


Mediators of socioeconomic inequalities in dietary behaviours among youth: A systematic review

Teferi Mekonnen¹  | Hanne Hennig Havdal¹ | Nanna Lien¹ |
Siobhan Anne O'Halloran¹ | Onyebuchi A. Arah² | Eleni Papadopoulou³ |
Mekdes Kebede Gebremariam¹

¹Department of Nutrition, Institute of Basic Medical Sciences, Faculty of Medicine, University of Oslo, Norway

²Department of Epidemiology and Department of Statistics, University of California, Los Angeles (UCLA), California, USA

³Department of Environmental Exposure and Epidemiology, Norwegian Institute of Public Health, Norway

Correspondence

Teferi Mekonnen, Department of Nutrition, Medical Faculty, the University of Oslo, P.O. Box 1046, Blindern, 0317 Oslo, Norway.
Email: t.m.yitayew@medisin.uio.no

Funding information

The Norwegian Research Council, Grant/Award Number: 273823

Summary

Children and adolescents with a lower socioeconomic position have poorer dietary behaviours compared to their counterparts with a higher socioeconomic position. A better understanding of the mechanisms behind such socioeconomic inequalities is vital to identify targets for interventions aimed at tackling these inequalities. This systematic review aimed to summarize existing evidence regarding the mediators of socioeconomic differences in dietary behaviours among youth. A systematic literature search of MEDLINE, Embase, PsycINFO, and Web of Science databases yielded 20 eligible studies. The dietary behaviours included in the reviewed studies were the intake of fruit and vegetables, sugar-sweetened beverages, unhealthy snacks/fast food and breakfast. The consistent mediators of the effects of socioeconomic position on dietary behaviours among youth were: self-efficacy, food preferences and knowledge at the intrapersonal level; and availability and accessibility of food items at home, food rules and parental modelling at the interpersonal level. Few studies including mediators at the organisational, community or policy levels were found. Our review found several modifiable factors at the intrapersonal and interpersonal levels that could be targeted in interventions aimed at combating inequalities in dietary behaviours among youth. Rigorous studies exploring organisational, community and policy level mediators are warranted.

KEYWORDS

dietary behaviours, inequality, mediators, youth

1 | BACKGROUND

Socioeconomic inequalities in children and adolescents' dietary behaviours have long been recognised as a public health problem.¹⁻⁶ Children and adolescents (hereafter called youth) with a low socioeconomic position (SEP) have a lower intake of fruit and

vegetables (FV),⁷⁻⁹ a higher intake of energy-dense food,^{2,10-12} a higher intake of sugar-sweetened beverages (SSB),^{9,13} and a higher likelihood for skipping a meal¹⁴ than their counterparts with a high SEP.

Social inequalities in dietary behaviours among youth could be among the contributing factors for the continued widening of social

This is an open access article under the terms of the Creative Commons Attribution-NonCommercial-NoDerivs License, which permits use and distribution in any medium, provided the original work is properly cited, the use is non-commercial and no modifications or adaptations are made.

© 2020 The Authors. *Obesity Reviews* published by John Wiley & Sons Ltd on behalf of World Obesity Federation

inequalities in health outcomes including overweight/obesity.¹⁵ Dietary behaviours established in childhood and adolescence could not only have an impact on the health of youth but can also influence adult dietary behaviours and health outcomes¹⁶ through tracking over time^{17,18} and through child morbid conditions that ultimately increase disease risk in later life. Thus, public health interventions aimed at tackling social inequalities in dietary behaviours among youth are vital. In order to inform such interventions, identifying the mechanisms explaining SEP differences in dietary intake is crucial.

The social-ecological model (SEM) postulates that there are multiple levels of influence on health behaviours.¹⁹ Accordingly, complex multilevel interacting determinants at the intrapersonal, interpersonal, community, institution, and macro/policy levels could influence dietary behaviours. Studies have found different correlates of dietary behaviours among youth.

Correlates of dietary behaviours at the intrapersonal level identified in the literature include perceived modelling, dietary intentions, norms, liking, preferences, time costs, lack of taste guarantee, satiety value, lack of knowledge, self-efficacy, time/occasions/settings for eating, symbolic value of food for image, gender identity, and short term outcome expectancies.²⁰⁻²⁵ At the interpersonal level, availability, accessibility, parental role modelling, parental permissiveness, family cohesion, parental concerns about child's health, parental norms, visibility of food items, methods of preparation, settings for eating, and parental monitoring were the most consistent correlates of dietary intake among youth.^{20,22,23,26-28} Exposure to unhealthy food outlets in the immediate food environment,²⁹ food advertising,³⁰ trade and agricultural policies,³¹ food prices³² and school food policies^{33,34} were also shown to be the factors influencing dietary intake.

Differences in these determinants by SEP can lead to socioeconomic differences in the dietary behaviours. In this regard, a systematic review previously concluded that predictors of children's dietary intake might differ for children of different socioeconomic circumstances.³⁵ In order to inform interventions targeting social inequalities in dietary behaviours, it is, however, important to explore if and to what extent such differences explain (mediate) socioeconomic differences in dietary behaviours. A mediating variable is an intervening causal variable which explains the relationship between a dependent variable and an independent variable.³⁶ Mediation analysis is aimed at exploring the causal mechanisms by which a predictor affects an outcome variable³⁷⁻³⁹ and is an emerging area in statistics. In this regard, studies exploring mediators of socioeconomic differences in dietary behaviours have been conducted. Summarising the results of these studies could provide valuable information for interventions to reduce SEP inequalities in dietary behaviours. To our knowledge, no systematic review focusing on mediators of SEP differences in dietary behaviours among youth has been conducted. Hence, this systematic review aimed to summarise the existing evidence on the factors that explain SEP differences in dietary behaviours among youth.

2 | METHODS

2.1 | Search strategy

The search was conducted following the PRISMA guidelines for systematic reviews⁴⁰ and registered with the International Prospective Register of Systematic Reviews (PROSPERO) with registration ID CRD42019121146. A search strategy was developed to identify studies reporting on mediators of socioeconomic inequalities in dietary behaviours among youth. The search was performed by combining key search terms for the following four categories of variables, combined by the "AND" Boolean operator. Mediators (e.g. mediat*, attenuat*, path model, path analysis, indirect path), SEP (e.g. socioeconomic factors, social class, educational status, income), dietary behaviour (e.g. feeding behaviour, food habits, dietary intake) and population of interest (e.g. infants, toddlers, children, adolescents). During the search, within each of the key search terms, keywords were combined using the "OR" Boolean operator. MEDLINE, Embase, PsycINFO, and Web of Science databases were searched for relevant articles.

2.1.1 | Inclusion and exclusion criteria

All types of quantitative studies including intervention studies (if baseline data or control group data were used) which assessed the mediators of the association between SEP and dietary behaviours among youth (up to 18 years) were included. Studies published in English in the time period from 1990 up to December 2018 were included. Studies with qualitative methodology, studies with unclear mediation analysis methods, and studies conducted among clinical populations or specific subgroups only were excluded.

2.2 | Identification of relevant studies and data extraction

The first author (TM) screened the titles and abstracts of all retrieved articles. Full texts were assessed when the abstract was found insufficient to make conclusions about inclusion.

The reference lists of identified articles were manually searched in addition to the electronic searches.

Two independent reviewers (TM, HHH) performed data extraction using pre-prepared data extraction forms, with disagreement resolved through discussion. In the first data extraction form, information about the study population (country of origin, age, and gender composition), sample size, study design, data collection methods and tools, indicators of dietary behaviours, indicators of SEP, and the mediators included in the analysis were collected. The second data extraction form was used to collect information about methods used to assess mediation and about the association between the hypothesized mediator(s) and dietary behaviours.

2.3 | Study quality assessment

The quality of the studies was assessed independently by two researchers (TM, HHH) using an adapted version of the Effective Public Health Practice Project Quality Assessment Tool.⁴¹ The quality assessment form had component ratings for selection bias, adjustment for confounders, validity and reliability of measurement instruments, non-response/dropouts and quality of statistical analyses. Each item was assessed based on the quality assessment criteria as weak, moderate or strong, and an overall global rating was made for the included studies. In the overall global ratings, studies with no weak scores and with at least four strong ratings for component ratings were assigned a strong quality score; studies with maximum two weak scores for component ratings were assigned a moderate quality score weak quality score was given for studies with three or more weak scores for component ratings.

Summary of the mediators explaining SEP differences in dietary behaviours among youth.

A descriptive presentation of the results of the included studies was made. A quantitative synthesis of results was not possible due to the heterogeneity of the indicators used in the exposure and outcomes of interest.

The social-ecological model (SEM)¹⁹ was used to group mediating variables into four levels (intrapersonal, interpersonal, organizational/community and macro/policy levels). The mediators explaining SEP differences in dietary behaviours among youth were then summarized using the adapted version of Sallis et al. coding rule.⁴² Accordingly, when the hypothesized mediator was used in four or more studies, the percentage of studies supporting the mediation report was determined by dividing the total number of studies that support the mediation effect to the total number of studies assessing their mediating role. Based on the percentage values obtained, the variables of interest were reported as a “mediator”, “indeterminate”,

“not a mediator” if the percent of studies supporting mediation was 60–100%, 34–59%, 0–33%, respectively. If the hypothesized mediators were used in less than four studies, inconclusive evidence of mediation was reported.

3 | RESULTS

The search output provided 8,464 studies for eligibility review after removal of duplicates, of which 8,417 studies were excluded upon review of titles and abstracts. From 47 studies eligible for the full-text review process, 27 studies were excluded, yielding an eligible 20 studies for the final review^{43–62} (Figure 1).

3.1 | Study characteristics

Table 1 describes the characteristics of the included studies (Table 1). The majority of the included studies were cross-sectional or used cross-sectional data ($n = 18$). A majority of the studies were conducted in Europe ($n = 17$). Two studies were conducted in Australia and one in Canada.

The dietary behaviours included and the number of studies assessing them were: Fruit and Vegetable intake (FV) ($n = 10$),^{43–45,48,50,51,56,57,60,61} sugar-sweetened beverage and soft drink consumption (SSB/SDC) ($n = 9$)^{44,46,48,49,55,58,59,61,62} breakfast consumption ($n = 3$),^{47,54,60} and energy-dense snack/fast food consumption ($n = 3$).^{44,59,62}

The SEP indicators that were assessed in the studies were maternal/paternal educational level ($n = 16$), socioeconomic deprivation (measured based on the percentage of children within the school receiving free school meals) ($n = 1$), further education plan (measured based on plans for further education (future education) after

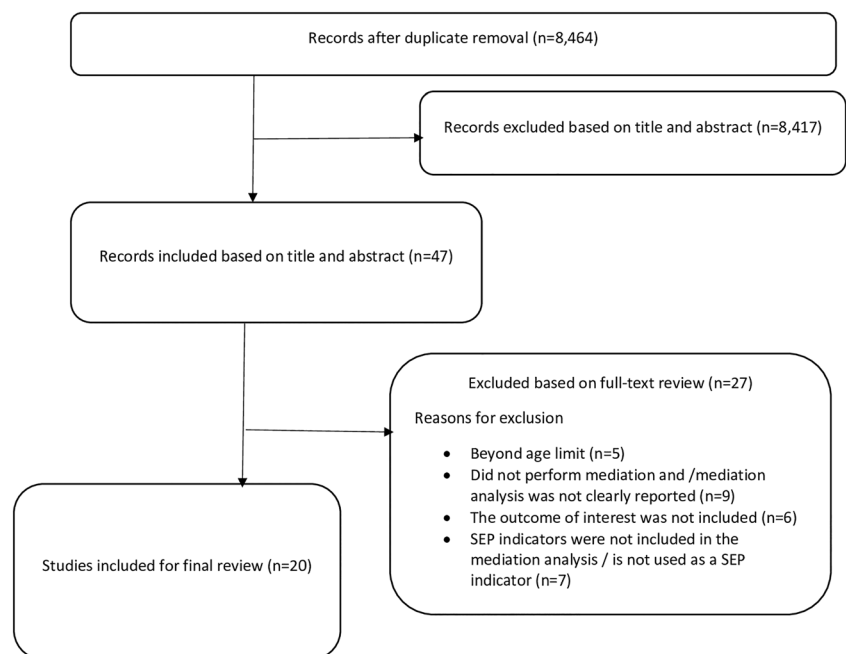


FIGURE 1 Flow chart of the steps used in the literature search

TABLE 1 Descriptive characteristics of the studies included in the systematic review

Authors (year), country	Study population (sample size), mean age \pm SD, % female	Study design	Dietary behaviours and assessment methods	Indicators of SEP used	Mediators included in the analysis	Quality score
Ahmadi, N., et al. (2015), Canada ⁴³	Children (n = 950), 12.5 yrs, 48.6%	Cross-sectional	Daily vegetable and SSB intake collected using FFQ	Parental educational level, food insecurity	Parental norms and peer modelling	W
Ball, K., et al. (2008), Australia ⁴⁴	Adolescents (n = 2529), 13.5 \pm 1.3.5 yrs, 54%	Cross-sectional	Food intake (fruit, energy-dense snacks, and fast food intake) collected using FFQ	Maternal educational level	Self-efficacy for increasing fruit and reducing 'junk' foods, perceived importance of health behaviours, social observation of best friends and family, social support for healthy eating, availability of FV and energy-dense snack foods at home	M
Bere, E., et al. (2008), Norway ⁴⁵	Adolescents (n = 896), mean age of 12.5, and 15.5 yrs (in 2002 and 2005)	Longitudinal	FV intake measured using food frequency questionnaire	Parental educational level, family income	Knowledge, accessibility, modelling, intention, preferences, self-efficacy	S
De Coen, V., et al. (2012), Belgium ⁴⁶	Pre-school children (n = 1639), 4.9 \pm 1.3 yrs, 50%	Cross-sectional	Soft drink consumption measured using FFQ	Maternal educational level	Availability at home, accessibility at the dinner table, permissiveness, discouragement through rationale, avoiding negative modelling.	W
Gebrenariam, M. K., et al. (2017), Norway ⁴⁷	Adolescents (n = 706), 13.6 \pm 0.3 yrs, 53%	Cross-sectional	Adolescents breakfast consumption measured by questionnaire	Parental educational level	Total screen time, perceived modelling, perceived availability, perceived rules, perceived co-participation	M
Gebrenariam, M. K., et al. (2016), Norway ⁴⁸	Adolescents (n = 440), 14.3 \pm 0.6 yrs, 52%	Cross-sectional	Vegetable and soft drinks intake measured using FFQ	Parental educational level	Perceived accessibility of vegetables and soft drinks, perceived rules related to the consumption of vegetables and soft drinks	M
Hilsen, M., et al. (2013), Norway ⁴⁹	Secondary school children (n = 2870), 15.5 yrs, 48.9%	Cross-sectional	SDC collected measured through the weekly frequency of SDC.	Future educational plan	Perceived accessibility of soft drinks at home, modelling, attitudes, and preferences.	M
Hilsen, M., et al. (2011), Norway ⁵⁰	10-12 yrs. old children (2001 n = 1488, 49.7%) (2008 n = 1339), 52.1%	Repeated cross-sectional	FV intake measured using FFQ	Parental educational level	Accessibility and preferences	M
Lehto, E., et al. (2015), Bulgaria, Finland, Germany, Greece, Iceland.	11 yrs. old school-children (n = 8159), 11.3 yrs, 50.4%	Cross-sectional	Fruit and vegetable measured using FFQ	Parental educational level	Availability of FV at home, facilitation of FV intake, liking for FV, self-efficacy to	M

(Continues)

TABLE 1 (Continued)

Authors (year), country	Study population (sample size), mean age \pm SD, % female	Study design	Dietary behaviours and assessment methods	Indicators of SEP used	Mediators included in the analysis	Quality score
Norway, Netherlands, Portugal, Slovenia, and Sweden ⁵¹					eat FV, knowledge about FV recommendations	
Lioret, S., et al.(2013), Australia ⁵²	Infants(n = 421), 48%	Cross-sectional data from RCT	Children dietary intake measured using multiple pass 24 hours recall	Maternal educational level	Mothers' dietary pattern (fruit, vegetables, high-energy snack and processed foods, high-fat foods, cereal, and sweet foods intake).	M
Michels, N., et al.(2018), Austria, Belgium, France, Germany, Greece, Hungary, Italy, Spain, and Sweden ⁵³	Adolescents(n = 2081), 14.8 \pm 1.2 yrs, 52.3%	Cross-sectional	Adolescent dietary intake measured using 24-h recall	Education status of mother and father, occupation of mother and father, and FAS	Self-efficacy, availability at school, soft drink unavailability at home, fruit availability at home, social influences, barriers, benefits, awareness, influencers (parental, school, test, health, friends, and prices), food readily available, hunger, habit, easy preparation	M
Moore, G. F., et al. (2007), Wales ⁵⁴	Children aged 9–11 yrs. old (n = 4314)	Cross-sectional	Breakfast eating behaviours measured using the 24-hour recall method.	Deprivation	Attitude towards eating breakfast	M
Pinket, A. S., et al. (2016), Belgium, Bulgaria, Germany, Greece, Poland, and Spain ⁵⁵	Preschool children (n = 6776), 4.8 \pm 0.4 yrs, 47.9%	Baseline data from an intervention study	Beverage intake measured using FFQ	Maternal educational level	Availability of soft drinks/prepacked juices and plain water, permissiveness, avoiding negative modelling, awareness, self-efficacy encouragement, rewarding.	M
Rodenburg, G., et al. (2012), The Netherlands ⁵⁶	Children(n = 1762), 8.18 \pm 0.46 yrs, 49.3%	Cross-sectional	Fruit consumption measured using FFQ	Parental educational level	Parental fruit consumption	M
Roos, E. B., et al. (2001), Finland ⁵⁷	Adolescents (n = 65,059), 49.9%	Cross-sectional	Consumption of raw vegetables measured using FFQ	Parental educational level	Family factors (the child living with), school achievements, meal pattern, health behaviours, smoking behaviours, weight status	W
Totland, T. H., et al. (2013), Norway ⁵⁸	Children (n = 866), 11.2 \pm 0.3 yrs, 48.5%.	Longitudinal	Adolescent SDC collected through FFQ	Parental educational level	Home availability, perceived accessibility by the adolescent, perceived accessibility by the mother.	S

(Continues)

TABLE 1 (Continued)

Authors (year), country	Study population (sample size), mean age \pm SD, % female	Study design	Dietary behaviours and assessment methods	Indicators of SEP used	Mediators included in the analysis	Quality score
Van Ansem, W. J. C., et al. (2014), Netherlands ⁵⁹	Children (n = 1318), 11 yrs., 49.2%	Cross-sectional data from longitudinal study	Children's snack and SSB consumption measured using FFQ	Maternal educational level	perceived accessibility by the father. Children's snack consumption: Home availability of snack, rules about snack consumption, parental intake, snack purchasing behaviour, peer sensitivity. Children's SSB consumption: Home availability of SSB, rules about SSB, parents' SSB intake	M
Van Ansem, W. J. C., et al. (2014), The Netherlands ⁶⁰	Children (n = 1318), 11 yrs., 49.2%	Cross-sectional data from L/S	Children's FV and breakfast consumption measured using FFQ	Maternal educational level	Parental intake of FV and breakfast, rules about FV consumption, home availability of FV	M
Vereecken, C. A., et al. (2004), Belgium ⁶¹	Children, (n = 316), 4.7 \pm 1.0 yrs, 49%.	Cross-sectional	FV intake, SDC consumption measured using FFQ	Maternal educational level	Maternal consumption of FV, soft drink and sweet foods, permissiveness, pressure, food as a reward, verbal praise, negotiation, encouragement and discouragement through rationale, catering on children's demand, avoiding negative modelling.	M
Wijtzes, A. I., et al. (2013), Netherlands ⁶²	Preschool children (n = 2814), median age of 48.2 months, 49.9%	Cross-sectional data from L/S	High-calorie snacks and SSB consumption measured using FFQ	Maternal educational level	Parental feeding practices, parental consumption of SSB, child television viewing time	M

FAS-family affluence scale, FFQ-food frequency questionnaire, FV-fruit and vegetable intake, L/s- longitudinal study, M-Moderate study quality, RCT;-randomized controlled trial, S-strong study quality, SD-standard deviation, SDC-soft drink consumption, SEP-socioeconomic positions, SSB-sugar sweetened beverage consumption, W -Weak study quality score.

graduation from secondary school) ($n = 1$), one study used both parents' educational level and family income level, and one study included indicators of parental educational level, parental occupation and family affluence scale.

3.2 | Potential mediator(s) assessed in included studies

The studies included in this review tested potential predictors at the intrapersonal, interpersonal, and organizational/community levels for their mediating role in the association between SEP and dietary behaviours (Table 1). Accordingly, eleven studies,^{44,45,47,49,51,53-55,57,59,62} seventeen studies,^{43-50,53,55-62} and three studies^{43,44,53} assessed mediators at the intrapersonal level, interpersonal level, and organizational/community level, respectively.

3.3 | Methods of mediation analysis used in the included studies

The majority of the studies used a formal test to check for mediation (MacKinnon, Freedman-Schatzkin test of mediation, Baron and Kenny, Preacher & Hayes tests) (Table 2). Only one study tested for interactions between SEP and the mediator⁴⁹; sensitivity analyses were conducted in one study only.⁴⁶ Most of the studies except four^{43,44,54,61} had a theoretical framework for mediation analysis.

3.4 | Mediators of the association between SEP and FV intake

Table 2 summarizes the results of mediation analyses in the included studies (Table 2). Among children aged 2.5–7 years, mothers' FV consumption mediated SEP differences in fruit and vegetable intake among children respectively. Verbally rewarding the child after consumption of healthy food items mediated SEP differences in FV intake.⁶¹

Among 8–12 year-old children, parental norms⁴³ and parental fruit consumption⁵⁶ were found to be the mediators that explained the association between parental educational level and fruit consumption.

Among children aged 10–12 years, the increase in SEP disparity in accessibility and preferences over time mediated the increase in SEP disparity in FV intake.⁴⁹ A multicenter European study among 11-year old showed that knowledge of FV recommendations, liking of FV, self-efficacy to eat FV, facilitation to eat fruit, availability of FV mediated the association between parental educational level and children's daily FV intake.⁵¹ Parental intake of FV, rules related to FV consumption, and home availability of FV mediated the association between maternal educational level and FV consumption among 11-year old.⁶⁰

Among elementary school adolescents, a longitudinal study showed that accessibility, preference, and knowledge (in 2002), and accessibility, preference, knowledge, modelling, and intention (in 2005) mediated the association between parental educational level and FV intake.⁴⁵ Among adolescents, self-efficacy for fruit and junk food, perceived importance of health behaviours, social observation of best friends and mother, social support from the family but not from a best friend, FV availability, energy-dense snack food availability mediated the association between maternal educational level and FV consumption.⁴⁴

Among adolescents aged 13–14 years, perceived accessibility of vegetables mediated the association between parental education level and adolescent vegetable intake; perceived rules related to the consumption of vegetables did not have a significant mediating effect.⁴⁸ School achievement mediated the association between parental educational level and raw vegetable consumption among adolescents aged 15 years.⁵⁷

3.5 | Mediators of the association between SEP and soft drink/sugar-sweetened beverage (SSB) consumption

Among pre-school aged children, parental consumption of sugar-containing beverages, children's television viewing time, and parental monitoring mediated the association between maternal educational level and SSB intake.⁶² Soft drinks served at meals, permissiveness and having a soft drink at home mediated the association between SEP and soft drink intake among preschool-aged children; however, discouragement and modelling did not mediate the association in this study.⁴⁶ A study among children in a similar age group conducted in six European countries showed that availability of soft drinks/prepacked fruit juice, availability of water, permissiveness towards sugared beverages, and lack of self-efficacy mediated the associations between SEP and soft drinks intake.⁵⁵ Another study among preschool children concluded that mothers' frequent consumption of soft drink and permissiveness explained the SEP differences in soft drink intake, and mothers' sweet consumption, permissiveness, and using sweet food as a reward mediated the SEP differences in sweet food intake.⁶¹

Among children aged 8–12 years, parental intake and home availability of SSB explained the association between maternal educational level and SSB consumption.⁵⁹

Among 11–13-year-olds, perceived accessibility of soft drinks reported by adolescents and mothers mediated the prospective associations between parental educational level and adolescent soft drink intake after 20 months of follow up⁵⁸; perceived accessibility reported by father did not mediate the association.

Among adolescents, perceived accessibility of soft drinks and perceived rules related to soft drink consumption mediated associations between parental educational level and soft drink intake.⁴⁸ In another study among secondary school children, perceived accessibility of soft drink at home, parental and peer modelling, preferences and attitudes

TABLE 2 Factors mediating the association between SEP and dietary behaviours among youth in the included studies

Authors	Pathway mediated (direction of association)	Mediation method	Mediation results
Ahmadi, N., et al. (2015)	Parent education → daily school day vegetable intake(+)	MacKinnon	Parental norms attenuated the magnitude of the association between SEP and daily school day vegetable intake (change in OR of 1.85(unadjusted) to 1.57 (adjusted). Peer modelling did not the association.
Ball, K., et al. (2009)	1.Maternal education → fruit intake (+) 2.Maternal education → EDSC (-) 3.Maternal education → fast food intake (-)	Freedman–Schatzkin test of mediation	1. Self-efficacy to increase fruit and decrease junk food intake, observation of best friend and mother, family support, availability of FV and energy-dense snack foods at home mediated SEP-fruit intake association. Social support from a best friend did not mediate the association. 2. Self-efficacy to increase fruit and decrease junk food intake, perceived importance of health behaviours, observation of best friend and mother, family support, and energy-dense snack food availability at home mediated SEP-EDSC association. The availability of FV at home and social support from a best friend did not mediate the association. 3. Self-efficacy to increase fruit and decrease junk food intake, perceived importance of health behaviour, observation of mother, support from family, FV and energy-dense snack food availability explained SEP- fast food intake association. Social observation of best friends and friend's support did not mediate the association.
Bere, E., et al. (2008)	1.Parental education → FV intake(+) 2.Family income → FV intake(+)	Baron and Kenny	1. In the year 2002, accessibility, preferences, and knowledge explained 92% of the SEP differences in FV intake, whereas in the year 2005, accessibility, preferences, knowledge, modelling, and intention explained 60% of SEP differences in FV intake. Perceived accessibility contributing the largest amount in the mediation model [45% in 2002 and 14% in 2005]. 2. Perceived accessibility and modelling together explained 89% of the family income disparities in FV intake. Perceived accessibility alone contributing 50%, and modelling 9% of the family income disparities in FV intake.
De Coen, V., et al. (2012)	Maternal education → SDC(-)	Regression based estimation of the mediating effect	Soft drinks served at meals, permissiveness, and home availability of soft drink explained

(Continues)

TABLE 2 (Continued)

Authors	Pathway mediated (direction of association)	Mediation method	Mediation results
			SEP-SDC association (explained 51%, 31%, and 16% of SEP differences in SDC intake, respectively). No mediation role for discouragement and modelling.
Gebremariam, M. K., et al. (2017)	Parental education → breakfast consumption(+)	Bootstrapping using Preacher & Hayes	Parental modelling, the availability of breakfast foods at home, and screen time explained SEP differences in breakfast consumption.
Gebremariam, M. K., et al. (2016)	1. Parental education → SDC(-) 2. Parental education → vegetable consumption(+)	Bootstrapping using Preacher & Hayes	1. Perceived accessibility and perceived rules related to soft drinks explained SEP differences in SDC (explained 47.5, and 8.5% of SEP differences in SDC, respectively). 2. Perceived accessibility of vegetables explained SEP differences in vegetable intake (explained 51% of SEP differences in vegetable consumption). No mediation effect for perceived rules related to the consumption of vegetables.
Hilsen, M., et al. (2011)	Plans of further education → SDC(-)	MacKinnon	Accessibility, modelling, preferences, and attitudes explained the SEP-SDC association (explained 80% of the total effect mediated). Modelling and accessibility of soft drinks were the strongest mediators (explained 69% and 43.7%, respectively).
Hilsen, M., et al.(2011)	Parental education → FV intake(+)	MacKinnon	The increase in SEP disparities in FV intake explained by an increase in SEP disparity in accessibility and preferences over time.
Lehto, E., et al. (2013)	1.Parental education → fruit intake(+) 2.Parental education → vegetable intake(+)	Regression based; assessment of the association after adjustment of potential mediators	1. Knowledge of fruit recommendations (Greece, Iceland, Norway, and Portugal), liking of fruit (Norway), self-efficacy to eat fruit (Portugal), facilitation to eat fruit (Norway), and availability of fruit (Finland) mediated SEP-fruit intake association. 2. Availability of vegetables at home (Finland, Germany, Iceland), knowledge of the vegetables recommendations (Greece, Iceland, Portugal), self-efficacy to eat vegetable (Norway), and liking of vegetable (Finland mediated SEP-vegetable intake association. The strongest mediator was the availability of vegetables at home in Finland, Germany, and Iceland.
Loiret, S., et al.(2013)	Maternal education → infants diet at 9 month(+)	MacKinnon	Mothers' diet explained the association between maternal educational level and diet of the child at 9 months age.

(Continues)

TABLE 2 (Continued)

Authors	Pathway mediated (direction of association)	Mediation method	Mediation results
Michels, N., et al. (2018)	Education (mother, father), occupation (mother, father), and FAS → DQI(+)	Bootstrapping using Preacher & Hayes	Availability of soft drinks and fruit at home, social support, parental influences, barriers, price influence, taste influence, health influence, and food being readily available mediated (explained 23–64% of the total indirect effect) SEP-diet quality association. Soft drink unavailability was the strongest mediator explaining 17–44% of the total effect. No mediating role for self-efficacy, availability at school, benefits, and awareness.
Moore, G. F., et al. (2007)	1. Deprivation → consumption of unhealthy items for breakfast (+) 2. Deprivation → consumption of healthy items for breakfast (-) 3. Deprivation → breakfast skipping (-)	Baron and Kenny	1. Attitude towards eating breakfast did not mediate the association of SEP with the consumption of unhealthy breakfast items. 2. Attitude towards eating breakfast explained the association between SEP with the consumption of healthy breakfast items. 3. Attitude towards eating breakfast explained the association of SEP with breakfast skipping.
Pinket, A. S., et al. (2016)	1. Maternal education → plain water consumption (+) 2. Maternal education → SDC (-) 3. Maternal education → prepacked fruit juice intake(-)	MacKinnon	1. Availability of soft drinks/prepacked fruit juice and plain water, permissiveness towards sugared beverages, lack of self-efficacy, rewarding with sugared beverages, and encouragement to drink plain water mediated SEP-plain water consumption association (explained 42.5%, 29.0%, 15.4%, 17.3%, x - 6.6%, and 12.1% of the SEP differences in plain water consumption, respectively). 2. Availability of soft drinks/prepacked fruit juice and plain water, permissiveness towards sugared beverages, lack of self-efficacy mediated SEP-SDC association (explained 18.1%, 6.5%, 15.0%, and 4.0% of SEP differences in the SDC consumption, respectively). 3. The availability of soft drinks/prepacked fruit juice and plain water, permissiveness towards sugared beverages, lack of self-efficacy rewarding, and awareness mediated the association of SEP with prepacked fruit juice intake. Avoiding negative modelling did not mediate the association.
Rodenburg, G., et al. (2012)	Parental education → child fruit consumption(+)	MacKinnon	Parental fruit consumption SEP differences in child fruit

(Continues)

TABLE 2 (Continued)

Authors	Pathway mediated (direction of association)	Mediation method	Mediation results
Roos, E. B., et al. (2001)	Parental education → consumption of raw vegetable	Regression based; assessment of change in the odds ratio up on inclusion of mediating variable	consumption (explained 45% of SEP differences in fruit consumption). Adolescents' school achievement explained the association between parental educational level and consumption of raw vegetables.
Totland, T. H., et al. (2013)	Parental education → adolescents SDC(-)	Bootstrapping using Preacher & Hayes	Perceived accessibility of soft drinks reported by adolescents and mothers explained the prospective association between parental educational levels with adolescent soft drink intake after 20 months (explaining 39% of the total effect mediated). No mediation effect for perceived accessibility reported by father.
Van Ansem, W. J. C., et al. (2014)	Maternal education → children's SSB consumption(-)	Baron & Kenny	Parental intake of SSB and home availability of SSB mediated SEP-SSB consumption association (explained 58.2% of the SEP differences in SSB consumption).
Van Ansem, W. J. C., et al. (2014)	1. Maternal education → children's FV consumption (+). 2. Maternal education → children's breakfast consumption (+)	Baron and Kenny	1. Home availability, food consumption rules, and parental consumption explained SEP-FV intake association (explained 89.5 and 58.89% of the SEP in fruit and vegetable intake, respectively) 2. Parental breakfast consumption explained the association between maternal education level and children's breakfast consumption (explained 67.89% of SEP differences in children's breakfast consumption).
Vereecken, C. A., et al. (2004).	1. Maternal education → FV intake (+) 2. Maternal education → SDC intake(-) 3. Maternal education → sweet intake (-)	Regression based/comparison of the models with and without the mediators	1. Mothers' frequent fruit consumption (explained only for fruit intake), verbally rewarding the child after consumption of healthy food items and mothers' own vegetable consumption (explained only for vegetable intake) explained SEP differences in fruit and vegetable intake 2. Mothers' SDC consumption and permissiveness explained SEP-SDC associations. 3. Mothers' sweet consumption, permissiveness and using sweet food as a reward explained SEP differences in sweet food intake among young children.
Wijtzes, A. I., et al. (2013).	1. Maternal education → EDSC (-) 2. Maternal educational level → SSB intake (-)	Baron and Kenny's	1. Monitoring, restriction, the pressure to eat, parental consumption of sugar-containing beverages, and children's television viewing time mediated the association between

(Continues)

TABLE 2 (Continued)

Authors	Pathway mediated (direction of association)	Mediation method	Mediation results
			<p>SEP-EDSC (explained –45% of the SEP differences in EDSC).</p> <p>2. Parental consumption of sugar-containing beverages, children's television viewing time and monitoring mediate SEP-SSB consumption association (explained-46% of SEP differences in SSB consumption. For both of the associations, parental consumption of sugar-containing beverages and children's television viewing time were the strongest mediators</p>

DQI: Dietary quality index, EDSC-energy dense snack consumption, FAS; Family affluence scale, FV; fruit and vegetable intake, SDC; soft drink consumption, SEP; socioeconomic status, SSB; Sugar sweetened beverage, (+); positive association, (-); inverse association, OR; odds ratio.

mediated the association between plans for further education and soft drink consumption.⁴⁹

3.6 | Mediators of the association between SEP and energy-dense snack consumption

Among pre-school children, parental consumption of sugar-containing beverages, children's television viewing time, restriction, the pressure to eat, and monitoring mediated associations between maternal educational level and consumption of high-calorie snacks.⁶² Among adolescents, self-efficacy to increase fruit and decrease junk food, perceived importance of health behaviour, and social observation of the mother and best friend, social support from the family mediated the associations between maternal educational level and energy-dense snack intake.⁴⁴ However, in this study, social support of best friend, and the availability of FV at home did not mediate the association.

3.7 | Mediators of the association between SEP and breakfast consumption

Among 11- year-olds, parental breakfast consumption mediated the association between maternal education level and children's breakfast consumption.⁶⁰ Among adolescents aged 12–15 years, attitudes towards eating breakfast mediated associations between deprivation and breakfast skipping, and consumption of healthy items for breakfast. Attitudes towards eating breakfast did not mediate the association between deprivation and consumption of unhealthy items for breakfast.⁵⁴

Among 13-year-old adolescents, parental modelling, availability of breakfast food at home and screen time mediated the association between parental educational level and breakfast consumption.⁴⁷

3.8 | Summary of the mediation findings

Table 3 summarises the mediators explaining socioeconomic differences in dietary behaviours among youth based on the criteria described in the "Methods" section (Table 3).

Consistent mediators of socioeconomic differences in dietary behaviours at the intrapersonal and interpersonal level were identified. Accordingly, at the intrapersonal level, self-efficacy (three of four studies), preferences (four of four studies), and knowledge (four of four studies) were found to be consistent mediators of the association between SEP and dietary behaviours among youth. At the interpersonal level, availability at home (eight of eight studies), accessibility at home (four of four studies), food rules (six of six studies), and modelling (nine of eleven studies) were found to be consistent mediators of the association between SEP and dietary behaviours among youth.

Consistent mediators explaining SEP differences in dietary behaviours at the community, institution, and macro/policy levels were not available. Taste influence, attitude, intention, school achievements, perceived barriers, screen time, facilitation to eat, and price influence were the mediators for which inconclusive evidence of mediation was found.

3.9 | Quality of the reviewed studies

The majority of the included studies had a moderate methodological quality ($n = 15$); three studies were assessed as having a weak methodological quality and two studies were assessed as having a strong methodological quality. The number of studies with a strong quality assessment scoring for different component ratings was as follows: selection bias ($n = 5$), adjustment for confounders ($n = 3$), use of reliable or valid tool to measure the outcome variable ($n = 13$), use of reliable or valid tool to measure the mediators ($n = 9$), mediation analysis approaches ($n = 16$), and study design ($n = 2$).

TABLE 3 Summary of the mediators explaining socioeconomic differences in dietary behaviours among youth

Mediator	Reference number for studies reporting mediation effect	Reference number for studies with no mediation effect	% of studies with mediation report	Mediation summary
Intrapersonal level factors				
Test influence	48	-	-	-
Self-efficacy	44,51,55	53	3/4*100 = 75%	Mediator
Knowledge	45,51,53,55	-	4/4*100 = 100%	Mediator
Attitudes	49,54	54 ^a	-	-
Preferences	45,49,50,51	-	4/4*100 = 100%	Mediator
Intentions	45	-	-	-
Adolescents school achievement	57	-	-	-
Perceived barriers	53	-	-	-
Perceived influence	53	-	-	-
Perceived price	53	-	-	-
Screen time	47,62	-	-	-
Interpersonal level factors				
Peer modelling	44 ^b	44 ^c , 46	-	-
Social support from a friend and/or family	44 ^d	44 ^e	-	-
Availability at home	44,46,47,51,53,55,59,60	53 ^f	8/8*100 = 100%	Mediator
Accessibility at home	45,48,49,58 ^g	58 ^h	4/4*100 = 100%	Mediator
Food rules	43, 48 ⁱ , 55, 60,61,62	48 ⁱ	6/6*100 = 85.7%	Mediator
Parental modelling	44,45,47,49,53,59,60,61,62	46,55 ^k	9/11*100 = 72.7%	Mediator
Facilitation	51,55	46	-	-
Rewarding with sugared beverage	55	-	-	-

^aConsumption of unhealthy item;

^bfruit and vegetable and energy dense snack intake;

^cfast food intake;

^dsupport from family;

^efast food intake;

^favailability at school;

^greported by mother and adolescent;

^hreported by father;

ⁱsoft drink intake;

^jvegetable intake;

^ksoft drink consumption.

4 | DISCUSSION

This review summarised evidence regarding the mediators explaining socioeconomic differences in dietary behaviours among youth. Twenty studies, conducted among youth aged up to 18 years old, were included. Consumptions of fruit and vegetables, sugar-sweetened beverages/soft drink, unhealthy snacks/fast food and breakfast were the dietary behaviours included in the reviewed studies.

Most of the studies looking at mediators of socioeconomic differences in dietary behaviours identified in this review included mediators at the intrapersonal and interpersonal levels, and consistent mediators were identified at these levels. On the other hand, few studies including mediators at the organisational, community and policy level were found. The factors found to mediate socioeconomic differences in dietary behaviours were self-efficacy, food preferences

and knowledge at the intrapersonal level; availability and accessibility at home, food rules and parental modelling at the interpersonal level.

The consistent mediators identified at the intrapersonal and interpersonal level could be targeted in interventions designed to tackle the inequalities in dietary behaviours. Targeting these intrapersonal and interpersonal factors such as improving knowledge about healthy eating, improving parental food rules related to healthy and unhealthy eating, increasing healthy food accessibility and decreasing accessibility of unhealthy food at home and promoting parental modelling for healthy eating can be valuable ways of promoting healthy eating and of decreasing inequalities in dietary behaviours among youth. Meanwhile, the SEM postulates that health behaviours are the result of a complex cluster of multilevel interacting determinants,¹⁹ which implies that there may be mediators at organisational/community and policy level which could be influencing as well as interacting with

interpersonal and intrapersonal level mediators. As a result, targeting only the intrapersonal and interpersonal level mediators may not yield significant results, because of the effects of more distal factors, including those at the organizational/community and policy level. This is particularly true for mediators such as availability of food at home that are likely to be affected by factors such as food price, which itself is influenced by food and market policies. Furthermore, individually targeted interventions focused on proximal determinants only might result in an exacerbation of inequalities.⁶³

Thus, more studies looking at organizational/community and policy level mediators explaining the SEP differences in dietary behaviours among youth are needed.

4.1 | Differences in mediators by dietary behaviours

The reviewed studies included different dietary behaviours (FV intake, SSB/SDC intake, breakfast consumption, energy-dense snack/fast food consumption). The review results indicated that there were no remarkable differences in mediators of socioeconomic differences between different dietary behaviours; thus, dietary behaviour-specific mediators were not separately summarized. The similarities in mediators explaining socioeconomic differences across dietary behaviours partly reflect the similarities in the predictors of dietary intake in general. Breakfast consumption (and in general pattern of meal consumption) is however a different dietary behaviour than the other dietary behaviours included, as it does not necessarily reflect the quality of food consumed. Thus, more studies exploring other dietary behaviours including breakfast quality in addition to intake are needed to further conclude on behaviour-related similarities and differences in mediators of socioeconomic differences.

4.2 | Differences in mediators by age and gender

Fourteen studies targeted adolescents and the other studies targeted children. Two studies considered different age categories in their analyses,^{45,58} but these studies did not report on differences in the explored mediators by age. The findings from the studies included in this review, which are conducted among different age groups however suggested that there might be no differences in mediators by age. Future studies which include different age groups should report on similarities and differences in the mediators by age group.

None of the included studies explored gender differences in mediators; future studies should address this gap in the literature.

4.2.1 | Approaches to mediation analysis

Three fourth of the studies used formal tests of mediation (MacKinnon, Freedman-Schatzkin test of mediation, Baron and Kenny, Preacher & Hayes tests). The remaining studies used changes

in regression parameters from multiple regression analyses to test for mediation. The product of coefficients method and difference method were the most used approaches to estimate the indirect/mediated effect. Small to large mediated proportion (4–92%) was found for those studies estimating the mediated effect. However, understanding the independent contributions of the mediators was difficult in most of the papers because several correlates were included together in the regression models to test for mediated effect or mediated proportions were not reported by the studies at all.

The product of coefficients method and difference method work best if there is no unmeasured-confounding and if there is no exposure-mediator interaction.⁶⁴ In this regard, nearly all of the studies included in our review had limited information regarding the use of sensitivity analysis and approaches for addressing unmeasured confounding and/or measurement error of mediators, the assessment of exposure-mediator interactions, all of which are vital to verify the validity of the mediation results. Therefore, future studies should provide detailed information about the mediation analysis approach using the reporting standards of mediation analysis.⁶⁵ Mediation analysis approaches that overcome the limitations of the difference and the product methods exist and should be used. In this regard, the counterfactual approach to mediation analysis allows for the decomposition of a total effect into a direct effect and an indirect effect even when there are interactions and non-linearity.⁶⁴

There are limitations to using cross-sectional data for causal mediation analyses.⁶⁶ The majority of the studies included in our review were cross-sectional, from which actual mediation analysis can only be inferred. There is thus a need for more longitudinal studies exploring mediators of socioeconomic differences in dietary behaviours among youth to make firm conclusions.

4.3 | Socioeconomic position indicators and associations with the mediators

Evidence of an independent association between different SEP indicators and various indices of dietary intake was published in a previous study.⁶⁶ This may indicate the potential existence of SEP indicator-specific pathways of influence on the mediators, which in turn influence the dietary behaviours among youth. In this regard, only two of the included studies in this review used multiple SEP indicators,^{45,53} and these studies did not explore the possible differential effect of different SEP indicators on the mediators. Therefore, the use of multiple SEP indicators in future research may help explore whether there are SEP indicator-specific pathways of influence on the mediators of the association between SEP and dietary behaviours among youth.

4.4 | Strengths and limitations

The strengths of this review were the application of a systematic review approach. Two independent researchers did the study quality assessment and data extraction, and consistent mediators were

identified using an existing coding rule and summarised using the social-ecological framework. To the best of our knowledge, this is the first systematic review that summarises evidence about mediators of socioeconomic differences in dietary behaviours among youth. The limitations, beyond methodological issues of the mediation analysis discussed above, include the fact that only studies published in the English language were included, and grey literature was not included.

4.5 | Conclusion and recommendations

Our review identified several modifiable factors explaining socioeconomic differences in dietary behaviours among youth which could be targeted in interventions to tackle socioeconomic inequalities in dietary behaviours and related non communicable diseases.

Further studies assessing mediators at the organisational or community and policy levels are needed to shed light on the complex and multilevel interacting causal determinants and mediators acting at different levels. Future studies should also consider the application of recent approaches to mediation analysis that decompose the total effect within the counterfactual framework.

ACKNOWLEDGEMENTS

This work was supported by the Norwegian Research Council project number 273823.

CONFLICT OF INTEREST

All the authors declare that they have no conflict of interest.

ORCID

Teferi Mekonnen  <https://orcid.org/0000-0002-3319-9138>

REFERENCES

- Campbell K, Crawford D, Jackson M, et al. Family food environments of 5–6 year-old-children: does socioeconomic status make a difference? *Asia Pac J Clin Nutr.* 2002;11(Supplement 3):553-561.
- Cameron A, Ball K, Pearson N, et al. Socioeconomic variation in diet and activity-related behaviours of australian children and adolescents aged 2–16 years. *Pediatr Obes.* 2012;7(4):329-342.
- Santos LP, Assunção MCF, Matijasevich A, Santos IS, Barros AJ. Dietary intake patterns of children aged 6 years and their association with socioeconomic and demographic characteristics, early feeding practices and body mass index. *BMC Public Health.* 2016;16(1):1055.
- De Irala-Estevez J, Groth M, Johansson L, Oltersdorf U, Prättälä R, Martínez-González MA. A systematic review of socio-economic differences in food habits in Europe: consumption of fruit and vegetables. *Eur J Clin Nutr.* 2000;54(9):706-714.
- Tate NH, Dillaway HE, Yarandi HN, Jones LM, Wilson FL. An examination of eating behaviors, physical activity, and obesity in African American adolescents: gender, socioeconomic status, and residential status differences. *J Pediatr Health Care.* 2015;29(3):243-254.
- Watts AW, Mason SM, Loth K, Larson N, Neumark-Sztainer D. Socioeconomic differences in overweight and weight-related behaviors across adolescence and young adulthood: 10-year longitudinal findings from project EAT. *Prev Med.* 2016;87:194-199.
- Drewnowski A, Rehm CD. Socioeconomic gradient in consumption of whole fruit and 100% fruit juice among US children and adults. *Nutr J.* 2015;14(1):3.
- Doku D, Koivusilta L, Raisamo S, Rimpelä A. Socio-economic differences in adolescents' breakfast eating, fruit and vegetable consumption and physical activity in Ghana. *Public Health Nutr.* 2013;16(5):864-872.
- Bjelland M, Brantsæter AL, Haugen M, Meltzer HM, Nystad W, Andersen LF. Changes and tracking of fruit, vegetables and sugar-sweetened beverages intake from 18 months to 7 years in the Norwegian mother and child cohort study. *BMC Public Health.* 2013;13(1):793.
- Cutler GJ, Flood A, Hannan P, Neumark-Sztainer D. Multiple sociodemographic and socioenvironmental characteristics are correlated with major patterns of dietary intake in adolescents. *J Am Diet Assoc.* 2011;111(2):230-240.
- Camara S, de Lauzon-Guillain B, Heude B, et al. Multidimensionality of the relationship between social status and dietary patterns in early childhood: longitudinal results from the French EDEN mother-child cohort. *Int J Behav Nutr Phys Act.* 2015;12(1):122.
- Sweeting H, West P. Dietary habits and children's family lives. *J Hum Nutr Diet.* 2005;18(2):93-97.
- Haerens L, Craeynest M, Deforche B, Maes L, Cardon G, De Bourdeaudhuij I. The contribution of psychosocial and home environmental factors in explaining eating behaviours in adolescents. *Eur J Clin Nutr.* 2008;62(1):51-59.
- Wijtzes AI, Jansen W, Jaddoe VW, et al. Social inequalities in young Children's meal skipping behaviors: the generation R study. *PLoS ONE.* 2015;10(7):e0134487.
- Chung A, Backholer K, Wong E, Palermo C, Keating C, Peeters A. Trends in child and adolescent obesity prevalence in economically advanced countries according to socioeconomic position: a systematic review. *Obes Rev.* 2016;17(3):276-295.
- Cohen S, Janicki-Deverts D, Chen E, Matthews KA. Childhood socioeconomic status and adult health. *Ann N Y Acad Sci.* 2010;1186(1):37-55.
- Craigie AM, Lake AA, Kelly SA, Adamson AJ, Mathers JC. Tracking of obesity-related behaviours from childhood to adulthood: a systematic review. *Maturitas.* 2011;70(3):266-284.
- Lien N, Lytle LA, Klepp K-I. Stability in consumption of fruit, vegetables, and sugary foods in a cohort from age 14 to age 21. *Prev Med.* 2001;33(3):217-226.
- Sallis JF, Owen N, Fisher EB. Chapter 20: Ecological models of health behavior. In: Glanz K, Rimer BK, Viswanath K, eds. *Health behavior and health education: theory, research, and practice.* 4th ed. San Francisco: Jossey-Bass; 2008:465-552.
- De Vet E, De Ridder D, De Wit J. Environmental correlates of physical activity and dietary behaviours among young people: a systematic review of reviews. *Obes Rev.* 2011;12(5):e130-e142.
- McClain AD, Chappuis C, Nguyen-Rodriguez ST, Yaroch AL, Spruijt-Metz D. Psychosocial correlates of eating behavior in children and adolescents: a review. *Int J Behav Nutr Phys Act.* 2009;6(1):54.
- Krølner R, Rasmussen M, Brug J, Klepp K-I, Wind M, Due P. Determinants of fruit and vegetable consumption among children and adolescents: a review of the literature. Part II: qualitative studies. *Int J Behav Nutr Phys Act.* 2011;8(1):112.
- Paes VM, Ong KK, Lakshman R. Factors influencing obesogenic dietary intake in young children (0–6 years): systematic review of qualitative evidence. *BMJ Open.* 2015;5(9):e007396.
- Fitzgerald A, Heary C, Kelly C, Nixon E, Shevlin M. Self-efficacy for healthy eating and peer support for unhealthy eating are associated with adolescents' food intake patterns. *Appetite.* 2013;63:48-58.
- Mazarello Paes V, Hesketh K, O'Malley C, et al. Determinants of Sugar-Sweetened Beverage Consumption in Young Children: A Systematic Review. *Obes Rev.* 2015;16(11):903-913.

26. Ong JX, Ullah S, Magarey A, Miller J, Leslie E. Relationship between the home environment and fruit and vegetable consumption in children aged 6–12 years: a systematic review. *Public Health Nutr.* 2017;20(3):464-480.
27. Pearson N, Biddle SJ, Gorely T. Family correlates of fruit and vegetable consumption in children and adolescents: a systematic review. *Public Health Nutr.* 2009;12(2):267-283.
28. Verloigne M, Van Lippevelde W, Maes L, Brug J, De Bourdeaudhuij I. Family- and school-based correlates of energy balance-related behaviours in 10–12-year-old children: a systematic review within the ENERGY (European Energy balance research to prevent excessive weight gain among youth) project. *Public Health Nutr.* 2012;15(8):1380-1395.
29. Díez J, Cebrecos A, Rapela A, Borrell LN, Bilal U, Franco M. Socioeconomic inequalities in the retail food environment around schools in a southern European context. *Nutrients.* 2019;11(7):1511.
30. Galbraith-Emami S, Lobstein T. The impact of initiatives to limit the advertising of food and beverage products to children: a systematic review. *Obes Rev.* 2013;14(12):960-974.
31. Friel S, Hattersley L, Snowdon W, et al. Monitoring the Impacts of Trade Agreements on Food Environments. *Obes Rev.* 2013;14:120-134.
32. Andreyeva T, Long MW, Brownell KD. The impact of food prices on consumption: a systematic review of research on the price elasticity of demand for food. *Am J Public Health.* 2010;100(2):216-222.
33. Cullen KW, Watson K, Zakeri I. Improvements in middle school student dietary intake after implementation of the Texas public school nutrition policy. *Am J Public Health.* 2008;98(1):111-117.
34. Bere E, Hilsen M, Klepp K-I. Effect of the nationwide free school fruit scheme in Norway. *Br J Nutr.* 2010;104(4):589-594.
35. Zarnowiecki D, Dollman J, Parletta N. Associations between predictors of children's dietary intake and socioeconomic position: a systematic review of the literature. *Obes Rev.* 2014;15(5):375-391.
36. Baron RM, Kenny DA. The moderator–mediator variable distinction in social psychological research: conceptual, strategic, and statistical considerations. *J Pers Soc Psychol.* 1986;51(6):1173-1182.
37. MacKinnon D. *Introduction to statistical mediation analysis.* New York: Routledge; 2012.
38. Robins JM, Hernan MA, Brumback B. Marginal structural models and causal inference in epidemiology. In: *LWW*; 2000, 11, 5, 550, 560, .
39. Wang A, Arah OA. G-computation demonstration in causal mediation analysis. *Eur J Epidemiol.* 2015;30(10):1119-1127.
40. Moher D, Liberati A, Tetzlaff J, Altman DG, Group P. Preferred reporting items for systematic reviews and meta-analyses: the PRISMA statement. *Int J Surg.* 2010;8(5):336-341.
41. Jackson N, Waters E. criteria for the systematic review of health promotion and public health interventions. *Health Promot Int.* 2005;20(4):367-374.
42. Sallis JF, Prochaska JJ, Taylor WC. A review of correlates of physical activity of children and adolescents. *Med Sci Sports Exerc.* 2000;32(5):963-975.
43. Ahmadi N, Black JL, Velazquez CE, Chapman GE, Veenstra G. Associations between socio-economic status and school-day dietary intake in a sample of grade 5–8 students in Vancouver, Canada. *Public Health Nutr.* 2015;18(5):764-773.
44. Ball K, MacFarlane A, Crawford D, Savage G, Andrianopoulos N, Worsley A. Can social cognitive theory constructs explain socio-economic variations in adolescent eating behaviours? A mediation analysis. *Health Educ Res.* 2008;24(3):496-506.
45. Bere E, van Lenthe F, Klepp K-I, Brug J. Why do parents' education level and income affect the amount of fruits and vegetables adolescents eat? *The European Journal of Public Health.* 2008;18(6):611-615.
46. De Coen V, Vansteelandt S, Maes L, Huybrechts I, De Bourdeaudhuij I, Vereecken C. Parental socioeconomic status and soft drink consumption of the child. The mediating proportion of parenting practices. *Appetite.* 2012;59(1):76-80.
47. Gebremariam MK, Henjum S, Hurum E, Utne J, Terragni L, Torheim LE. Mediators of the association between parental education and breakfast consumption among adolescents: the ESSENS study. *BMC Pediatr.* 2017;17(1):61.
48. Gebremariam MK, Lien N, Torheim LE, et al. Perceived rules and accessibility: measurement and mediating role in the association between parental education and vegetable and soft drink intake. *Nutr J.* 2016;15(1):76.
49. Hilsen M, te Velde SJ, Bere E, Brug J. Predictors and mediators of differences in soft drinks consumption according to gender and plans of further education among Norwegian secondary-school children. *Public Health Nutr.* 2013;16(7):1250-1256.
50. Hilsen M, van Stralen MM, Klepp K-I, Bere E. Changes in 10-12 year old's fruit and vegetable intake in Norway from 2001 to 2008 in relation to gender and socioeconomic status—a comparison of two cross-sectional groups. *Int J Behav Nutr Phys Act.* 2011;8(1):108.
51. Lehto E, Ray C, Te Velde S, et al. Mediation of parental educational level on fruit and vegetable intake among schoolchildren in ten European countries. *Public Health Nutr.* 2015;18(1):89-99.
52. Lioret S, Cameron AJ, McNaughton SA, et al. Association between maternal education and diet of children at 9 months is partially explained by mothers' diet. *Matern Child Nutr.* 2015;11(4):936-947.
53. Michels N, Vynckier L, Moreno LA, et al. Mediation of psychosocial determinants in the relation between socio-economic status and adolescents' diet quality. *Eur J Nutr.* 2018;57(3):951-963.
54. Moore GF, Tapper K, Murphy S, et al. Associations between deprivation, attitudes towards eating breakfast and breakfast eating behaviours in 9–11-year-olds. *Public Health Nutr.* 2007;10(6):582-589.
55. Pinket A-S, De Craemer M, De Bourdeaudhuij I, et al. Can parenting practices explain the differences in beverage intake according to socio-economic status: the toybox-study. *Nutrients.* 2016;8(10):591.
56. Rodenburg G, Oenema A, Kremers SP, van de Mheen D. Parental and child fruit consumption in the context of general parenting, parental education and ethnic background. *Appetite.* 2012;58(1):364-372.
57. Roos E, Hirvonen T, Mikkilä V, Karvonen S, Rimpelä M. Household educational level as a determinant of consumption of raw vegetables among male and female adolescents. *Prev Med.* 2001;33(4):282-291.
58. Totland TH, Lien N, Bergh IH, et al. The relationship between parental education and adolescents' soft drink intake from the age of 11–13 years, and possible mediating effects of availability and accessibility. *Br J Nutr.* 2013;110(5):926-933.
59. van Ansem WJ, van Lenthe FJ, Schrijvers CT, Rodenburg G, van de Mheen D. Socio-economic inequalities in children's snack consumption and sugar-sweetened beverage consumption: the contribution of home environmental factors. *Br J Nutr.* 2014;112(3):467-476.
60. van Ansem WJ, Schrijvers CT, Rodenburg G, van de Mheen D. Maternal educational level and children's healthy eating behaviour: role of the home food environment (cross-sectional results from the INPACT study). *Int J Behav Nutr Phys Act.* 2014;11(1):113.
61. Vereecken CA, Keukelier E, Maes L. Influence of mother's educational level on food parenting practices and food habits of young children. *Appetite.* 2004;43(1):93-103.
62. Wijtzes AI, Jansen W, Jansen PW, Jaddoe VW, Hofman A, Raat H. Maternal educational level and preschool children's consumption of high-calorie snacks and sugar-containing beverages: mediation by the family food environment. *Prev Med.* 2013;57(5):607-612.
63. Lorenc T, Petticrew M, Welch V, Tugwell P. What types of interventions generate inequalities? Evidence from systematic reviews. *J Epidemiol Community Health.* 2013;67(2):190-193.
64. Valeri L, VanderWeele TJ. Mediation analysis allowing for exposure–mediator interactions and causal interpretation: theoretical assumptions and implementation with SAS and SPSS macros. *Psychol Methods.* 2013;18(2):137-150.

65. Liu SH, Ulbricht CM, Chrysanthopoulou SA, Lapane KL. Implementation and reporting of causal mediation analysis in 2015: a systematic review in epidemiological studies. *BMC Res Notes*. 2016;9:354.
66. Zarnowiecki D, Ball K, Parletta N, Dollman J. Describing socioeconomic gradients in children's diets – does the socioeconomic indicator used matter? *Int J Behav Nutr Phys Act*. 2014;11(1):44.

How to cite this article: Mekonnen T, Havdal HH, Lien N, et al. Mediators of socioeconomic inequalities in dietary behaviours among youth: A systematic review. *Obesity Reviews*. 2020;21:e13016. <https://doi.org/10.1111/obr.13016>