Socioeconomic and cultural disparities in diet among adolescents and young adults: a systematic review.

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Shortened version of the title

Disparities in diet among adolescents.

Disclosure statements

Acknowledgements

We thank Valérie Durieux for her technical guidance on literature search and Jerri Bram for English editing.

Funding

This work was supported by the French Community of Belgium, as part of the "Actions de Recherche Concertée" funding program.

The French Community of Belgium had no role in the design, analysis or writing of this article.

Conflict of interest

None.

Authors' contributions

LD and KC formulated the research question and designed the study; LD carried out the research; LD and KC analyzed the data; LD wrote the paper; KC, CM, and SD edited the article.

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Abstract

Objective

To explore dietary differences according to socioeconomic and sociocultural characteristics of adolescents and young adults.

Design

A systematic review was conducted.

Setting

The main search source was Medline, consulted between January 2012 and March 2017. Quality of selected studies was assessed based on dietary measurement method, sample selection, socioeconomic indicator choice and statistical modelling.

Subjects

Cross-sectional and longitudinal studies, assessing relationships between socioeconomic status and dietary intake (patterns, scores and food groups) in the 10-to-40-year-old general population of high-income countries, were selected.

Results

Among the 7,250 reports identified, 40 were selected, 17 of which were of high quality; their conclusions, related only to adolescents, were combined and presented. The most favourable dietary patterns, higher dietary scores, greater consumption of fruits, vegetables and dairy products, and lower consumption of sugary sweetened beverages and energy-dense foods, were associated with better parental socioeconomic status, particularly in terms of higher education. Migrant status was associated with plant-based patterns, greater consumption of fruits and vegetables and of sugary sweetened beverage and energy-dense foods. For the other food groups, and for young adults, very few high-quality studies were found.

Conclusions

The socioeconomic gradient in adolescent diets requires confirmation by higher-grade studies of a wider set of food groups, and must be extended to young adult populations. Future nutritional interventions should involve the most vulnerable adolescent populations, taking into account socioeconomic status and migration.

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Keywords

Diet; Nutrition; Socioeconomic factors; Adolescent; Young adult.

Introduction

Dietary risk was shown to be responsible for more than one-third of deaths worldwide in 2013 [1]. Nutritional behaviour has thus been targeted by the WHO so as to reduce the current increase in non-communicable diseases [2]. At each life stage, a balanced, diversified diet is necessary. Adolescence is one of the most crucial stages in life, requiring specific nutrition [3]. Adolescence and early adulthood correspond to key transition periods for acquisition of health behaviour (e.g tobacco and alcohol consumption, diet-related habits, physical activity and sleep, etc.) that otherwise might later provoke non-communicable diseases [4]. Important changes in health behaviour may occur during this period, while previously acquired habits may be strengthened [5–7].

In Europe and the US, socioeconomic disparities in mortality and morbidity rates, as well as in perceived health, are widening [8–11]. Nutritional issues are also involved [12–15]. A reference literature review focusing on diet disparities concluded that, in adult populations in industrialized countries, a socioeconomic gradient existed [16]. Indeed, consumption of whole grain, fresh fruits and vegetables and low-fat dairy products increased with SES, while that of less healthy products such as refined grains and added fats decreased. In a more recent expert report comprising a comprehensive literature review on socioeconomic diet disparities, conclusions pertaining to adults also tended to converge towards a socioeconomic gradient, despite studies heterogeneously available according to food group [17]. Only 20 European studies combining children and adolescents were identified. They came to diverging conclusions, mainly based on dietary behaviour (e.g. weekly daily breakfast frequency) rather than on quantitative amounts of food eaten. Other recent reviews involving specific food groups or populations gave scattered information, and included only children [18–20], or else did not make a distinction between children and adolescents [21]. Overall, maternal education was shown to be a strong determinant of a child's dietary quality [18]. Lower parental socioeconomic status (SES) has been related to higher consumption of sugar-sweetened beverages (SSB), while children of married couples or co-habitating parents may have lower SSB consumption [19]. Finally, fruit and vegetable consumption by low-income children differed according to their race/ethnicity [21]. For the other food groups, available information was

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insufficient for drawing evidence-based conclusions. And, to our knowledge, no study has specifically focused on diet disparities in young adults.

Education, employment, and income, the three components that generally characterise SES in research, are responsible for major health disparities [22]. Although closely related, they are not interchangeable [23], and may even influence pathways leading to health inequalities [22]. Moreover, individual characteristics (age, sex, generation, family conditions, etc.) may interact with SES characteristics, and should therefore be taken into account so as to better interpret observed gradients [17]. Dietary disparities have also been studied via less common indicators, such as place of living, ethnicity and migration background, which were assimilated as socioeconomic and cultural indicators [17,19]. In addition, nutrition-related characteristics like body mass index (BMI) and physical activity might also be included in statistical modelling that explores diet disparities, but their role in potential overadjustment needs clarification. Indeed, interrelationships between all these indicators require careful interpretation of observed dietary disparities according to SES characteristics.

However, information available on such disparities during adolescence and early adulthood is scattered. Although conclusions have tended to indicate a social gradient for certain food groups, specificities of life-stage disparities have not been thoroughly addressed**,** and their identification could be relevant for developing targeted interventions. To our knowledge, no recent work has systematically updated available information on diet disparities focusing on adolescence and young adulthood, and oriented toward a wide set of socioeconomic factors, including migratory characteristics. The aim of this systematic review was thus to explore how diet (overall and by food group) differs according to socioeconomic and cultural characteristics of adolescents and young adults from high-income countries.

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Methods

Search strategy

A systematic review of the literature according to Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) guidelines [24] was conducted between December 2016 and March 2017. Targeted studies sought to examine individual diet according to social, economic and cultural characteristics as their primary or secondary objective. The Population, Intervention, Comparison, Outcomes and Study design (PICOS) inclusion and exclusion criteria are presented in Table 1. A relatively large range of ages was targeted (10 to 40 years) in order to include those studies examining the general population and which analysed subgroups of adolescents and young adults.

In order to follow up previously published reviews, articles published between 1 January 2012 (the endpoint of the most recently updated review [17]) and 31 March 2017 were searched for in Medline®. A controlled vocabulary from the Medical Subject Headings (MeSH) was used to build a syntax (Appendix A) according to keywords encountered in the articles selected in previous works [16,17]. MeSH keywords relative to diet were “Diet”, “Food” (without tree explosion), “Fruits”, “Vegetables”, “Dairy Products”, “Nutrition surveys”, “Feeding behavior” (without tree explosion), “Food preferences” and “Nutrition”. MeSH keywords concerning the social, economic or cultural factors were: “Socioeconomic factors”, “Risk factors”, “Ethnic groups”, “Family”, “Family characteristics”, “Health status”, “Human migration” and “Residence characteristics”. Geographic keywords were added: “Europe", “Canada”, “United States”, “Australia” and “New Zealand”. Asia was not included due to specific dietary habits (types of food, dietary patterns). Since recently published articles may not be referenced in Medline according to the MeSH thesaurus, the review was completed by a free search, covering the latest year and using a similar vocabulary. No language restriction was used, so as to obtain a maximum of available information. In fact, no full texts in any language other than English were finally selected. Finally, references cited in literature reviews published on similar topics [15,18–21,25–32] were searched for via Medline®, examined and added to the corpus if relevant.

Selection process

PRISMA guidelines [24] were used to present the flow selection process (Figure 1). Titles were independently screened by two investigators, while abstracts and full texts were read by one

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investigator. All full texts were available through academic resources, except for 2, which were obtained after electronic contact with authors.

Reasons for record exclusion are presented in the flow chart (Figure 1). Among 140 abstracts assessed for eligibility, 95 full texts were excluded: 61 because results were not specifically presented for adolescents or young adults, but for a broader age range, and 14 because diet description covered only nutrients or diet behaviour (e.g., fast foods, breakfast frequency, etc.).

Information was extracted according to a previously established reading grid, which included the following items: name of first author, year of publication, study objectives, country(-ies) or region, data collection period, study design, sampled population (i.e. national, student, etc.), number of subjects included in diet analysis according to socioeconomic and cultural factors, age range, diet collection method, diet outcome, socioeconomic and cultural status variables, and main results concerning associations between diet and socioeconomic or cultural status and adjustment variables.

Quality assessment

Appropriate methods and the quality of each included study were assessed using a set of criteria (Figure 2). First, to verify risk of information bias, diet collection methods were examined: repeated 24-h recalls, food-frequency questionnaires (FFQ) including a sufficient number of food items (i.e. at least several tens items) and diet records were considered a valid method for food intake data collection [33,34]. Studies based on other types of questionnaires (short FFQ, diet history and single 24-h recall, for example) were considered to be of lesser quality, were not described in detail and were not tabulated.

Risk of selection bias was investigated by examining the sampling method; attention was primarily paid to sample size and scope. When a small sample was studied (fewer than 500 subjects), or when only a call for volunteers or convenience sampling was used, the quality of the methods was considered "low". Moreover, if the study population was highly specific (e.g., one year of school grade in one city), the study was considered to be of poor quality.

Accuracy of the exposure measurement was then assessed by the relevance of socioeconomic categories chosen (sufficient number of categories making possible a potential gradient, i.e. minimum of three categories, adapted to the population under study) and reliability of the index when such a composite socioeconomic status was used (e.g. based on both education level and occupation status).

Finally, we focused on analysis modeling, i.e. appropriateness of the final model, and whether potential confounding factors and mediators (i.e. BMI, physical activity, screen time, age, gender,

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168 place of living) were identified and accurately integrated into the model. Factors possibly causing
169 confounding results, either concomitant or as mediators in the relationship between socioeconomic
170 status and diet, are numerous and differently involved depending on the context. Therefore, the
171 objective was to identify potentially overadjusted models or inappropriate choices of adjustment
172 variables. If no multivariate analysis was found in the article, univariate results were considered, as
173 well as stratification options.

174 **Analysis process**

175 A narrative synthesis, completed by detailed tables, is presented here. Given the small number and
176 heterogeneity of selected reports, findings concerning young adults (18-40-years-old), food groups
177 such as meat, fish, and eggs, starchy food and legumes, water and low-calorie drinks, fat, pulses,
178 nuts and alcoholic drinks, along with disparities according to rural or urban living environment, are
179 not presented.

180 Results were sorted by type of diet outcome: patterns, diet scores and food groups (vegetables and
181 fruits, dairy food, SSB, salty and energy-dense food). For each, socioeconomic indicators related to
182 education, occupation, income level, migration status and family structure were presented when
183 available. Names of dietary patterns have been quoted as named in the original articles. Only results
184 of high-quality studies have been detailed in summary tables. Those with lower quality have been
185 added as complementary information in the text. In the tables, studies have been arranged in
186 alphabetical order by first author's name.

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Results

Among 7,250 records identified after removing duplicates, 40 met inclusion criteria (Figure 1). Among the 40 selected studies, 17 were considered of satisfactory quality and have been presented in detail and tabulated. The main reason for lower quality was lack of accuracy concerning diet outcome measurement. Indeed, 22 studies of poor quality used a short FFQ, a single 24-h recall or dietary history.

Dietary patterns

In total, six reports corresponding to five studies presented *a posteriori* dietary patterns. Among them, three studies (four reports) were considered of good quality (Table 2) and two of lower quality [35,36].

Different categories of dietary patterns were identified and considered according to their potential health benefits or disadvantages. Methods used were cluster analyses [35,37–39] and principal component analyses [36,40]. Pattern content varied according to the context. "Healthy" [37,38], "Mediterranean" [40], "vegetarian" [39] and "dairy product" [37] patterns were identified. Such healthy patterns were confronted with less favourable profiles [37–39]. "Western" [40] and "traditional" [38] pattern compositions strongly depended on the context: they differed from healthier profiles by their high content in meat, potatoes, bread and cereals, and might also include energy-dense and ultra-processed products. Overlaps between healthy and traditional patterns were also described, creating "western and Mediterranean" [40] and "traditional/health conscious" [39] patterns, with the latter considered as "fairly healthy".

Among the four dietary pattern studies of good quality (Table 2), in three out of three studies examining education level, patterns considered as healthy were associated with higher parental education levels, especially maternal [37,39], for girls only in one study [40]. In three out of these three studies analysing occupation, healthy patterns were related to higher parental occupation position [37], in girls only in one study [40], and were observed more frequently when the adolescents' mothers were unemployed, in comparison to working mothers in a third study [39]. In all these studies, less favourable patterns were associated with lower parental education [37,39] (in girls only in one study) [40]. The "western" profile was related to a lower parental occupation [40], and "snacks/sugared drinks" were more frequent among working mothers of adolescents [39]. Moreover in a fourth study, tracking healthy or unfavourable patterns at three time-points was correlated with higher and lower maternal education level, respectively [38]. Results were consistent in studies using less accurate diet measurement methods [35,36], but slightly discordant when the SES index based on parental

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education, occupation and income was examined in Germany: the "western" pattern was associated with higher parental SES, while the reverse was observed for the "traditional and western" profile [36].

Ethnicity was explored in the Avon area of the United-Kingdom at 13-year follow-up [39]: the "vegetarian" pattern was associated with being "non-white" in comparison with the "white" group in this predominantly white population. On the other hand, the unfavourable "snacks and sugared drinks" profile was more frequent among white than among non-white adolescents. Nevertheless, non-white adolescents were more likely to remain in the "processed" pattern when they were tracked over time, according to a second report concerning the same cohort [38]. Finally, in one study regarding family structure indicators, "snacks and sugared drinks" and "processed" patterns were pointed out as being more frequent in families with more siblings [39].

Scores

Eleven selected reports, corresponding to ten studies, analysed *a priori* diet scores in adolescent populations. Five studies (six reports) were considered of good quality (Table 3) and five of lower quality, and were not tabulated [41–45]. One study (two reports) of good quality was conducted in low-socioeconomic areas [46,47].

Different types of scores adapted to adolescents were used, measuring the compliance with a nationally recommended diet [44,48,49] or to a Mediterranean diet [46,47,50,51]. All these scores were calculated from consumed amounts of several predefined food groups, ranging from 7 to 16 groups. The Diet Quality Index for Adolescents was used in one study [48]: in addition to compliance with recommendations, this score takes into account diet diversity, dietary balance and meal frequency.

Among studies of good quality (Table 3), in five out of five studies, the diet score of adolescents was higher when the parental education level was higher [48,49], especially maternal education [46,47,51]. A similar trend according to parental occupation was observed in two out of three studies [48,51], while occupation was not significantly associated in the third [49]. In addition, the diet score was higher when the SES index based on parental education and occupation was higher in the only study that explored such an index [50]. The relationship of diet with income was explored in three studies: among students in Greek areas with low SES, adherence to a Mediterranean diet was positively associated with family affluence [47] and was higher when the father had an income [46]. Household income was not associated with diet score in the third study [49].

In the high-quality study examining migration among Greek students attending schools from low SES areas, adherence to a Mediterranean diet was higher if the mother was a native Greek [46].

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Similar trends were pointed out in two studies of lesser quality, showing healthier diet when subjects were natives compared with migrants [41] and when they were first- or second-generation migrants compared with the third generation [44].

Food groups

Twenty-six selected reports, corresponding to 22 different studies, described adolescent diets using food groups. Eight studies (nine reports) were considered of good quality (Tables 4 to 7), including five reports that focused on one or several specific food groups [49,52–55], and four reports that covered almost all main food groups and subgroups [50,56–58]. The other 14 studies (17 reports) were considered of lower quality [41,59–74].

Fruits and vegetables

The "vegetable" group was not defined in most reports [50,54,56–58]; in others [49,55], it was composed of raw, frozen, canned and cooked vegetables. The "fruit" group composition was less homogeneous: some included 100% fruit juice [56], all types of fruit juice [58], dried fruits [56] or only fresh [49] or whole fruits [57], while some did not define composition [50,54,55]. One report showed analyses of grouped fruits and vegetables [58]. Fruit and vegetable consumption was generally higher when SES indicators were more favourable, and none of the selected studies showed an inverse association (Table 4).

Four studies of good quality analysed the association between parental education and vegetable intake. In two studies, and after various adjustments, adolescents with more highly educated parents daily consumed more vegetables [54,55]. In one study, vegetable intake did not vary according to parental education level after adjustment for sex, age and energy intake [56]. Nevertheless, in the fourth study, the highest intake category was associated with higher parental education for boys, after adjustment for sex- and age-recommended amounts of vegetables [49]. In addition, these four studies all showed higher fruit intake and daily consumption when parental education was higher [49,54–56]. Moreover, studies of lower quality showed positive associations between parental education and fruit and vegetable consumption frequency [60,67].

Two studies investigated the association between vegetable intake and household income/wealth, but found no statistical association [49,56]. In one of three studies investigating fruit consumption, daily fruit intake was higher when household income and wealth levels were higher, after adjustment for age, sex and energy intake in one study [56], whereas, in another study [49] dichotomized fruit intake was not associated with household income after various adjustments. In a third study, total and whole fruit intake was higher when the family income-to-poverty ratio was

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283 higher, whereas 100% fruit juice intake was not associated with family income [52]. In five out of
284 seven lower-quality studies of fruit and vegetable consumption according to the Family Affluence
285 Scale (FAS) or food insecurity, higher daily consumption was associated with higher FAS
286 [61,62,65,70,71]. Another of these studies also showed that adolescents with a decreasing or increasing
287 poverty level over time consumed less fruits and vegetables than adolescents with a stable non-poor
288 trajectory [59].

289 Vegetable intake was not associated with parental occupation in two studies [49,56], but in one of
290 these [56], fruit intake was higher when parental occupational status was higher. Higher daily
291 consumption of vegetables and fruits was associated with parental skilled professions, after various
292 adjustments [54]. Moreover, fruit intake was higher when the global SES index was higher in one
293 study [56], while it was not associated in another [50]. Vegetable intake was not associated with the
294 overall SES level in these two studies.

295 Nor was there an association between tracking or change in vegetable and fruit intake over time
296 according to parental education or family income in the only study that examined this aspect [57].

297 For sociocultural characteristics, fruit and vegetable consumption differed according to birthplace
298 [58] and ethnic origins [52] highly specific to each study context. The first study showed that fruit and
299 vegetable consumption was generally higher for migrants from distant countries and more recent
300 migrants than for natives [58]. In a US sample in the second study, a lower proportion of non-
301 Hispanic Blacks and "other Hispanics" daily consumed smaller amounts of total fruits than non-
302 Hispanic Whites [52]. In three out four studies of lower quality, consumption of fruits and vegetables
303 also differed according to migration status [41] and ethnic origin [63,72].

304 ***Dairy***

305 Most reports defined the "dairy" group as being composed of milk, yoghurt and cheese [50,57,58].
306 Some reports also included dairy drinks [56], flavoured milk, smoothies and milkshakes [53] in this
307 group. Some studies indicated higher dairy intake associated with more favourable SES, but overall
308 findings were not consistent (Table 5). Among three studies, one showed that yoghurt intake was
309 higher when parental education, income, wealth and overall SES index were higher, after adjusting
310 for age, sex and energy intake [56]. However in that study, the studied dairy product intake was never
311 associated with parental occupation, and milk and cheese consumption was not associated with any
312 SES indicator. In the other two studies, dairy intake was higher when parents had tertiary
313 qualifications, but was not associated with occupation [53] or SES index (parental occupation and

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education levels) [50]. Neither changing nor tracking dairy intake over time was associated with parental education or income in the only study concerned [57].

Neither of two studies examining the association between dairy consumption and ethnicity showed a significant association [53,58]. Among two studies of lesser quality, one described higher consumption of dairy products for breakfast among Spanish adolescents than among other nationalities [41]. The other described a proportion of adolescents consuming whole or skimmed milk that differed according to ethnicity, with fewer non-Hispanic Blacks consuming such dairy products [72].

Sugar-sweetened beverages

The SSB group was defined throughout the reports as sugary, soft and diet drinks [50,56,58]. In one study, it was also composed of fruit and vegetable juices [57]. SSB drinking, explored in two studies, was higher when parental education [50,56], household wealth [56], and global SES [56] were lower, after various adjustments (Table 6). However, SSB intake was not associated with parental occupation or household income [56]. Four out of five studies of lower quality were rather consistent with each other, showing more frequent SSB consumption when parental education [60] and FAS [62] were lower and when poverty level indicators were higher.

One study carried out in the Balearic Islands explored diet according to birthplace. SSB consumption was higher for adolescents born in Latin America and other foreign countries than for natives, and also higher for those of non-Mediterranean than of Mediterranean origin [58]. Moreover, it was higher when the length of time living in the Balearic Islands was lower. Three out of four lower-quality studies showed significant differences between ethnic groups [68,69,74].

Changing or tracking SSB intake over time was not associated with parental education or family income [57]. A lower-quality study of SSB intake decline over time reported differences according to ethnicity, but this was not statistically tested [73].

Salty and sweet energy-dense food

In this group, studies included informal meals generally composed of fatty, salty and sweet snacks and fast food, without defining a threshold of energy density. Other studies also included soft drinks [49] or stewed fruits and fruits in syrup [56]. One study focused only on sweet and fatty snacks [57], and another on sweets and pastries [58]. Amounts of energy-dense food consumed by adolescents were globally higher when socioeconomic characteristics were less favourable, but such findings were not systematically retrieved (Table 7). Two studies out of three showed higher intake when parental education [49,56], occupation [49,56] and household income and wealth [49,56] were lower, after

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346 various adjustments. However, an exception was seen: cake and pastry intake was lower when
347 occupational status and global SES were lower [56]. Stewed fruits, fruits in syrup, confectionery,
348 pizza, sandwiches, fast food and sweets intake were otherwise not associated with SES-related
349 indicators [50,56]. Studies of lower quality mainly showed higher consumption of sweets when FAS
350 [62,70] and parental education [67] were lower, and higher daily consumption of energy-dense and
351 nutrient-poor snacks when SES was lower, but such associations were not statistically tested [74].

352 Only one study in the Balearic Islands explored the birthplace. Latin American, and, more
353 generally, non-Mediterranean adolescents had higher sweets consumption than natives, and sweets
354 and pastry consumption was higher when the length of time living on islands was lower [58]. One
355 study of lesser quality showed higher sweets and fast food consumption among adolescents of
356 nationalities other than Spanish [41].

357 Changing or tracking sugar-sweetened food intake over time was not associated with education or
358 income [57]. A decline in sweet and salty snack intake over time was observed among Black
359 adolescents with a healthy weight, but ethnic differences were not tested in that study [73].

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Discussion

Our objective was to update overall knowledge of socioeconomic and cultural disparities in dietary patterns, scores and food group consumption by adolescents and young adults. Recent literature on diet disparities has been abundant, but when focusing on this life period, the quality of the studies appears highly variable and available information is scattered. Among adolescents, however, evidence and consistent findings were sufficient to conclude that higher dietary scores and healthier patterns were associated with higher parental education and occupational status, while less favourable patterns were associated with lower SES. Such findings therefore confirmed, at least in part, that a favourable social status is generally associated with a healthier diet.

Regarding food groups, the most substantial bibliographic corpus concerned fruits and vegetables. Such consumption was consistently associated with higher education. In addition, fruit consumption was somewhat higher when household income and wealth were higher. Despite a smaller number of conclusive high-quality studies, SSB, energy-dense food and dairy product consumption were globally associated with SES: SSB and energy-dense food consumption was higher when SES indicators were less favourable, while dairy intake tended to be higher when SES was more favourable. However, available information regarding other groups was very scarce. In addition to SES-related indicators, ethnic and migration disparities were pointed out in several studies, but proved to be highly specific to each country and geographic area.

Overall, conclusions are limited due to the heterogeneity of the populations, diet outcome and socioeconomic and cultural indicators in question. Thus, it would not have been feasible to carry out a meta-analysis, nor to explore potential publication bias. Moreover, use of a quantitative scale assessing methodological quality would have been too restrictive. Nevertheless, quality assessment was used, making possible a selection based on objective criteria adapted to the diversity of the publications.

Diversity of methods

Most studies using scores were adapted to recommendations dedicated to adolescents, leading to conclusions that could be compared. Since they depended on the population and context of the study, dietary patterns differed from one study to another, making findings between some countries not directly comparable. However, consistent conclusions were generally drawn. The advantage of describing disparities according to food groups lies in being able to identify specific associated indicators. Food choice and consumption mechanisms may also differ according to food group [16]. The issue is to consequently adapt dietary recommendations based on such findings. However, diet

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collection and description methods differed across studies, and thus, for some food groups, it was difficult to draw conclusions.

Statistical models and adjustments were highly variable between studies. Adjustments for sex, age and total energy intake (scores, food groups) enabled taking into account differences in requirements. BMI was sometimes used as an adjustment variable, limiting interpretation, since it may be both a consequence of an unhealthy diet and a reason for adopting a balanced diet. Some authors also chose to adjust for other nutrition-related behaviour (e.g., physical activity, screen time) in order to identify potential confounders, and thus overadjustment was probable. In some models, identification of the true role of adjustment variables was challenging. Nutrition-related behaviour variables may have been mediators, logically weakening the association between SES and diet. Some adjustment variables were also presented as confounding factors; however, although they were influenced by the SES, they could not substitute for that variable in the relationship with diet.

Mechanisms of disparities

Dietary disparities among adolescents overwhelmingly involved inequalities in parental education, particularly maternal. Education is linked to health literacy, i.e. the ability to appropriate health and nutrition information and to generate dietary behaviour that would provide long-term benefits [(75)]. However, occupation and income were not systematically associated with diet. Income is directly related to financial accessibility to food, and occupation may influence food intake partly via the workplace culture and social networks [(76)]. Moreover, it has been clearly established that education is a determinant of occupation and income, and that these three indicators are involved in diet disparities, but differently, according to the SES indicator [(16,77,78)]. In addition, reliability and availability of some SES indicators were insufficient to draw clear conclusions. Nevertheless, the present review shows that parental education was a more systematic determinant of diet than occupation or income. In terms of public health policies, it again emphasizes that nutritional information should be adapted to different education backgrounds and integrated into early education, targeting mothers or caregivers.

According on the food group in question: a) either all socio-economic indicators were associated (e.g. fruits); b) only some SES characteristics were associated (e.g. vegetables, dairy, SSB); or c) these associations were contradictory (e.g. in the case of energy-dense foods). Such disparities within a food group have been described previously; authors have suggested exploring causal mechanisms involved, such as biological (possibly related to higher palatability and lower satiety provided by such energy-dense foods) or behavioural components (accessibility and affordability)

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[16]. For instance, SSB consumption was determined by lower parental financial status (along with less schooling). Indeed, SSB are financially and physically accessible products, often associated with positive values through sports marketing, on the one hand, and time spent in front of screens and sedentary behaviour, on the other [19].

In addition to the main SES indicators, ethnicity and migration status were often associated with diet, but findings appeared to be related to the general background. In some studies carried out in the US [52,72], Australia [53] and the UK [38,39], ethnicity was explored mainly as a reflection of SES. In other Mediterranean [46,58], American [44] and Canadian [71] studies, parental place of birth, migratory generation and length of time living in the host country were studied. The migration background was thus also explored under the angle of dietary habit acquisition and acculturation [79–81]. For instance, in the general adolescent Balearic population, it was difficult to distinguish effects related to acculturation from those related to SES, since SES indicators were not examined [58]. Nevertheless, higher consumption of SSB and energy-dense foods in recent adolescent migrants may be due to their increased accessibility; furthermore, higher vegetable consumption may be related to culture-specific dietary habits. In addition, variations according to country of origin and stage of nutritional transition should be taken into account.

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Conclusions

Based on the present review, findings on dietary patterns and scores, along with fruit and vegetable consumption in adolescents, consistently confirmed the socioeconomic gradient observed in adults. However, overall conclusions were much more limited for several food groups and warrant further examination. In addition, high-quality studies remain necessary, especially in terms of reliable dietary and socioeconomic evaluations. Sampling of both the general adolescent population and potentially at-risk subgroups such as migrants should also be more carefully examined. Finally, diet in young adults has thus far been poorly described and needs to be concomitantly evaluated so as to improve our understanding of changes in socioeconomic and cultural disparities during this transition period.

Nevertheless, the present review, consistent with wide dietary disparities among adolescents, underlines the importance of developing interventions targeted to this age group. Future public health programs must take into account the socioeconomic gap, addressing nutritional intervention towards both populations as a whole, with the most vulnerable being the adolescent population. Indeed, such initiatives should seek to improve literacy by involving care-givers, and taking into account the migration background and associated food culture. Although its long-term sustainability requires confirmation, an improvement in dietary habits during adolescence may continue into adulthood, and could contribute to a reduction in non-communicable disease inequalities.

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Tables and Figures

Table 1. PICOS (Population, Intervention, Comparison, Outcomes and Study design) criteria for inclusion and exclusion of the studies in the systematic review

Population	General population, 10 to 40 years, living in Europe, United States, Canada, Australia or New Zealand. Results specifically presented in adolescent (i.e. 10-17-year-old) and/or young adult (i.e. 18-40-year-old) subgroups. *Excluded: patients, elderly, infant or pre-school children, pregnant or lactating women, overweight or obese persons, those participating in a diet program, persons with eating disorders, specific ethnic groups (e.g. Inuits), low income countries or geographic areas such as Asia.*
Intervention	Not applicable.
Comparison	Of subjects, their parents, their household: - Socioeconomic status: education level, income, occupation, employment status. - Family structure: matrimonial status, parenthood, sibling(s), household size. - Cultural aspects and migration status: country of origin, language spoken, migration background. *Excluded: socioeconomic status of a geographic area, a school or another non-individual level.*
Outcome	Diet assessed by usual intake or food frequency, in terms of food groups, food patterns and diet scores. *Excluded outcomes: energy, macro- and micronutrient intake, eating behaviour (meal frequency, breakfast skipping, take-away or fast-food consumption), and diet assessed through biomarkers.*
Study design	Cross-sectional Longitudinal: description of cohort at baseline or at follow-up point.

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Table 2. Dietary patterns according to socioeconomic and cultural characteristics of adolescents[a] (n=4)

Reference	Population, design, time of collection, country	Age range	n	Diet collection method	Exposure variables (number of categories)	Main associations	Adjustments
Araujo (2015)[37]	EPITeen study, public and private schools of Porto, cohort at baseline, 2003-04, Portugal,	13	1,489	FFQ	• Parental educ. (in years, 4)	• Higher % of higher educ. in "Healthier" and "Dairy products" patterns	• None
					• Parental educ. (in years, 4)	• Higher educ. increase odds to be in "Healthier" and "Dairy products" patterns and decrease odds to be in "Fast-food and sweets" pattern	• Sex, regular practice of sports, leisure-time activities, TV watching on weekend, fried food consumption, BMI, and mother's BMI
					• Living with both parents (2)	• NS	• None
					• Mother's occup. (3)	• Higher % of white collar in "Healthier" and "Dairy products" patterns	• None
Bibiloni (2012)[40]	Balearic Islands, cross-sectional, 2007-08, Spain	12-17	1,231	24h-R (x2), FFQ	• Parental educ. (3)	• "Western" pattern asso. with low educ. (girls) and "Mediterranean" pattern asso. with medium and high educ. (girls)	In univariate analysis only. Not significant when adjusted for age group, number of daily meals and snacks, media screen time, sleep time, physical activity, body composition, desire to change weight, and all SES variables
					• Parental occup. (3)	• "Western" pattern asso. with low occup. and "Mediterranean" pattern asso. with high occup. (girls)	
Northstone (2013)[38]	ALSPAC study, cohort at follow-up age 7, 10 and 13, 1998, 2001, and 2004, United-Kingdom	7, 10, and 13	6,837 6,972 5,661	Record (3 days)	• Ethnicity (2)	• Staying in "processed" cluster asso. with being non-White (vs. White)	Sex, ethnicity, maternal age, maternal smoking, and all SES variables
					• Maternal educ. (3)	• Staying in "healthy" cluster at 3 time point asso. with higher maternal educ. and staying in "processed" cluster asso. with lower maternal educ.	
					• Housing tenure (3)	• NS	
Northstone (2014)[39]	ALSPAC study, cohort at follow-up age 13, 2004, United-Kingdom	13	3,951	FFQ	• Ethnicity (2)	• "Snack/sugared drinks" pattern asso. with being White (vs. non-White) and "vegetarian" pattern asso. with being non-White (vs. White)	Sex, maternal age, and all SES variables
					• Maternal educ. (5)	• "Traditional/health conscious" and "vegetarian" pattern asso. with higher maternal educ. and "processed" and "snack/sugared drinks" patterns asso. with lower maternal educ.	
					• Mother has a partner (2)	• NS	
					• Mother in employment (2)	• "Traditional/health conscious" pattern asso. with being unemployed (vs working) and "snack/sugared drinks" pattern asso. with working (vs. being unemployed)	
					• Older sibling (3)	• "Processed" and "snack/sugared drinks" patterns asso. with presence of two or more older or younger siblings	
					• Younger siblings (3)		

FFQ: food-frequency questionnaire; educ.: education; TV: television; NS: non-statistically significant; occup: occupation; 24h-R: 24-h recall; SES: socioeconomic status. [a]: details on risk of bias assessment are not presented since only studies of good quality are tabulated.

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Table 3. Diet scores according to socioeconomic or cultural characteristics of adolescents[a] (n=6)

Reference	Population, design, time of collection, country	Age range	n	Diet collection method	Score	Exposure variables (number of categories)	Main associations	Adjustments
Beghin (2014)[48]	HELENA study, cross-sectional, 2006-07, 8 European countries	12.5-17.5	1,768	24h-R (x2)	DQI-AM	• Parental educ. (3) • Parental occup. (3)	• Higher score when educ. higher (Northern Europe) • Higher score when occup. higher	Sex, age, and energy intake
Finger (2015)[49]	KiGGs study, cross-sectional, 2003-06, Germany	11-17	6,359	FFQ	HuSKY	• Parental educ. (3) • Parental occup. (3) • Household income (tertiles)	• Higher score when educ. higher • NS • NS	Age, region, leisure time, media use, total energy expenditure, BMI-for-age, perceived weight status and all SES variables
Grosso (2013) (a)[50]	Secondary schools of Sicily, cross-sectional, 2010-11, Italy	13-16	1,135	FFQ	KIDMED index	• SES index (parental educ. and occup., 3)	• Higher score when SES higher	Sex, BMI, physical activity, and all SES variables
Kastorini (2016)[46]	DIATROFI, schools in areas of low SES, intervention study at baseline and after intervention, 2012-13, Greece	3-18	3,941	FFQ	KIDMED index	• Maternal educ. (3) • Mother's country of birth (2) • Paternal income source (yes/no)	• Higher score when maternal educ. higher • Higher score when mother born in Greece than in another country • Higher score when presence of paternal income	Age, sex, food insecurity, time of collection (before vs. after), and all SES variables
Ozen (2015)[51]	Balearic Islands, cross-sectional, 2007-08, Spain	12-17	1,691	24h-R (x2), FFQ	Mediterranean diet score	• Parental educ. (3) • Parental occup. (3)	• Low adherence to score asso. with low maternal educ. (vs. high) among non-functional food consumers • Low adherence to score asso. with medium paternal work status (vs. high), among non-functional food consumers	Age, sex, BMI, physical activity, chronic diseases, and all SES variables
Yannakoulia (2016)[47]	DIATROFI, schools in areas of low SES, cross-sectional, 2012-13, Greece	3-18	11,717	FFQ	KIDMED index	• Parental educ. (3) • FAS (3)	• Higher score when educ. higher • Higher score when maternal educ. higher • Higher score when FAS higher	Age, sex, sedentary and sports activities, and all SES variables

24h-R: 24-h recall; DQI-AM: diet quality index for adolescents; educ.: education; occup.: occupation; FFQ: food-frequency questionnaire; HuSKY: healthy nutrition score for children and youth; NS: non-statistically significant; SES: socioeconomic status; KIDMED: Mediterranean diet quality index for children and adolescent; FAS: family affluence scale. [a]: details on risk of bias assessment are not presented since only studies of good quality are tabulated.

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Table 4. Vegetable and fruit consumptions according to socioeconomic or cultural characteristics of adolescents[a] (n=8)

Reference	Population, design, time of collection, country	Age range	n	Diet collection method	Intake or frequency of consumption	Exposure variables (number of categories)	Association	Adjustments
Drewnowski (2015)[52]	NHANES, repeated cross-sectional, 2007-10, United-States	14-19	1,834	24h-R (x2)	• % of population having total fruit intake < 1.5 cup-equivalents/day	• Race/ethnicity (4)	• Lower % of non-Hispanic-Black and "other Hispanic" than non-Hispanic-White	• None
						• Family PIR (3)	• Higher % of population when income lower	• None
					• Whole fruit intake (cup-equiv./day)	• Family PIR (3)	• Higher when income higher	• None and for sex and race/ethnicity
					• 100% fruit juice intake (cup-equiv./day)	• Family PIR (3)	• NS	• None and for sex and race/ethnicity
Drouillet-Pinard (2017)[56]	INCA2 study, cross-sectional, 2006-07, France	11-17	881	Record (7 days)	• Vegetable intake (g/day)	• Parental occup. (4)	• NS	Age, sex, and energy intake
						• Parental educ. (3)	• NS	
						• Household income (tertiles)	• NS	
						• Household wealth index (tertiles)	• NS	
						• Global SES index (all SES indicators combined, tertiles)	• NS	
					• Fruit intake (g/day)	• Parental occup. (4)	• Higher when educ., occup. status, income, wealth, and SES higher	
						• Parental educ. (3)		
						• Household income (tertiles)		
						• Household wealth index (tertiles)		
						• Global SES index (all SES indicators combined, tertiles)		
Finger (2015)[49]	KIGGS study, cross-sectional, 2003-06, Germany	11-17	6,359	FFQ	• Vegetable high or low intake (ratio of g/day intake divided by age- and sex- recommended amount)	• Parental educ. (3)	• Higher when educ. higher (boys)	Age, region, leisure time physical activity, media use, total energy expenditure, BMI-for-age, and all SES variables
						• Parental occup. (3)	• NS	
						• Household income (tertiles)	• NS	
					• Fruit high or low intake (ratio of g/day intake divided by age- and sex-recommended amount)	• Parental educ. (3)	• Higher when educ. higher	
						• Parental occup. (3)	• NS	
						• Household income (tertiles)	• NS	
Grosso (2013) (a)[50]	Secondary schools of Sicily, cross-sectional, 2010-11, Italy	13-16	1,135	FFQ	• Vegetable intake (g/day)	• SES index (parental educ. and occup., 3)	• NS	Age, sex, BMI, physical activity, place of living, and SES
					• Fruit intake (g/day)	• SES index (parental educ. and occup., 3)	• NS	

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Table 4. (Continued)

Reference	Population, design, time of collection, country[a]	Age range	n	Diet collection method	Intake or frequency of consumption	Exposure variables (number of categories)	Association	Adjustments
Grosso (2013) (b)[54]	Secondary schools of Sicily, cross-sectional, 2010-11, Italy	13-16	1,135	FFQ	• Vegetable daily consumption	• Parental educ. (3) • Parental occup. (3) • Child educ. (2)	• Higher when educ. higher • Higher when skilled professions • NS	Age, sex, BMI, daily eat between meals, weekly breakfast, lunch and dinner with parents, influences on food choice, and all SES variables
					• Fruit daily consumption	• Parental educ. (3) • Parental occup. (3) • Child educ. (2)	• Higher when educ. higher • Higher when skilled professions • NS	
Harris (2015)[57]	GINIplus study, cohort at follow-up age 10 and 15, 2005-08 and 2010-13, Germany	10-15	1,232	FFQ	• Change vs. tracking vegetable intake over time (% of energy intake)	• Parental educ. (2) • Family income (tertiles)	• NS • NS	Age at baseline, baseline energy intake, diet changes, study center, study intervention arm, pubertal onset, BMI, screen-time, and all SES variables
					• Change vs. tracking fruit intake over time (% of energy intake)	• Parental educ. (2) • Family income (tertiles)	• NS • NS	
Lehto (2015)[55]	PROGREENS study, cross-sectional, 2009, 10 European countries	11	479 to 1,218	FFQ	• Vegetable daily consumption	• Parental educ. (2)	• Higher when educ. higher (FI, DE, GR, IS, NO, PT, SL)	Sex and age
					• Fruit daily consumption	• Parental educ. (2)	• Higher when educ. higher (BG, GR, IS, NO, PT)	
Llull (2015)[58]	Balearic Islands, cross-sectional, 2007-08, Spain	12-17	1,231	FFQ	• Vegetable daily consumption	• Birthplace (4)	• Higher for Latin America than Balearic Islands	Sex and age
						• Birthplace (2)	• Higher for non-Mediterranean	
						• Length of time living in Balearic Islands (4)	• Lower when length of time higher	
					• Fruit daily consumption	• Birthplace (4)	• Higher for Latin America than Balearic Islands	
						• Birthplace (2)	• NS	
						• Length of time living in Balearic Islands (4)	• NS	
					• Fruit and vegetable daily consumption	• Birthplace (3)	• Higher for Latin America than Balearic Islands	
						• Birthplace (2)	• Higher for non-Mediterranean	

24h-R: 24-h recall; PIR: Poverty income ratio; occup.: occupation; educ.: education; NS: non-statistically significant; SES: socioeconomic status; FFQ: food-frequency questionnaire; FI: Finland; DE: Germany ; GR: Greece; IS: Iceland; NO: Norway; PT: Portugal; SL: Slovenia; BG: Bulgaria. [a]: Details on risk of bias assessment are not presented since only studies of good quality are tabulated.

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Table 5. Dairy food consumption according to socioeconomic or cultural characteristics of adolescents[a] (n=5)

Reference	Population, design, time of collection, country	Age range	n	Diet collection method	Intake or frequency of consumption	Exposure variables (number of categories)	Association	Adjustments
Drouillet-Pinard (2017)[56]	INCA2 study, cross-sectional, 2006-2007, France	11-17	881	Record (7 days)	Milk, yoghurts, and cheese intake (g/day)	• Parental occup. (4) • Parental educ. (3) • Household income (tertiles) • Household wealth index (tertiles) • Global SES index (all SES indicators combined, tertiles)	• NS • Yoghurts higher when educ., income, wealth, and SES higher	Age, gender, and energy intake
Gopinath (2014)[53]	Sydney Childhood Eye study, cohort at baseline (age 12) and at follow-up age 17, 2004-05 and 2009-11, Australia	12-17	634	FFQ	Intake≥ 3.5 serves/day five years later and maintaining consumption above the median over time	• Parental educ. at baseline • Ethnicity • Parental occup.	• Higher for tertiary qualifications • NS • NS	None
Grosso (2013) (a)[50]	Secondary schools of Sicily, cross-sectional, 2010-11, Italy	13-16	1,135	FFQ	Intake (g/day)	• SES index (parental educ. and occup., 3)	• NS	Age, gender, BMI, physical activity, place of living, and SES
Harris (2015)[57]	GINIplus study, cohort at follow-up age 10 and 15, 2005-08 and 2010-13, Germany	10-15	1,232	FFQ	Change vs. tracking intake over time (% of energy intake)	• Parental educ. (2) • Family income (tertiles)	• NS • NS	Age at baseline, baseline energy intake, diet changes, study center, study intervention arm, pubertal onset, BMI, screen-time, and all SES variables
Llull (2015)[58]	Balearic Islands, cross-sectional, 2007-08, Spain	12-17	1,231	FFQ	Daily consumption	• Birthplace (4) • Birthplace (2) • Length of time living in Balearic Islands (4)	• NS • NS • NS	Gender and age

Occup.: occupation; NS: non-statistically significant; educ.: education; SES: socioeconomic status; FFQ: food-frequency questionnaire. [a]: details on risk of bias assessment are not presented since only studies of good quality are tabulated.

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Table 6. Sugar sweetened beverage consumption according to socioeconomic or cultural characteristics of adolescents[a] (n=4)

Reference	Population, design, time of collection, country	Age range	n	Diet collection method	Intake or frequency of consumption	Exposure variables (number of categories)	Association	Adjustments
Drouillet-Pinard (2017)[56]	INCA2 study, cross-sectional, 2006-2007, France	11-17	881	Record (7 days)	Intake (g/day)	• Parental occup. (4) • Parental educ. (3) • Household income (tertiles) • Household wealth index (tertiles) • Global SES index (all SES indicators combined, tertiles)	• NS • Higher when educ. lower • NS • Higher when wealth lower • Higher when SES lower	Age, gender, and energy intake
Grosso (2013) (a)[50]	Secondary schools of Sicily, cross-sectional, 2010-11, Italy	13-16	1,135	FFQ	Intake (g/day)	• SES index (parental educ. and occup., 3)	• Higher when SES lower	Age, gender, BMI, physical activity, place of living, and SES
Harris (2015)[57]	GINIplus study, cohort at follow-up age 10 and 15, 2005-08 and 2010-13, Germany	10-15	1,232	FFQ	Change vs. tracking intake over time (% of energy intake)	• Parental educ. (2) • Family income (tertiles)	• NS • NS	Age at baseline, baseline energy intake, diet changes, study center, study intervention arm, pubertal onset, BMI, screen-time, and all SES variables
Llull (2015)[58]	Balearic Islands, cross-sectional, 2007-08, Spain	12-17	1,231	FFQ	Daily consumption	• Birthplace (4) • Birthplace (2) • Length of time living in Balearic Islands (4)	• Higher for Latin America and other countries than Balearic Islands • Higher for non-Mediterranean • Higher when length of time lower	Gender and age

Occup.: occupation; NS: non-statistically significant; educ.: education; SES: socioeconomic status; FFQ: food-frequency questionnaire. [a]: details on risk of bias assessment are not presented since only studies of good quality are tabulated.

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Table 7. Salty and sweet energy-dense food consumption according to socioeconomic or cultural characteristics of adolescents[a] (n=5)

Reference	Population, design, time of collection, country	Age range	n	Diet collection method	Intake or frequency of consumption	Exposure variables (number of categories)	Association	Adjustments
Drouillet-Pinard (2017)[56]	INCA2 study, cross-sectional, 2006-2007, France	11-17	881	Record (7 days)	Stewed fruit/fruit in syrup, dairy desserts, cakes and pastries, confectionery, and pizza and sandwiches intake (g/day)	• Parental occup. (4) • Parental educ. (3) • Household income (tertiles) • Household wealth index (tertiles) • Global SES index (all SES indicators combined, tertiles)	• Dairy desserts higher and cakes and pastries lower when occup. lower • Dairy desserts higher when educ. lower • NS • NS • Cakes and pastries lower when SES lower	Age, gender, and energy intake
Finger (2015)[49]	KIGGS study, cross-sectional, 2003-2006, Germany	11-17	6,359	FFQ	High or low energy-dense food intake (ratio of g/day intake divided by age- and sex- recommended amount)	• Parental educ. (3) • Parental occup. (3) • Household income (tertiles)	• Higher when educ. lower • Higher when occup. lower • Higher when income lower (boys)	Age, region, media use, total energy expenditure, familial leisure activity, BMI-for-age, perceived weight status, and all SES variables
Grosso (2013) (a)[50]	Secondary schools of Sicily, cross-sectional, 2010-11, Italy	13-16	1,135	FFQ	Fast food, snacks, and sweets intake (g/day)	• SES index (parental educ. and occup., 3)	• NS	Age, gender, BMI, physical activity, place of living, and SES
Harris. (2015)[57]	GINIplus study, cohort at follow-up age 10 and 15, 2005-08 and 2010-13, Germany	10-15	1,232	FFQ	Sugar-sweetened food intake: change vs. tracking over time (% of energy intake)	• Parental educ. (2) • Family income (tertiles)	• NS • NS	Age at baseline, baseline energy intake, diet changes, study center, study intervention arm, pubertal onset, BMI, screen-time, and all SES variables
Llull. (2015)[58]	Balearic Islands, cross-sectional, 2007-08, Spain	12-17	1,231	FFQ	Sweets and pastries daily consumption	• Birthplace (4) • Birthplace (2) • Length of time living in Balearic Islands (4)	• Sweets higher for Latin America than Balearic Islands • Sweets higher for non-Mediterranean • Higher when length of time lower	Gender and age

Occup.: occupation; educ.: education; NS: non-statistically significant; SES: socioeconomic status; FFQ: food-frequency questionnaire. [a]: details on risk of bias assessment are not presented since only studies of good quality are tabulated.

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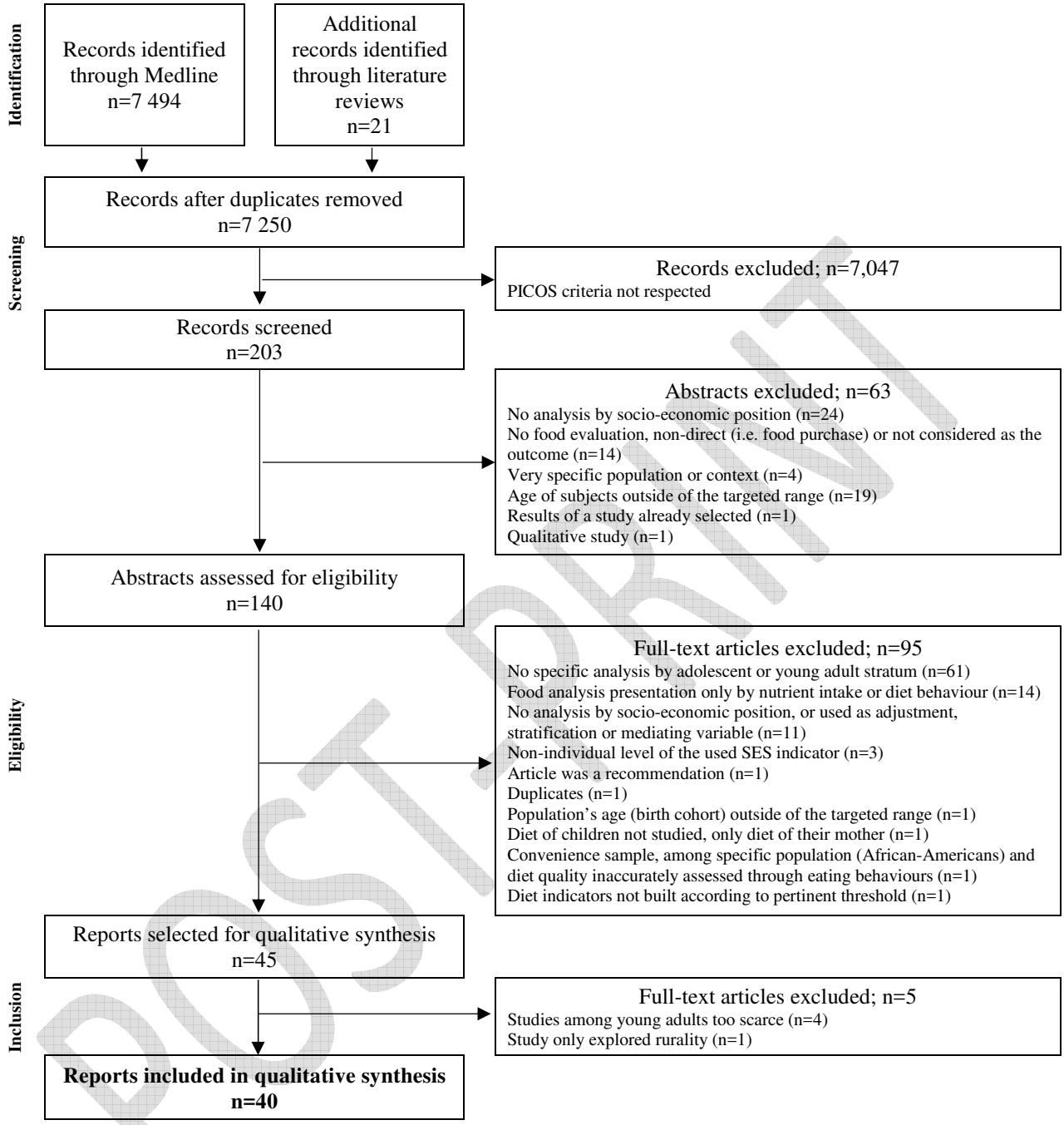

Figure 1. Flowchart showing selection of reports included in the systematic review using PRISMA guidelines (PRISMA, Preferred Reporting Items for Systematic Reviews and Meta-Analyses; PICOS, Population, Intervention, Comparison, Outcomes and Study design)

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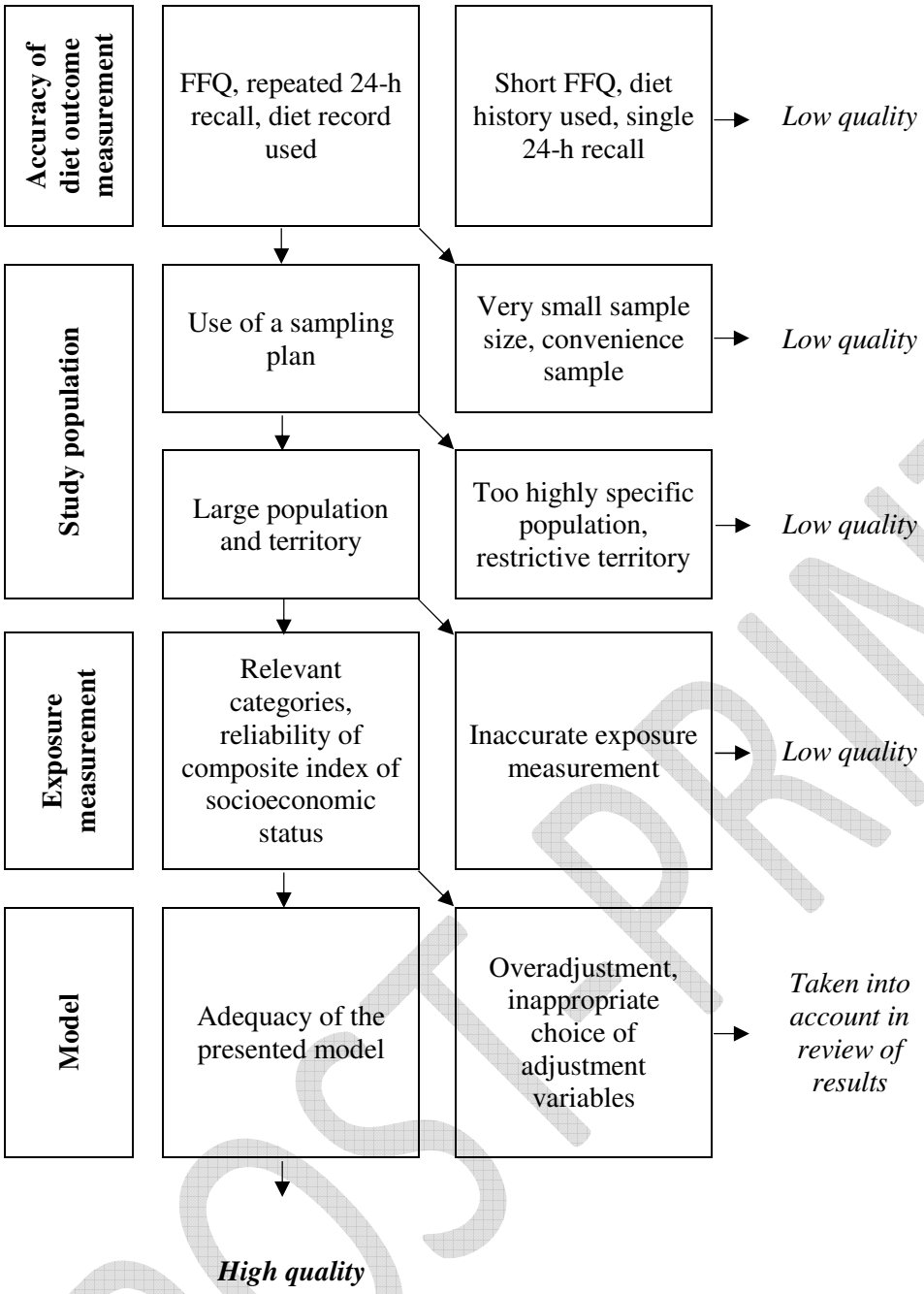

Figure 2. Criteria used to assess the methodological quality of studies included in the systematic review.

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