaire	Sweetened snacks or drinks	Frequency/d	0, 1, 2, 3 or 4	dmft count	Mean dmft	Univariate analysis: % caries free by intake (unadjusted P < 0.05), number of caries by intake (P < 0.01)	Critical
Hooley 2012	Hooley et al., 2012	4.79 y	2.05 y	4149	24-h dietary recall	High fat foods (meat pie, hamburger, hot dog, sausage, or sausage roll; hot chips or French fries; potato chips or savory snacks and biscuits, doughnuts, cake, pie, or chocolate)	Frequency/d	Continuous	Dental caries (reported by primary caregiver) at 6-7 y and 8-9 y	Yes/No to occurrence of cavities, extractions or fillings since last survey	OR 1.10, SE 0.04, P = 0.02 at 2 y; OR 1.13, SE=0.06, P = 0.01 at 4 y	Serious
Pang 2015	Pang et al., 2015	3-6 y	2 y	887	Questionnaire completed by parents	Cookies and sweet breads	Frequency/d	≥ 1/d vs.< 1/d; ≥ 1/d vs.< 1/d	DMFT/dmft caries	New cases of caries	OR = 2.01, 95% CI = 1.39, 2.92	Serious
Peltzer 2014	Peltzer et al., 2014	24 mo	12 mo	597	Diary completed by parents	Sweet candy	Frequency/wk	Weekly sweet candy intake at 30 mo: 3-7 d/wk vs.0-2 d/wk	dmft and dmfs	dmft value at age 36 mo minus that at 24 mo	OR = 1.97, 95% CI = 1.17, 3.31, P < 0.05	Critical
Rodrigues 2000	Rodrigues et al., 2000	3 y	12 mo	510	3-d weighed inventory Frequency of consumption	Sugary food	Frequency/d	4-5 times/d vs.1-2.9 times/d	Change in dmfs	Score	OR = 4.29, 95% CI 1.7, 10.7	Moderate

Ruottinen 2004	Karjalainen et al., 2015	37.4 mo	6 y	89	4-d food record	Added sucrose (sucrose and other free sugars)	%EI	<10%EI vs. ≥10%EI	dmft/DMFT	Change in score	Mean 2.82 (SEM 0.51) v 1.63 (SEM 0.26) P = 0.014	Serious
Skafida 2018	Skafida et al., 2018	2 y	3 y	3770	FFQ	Daily sugar Sweets or chocolate	Continuous Frequency/mo	≥1/d vs. < 1/d	Decayed, extracted, or filled teeth	Dichotomous (0, 1)	P = 0.012 OR = 1.53, 95% CI = 1.24, 1.89 P < 0.001	Serious
Tamaki 2009	Tamaki et al., 2009	5 or 6 y	2.5 y	500	FFQ	Sweet snacks	Frequency/d	Continuous	Incident caries (baseline to follow-up)		OR = 1.286, 95% CI = 0.822, 2.013, P = 0.271	Critical
Thornley 2020	Thornley et al., 2020	2 y	5 y	4111	FFQ	Confectionary/cakes; noodles/rice porridge; ice-cream; takeaways	Frequency/mo	Continuous	dmft	Score	Univariate analysis: Confectionary or cake P < 0.001; Noodles or rice porridge P < 0.001; Ice-cream P < 0.001; Refined breakfast cereals P < 0.001; Takeaways P < 0.001	Critical
Winter 2015	Winter et al., 2015	3.5 y	3 y	566	Questionnaire	Sugar index	Frequency: never, seldom, occasionally, often, always	Above vs. below median score (>24 vs. ≤ 24)	dmft increment	Incremental change	OR = 1.53, 95% CI = 1.07, 2.2, P = 0.027	Critical
Wu 2020	Wu et al., 2020	4.2 y	1 y	212	Questionnaire	Candy	Frequency/wk	> 1/wk vs. <1/wk	dmft rate	Score	Parameter estimate = -3.093 95% CI = -1.095, -0.242, P = 0.004	Serious

*Estimates are adjusted odds ratios unless otherwise stated

[1]AOR, adjusted OR; dmfs, decayed-missing-filled surfaces (for primary teeth); DAT, dietary assessment tool; dmft, decayed-missing-filled teeth (for primary teeth); DMFT, decayed-missing-filled teeth (for permanent teeth); d1, non-cavitated lesions; d2-3, cavitated lesions; ECC, early childhood caries; FFQ, food-frequency questionnaire; RoB, risk of bias; SSB, sugar-sweetened beverages; %EI, percentage of energy intake

[2]Minimum analytical sample size.

Table 15: GRADE evidence profile for sugar-sweetened beverage consumption and growth, body composition and overweight/obesity outcomes

Question: High consumption of sugar-sweetened beverages compared to low or no consumption for increased risk of overweight/obesity among children ≤ 10 years
Setting: All countries, community settings
Bibliography: Alviso-Orellana et al., 2018; Byrne et al., 2018; Cantoral et al., 2016; Carlson et al., 2012; Costa et al., 2019; Fiorito et al., 2009; Flores et al., 2013; Hasnain et al., 2014; Hur et al., 2015; Jackson et al., 2017; Jensen et al., 2013; Johnson et al., 2007; Laurson et al., 2008; Leermakers et al., 2015; Lim et al., 2009; Marshall et al., 2019; Millar et al., 2014; Muckelbauer et al., 2016; Newby et al., 2004; Pan et al., 2014; Quah et al., 2019; Santorelli et al., 2014; Striegel-Moore et al., 2006; Traub et al., 2018; Wijga et al., 2010; Wang et al., 2013; Zheng et al., 2014; Zheng et al., 2015; Zulfiqar 2019.

Certainty assessment							Impact	Certainty	Importance
№ of studies	Study design	Risk of bias	Inconsistency	Indirectness	Imprecision	Other considerations			
Mean BMI/BMI z-score or change in BMI/BMI z-score in children < 2 years at exposure									
3[1,2,3]	observational studies	very serious[a]	not serious[b]	not serious[c]	not serious[d]	none	Increased BMI (0 studies); Different effects (2 studies, n = 3138); different effect in boys vs girls (Quah 2019); different effects by age of follow up: from age 18 m to 6 y, β = 0.06, 95% CI = -0.20, 0.31, P = 0.67 and from age 5 y to 6 y β = 0.34, 95% CI = 0.11, 0.58, P = 0.004 (Leermakers 2015); No significant association (1 study, n = 743): Mean BMIz diff -0.10, 95% CI -0·36, 0·16 (Santorelli 2014) [e,f]	⨁⨁◯◯ Low	CRITICAL
Mean BMI/BMI z-score or change in BMI/BMI z-score in children 2 - < 5 years at exposure									

Certainty assessment							Impact	Certainty	Importance
№ of studies	Study design	Risk of bias	Inconsistency	Indirectness	Imprecision	Other considerations			
6[4,5,6,7,8,9]	observational studies	very serious[g]	not serious[b]	not serious[c]	not serious[d]	none	Increased BMI (2 studies, n = 4792): β = 0.05, 95% CI = 0.022, 0.079, P = 0.001 (Marshall 2019); β = 0.017, 95% CI = 0.007, 0.027, P < 0.01 (Millar 2014); Different effects (0 studies); No significant association (4 studies, n = 2163): β -0.01, 95% CI -0.05 to 0.04, P = 0.852 (Costa 2019); ANCOVA P = 0.0626 (Hasnain 2014); β = -0.01, SE = 0.02, P = 0.50 (Newby 2004); P > 0.05 (Byrne 2018) [e,f]	⨁⨁◯◯ Low	CRITICAL

Mean BMI/BMI z-score or change in BMI/BMI z-score in children 5- ≤ 10 years at exposure

Certainty assessment							Impact	Certainty	Importance
№ of studies	Study design	Risk of bias	Inconsistency	Indirectness	Imprecision	Other considerations			
10[10,11,12,13,14,15,16,17,18,19]	observational studies	very serious[h]	not serious[b]	not serious[c]	not serious[d]	none	Increased BMI (2 studies, n=158) β = 0·74, 95% CI = 0·15, 1.33 (Alviso-Orellana 2018); β = 0.10, SE = 0.03, P = 0.003 (Zheng 2015); Different effects (1 study, n = 2371); Positive association for sodas (β = 0.011, SE = 0.005, P < 0.05) but not other SSBs (β = 0.009, SE = 0.007, P > 0.05); No significant association (7 studies, n=6726); β = 0.11, CI = -0.03, 0.25 (Carlson 2012); ANOVA p > 0.05 (Fiorito, 2009); β = -0.02, SE = 0.03, P > 0.05 (Hur 2015); P > 0.05 (parameter estimate from a cross-lagged autoregressive model, Jackson 2017); intake at 6 y and BMI change 6-9 y β = -0.014, 95% CI = -0.063, 0.035, P = 0.55 (Jensen 2013); boys β = -0.037, SE = 0.019, P = 0.707, girls β = 0.086, SE = 0.027, P = 0.450 (Laurson 2008); at 9 y > 1 serve β= 1.42, SE 0.68, P = 0.29 (Zheng 2014) [e,f]	⨁⨁◯◯ Low	CRITICAL

Certainty assessment							Impact	Certainty	Importance
№ of studies	Study design	Risk of bias	Inconsistency	Indirectness	Imprecision	Other considerations			
Mean change in BMI/BMI z-score in children 5- ≤ 10 years at exposure									
1[20]	randomised trials	serious[i]	not serious[j]	serious[k]	not serious[d]	none	1 study (n=1987) BMI change: β = 0.02, 95% CI 0.00, 0.03 with each glass of sugar-containing beverage consumption/day.	⨁⨁◯◯ Low	CRITICAL
Prevalence of overweight and obesity or prevalence of obesity only in children aged < 2 years (assessed with: %)									
6[2,21,22,23,24,25]	observational studies	extremely serious[l]	not serious[b]	not serious[c]	not serious[d]	none	Increased overweight/obesity (3 studies, n = 3372); aOR = 2.99, 95% CI: 1.27, 7.00 (Cantoral 2016); ≥3 times/week aOR = 2.00, 95% CI = 1.02, 3.90 (Pan 2014); aOR = 1.6, CI = 1.04, 1.93, P < 0.01 (Wang 2013); Different effects (2 studies, n = 7567); At 2 y no significant association, at 5 y aOR = 2.3, 95% CI 1.4, 3.7 (Flores 2013); at 18 m no significant association, at 5 y RR = 1.10, 95% CI = 0.67, 1.81, P = 0.204 (Quah 2019); No significant association (1 study, n = 1871); aOR = 0.91, 95% CI = 0.44, 1.88 (Wijga 2010)	⨁◯◯◯ Very low	CRITICAL

Certainty assessment							Impact	Certainty	Importance
№ of studies	Study design	Risk of bias	Inconsistency	Indirectness	Imprecision	Other considerations			
Prevalence of overweight and obesity or prevalence of obesity only in children aged 2-< 5 years (assessed with: %)									
5[26,27,28,29,30]	observational studies	very serious[m]	not serious[b]	not serious[c]	not serious[d]	none	Increased overweight/obesity (1 study, n= 473); aOR = 1.92, 95% CI = 1.19, 3.11, P ≤ 0.01); Different effects (1 study, n = 2986); overweight/obesity no association, obesity only aOR= 1.65, 95% CI = 1.12, 2.44, P = 0.01 (Macintyre 2018); No significant association (3 studies, 17083); Not significant (no estimate, Dubois 2007); aOR = 1.3, 95% CI = 0.8, 2.1 (Welsh 2005); Boys aOR = 1.01, 95% CI = 0.8, 1.29; girls aOR = 1.08, 95% CI = 0.87, 1.35 (Zulfiqar 2019)	⨁⨁◯◯ Low	CRITICAL
Prevalence of overweight and obesity or prevalence of obesity only in children aged 5- ≤ 10 years (assessed with: %)									

Certainty assessment							Impact	Certainty	Importance
№ of studies	Study design	Risk of bias	Inconsistency	Indirectness	Imprecision	Other considerations			
3[19,31,32]	observational studies	very serious[g]	not serious[b]	not serious[c]	not serious[d]	none	Increased overweight/obesity (2 studies, n = 1668): aRR= 2·12, 95% CI 1·05, 4·28 (Alviso-Orellana 2018); aOR = 1.04, 95% CI = 1.01, 1.07, P < 0.05 (Lim 2008); Different effects (0 studies); No significant association (1 study, n = 1250) Overweight only aOR = 1.29, 95% CI = 0.84, 1.96, p = 0.246; obese only aOR = 1.57, 95% CI = 0.82, 3.03, p = 0.177 (Traub 2018)	⨁⨁◯◯ Low	CRITICAL

Prevalence of overweight and obesity or prevalence of obesity only in children aged 5 - ≤10 years (assessed with: %)

1[20]	randomised trials	serious[i]	not serious[j]	serious[k]	not serious[d]	none	Increased risk (1 study, n = 1987); Each glass/day of sugar-sweetened beverage consumption increased the odds of obesity (aOR 1·22; 95% CI 1·04, 1·44, p= 0.014) but not overweight (P=0.83)	⨁⨁◯◯ Low	CRITICAL

Mean percent body fat in children aged ≤ 10 years

Certainty assessment							Impact	Certainty	Importance
№ of studies	Study design	Risk of bias	Inconsistency	Indirectness	Imprecision	Other considerations			
7[3,7,11,16,17,18,33]	observational studies	very serious[n]	not serious[b]	not serious[c]	not serious[d]	none	Increased % body fat (3 studies, n = 578); ANOVA P < 0.01 (Fiorito 2009); β = 1.40, CI = 0.09, 2.72, P = 0.036 (Carlson 2012); β = 1.04, SE = 0.32, P = 0.001 (Zheng 2015); Different effects (0 studies); No significant association (4 studies, n = 3436); ANCOVA P = 0.929 (Hasnain 2014); β = 0.02, SE = 0.21, P > 0.05 (Hur 2015); β = -0.15, 95% CI = -0.54, 0.24, P = 0.45 (Johnson 2007); Boys β= 0.05, 95% CI = -0.11, 0.20, P =0.53; girls β = 0.09, 95% CI = -0.06, 0.23, P = 0.25 (Leermakers 2015). o	⨁⨁◯◯ Low	CRITICAL

CI: confidence interval

Explanations

a. Risk of bias was moderate in 1 study (Santorelli, 2014) and serious in 2 studies (Quah 2019, Leermakers 2015). Downrated by 2 levels due to non-randomization leading to confounding and selection bias.

b. Not downrated for inconsistency but note that interventions and comparators were were different across studies

c. Not downrated as study populations, exposures and comparators were relevant to review question, although no studies were from low income country populations

d. Not downrated as no evidence of imprecision (i.e. not wide confidence intervals, small sample size or low number of events)

e. Meta-analysis of 3 studies across different age groups: BMI change effect size 0.01 (-0.00, 0.02) (Jensen 2013, Newby 2004, Laurson 2008)

f. Meta-analysis of 3 studies across different age groups: BMI z-score change effect size 0.10 95% CI -0.11 - 0.31 (Carlson 2012, Marshall 2019, Quah 2019)

g. Risk of bias was moderate for all studies. Downrated by 2 levels due to non-randomization in observational studies leading to confounding and selection bias.

h. Risk of bias was moderate in 5 studies (Alviso-Orellana 2018, Jackson 2017, Jensen 2013, Laurson 2008, Zheng 2015) and serious in 5 studies (Carlson 2012, Fiorito 2009, Hur 2015, Striegel-Moore 2006, Zheng 2015). Downrated by 2 levels due to non-randomization in observational studies leading to confounding and selection bias

i. Some concerns due to missing outcome data and bias in selection of reported result

j. Not downrated as only 1 study

k. Downrated by 1 level as sugar-sweetened beverage consumption was a secondary outcome of the RCT

l. Risk of bias was serious for all 5 studies. Downrated by 2 levels for inherent risk of bias due to non-randomisation and 1 further level due to serious risk of bias in all studies.

m. Risk of bias was moderate in 4 studies (Dubois 2007, Macintyre 2018, Welsh 2005, Zulfiqar 2019) and serious in 1 study (DeCoen 2014)

n. Risk of bias was moderate in 3 studies (Hasnain 2014, Johnson 2007, Leermakers 2015), serious in 4 studies (Carlson 2012, Fiorito 2009, Hur 2015, Zheng 2015). Downrated by 2 levels for risk of bias due to non-randomization in observational studies leading to confounding and selection bias

o. Meta-analysis of 3 studies (Carlson 2012; Hur 2015; Zheng 2015): pooled effect estimate β=1.86 [0.38, 3.34].

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Table 16: GRADE evidence profile for artificially sweetened beverage consumption and growth, body composition and overweight/obesity outcomes

Question: High consumption of artificially-sweetened beverages compared to low or no consumption of artificially-sweetened beverages for increased risk of overweight/obesity among children ≤ 10 years
Setting: All countries, community settings
Bibliography: Hasnain et al., 2014; Johnson et al., 2007; Newby et al., 2004; Macintyre et al., 2018; Striegel-Moore et al., 2006; Zheng et al., 2015;

Certainty assessment							Impact	Certainty	Importance
№ of studies	Study design	Risk of bias	Inconsistency	Indirectness	Imprecision	Other considerations			
Mean BMI/BMI z-score or change in BMI/BMI z-score in children < 2 years at exposure									
0							No included studies	-	
Mean BMI/BMI z-score or change in BMI/BMI z-score in children 2- < 5 years at exposure									
2[1,2]	observational studies	very serious[a]	not serious[b]	not serious[c]	not serious[d]	none	Increased BMI (0 studies); Different effects (0 studies); No significant association (2 studies, n=1443): ANCOVA p = 0.444 (Hasnain 2014); β = 0.01, SE = 0.02, p = 0.83 (Newby 2004)	⨁⨁◯◯ Low	CRITICAL
Mean BMI/BMI z-score or change in BMI/BMI z-score in children 5 - ≤ 10 years at exposure									
2[3,4]	observational studies	extremely serious[e]	not serious[b]	not serious[c]	not serious[d]	none	Increased BMI (0 studies); Different effects (0 studies); No significant association (1 study, n=2371); β = 0.01, SE = 0.013, p > 0.05 (Striegel-Moore 2006); Decreased BMI (1 study, n= 158); β = -0.20, SE = 0.07, p = 0.01 (Zheng 2015)	⨁◯◯◯ Very low	CRITICAL

Certainty assessment							Impact	Certainty	Importance
№ of studies	Study design	Risk of bias	Inconsistency	Indirectness	Imprecision	Other considerations			
Prevalence of overweight and obesity or prevalence of obesity only in children aged < 2 years (assessed with: %)									
0							No included studies	-	
Prevalence of overweight and obesity or prevalence of obesity only in children aged 2-< 5 years (assessed with: %)									
1[5]	observational studies	very serious[a]	not serious[f]	not serious[c]	not serious[d]	none	Different effects (1 study, n=2986); No signficant association with overweight/obesity (aOR = 0.85, 95% CI 0.63, 1.15 p = 0.85) but increased risk of obesity (aOR = 1.57, 95% CI = 1.05, 2.36, p = 0.03) (Macintyre 2018)	⨁⨁◯◯ Low	CRITICAL
Prevalence of overweight and obesity or prevalence of obesity only in children aged 5- ≤ 10 years (assessed with: %)									
0							No included studies	-	
Mean percent body fat in children aged ≤ 10 years (assessed with: %)									
3[2,3,6]	observational studies	very serious[g]	not serious[b]	not serious[c]	not serious[d]	none	No significant association (1 study, n=98): ANCOVA p = 0.584 (Hasnain 2014); Positive association (1 study, n=362) β = 0.26, 95% CI = -0.004, 0.52, p = 0.05 (Johnson 2007); Negative association (1 study, n=158) β = -1.41, SE = 0.70, p = 0.046, (Zheng 2015)	⨁⨁◯◯ Low	CRITICAL

CI: confidence interval

Explanations

a. Risk of bias was moderate for all studies. Downrated by 2 levels for inherent bias due to non-randomization in observational studies leading to confounding and selection bias.

b. Not downrated for inconsistency but note that there were differences between interventions and comparators across studies.

c. Not downrated as study populations, exposures and comparators were relevant to review question, although no studies were from low income country populations

d. Not downrated as no evidence of imprecision (i.e. not wide confidence intervals, small sample size or low number of events)

e. Risk of bias was serious for all studies. Downrated by 2 levels for risk of bias due to non-randomization (confounding and selection bias) and 1 further level for serious risk of bias across the body of evidence.

f. Not downrated as only one study

g. Risk of bias was moderate in 2 studies (Hasnain 2014, Johnson 2007) and serious in 1 study (Zheng 2015). Downrated by 2 levels due to risk of bias due to non-randomization in observational studies leading to confounding and selection bias

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Table 17: GRADE evidence profile for 100% fruit juice consumption and growth, body composition and overweight/obesity outcomes

Question: High consumption of 100% fruit juice compared to low or no consumption of 100% fruit juice for increased risk of overweight/obesity among children ≤ 10 years
Setting: All countries, community settings,
Bibliography: Budree et al., 2017; Carlson et al., 2012; Hasnain et al., 2014; Johnson et al., 2007; Marshall et al., 2019; Newby et al., 2004; Shefferly et al., 2016; Skinner et al., 1999; Sonneville et al., 2015; Welsh et al., 2005; Zheng et al., 2015.

Certainty assessment							Impact	Certainty	Importance
№ of studies	Study design	Risk of bias	Inconsistency	Indirectness	Imprecision	Other considerations			
Mean BMI/BMI z-score or change in BMI/BMI z-score in children < 2 years at exposure									
1[1]	observational studies	very serious[a]	not serious[b]	not serious[c]	not serious[d]	none	Increased BMI (0 studies); No significant association (1 study, n= 1038) β=0.30, 95% CI = −0.01, 0.61 at 2.1 y follow-up; β=0. 0.27, 95% CI = −0.05, 0.59 at 6.7 y follow-up (Sonneville 2015)[e]	⨁⨁◯◯ Low[a]	CRITICAL
Mean BMI/BMI z-score or change in BMI/BMI z-score in children 2- < 5 years at exposure									

Certainty assessment							Impact	Certainty	Importance
№ of studies	Study design	Risk of bias	Inconsistency	Indirectness	Imprecision	Other considerations			
5[2,3,4,5,6]	observational studies	very serious[f]	not serious[g]	not serious[c]	not serious[d]	none	Increased BMI (0 studies); Different effects (1 study, n= 6250): Mean BMI z-score change 0.282 (SE 0.028) vs 0.030 (SE 0.037), p = 0.0003 at 2-4 y, 0.034 (SE 0.031) 0.020 (SE 0.021) p = 0.6778 at 4-5 y (Shefferly 2016); No significant association (4 studies, n= 2138): ANCOVA p = 0.062 (Hasnain 2014); β = 0.01 SE = 0.00, p = 0.20 (Newby 2004); β = -0.001, 95% CI = -0.059, 0.057, p = 0.97 (Marshall 2019); β = -0.057, p = 0.099 (SE not stated) (Skinner 1999) [e]	⨁⨁◯◯ Low	CRITICAL
Mean BMI/BMI z-score or change in BMI/BMI z-score in children 5- ≤ 10 years at exposure									
2[7,8]	observational studies	extremely serious[h]	not serious[g]	not serious[c]	not serious[d]	none	Increased BMI (0 studies); Different effects (0 studies); No significant association (2 studies, n=412): β = -0.04, CI = -0.21, 0.13, p = 0.631 (Carlson 2012); β = 0.07, SE = 0.05, p = 0.12 (Zheng 2015). [e]	⨁◯◯◯ Very low	CRITICAL
Prevalence of overweight and obesity or prevalence of obesity only in children aged < 2 years (assessed with: %)									

Certainty assessment							Impact	Certainty	Importance
№ of studies	Study design	Risk of bias	Inconsistency	Indirectness	Imprecision	Other considerations			
1[9]	observational studies	extremely serious[h]	not serious[b]	not serious[c]	not serious[d]	none	No significant association (1 study, n = 1076); Odds of overweight including obesity, aOR = 1.0, 95% CI = 0.5, 2.0, p = 0.916 (Budree 2017)	⊕◯◯◯ Very low	CRITICAL

Prevalence of overweight and obesity or prevalence of obesity only in children aged 2-< 5 years (assessed with: %)

2[2,10]	observational studies	very serious[a]	not serious[g]	not serious[c]	not serious[d]	none	Increased overweight/obesity (0 studies); Different effects (1 study, n=6250); overweight/obesity aOR = 1.30, 95% CI = 1.06-1.59, p = 0.0129 at 2-4 y follow-up; aOR = 0.80, 95% CI = 0.43-1.49, p= 0.473 at 4-5 y follow-up) (Shefferly 2016); No significant association (1 study, n=10904): high vs low intake among normal weight at baseline: aOR = 1.2 95% cI = 0.8-1.7); high vs low intake among at risk of overweight at baseline aOR= 0.8 95% CI = 0.5- 1.1 (Welsh 2005)	⊕⊕◯◯ Low	CRITICAL

Prevalence of overweight and obesity or prevalence of obesity only in children aged 5- ≤ 10 years (assessed with: %)

0							No included studies	-	

Mean percent body fat in children aged ≤ 10 years (assessed with: %)

Certainty assessment							Impact	Certainty	Importance
№ of studies	Study design	Risk of bias	Inconsistency	Indirectness	Imprecision	Other considerations			
4[6,7,8,11]	observational studies	very serious[i]	not serious[g]	not serious[c]	not serious[d]	none	Increased % body fat (0 studies); Different effects (0 studies); No significant association (4 studies, n= 872); β= -1.06, 95% CI = -2.70, 0.57, p = 0.202 (Carlson 2021); ANCOVA p = 0.119 (Hasnain 2014); β = -0.11, 95% CI = -0.61, 0.38, p = 0.66 (Johnson 2007); β = -0.05, SE = 0.44, p = 0.91 (Zheng 2015)	⨁⨁◯◯ Low	

CI: confidence interval

Explanations

a. Risk of bias was moderate in all studies. Downrated by 2 levels due to non-randomization in observational studies leading to confounding and selection bias.

b. Not downrated as only 1 study

c. Not downrated as study populations, exposures and comparators were relevant to review question, although no studies were from low income country populations

d. Not downrated as no evidence of imprecision (i.e. not wide confidence intervals, small sample size or low number of events)

e. Meta-analysis of 3 studies across age groups on BMI z-score effect size: 0.01, 95% CI 0.00, 0.01

f. Risk of bias was moderate in four studies (Hasnain 2014, Marshall 2019, Newby 2004, Shefferly 2016) and serious in one study (Skinner 1999). Downrated by 2 levels due to non-randomization in observational studies leading to confounding and selection bias

g. Not downrated for inconsistency but note that interventions and comparators were not the same across studies

h. Risk of bias was serious in all studies. Downrated by 2 levels for inherent risk of bias due to non-randomisation and 1 further level due to body of evidence based on studies at serious risk of bias.

i. Risk of bias was moderate in 2 studies (Hasnain 2014 and Johnson 2007) and serious in 2 studies (Carlson 2012 and Zheng 2015). Downrated by 2 levels due to non-randomization leading to bias due to confounding and selection bias.

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Table 18: GRADE evidence profile for consumption of unhealthy food items and growth, body composition and overweight/obesity outcomes

Question: High consumption of unhealthy food items compared to low or no consumption of unhealthy food items for increased risk of overweight/obesity among children ≤ 10 years
Setting: All countries, community settings
Bibliography: Alviso-Orellana et al., 2018; Bel-Serrat et al., 2019; Buyken et al., 2011; Carlson et al., 2012; Costa et al., 2019; Costa et al., 2020; DeCoen et al., 2014; Emond et al., 2020; Garden et al., 2011; Hur et al., 2015; Jackson et al., 2017; Millar et al., 2014; Moore et al., 2019; Russo et al., 2018; Santorelli et al., 2014; Vedovato et al., 2020; Wijga et al., 2010; Zulfiqar et al., 2019

Certainty assessment							Impact	Certainty	Importance
№ of studies	Study design	Risk of bias	Inconsistency	Indirectness	Imprecision	Other considerations			
Mean BMI/BMI z-scores or change in BMI/BMI z-scores in children aged < 2 years									
3[1,2,3]	observational studies	very serious[a]	not serious[b]	not serious[c]	not serious[d]	none	Increased BMI (1 study, n = 666): candies, ANOVA F= 3.23, P = 0.03 (Moore 2019); Different effects (0 studies); No significant association (2 studies, n = 1105); 'extra foods' β = -0.10, 95%CI = -0.30, 0.11, p = 0.36 (Garden 2011); sweetened foods BMIz mean difference 0.03 95% CI -0.12, 0.19 (Santorelli 2014)	⨁⨁◯◯ Low	CRITICAL
Mean BMI/BMI z-scores or change in BMI/BMI z-scores in children aged 2- <5 years at exposure									

Certainty assessment							Impact	Certainty	Importance
№ of studies	Study design	Risk of bias	Inconsistency	Indirectness	Imprecision	Other considerations			
6[4,5,6,7,8,9]	observational studies	very serious[e]	not serious[b]	not serious[c]	not serious[d]	none	Increased BMI (3 studies, n = 11639); Fast foods aRR: 1.38, 95% CI 1.13, 1.67, P < 0.01 (Emond 2020); High fat foods β = 0.021, 95% CI 0.014, 0.029 P < 0.001 (Millar 2014); Sugar-added to foods 2 < 6 y: boys P = 0.005, girls P = 0.03; 6 < 10 y: boys P = 0.001, girls P > 0.05 (Russo 2018); Different effects (1 study, n = 1175); Ultra-processed food intake at 4 y β=0·028; 95% CI = 0.006, 0.051, intake at 7 y β=0·014; 95% CI = -0.007, 0.036 (Vedovato 2020); No significant association (2 studies, n = 695); Added sugar β = -0.001, SE = 0.010, P = 0.9 (Buyken 2011); Ultra-processed foods β = 0.05, 95% CI = -0.04, 0.15, P = 0.282 (Costa 2019)	⨁⨁◯◯ Low	CRITICAL

Mean BMI/BMI z-scores or change in BMI/BMI z-scores in children aged 5 - ≤ 10 years at exposure

Certainty assessment							Impact	Certainty	Importance
№ of studies	Study design	Risk of bias	Inconsistency	Indirectness	Imprecision	Other considerations			
4[10,11,12,13]	observational studies	very serious[f]	not serious[b]	not serious[c]	not serious[d]	none	Increased BMI (1 study, n=1414); Snack foods β = 0.71, 95% CI = 0.14, 1.28 (Alviso-Orellana 2018); Different effects (0 studies); No significant association (3 studies, n = 5797); High fat foods β = -0.02, CI = -0.06, 0.03, P = 0.409 (Carlson 2012); Other sugars β = 0.16, SE = 0.10, P > 0.05 (Hur 2015); Fast foods P > 0.05 (parameter estimate from a cross-lagged autoregressive model (Jackson 2017)	⨁⨁◯◯ Low	CRITICAL

Prevalence of overweight and obesity or prevalence of obesity only in children aged < 2 years (assessed with: %)

1[14]	observational studies	extremely serious[g]	not serious[b]	not serious[c]	not serious[d]	none	Increased odds of overweight/obesity (0 studies); Different effects (0 studies); No significant association (1 study, n=1871); Fast foods aOR = 1.14, 95% CI = 0.77, 1.67; snack consumption aOR = 0.71, 95% CI = 0.52, 0.98 (Wijga et al 2010)	⨁◯◯◯ Very low	CRITICAL

Prevalence of overweight and obesity or prevalence of obesity only in children aged 2- < 5 years (assessed with: %)

Certainty assessment							Impact	Certainty	Importance
№ of studies	Study design	Risk of bias	Inconsistency	Indirectness	Imprecision	Other considerations			
2[15,16]	observational studies	very serious[h]	not serious[b]	not serious[c]	not serious[d]	none	Increased overweight/obesity (0 studies); Different effects (0 studies); No significant association (2 studies, n = 4680); Sweet and savory snacks aOR = 0.76, 95% CI = 0.41, 1.40, P > 0.05 (De Coen 2014); High fat foods boys: aOR = 0.85, 95% CI = 0.6, 1.19; girls: aOR = 0.97, 95% CI = 0.7, 1.35 (Zulfiqar 2019)	⨁⨁◯◯ Low	CRITICAL

Prevalence of overweight and obesity or prevalence of obesity only in children aged 5 - ≤ 10 years (assessed with: %)

2[13,17]	observational studies	very serious[i]	not serious[j]	not serious[c]	not serious[d]	none	Increased overweight/obesity (0 studies); Different effects (1 study, n=2755); savory snacks never vs everyday aOR = 0.27, 95% CI = 0.10, 0.72, P <0.01; fast food never vs everyday aOR = 0.91, 95% CI = 0.19, 4.31, P >0.05 (Bel-Serrat 2019); No significant association (1 study, n = 1414); Savory snacks aRR = 1.43 0.78, 2.69 (Alviso-Orellana 2018)	⨁⨁◯◯ Low	CRITICAL

Percent body fat ≤ 10 years

Certainty assessment							Impact	Certainty	Importance
№ of studies	Study design	Risk of bias	Inconsistency	Indirectness	Imprecision	Other considerations			
4[9,11,12,18]	observational studies	extremely serious[k]	not serious[b]	not serious[c]	not serious[d]	none	Increased percent body fat (1 study, n = 3514); Ultra-processed foods β = 0.05, 95% CI = 0.04, 0.06, P < 0.001 (NOTE fat mass index, not % body fat) (Costa 2020); Different effects (0 studies); No significant association (3 studies, n = 1239); Added sugar β = 0.048, SE = 0.046, P = 0.3 (Buyken 2011); HIgh fat foods β = -0.38, CI = -0.81, 0.05, P = 0.081 (Carlson 2012); Other sugars β = 0.83, SE = 0.72, P > 0.05 (Hur 2015)	⨁◯◯◯ Very low	CRITICAL

CI: confidence interval

Explanations

a. Risk of bias was moderate in 2 studies (Garden 2011, Moore 2019), serious in 1 study (Santorelli 2014). Downrated by 2 levels for risk of bias due to non-randomization in observational studies leading to confounding and selection bias

b. Not downrated for inconsistency but note that interventions and comparators were different across studies

c. Not downrated as study populations, exposures and comparators were relevant to review question, although no studies were from low income country populations

d. Not downrated as no evidence of imprecision (i.e. not wide confidence intervals, small sample size or low number of events)

e. Risk of bias was moderate in 5 studies (Costa 2019, Emond 2020, Millar 2014, Russo 2018, Vedovato 2020) and serious in 1 study (Buyken 2011). Downrated by 2 levels for risk of bias due to non-randomization in observational studies leading to confounding and selection bias.

f. Risk of bias was moderate in 2 studies (Alviso-Orellana 2018, Jackson 2017) and serious in 2 studies (Carlson 2012, Hur 2015). Downrated by 2 levels for risk of bias due to non-randomization in observational studies leading to confounding and selection bias.

g. Risk of bias was serious in all studies (Wijga 2010). Downrated by 2 levels for non-randomization in observational studies leading to confounding and selection bias, and 1 level further due to body of evidence all from studies with serious risk of bias

h. Risk of bias was moderate in 1 study and serious in 1 study. Downrated by 2 levels for inherent risk of bias due to non-randomisation in observational studies.

i. Risk of bias was modearte in 1 study (Alviso-Orellana 2018) and serious in 1 study (Bel-Serrat 2019). Downrated by 2 levels for risk of bias due to non-randomization leading to confounding and selection bias.

j. Not downrated as only 1 study

k. Risk of bias was moderate for 1 study (Leffa 2020) and serious for 3 studies (Leermakers 2015, Rauber 2015, Van Rompey 2015). Downrated by 2 levels for risk of bias due to non-randomization leading to confounding and selection bias and 1 level further due to majority of the body of evidence had serious risk of bias.

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Table 19: GRADE evidence profile for consumption of unhealthy foods and beverages and diet-related NCD outcomes

Question: High consumption of unhealthy foods and beverages compared to low or no consumption of unhealthy food and beverages for increased NCD risk among children ≤ 10 years
Setting: All countries, community settings
Bibliography: Costa et al., 2019; Hur et al., 2015; Leermakers et al., 2015; Leffa et al., 2020; Rauber et al., 2015; Van Rompay et al., 2015.

Certainty assessment							Impact	Certainty	Importance
№ of studies	Study design	Risk of bias	Inconsistency	Indirectness	Imprecision	Other considerations			
Blood lipids									
4[1,2,3,4]	observational studies	very serious[a]	not serious[b]	not serious[c]	not serious[d]	none	Increased risk (2 studies, n = 613); Ultra-processed foods (UPF): change in total cholesterol, β = 0.430 95% CI 0.008, 0.853 P = 0.046; change LDL-C, β = 0.369 95% CI 0.005, 0.733 P = 0.047; change non-HDL-C, β = 0.319, 95% CI 0.059, 0.697 P = 0.098; change triglycerides, β = 0.465, 95% CI 0.955, 0.025 P = 0.06; change HDL-C, β = 0.125, 95% CI 0.026, 0.277 P = 0.105 (Rauber 2015); UPF intake: increased total serum cholesterol β 0·22 mmol/l; 95% CI 0·04, 0·39 and TAG 0·11 mmol/l, 95% CI 0·01, 0·20 (Leffa 2020). No significant association (2 studies, n = 2172); No association between SSB at 13 m and systolic or diastolic blood pressure, pulse wave velocity, blood lipds or insulin at 6 years of age (Leermakers 2015); No association between mean SSB intake and changes in HDL cholesterol or TG changes (Van Rompay 2015)	⊕⊕◯◯ Low	CRITICAL

Certainty assessment							Impact	Certainty	Importance
№ of studies	Study design	Risk of bias	Inconsistency	Indirectness	Imprecision	Other considerations			
Glucose/insulin									
1[5]	observational studies	very serious[e]	not serious[f]	not serious[c]	serious[g]	none	Increased risks (0 studies); No significant association (1 study, n = 315); No significant association between ultraprocessed food consumption and glucose profiles (Costa 2019)	⨁◯◯◯ Very low	CRITICAL
Metabolic syndrome									
1[6]	observational studies	extremely serious[h]	not serious[b]	not serious[c]	serious[g]	none	Increased risks (0 studies); No significant association (1 study, n = 605); No significant association between beverage sugar or non-beverage sugars and metabolic syndrome score (Hur 2015)	⨁◯◯◯ Very low	CRITICAL

CI: confidence interval

Explanations

a. Risk of bias was moderate in 3 studies, (Leermakers 2015, Leffa 2020, Rauber 2015) and serious in 1 study (Van Rompay 2015). Downrated by 2 levels for risk of bias due to non-randomization in observational studies. leading to confounding and selection bias.

b. Not downrated for inconsistency but note that interventions and outcomes were different across studies.

c. Not downrated as study populations, exposures and comparators were relevant to review question, although no studies were from low income country populations

d. Not downrated as no evidence of imprecision (i.e. not wide confidence intervals, small sample size or low number of events).

e. Risk of bias was moderate (Costa 2019). Downrated by 2 levels for risk of bias due to non-randomization in observational studies leading to confounding and selection bias.

f. Only 1 study so not downrated for inconsistency.

g. Downrated by 1 level because of uncertainty around the probability of risk occurring within the included sample.

h. Risk of bias was serious for all studies (Hur 2015). Downrated by 2 levels for risk of bias due to non-randomisation in observational studies and 1 further level because body of evidence was from studies with serious risk of bias.

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Table 20: GRADE evidence profile for consumption of unhealthy foods and beverages and displacement of healthy foods or breastmilk

Question: High consumption of unhealthy foods and beverages compared to low or no consumption for increased displacement of healthy foods or breastmilk intake in children ≤ 10 years

Setting: All countries, community settings

Bibliography: Bayer et al., 2014; Byrne et al., 2018; Scheiss et al., 2010.

Certainty assessment							Impact	Certainty	Importance
№ of studies	Study design	Risk of bias	Inconsistency	Indirectness	Imprecision	Other considerations			
Displacement of healthy food items/breastmilk									
3[1,2,3]	observational studies	very serious[a]	not serious[b]	not serious[c]	not serious[d]	none	Increased risks (1 study, n=875); energy-providing liquid intake associated with significantly lower energy intake from formula from 2 - 5 mo (Schiess 2010); Different effects (1 study, n = 515); No significant association between SSB intake and fruit and vegetable intake but weak inverse correlation between SSB intake and milk/alternatives at 2 y (r = −0.11, P = 0.015) and 5 y (r = −0.11, P = 0.012) (Byrne 2018); No significant association (1 study, n = 1252); Change in high-caloric drink and change in energy-dense sweet consumption was not significantly correlated with change in fruit or change in vegetable consumption (Bayer 2014).	⨁⨁◯◯ Low	CRITICAL

CI: confidence interval

Explanations

a. Risk of bias was moderate in 2 studies (Byrne 2018, Scheiss 2010) and serious in 1 study (Bayer 2014). Downrated by 2 levels for risk of bias due to non-randomization in observational studies leading to confounding and selection bias

b. Not downrated for inconsistency but note that interventions and comparators were different across studies

c. Not downrated as study populations, exposures and comparators were relevant to review question, although no studies were from low income country populations

d. Not downrated as no evidence of imprecision (i.e. not wide confidence intervals, small sample size or low number of events)

References

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Table 21: GRADE evidence profile for consumption of unhealthy foods and beverages and dietary quality and dietary diversity

Question: High consumption of unhealthy foods and beverages compared to low or no consumption of unhealthy foods and beverages for dietary quality and diversity in children ≤ 10 years

Setting: All countries, community settings

Bibliography: Russo et al., 2014; Vilela et al., 2014; Wan et al., 2020; Woo et al., 2020.

Certainty assessment							Impact	Certainty	Importance
№ of studies	Study design	Risk of bias	Inconsistency	Indirectness	Imprecision	Other considerations			
Dietary quality and diversity indicators (assessed with: Healthy eating index/healthy dietary assessment score)									
4[1,2,3,4]	observational studies	very serious[a]	not serious[b]	not serious[c]	not serious[d]	none	Increased diversity (1 study, n = 100); increased 100% fruit juice associated with increase healthy eating index (Wan 2020); No significant association (0 studies); Decreased diversity (3 studies, n= 7986); Sugar-added foods associated with lower healthy dietary adherence score (P < 0.001 for trend) (Russo 2018); Daily high energy-dense food intake at 2 y associated with lower healthy eating index score at 4 y, IRR = 0·56, 95% CI 0·41, 0·77 (Vilela 2014); Lower consumption SSB associated with higher odds of healthy eating index (AOR 2.7, 95% CI 1.6 to 4.3, P < 0.001) (Woo 2020)	⨁⨁◯◯ Low	CRITICAL

CI: confidence interval

Explanations

a. Risk of bias was moderate in 3 studies (Russo 2018, Vilela 2014, Woo 2020) and serious in 1 study (Wan 2020). Downrated by 2 levels for risk of bias due to non-randomization in observational studies leading to confounding and selection bias

b. Not downrated for inconsistency but note that interventions, comparators and outcomes (specific indicators of dietary diversity) were different across studies.

c. Not downrated as study populations, exposures and comparators were relevant to review question, although no studies were from low income country populations

d. Not downrated as no evidence of imprecision (i.e. not wide confidence intervals, small sample size or low number of events)

References

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Supplementary materials

Table S1 Funding sources and declaration of competing interests for studies reporting on growth and body composition outcomes[1]

Study ID	Reference	Funding sources	Authors' declaration of interests[2]
Alviso-Orellana 2018	Alviso-Orellana et al., 2018	Wellcome Trust Research Training Fellowship in Public Health and Tropical Medicine	None
Arcan 2013	Arcan et al., 2013	National Institutes of Health, USA	Not stated
Bayer 2014	Bayer et al., 2014	Bavarian Health and Food Safety Authority	None
Bel-Serrat 2019	Bel-Serrat et al., 2019	Health Service Executive of Ireland	None
Berkey 2004	Berkey et al., 2004	Boston Obesity Nutrition Research Center NIH Grant DK46834. Prevention Research Center Grant P30DK46200. Centers for Disease Control and Prevention Grant U48/CCU115807. Economic Research Service of the U.S. Department of Agriculture Research Grant 43-3AEM-0-80074. Kellogg's.	Not stated
Bisset 2007	Bisset et al., 2007	Operating grant from the Medical Research Council of Canada; National Health Research Development Programme; CIHR Doctoral Research Award	None
Blum 2005	Blum et al., 2005	NS	Not stated
Budree 2017	Budree et al., 2017	Bill and Melinda Gates Foundation. The South African Medical Research Council. GlaxoSmithKline/South African Thoracic Society. The Harry Crossley Foundation. The Discovery Foundation.	None
Byrne 2018	Byrne et al., 2018	Australian National Health and Medical Research Council (426704, APP1021065). HJ Heinz. Meat & Livestock Australia. Department of Health South Australia. Food Standards Australia New Zealand. Queensland University of Technology	None
Cantoral 2016	Cantoral et al., 2016	US NIEHS (P01-ES022844, R01-ES021446, R01-ES005947). Consejo Nacional de Ciencia y Tecnología (CONACyT) 41912-M. The NIEHS/USEPA Formative Children's Center for Environmental Health and Disease Prevention Research (NIH P20-ES018171/EPA RD#834800).	None
Carlson 2012	Carlson et al., 2012	National institute of Diabetes and Digestive and Kidney Diseases (NiDDK) grant #R01DK072994	None
Costa 2020	Costa et al., 2020	Wellcome Trust. DECIT (Departamento de Ciencia e Tecnologia). Conselho Nacionalde Desenvolvimento. Científico e Tecnológico - Brazil CNPq.	None
Cowin 2001	Dong et al., 2015 Johnson et al., 2007	Northern and Yorkshire Regional Health Authority NHS Research and Development Programme on Cardiovascular Disease and Stroke.	Not stated
DeBoer 2013	DeBoer et al., 2013	National Institutes of Health	None

DeCoen 2014	De Coen et al., 2014	Ministry of the Flemish Community (Department of Economics, Science, and Innovation; Department of Welfare, Public Health and Family	None
Dubois 2007	Dubois et al., 2007	Canadian Institute of Health Information. Population Health Initiative. Canadian Institute of Health Research.	Not stated
Emond 2020	Emond et al., 2020	National Institute of Child Health and Human Development, Grant. National Institute of Diabetes and Digestive and Kidney Disease, Grant.	None
Faith 2006	Faith et al., 2006	Economic Research Service; Food Assistance and Nutrition Research Program; US Department of Agriculture grant	Not stated
Feldens 2010	Costa et al., 2019	Brazil CNPq (National Funding for Research). Capes Foundation. Ministry of Education (FR doctoral fellowship, proc. no. 9853-11-1).	None
Field 2004	Field et al., 2004	Special Interest Project Grant from Centers for Disease Control and Prevention. Boston Obesity Nutrition Research Center research grant. National Institutes of Health. Kellogg Company	Not stated
Fiorito 2009	Fiorito et al., 2009	NS	None
Flores 2013	Flores et al.,2013	NS	None
Garden 2011	Garden et al., 2011 Garden et al., 2012 Zheng et al., 2015	The National Health and Medical Research Council of Australia. Cooperative Research Centre for Asthma. New South Wales Department of Health. Children's Hospital Westmead. University of Sydney, Faculty of Medicine. Commonwealth Department of Health and Aging	None
Guerrero 2016	Guerrero et al., 2016	US Department of Health and Human Services, Health Resources and Services Administration grant. Maternal and Child Health Research Program grant.	None
Hasnain 2014	Hasnain et al., 2014	Grant (HL35653) from the National Heart, Lung, and Blood Institute. National Dairy Council	None
Hooley 2012	Millar et al., 2014 Wheaton et al., 2015 Zulfiqar et al., 2019	None	None
Hur 2015	Hur et al., 2015	Ministry of Food and Drug Safety, grant (13162MFDS105).	None
Huus 2009	Huus et al., 2009	DRF-Wallenberg Foundations. The Swedish Medical Research Council. The Swedish Child Diabetes Foundation. The Swedish Diabetes Association. Swedish Diary Association R & D. Novo Nordisk Foundation.	Not stated
Hwang 2020	Hwang et al., 2020	Kangdong Sacred Heart Hospital Fund grant.	None
Ismail 2008	Lim et al., 2009	National Institute of Dental and Craniofacial Research, grant. Delta Dental Fund of Michigan. University of Michigan.	Not stated
Jackson 2017	Jackson et al., 2017	Eunice Kennedy Shriver National Institute of Child Health & Human Development, grant. Emory University's University Research Committee.	None

Jardi 2019	Jardi et al., 2019	NS	None
Jensen 2013 (1)	Jensen et al., 2013a	Tryg Foundation. Centre for Intervention Research in Health Promotion and Disease Prevention. The Danish Heart Foundation. Familien Hede Nielsens Foundation. University of Southern Denmark.	None
Jensen 2013 (2)	Jensen et al., 2013b	Victorian Department of Health. National Health and Medical Research Council (in conjunction with the Health Research Council (New Zealand) and the Wellcome Trust (UK). AusAID. Commonwealth Department of Health and Ageing. Victorian Department of Human Services and the Victorian Health Promotion Foundation. Tryg Foundation. Centre for Intervention Research in Health Promotion and Disease Prevention. The Danish Heart Foundation. Familien Hede Nielsen Foundation. University of Southern Denmark. NHMRC Capacity Building Grant. Jack Brockhoff Foundation.	None
Johnson 2012	Johnson et al., 2012	Commonwealth Department of Health and Ageing. Victorian Department of Human Services. Victorian Health Promotion Foundation (VicHealth).	None
Kramer 2004	Kramer et al., 2004	NS	Not stated
Laurson 2008	Laurson et al., 2008	Award 0004499 through the Initiative for Future Agriculture and Food Systems (IFAFS) Competitive Grants Program/USDA.	Not stated
Lee 2018	Lee et al., 2018	Social Problem Solving Research Program through the National Research Foundation for Korea funded by the Ministry of Science, ICT and Future Planning.	None
Leermakers 2015	Leermakers et al., 2015	Netherlands Organization for Health Research and Development (ZonMw-VIDI 016.136.361)	Oscar H Franco received a grant from NestlÃ© Nutrition (Nestec Ltd), Metagenics Inc. and AXA to establish an ageing research center called ErasmusAGE
Libuda 2008	Alexy et al., 1999 Alexy et al., 2011 Buyken et al., 2008 Herbst et al., 2011	German Federal Ministry of Food, Agriculture and Consumer Protection.	Not stated

	Libuda et al., 2008		
Lissau 1993	Lissau et al., 1993	Sygekassernes Helsefond Grant. Danish Heart Foundation (Hjerteforeningen). Novo Nordisk. Danish Medical Research Council Grant.	Not stated
Macintyre 2018	Macintyre et al., 2018	Medical Research Council (grant numbers MC_PC_13027, MC_UU_12017/12 and MC_UU_12017/14). Chief Scientist Office of the Scottish Government Directorates (grant numbers SPHSU12 and SPHSU14). Farr Institute @ Scotland. MRC grant number MR/K023209/1.	None
Marshall 2003	Marshall et al., 2018 Marshall et al., 2019	National Dairy Council. National Institute for Dental. Craniofacial Research (RO1-DE9551 and RO1-DE12101). General Clinical Research Centers (RR00059)	Not stated
Moore 2019	Moore et al., 2019	National Institutes of Health (grant R01DK094841)	None
Mrdjenovic 2003	Mrdjenovic et al., 2003	USDA Grant 94-34324-0987	None
Muckelbauer 2016	Muckelbauer et al., 2016	None	None
Mundt 2006	Mundt et al., 2006	The Canadian National Health and Research Development Program (NHRDP). Canadian Institute of Health Research (CIHR). Saskatchewan Health Research Foundation (SHRF).	Not stated
Neumann 2007	Neumann et al., 2007 Neumann et al., 2013	Global Livestock Collaborative Research Support Program (GL-CRSP). United States Agency for International Development (no. DAN-1328-G-00-0046-00). James A. Coleman African Study Center (UCLA). National Cattlemen's Beef Association (no. PCE-G-98-00 036-00).	None
Newby 2004	Newby et al., 2003	United States Department of Agriculture, grant (#43-3AEM-8-8900). National Institutes of Health Harvard Education Program in Cancer Prevention Control, grant (#CA57711). Boston Obesity Nutrition Research Center, grant (DK46200)	Not stated
	Newby et al., 2004		Not stated
Nissinen 2009	Nissinen et al., 2009	Academy of Finland (grant no. 77841 and 210283). Finnish Cultural Foundation. Juho Vainio Foundation. Yrjö Jahnsson Foundation.	None
Olafsdottir 2014	Olafsdottir et al., 2014 Russo et al., 2018	European Commission within the Sixth RTD Framework Programme Contract No. 016181 (FOOD)	None
Olsen 2012	Olsen et al., 2012	Danish Heart Foundation, Danish Medical Research Council, Health Foundation, Danish Council for Sports Research, Foundation of 17-12-1981, Foundation in Memory of Asta Florida Bolding nee Andersen, Faculty of Health Sciences, University of Southern Denmark, and the Tryg Foundation	None

Pan 2014	Pan et al., 2014	US Food and Drug Administration. Centers for Disease Control and Prevention. Office of Women's Health. National Institutes of Health. Maternal and Child Health Bureau in the US Department of Health and Human Services.	None
Phillips 2004	Phillips et al., 2004	National Institutes of Health Grants (MOI-RR-00088, DK-HD50537, and 5P30 DK46200). Mars Inc.	Not stated
Quah 2019	Quah et al., 2019	Singapore national Research Foundation. Singapore Institute for Clinical Science, Agency for Science, Technology and Research.	None
Santorelli 2014	Santorelli et al., 2014	National Institute for Health Research (NIHR) Programme Grants for Applied Research Programme (RP-PG-0407-10044).	None
Seferidi 2018	Seferidi et al., 2018	National Institute for Health Research (NIHR) via a Research Professorship Award to CM (one of the authors).	None
Shefferly 2016	Shefferly et al., 2016	NIH grant (5K08HD060739-05), Doris Duke Charitable Foundation Career Development Award.	None
Shroff 2014	Shroff et al., 2014	ASISA Research Fund at the University of Michigan	None
Skinner 1999	Skinner et al., 1999	Gerber Production Company. Tennessee Agricultural Experiment Station.	Not stated
	Skinner et al., 2001		
Sonneville 2015	Sonneville et al., 2015	U.S. NIH (R01HD34568, K24 HD069408, R01 ES016314).	None
Striegel-Moore 2006	Striegel-Moore et al., 2006	Supported by a grant from the National Heart, Lung, and Blood Institute (NHLBI)(HL/DK71122). Also supported by contracts HC55023-26 and Cooperative Agreements U01-HL-48941-44	Not stated
Sugimori 2004	Sugirmori et al., 2004	Research Grants (1998-Child-022) from Ministry of Health and Welfare of Japan	Not stated
Tam 2006	Tam et al., 2006	NS	Not stated
Thurber 2017	Thurber et al., 2017	Australian National University (KT). The National Health and Medical Research Council of Australia (EB).	None
Traub 2018	Traub et al., 2018	Baden Württemberg Stiftung	None
Vilela 2014	Durao et al., 2015	Health Operational Programme - Saúde XXI, Community Support Framework III and the Regional Department of Ministry of Health. FEDER from the Operational Programme Factors of Competitiveness. Foundation for Science and Technology - FCT (Portuguese Ministry of Education and Science) (POCI-01-0145-FEDER-030334; PTDC/SAU-EPI/30334/2017). Investigator Contract (IF/01350/2015 -Andreia Oliveira). Calouste Gulbenkian Foundation.	None
	Vedovato et al., 2020		
Wan 2020	Wan et al., 2020	National Heart, Lung, and Blood Institute, grant (5R01 HL35653-10). Juice Products Association.	None
Wang 2013	Wang et al., 2013	NS	Not stated

Weijs 2011	Weijs et al., 2011	The Ministry of Health, Welfare and Sports (grant 3989 83-01)	None
Welsh 2005	Welsh et al., 2005	NS	None
Wijga 2010	Wijga et al., 2010	NS	Not stated
Xue 2016	Xue et al., 2016	Eunice Kennedy Shriver National Institute of Child Health & Human Development, grant (U54HD070725)	None
Zheng 2014	Zheng et al., 2014	NS	None

[1] NS, not stated; [2] or role of the funder in the design, conduct, analysis or reporting of results of the study.

Table S2 Funding sources and declaration of competing interests for studies reporting on diet-related non-communicable disease indicators, displacement of health foods/breastmilk or diet quality and diversity outcomes[1]

Study ID	Reference	Funding sources	Authors' declaration of interests[2]
Diet-related non-communicable disease indicators			
Asghari 2015	Asghari et al., 2015 Asghari et al., 2016 Mirmiran et al., 2015	Research Institute for Endocrine Sciences, Shahid Beheshti University of Medical Sciences, Tehran, Iran.	None
Chaffee 2015	Leffa et al., 2020	NIH National Institute for Dental and Craniofacial Research (F30DE022208). NIH National Center for Advancing Translational Sciences (KL2TR000143). Rio Grande do Sul Research Support Foundation (FAPERGS)	None
Cowin 2001	Cowin et al., 2001	Northern and Yorkshire Regional Health Authority NHS Research and Development Programme on Cardiovascular Disease and Stroke	Not stated
Feldens 2010	Costa et al., 2019 Rauber et al., 2015	Brazil CNPq (National Funding for Research). Capes Foundation. Ministry of Education (FR doctoral fellowship, proc. no. 9853-11-1).	None
Hur 2015	Hur et al., 2015	Ministry of Food and Drug Safety, grant (13162MFDS105).	None
Leermakers 2015	Leermakers et al., 2015	Netherlands Organization for Health Research and Development (ZonMw-VIDI 016.136.361).	Oscar H Franco received a grant from NestlÃ© Nutrition (Nestec Ltd), Metagenics Inc. and AXA to establish an ageing research center called ErasmusAGE
Szymlek-Gay 2009	Szymlek-Gay et al., 2018	NS	Not stated
VanRompay 2015	VanRompay et al., 2015	NIH National Heart, Lung, and Blood Institute grant (R01HL106160)	Not stated

Displacement of healthy foods/breastmilk			
Bayer 2014	Bayer et al., 2014	Bavarian Health and Food Safety Authority	
Byrne 2018	Byrne et al., 2018	Australian National Health and Medical Research Council (426704, APP1021065). HJ Heinz. Meat & Livestock Australia. Department of Health South Australia. Food Standards Australia New Zealand. Queensland University of Technology	None None
Libuda 2008	Libuda et al., 2009	German Federal Ministry of Food, Agriculture and Consumer Protection.	Not stated
Schiess 2010	Schiess et al., 2010	The European Community, under the 5th Framework Programme for Research, Technology & Demonstration "Quality of Life and Management of Living Resources", Key Action 1 (Food, Nutrition & Health), contract number QLK1-CT2002-389 and 6th Framework priority 5.4.3.1 Food quality and safety (Early nutrition programming - long-term follow up of efficacy and safety trials and integrated epidemiological, genetic, animal, consumer and economic research, EARNEST, Food-CT-2005-007036)	None
Dietary quality & diversity			
Libuda 2008	Alexy et al., 2011 Libuda et al., 2009	German Federal Ministry of Food, Agriculture and Consumer Protection.	Not stated
Olafsdottir 2014	Russo et al., 2018	European Commission within the Sixth RTD Framework Programme Contract No. 016181 (FOOD)	None
Vilela 2014	Vilela et al., 2014	Health Operational Programme - Saúde XXI, Community Support Framework III and the Regional Department of Ministry of Health. FEDER from the Operational Programme Factors of Competitiveness. Foundation for Science and Technology - FCT (Portuguese Ministry of Education and Science) (POCI-01-0145-FEDER-030334; PTDC/SAU-EPI/30334/2017). Investigator Contract (IF/01350/2015 -Andreia Oliveira). Calouste Gulbenkian Foundation.	None
Wan 2020	Wan et al., 2020	National Heart, Lung, and Blood Institute, grant (5R01 HL35653-10). Juice Products Association.	None
Woo 2020	Woo et al., 2020	National Institutes of Health/National Heart, Lung, and Blood Institute (R01 HL064022). Cincinnati Children's Hospital Medical Center and the Center for Clinical and Translational Science and Training grant (5UL1TR001425-04).	None

[1] NS, not stated; [2] or role of the funder in the design, conduct, analysis or reporting of results of the study

TABLE S3 Funding sources and declaration of competing interests for studies reporting on food taste preferences, oral health (dental caries), micronutrient deficiencies or child development[1]

Study ID	Reference	Funding sources	Authors' declaration of interests[2]
Food taste preferences			
Beauchamp 1984	Beauchamp et al., 1984	USDA 5932U4-03. NIH 1 ROI HL31736-01.	Not stated
Byrne 2018	Jackson et al., 2020	Australian National Health and Medical Research Council (426704, APP1021065). HJ Heinz. Meat & Livestock Australia. Department of Health South Australia. Food Standards Australia New Zealand. Queensland University of Technology	None
Fiorito 2010	Fiorito et al., 2010	National Institutes of Health (NIH) grant no. RO1 HD32 The National Dairy Council, and General Clinical Research Center NIH grant no. M01RR10732.	None
Liem 2002	Liem et al., 2002	Grant HD37119 from the National Institute of Child Health and Human Development.	Not stated
Nicklaus 2004	Nicklaus et al., 2004	INRA through grants (AIP) from the 'Consumer Behavior' network and from the Direction Scientifique 'Nutrition Humaine et Securitedes Aliments' and by the Regional Council of Burgundy	Not stated
Okronipa 2019	Okronipa et al., 2019	Bill & Melinda Gates Foundation	None
Pan 2014	Park et al., 2014	US Food and Drug Administration. Centers for Disease Control and Prevention. Office of Women's Health. National Institutes of Health. Maternal and Child Health Bureau in the US Department of Health and Human Services.	None
Oral health (Dental caries)			
Bankel 2011	Bankel et al., 2011	Västra Götaland County Council	Not stated
Bernabe 2020	Bernabe et al.,2020	Chief Scientist Office of the Scottish Office Department of Health (grant K/OPR/2/2/DTSO)	None
Chaffee 2015	Chaffee et al., 2015	NIH National Institute for Dental and Craniofacial Research (F30DE022208). NIH National Center for Advancing Translational Sciences (KL2TR000143). Rio Grande do Sul Research Support Foundation (FAPERGS)	None
deMelo 2019	deMelo et al., 2019	No funding	None
Devenish 2020	Devenish et al., 2020	National Health and Medical Research Council Project Grant	None
Feldens 2010	Feldens et al., 2010	NS	None
Grindefjord 1996	Grindefjord et al., 1996	Commission for Social Research. Swedish Ministry of Health and Social Affairs. Swedish Patient Revenue Research Fund	Not stated

		Karolinska Institute. Swedish Dental Society	
Hao 2015	Hao et al., 2014 Hao et al., 2015	Beijing Medical Research and Development, grant. Capital Clinical Characteristics Applied Research Projects, grant. Construct Program of the National Key Discipline, grant.	None
Holt 1991	Holt et al., 1991	NS	Not stated
Hooley 2012	Hooley et al., 2012	None	None
Ismail 2008	Ismail et al., 2008 Ismail et al., 2009 Lim et al., 2015 Lim et al., 2019	National Institute of Dental and Craniofacial Research, grant. Delta Dental Fund of Michigan. University of Michigan.	Not stated
Jordan 2020	Jordan et al., 2020	NS	None
MacKeown 2000	MacKeown et al., 2000	NS	Not stated
Marshall 2003	Chankanka et al., 2011 Chankanka et al., 2015 Curtis et al., 2018 Levy et al., 2003 Marshall et al., 2003 Warren et al., 2002	National Dairy Council. National Institute for Dental. Craniofacial Research (RO1-DE9551 and RO1-DE12101). General Clinical Research Centers (RR00059)	Not stated
Mattila 2001	Mattila et al., 2001 Mattila et al., 2005	Suomen Naishammaslääkärit ry (The Finnish Female Dentists Society). Turun Hammaslääkäriseura ry (The Dental Society of Turku). Gyllenberg Foundation. Finnish Dental Society Apollonia.	Not stated
Meurman 2010	Meurman et al., 2010	The Research Fund of the Finnish Dental Organizations	None
Pan 2014	Park et al., 2015	US Food and Drug Administration	None
Pang 2015	Pang et al., 2015	NS	None
Peltzer 2014	Peltzer et al., 2014 Peltzer & Mongkolchati, 2015	Thailand Research Fund. Health System Research Institute of Thailand. Ministry of Public Health of Thailand. WHO	None
Peres 2016	Peres et al., 2016	Welcome Trust. The European Union. The National Support Program for the Centers of Excellence. Brazilian National Research Council. The Brazilian Ministry of Health	None
Rodrigues 2000	Rodrigues et al., 2000	NS	Not stated
Ruottinen 2004	Karjalainen et al., 2001 Karjalainen et al., 2015	NS	Not stated

	Ruottinen 2004		
Sakuma 2007	Sakuma et al., 2007	NS	Not stated
Skafida 2018	Skafida et al., 2018	The British Academy [Grant number PF110041 to V.S.]. Medical Research Council [Grant numbers MC_PC_13027; MC_UU_12017/ 12; MC_UU_12017/14 to S.C.]. The Chief Scientist Office of the Scottish Government Health Directorates [Grant numbers SPHSU12 and SPHSU14 to S.C.].	None
Tamaki 2009	Tamaki et al., 2009	NS	Not stated
Thornley 2020	Thornley et al., 2020	New Zealand Ministry of Social Development, supported by the Health Research Council. Auckland University Services. The University of Auckland. Starship Foundation.	None
Warren 2009	Warren et al., 2009	NIH grant R21DE015008	None
Watanabe 2014	Watanabe et al., 2014	NS	None
Wigen 2015	Wigen et al., 2015	Norwegian Ministry of Health and the Ministry of Education and Research, NIH/NIEHS (contract no N01-ES-75558), NIH/NINDS (grant no.1 UO1 NS 047537-01 and grantno.2 UO1 NS 047537-06A1). Norwegian Research Council/FUGE (grant no. 151918/S10).	None
Winter 2015	Winter et al., 2015	GABA International.	None
Wu 2020	Wu et al., 2020	National health organizations	None
Micronutrient deficiencies			
Olaya 2013	Olaya et al., 2013	NS	None
Sheng 2019	Sheng et al., 2019	National Natural Science Foundation of China, grants (No. 81302446, No. 81172686, No. 81703249 and No. 81673178). Thrasher Research Fund (TRF 200708-029)	None
Szymlek-Gay 2009	Szymlek-Gay et al., 2009	NS	Not stated
Child development			
Busch 2002	Busch et al., 2002	Mars Inc	
Cowin 2001	Mesirow et al 2017 Peacock et al., 2011 Wiles et al., 2009	The United Kingdom Medical Research Council, the Wellcome Trust and the University of Bristol	Not stated
Hulett 2014	Hulett et al., 2014	GL-CRSP, United States Agency for International Development. James A. Coleman African Study Center. National Cattlemen's Beef Association.	None
Littlecott 2016	Littlecott et al., 2016	National Preventive Research Initiative. Funding from the British Heart Foundation; Cancer Research UK; Department of Health; Diabetes UK; Economic and Social Research Council; Medical Research Council; Research and Development Office for the Northern Ireland Health and Social Services; Chief Scientist Office, Scottish Executive Health Department; The Stroke Association; Welsh Government; and World Cancer Research Fund; British Heart Foundation, Cancer Research UK, Economic and Social Research Council, Medical Research Council, the Welsh Government; Wellcome Trust	None

Neumann 2007	Neumann et al., 2007	Global Livestock Collaborative Research Support Program (GL-CRSP). United States Agency for International Development (no. DAN-1328-G-00-0046-00). James A. Coleman African Study Center (UCLA). National Cattlemen's Beef Association (no. PCE-G-98-00 036-00).	None
Sheng 2019	Sheng et al., 2019	National Natural Science Foundation of China, grants (No. 81302446, No. 81172686, No. 81703249 and No. 81673178). Thrasher Research Fund (TRF 200708-029)	None
Sonneville 2015	Cohen et al., 2018	U.S. NIH (R01HD34568, K24 HD069408, R01 ES016314).	None
Thorne-Lyman 2019	Thorne-Lyman et al., 2019	United States Agency for International Development through the Feed the Future Innovation Lab for Nutrition [USAID grant number AID-OAA-L-1-00005],	None
Wang 2020	Wang et al., 2020	National Institute of Diabetes and Digestive and Kidney Diseases, Grant/Award Number: T32 DK071212; National Institute of Environmental Health Sciences, Grant/Award Numbers: P01ES022844/RD83543601, R01ES0007821	None

[1]NS, not stated; [2] or role of the funder in the design, conduct, analysis or reporting of results of the study.

Figure S1a: Risk of bias assessment for non-randomized studies reporting growth, body composition and overweight/obesity outcomes using ROBINS-I

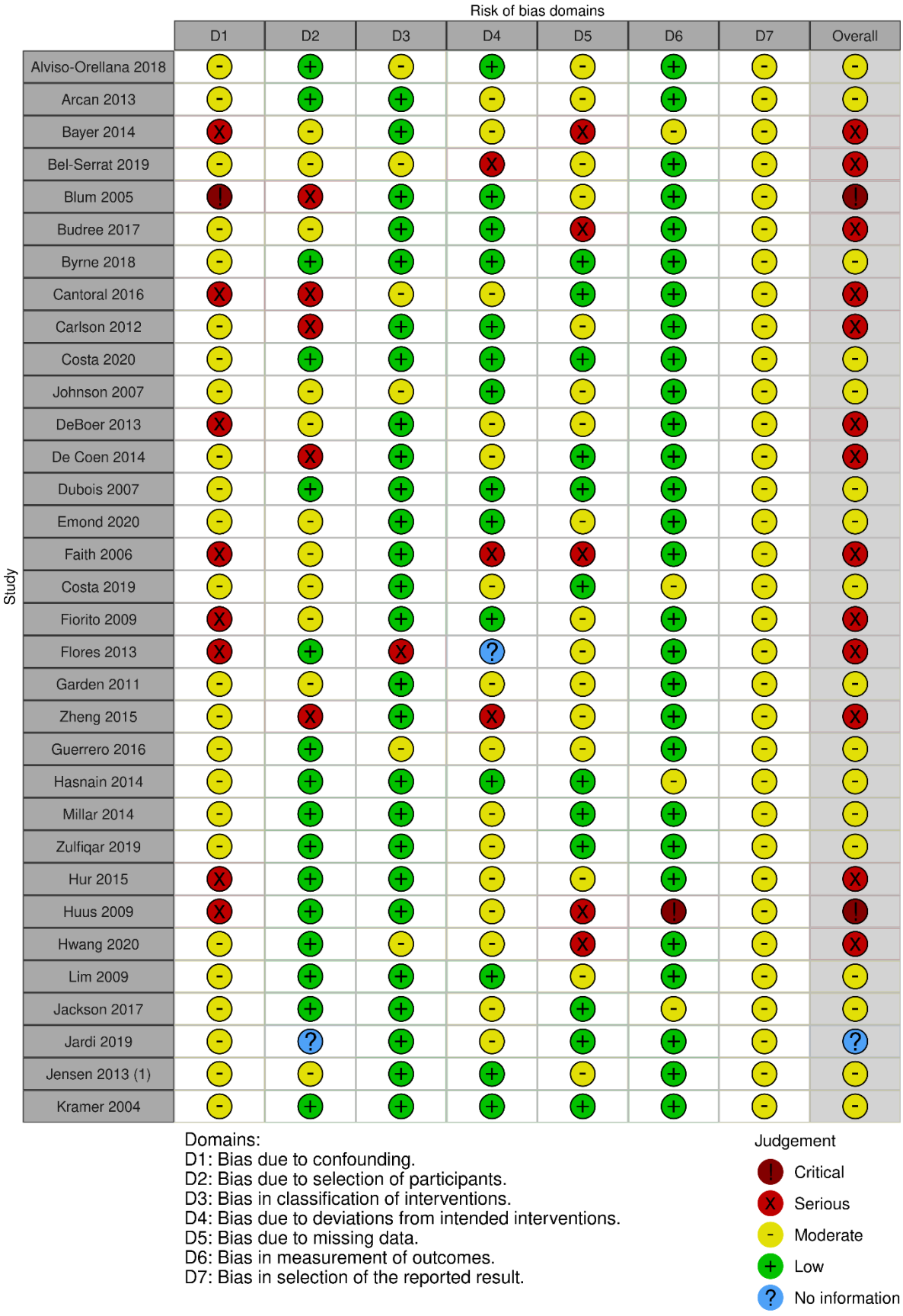

Figure S1a (continued): Risk of bias assessment for non-randomized studies reporting on growth and body composition outcomes using ROBINS-I

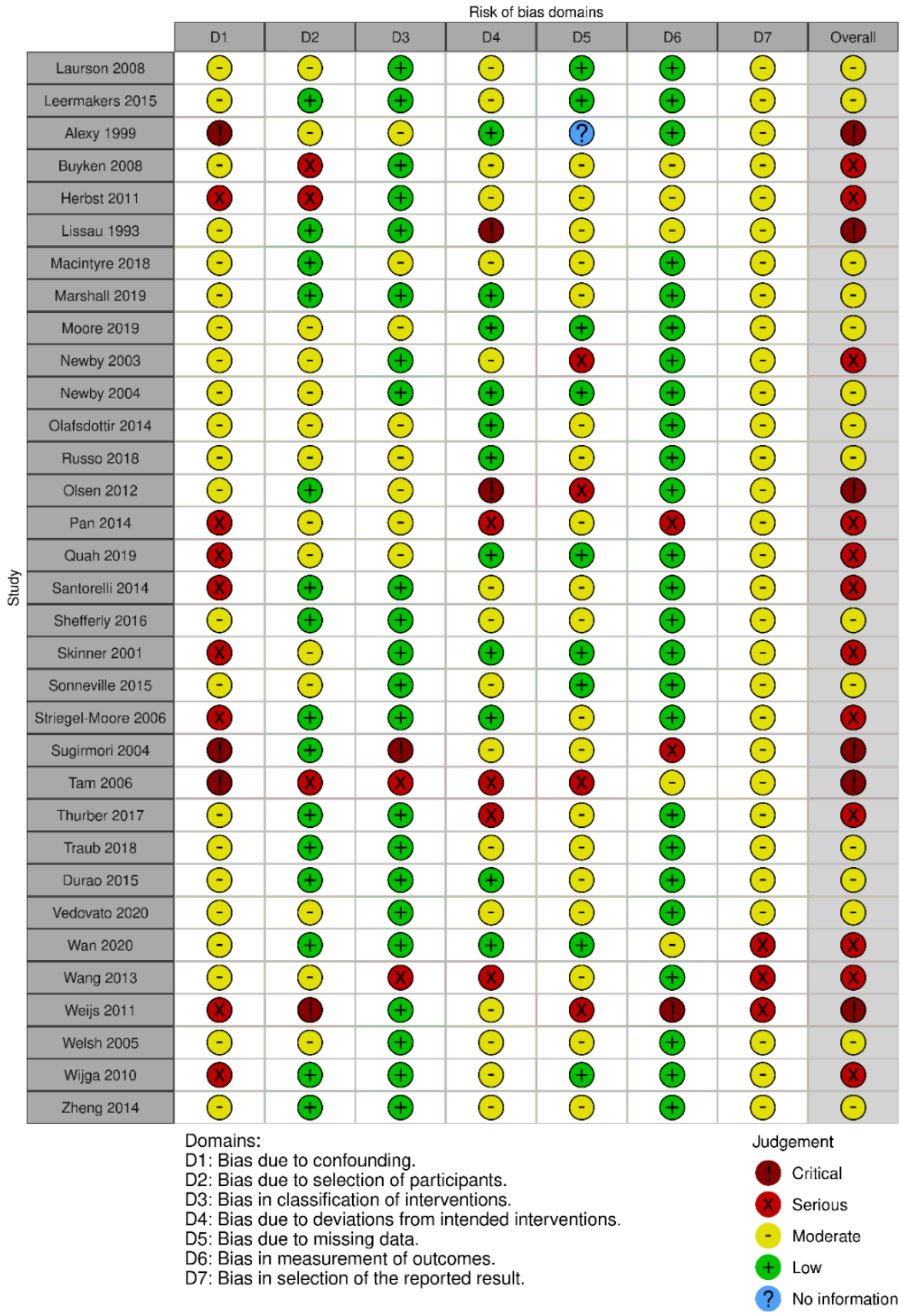

Figure S1b: Risk of bias assessment for randomized controlled trials reporting growth, body composition and overweight/obesity outcomes using RoB V2.0

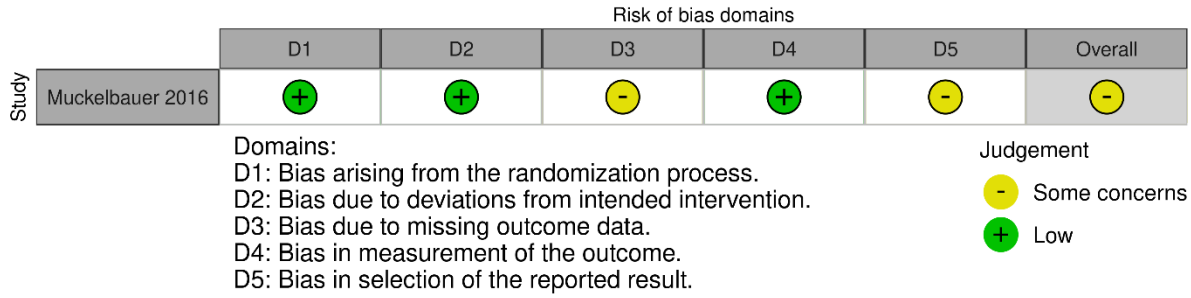

Figure S2a: Risk of bias assessment for non-randomized studies reporting diet-related non-communicable disease indicators using ROBINS-I

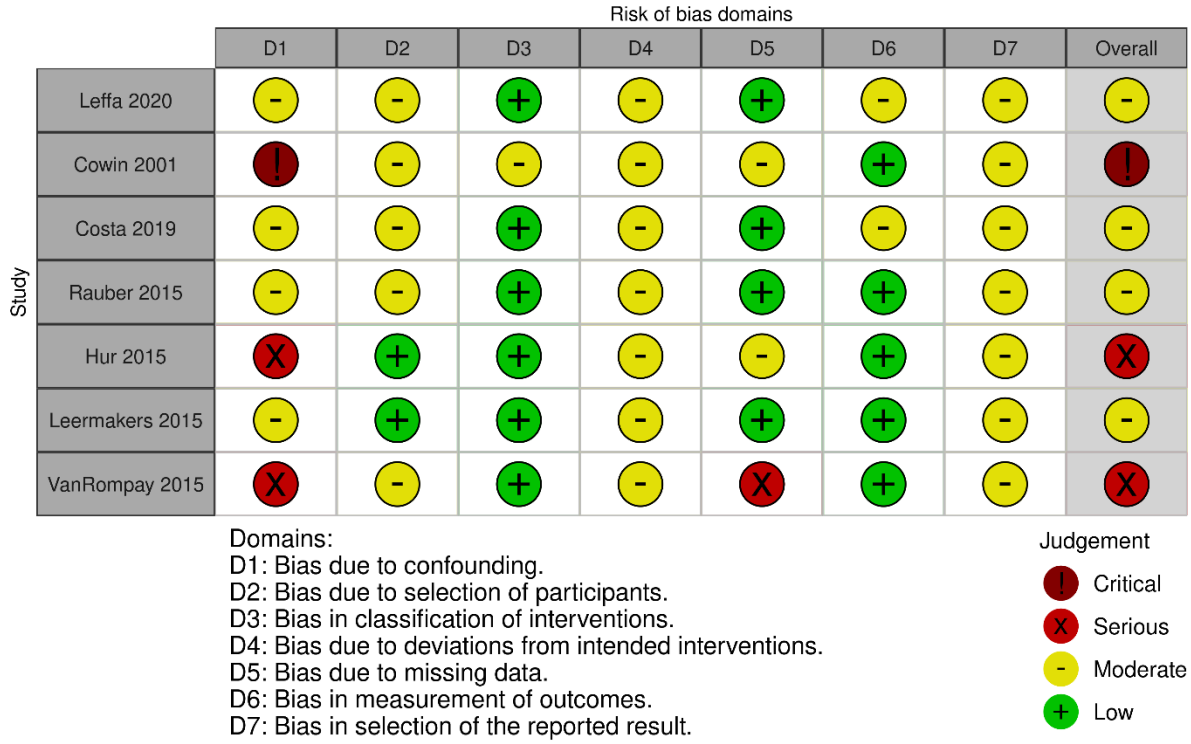

Figure S2b: Risk of bias assessment for randomized controlled trials reporting diet-related non-communicable disease indicators using RoB V2.0

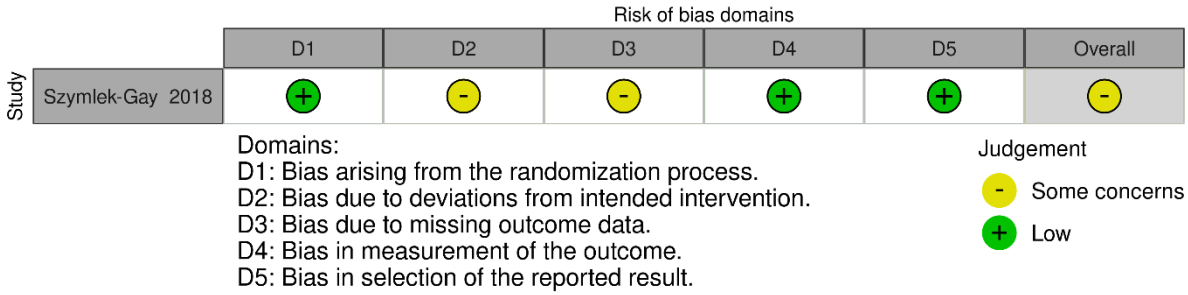

Figure S3: Risk of bias assessment for non-randomized studies reporting on displacement of healthy foods/breastmilk using ROBINS-I

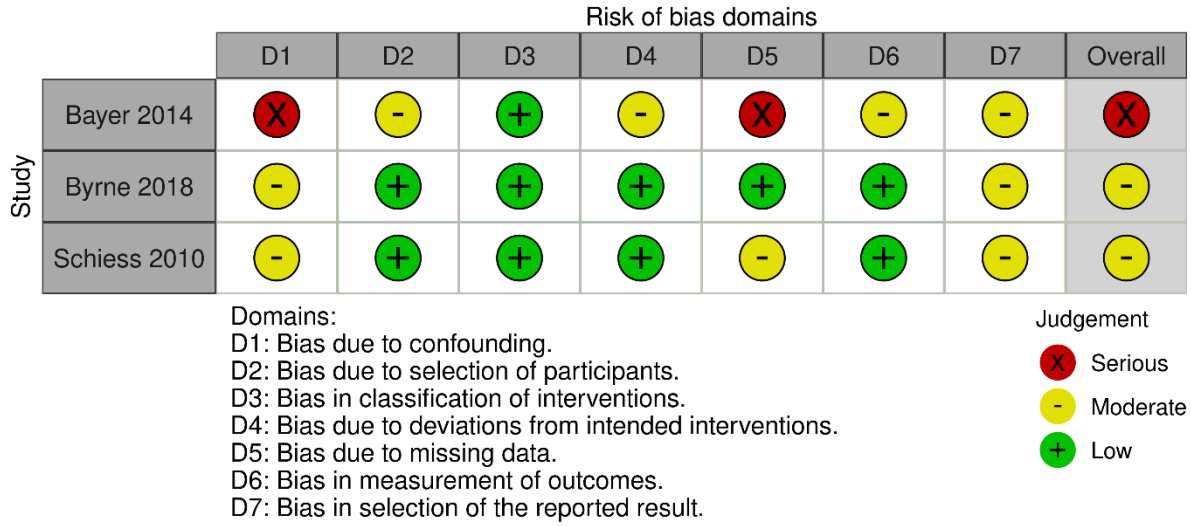

Figure S4: Risk of bias assessment for non-randomized studies reporting dietary quality and diversity using ROBINS-I

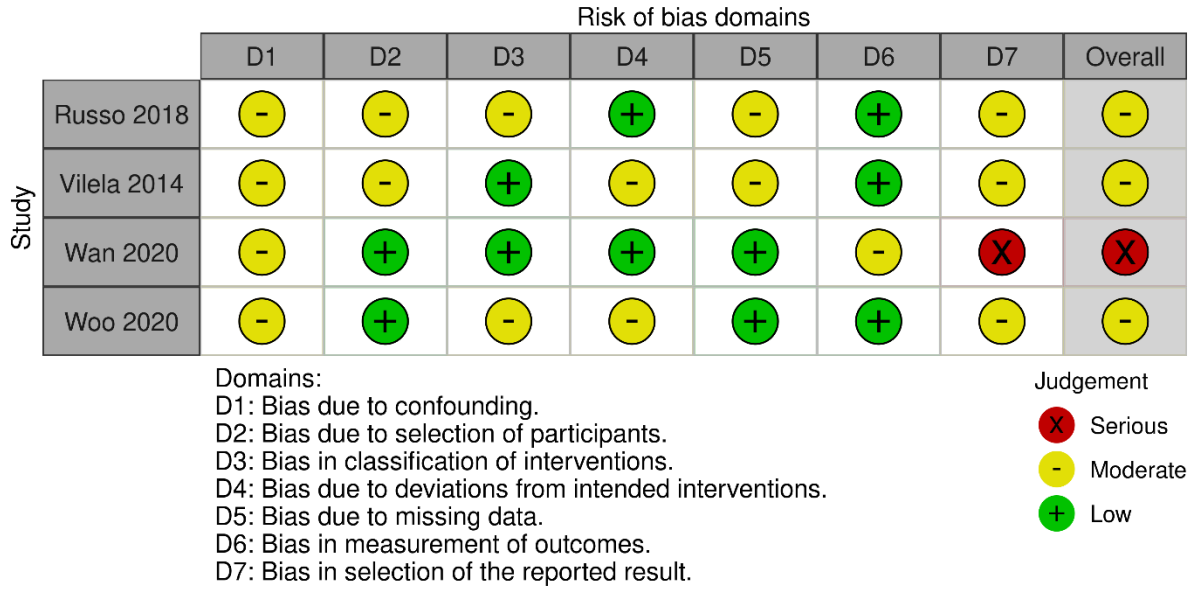

Figure S5: Risk of bias assessment for non-randomized studies reporting food taste preferences using ROBINS-I

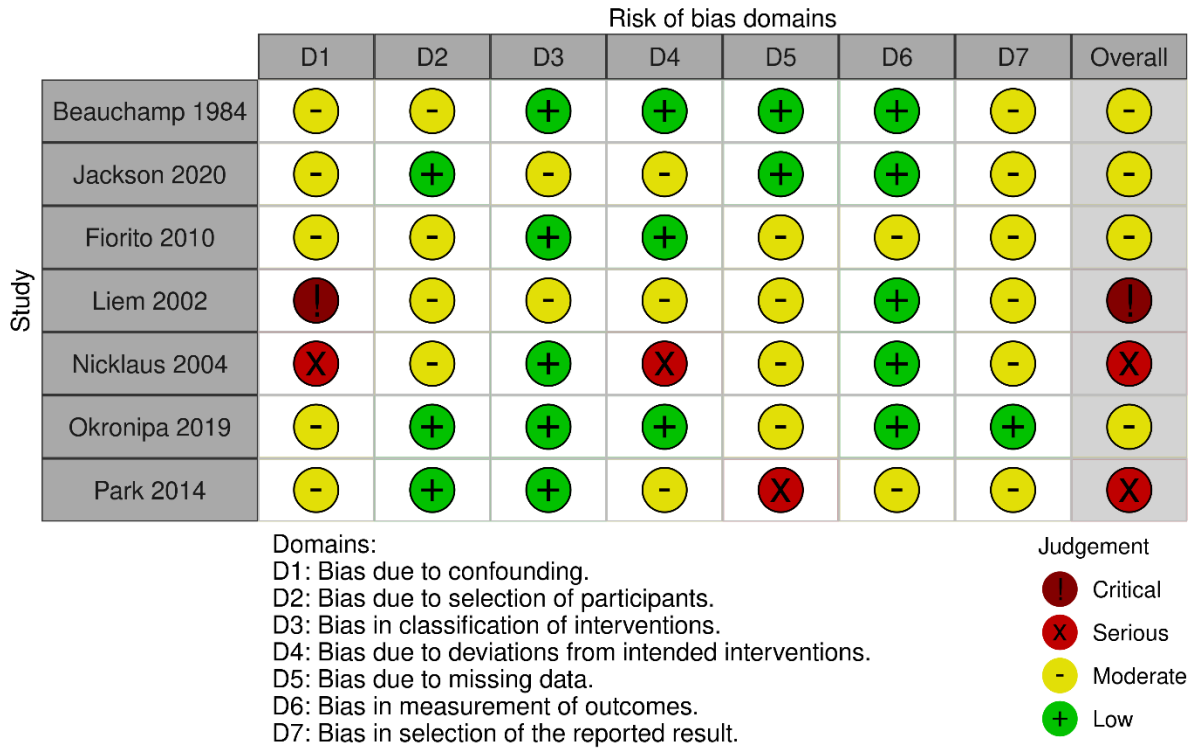

Figure S6: Risk of bias assessment for non-randomized studies reporting oral health (dental caries) outcomes using ROBINS-I

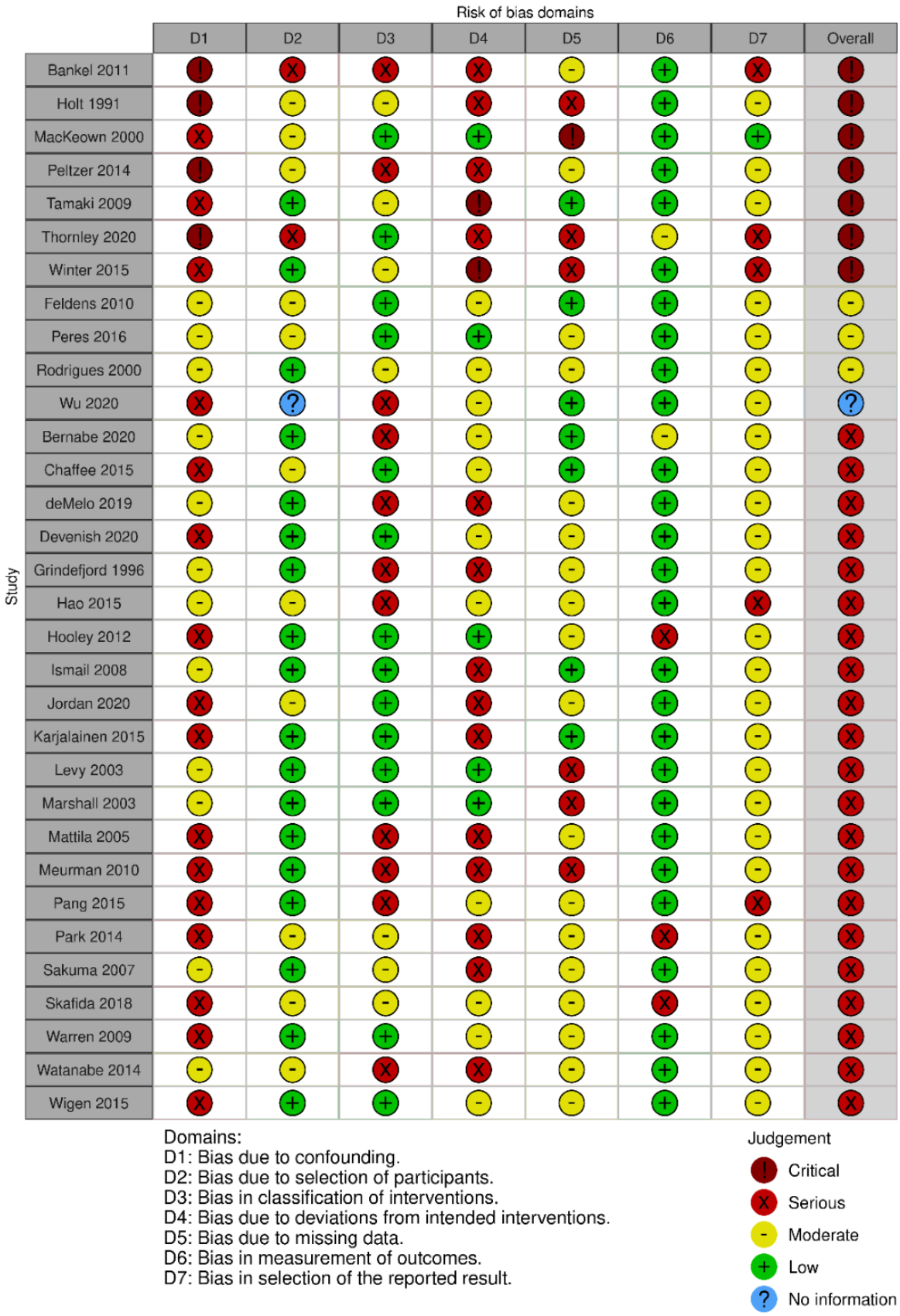

Figure S7: Risk of bias assessment for randomized controlled trials reporting on micronutrient deficiencies using RoB V2.0

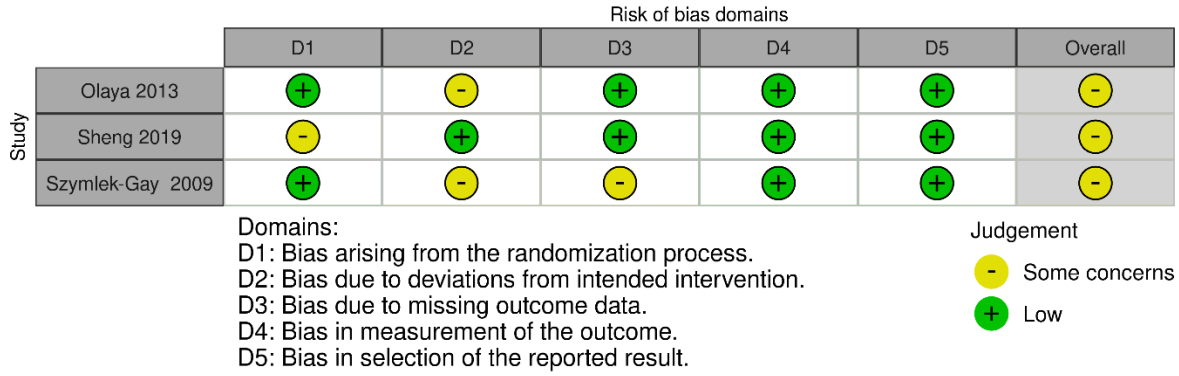

Figure S8a: Risk of bias assessment for non-randomized studies reporting on early child development outcomes using ROBINS-I

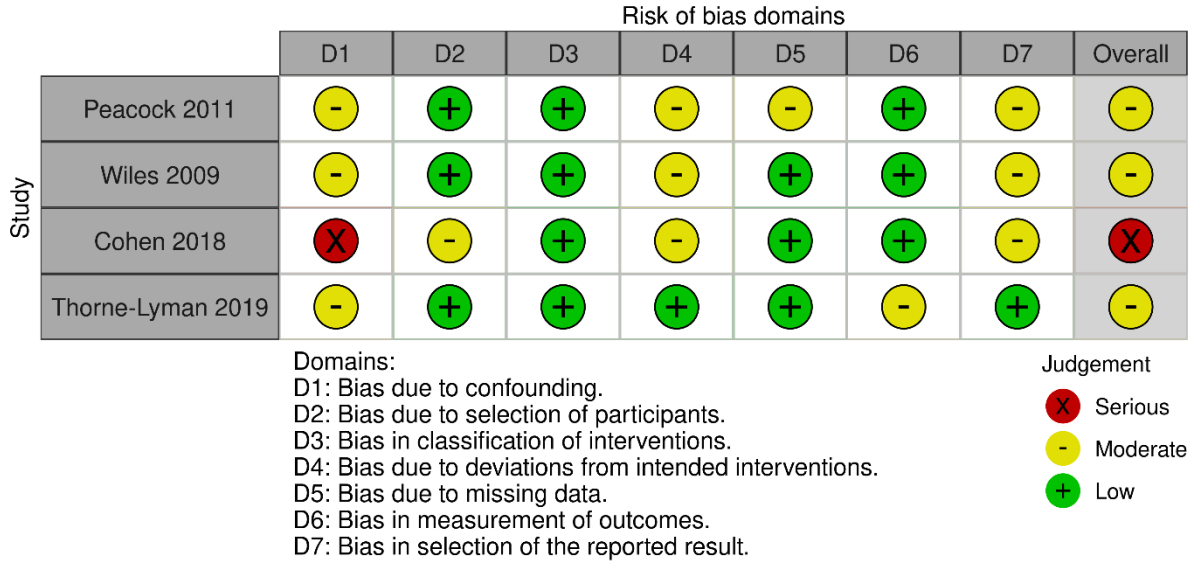

Figure S8b: Risk of bias assessment for randomized controlled trials reporting on early child development outcomes using RoB V2.0