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Nutritional problems in childhood and adolescence: a narrative review of identified disparities

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Abstract

To inform programmes and policies that promote health equity, it is essential to monitor the distribution of nutritional problems among young individuals. Common nutritional problems include overall low diet quality, the underconsumption and overconsumption of certain dietary components, unhealthy meal and snack patterns, problematic feeding practices and disordered eating. The objective of the present narrative review was to summarise recent evidence of disparities among US children (2–19 years) according to age, sex, socio-economic status, ethnicity/race and rural–urban location. Searches in PubMed® and MEDLINE® were completed to identify peer-reviewed research studies published between January 2009 and January 2019. Findings from the ninety-nine reviewed studies indicate adolescent females, young individuals from lower socio-economic households and individuals who identify as non-Hispanic Black race are particularly vulnerable populations for whom targeted strategies should be developed to address evidence of increased risk with regards to multiple aspects of nutritional wellbeing. Limitations of the existing evidence relate to the accuracy of self-reported dietary data; the need for consistent definitions of disordered eating; the focus on individual dietary components *v.* patterns; the complexities of categorising socio-economic status, ethnicity/race, and rural and urban areas; and the cross-sectional, observational nature of most research designs. There is an urgent need for research to address these limitations and fill a large gap in evidence on rural–urban differences in nutritional problems. It will further be important for future studies to build greater understanding of how nutritional problems cluster among population groups.

Key words: **Dietary intake: Feeding practices: Disparity: Children: Adolescents**

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Introduction

The eating patterns of most Americans are not aligned with federal dietary recommendations for health promotion and the prevention of excess weight gain[1-3]. Poor dietary intake and related eating behaviours contribute to several common health problems among US paediatric populations, including obesity, dyslipidaemias, insulin resistance, high blood pressure, pulmonary disorders, dental caries and anaemia[4-10]. Approximately 18 % of young US individuals are at a weight categorised as obese, 19 % have unfavourable lipid levels, and 14 % have high blood pressure[11-13]. Young individuals who gain weight in excess of health recommendations are also more likely to experience weight-related teasing and struggle with psychosocial health problems and poor body image[14,15]. Poor body image puts young individuals at risk for engaging in disordered eating and such unhealthy attempts at weight control tend to promote greater weight gain over time[16-19]. In order to design effective and equitable solutions to these health problems it is important to identify disparities in their burden among the population and contributing nutritional disparities[20-25].

In the USA and internationally, there are several disparities in obesity and nutrition-related health conditions among paediatric populations[26-33]. The prevalence of obesity among young US individuals aged 2–19 years varies from approximately 10 % among Asian children to 24 % among Hispanic children, and is inversely related to the educational attainment of parents[33,34]. Similarly, the odds of elevated blood pressure are higher among adolescents who receive Medicaid health benefits or are uninsured in comparison with adolescents who receive private health insurance benefits[32]. Differences in dietary intake and eating behaviours across population subgroups are likely contributors to these disparities among children and adolescents[30,35]. The design of nutrition programmes and policies thus needs to be informed by the most current information on the distribution of nutritional problems, including overall low diet quality, markers of poor dietary intake, unhealthy meal and snack patterns, problematic feeding practices and disordered eating.

Although many national and local programmes are working to eliminate disparities in nutritional and weight-related health, to the best of the authors' knowledge, no recent reviews focusing on US children and adolescents have been published that comprehensively summarise disparities in dietary intake, eating behaviours and feeding practices. The objective of the present narrative review was to summarise current evidence of

Abbreviations: HEI-2010, Healthy Eating Index 2010; NSLP, National School Lunch Program; SES, socio-economic status; WIC, Special Supplemental Nutrition Program for Women, Infants and Children.

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disparities in these nutritional problems among young US individuals (2–19 years) according to age, sex, socio-economic status (SES), ethnicity/race and rural–urban location. Markers of poor dietary intake (overall low diet quality, underconsumed and overconsumed dietary components), unhealthy meal and snack patterns, and problematic feeding practices are examined across the life course from early childhood to adolescence; however, the literature on disordered eating is examined with a focus on adolescence in accordance with the prevalence of problems. The evidence base is further discussed in terms of scientific gaps and what future research is needed to better promote equity through programme and policy development.

Methods

The content of the evidence summary that is presented in this review is narrative in approach; however, the scientific literature was systematically searched in order to identify and retrieve relevant studies in a comprehensive manner. An electronic search of the PubMed® and MEDLINE® databases (https://www.nlm.nih.gov/bsd/pmresources.html) was completed to identify peer-reviewed research studies published between January 2009 and January 2019. Research published before January 2009 was not reviewed given the importance of understanding the current distribution of nutritional problems and because there have been many efforts over the past decade to strengthen food and nutrition policies. The following search terms were used in various combinations: toddlers, preschoolers, children, adolescents, disparity, nutrition, dietary intake, fast food, breakfast, meal skipping, family meals, feeding practices, binge eating, disordered eating, and unhealthy weight-control behaviour. Search results, including article titles and abstracts, were examined by the author and the full text of all potentially relevant articles was retrieved for detailed evaluation. Reference citations within identified articles were also examined to ensure that all relevant evidence was retrieved.

Articles had to be published in English, conducted in the USA among a paediatric sample (2–19 years), and address at least one aspect of dietary intake, meal/snack patterns, feeding practices or disordered eating in order to be included in the present review. Studies were included regardless of whether all children (2–19 years) were analysed together or separately according to various age groupings (for example, toddlers and preschool-age children: 2–5 years; middle childhood: 6–11 years; adolescence: 12–19 years). Studies reporting only on breast-feeding, the nutritional wellbeing of infants or outcomes of poor dietary intake (for example, Fe-deficiency anaemia, dental caries) were excluded from the present review.

Three categories of dietary intake markers were defined: overall dietary quality, underconsumed dietary components and overconsumed dietary components. Markers of overall dietary quality were defined to include dietary pattern indexes and scores such as the Healthy Eating Index (HEI)[36,37]. Underconsumed dietary components were defined with reference to the current Dietary Guidelines for Americans and the recommended shifts in intake that this document describes are needed to align with healthy eating patterns[38]. Similarly, overconsumed dietary components were defined with reference to the Dietary Guidelines for Americans and the guidance it outlines for limiting juice intake to half the recommended amount for fruits and for limiting intake of added sugars, saturated fat and Na[38,39].

Results

The literature search of original research addressing various aspects of nutritional wellbeing identified a total of ninety-nine studies, including five studies of overall diet quality[40-44], forty-five studies that examined underconsumed dietary components[1,2,41,45-86], fifty-three studies that examined overconsumed dietary components[1,47,49-53,56-69,71,72,75,77,79,82-84,86-109], twenty-six studies that examined unhealthy meal and snack patterns[47,49,54,77,82,91-94,97,110-125], nine studies that examined problematic feeding practices[52,65,97,118,126-130] and seven studies of disordered eating behaviours[49,131-136]. In addition, recent literature reviews regarding feeding practices[137] and binge eating behaviours[138] were identified and used in summarising the results. The detailed summary of identified studies that follows is organised according to aspect of nutritional wellbeing. Tables with details of the included studies are organised such that nationally representative studies relating to dietary intake and eating patterns are included in Table 1, studies relating to feeding practices are included in Table 2, and studies relating to disordered eating are included in Table 3. Given the large number of studies that relate to dietary intake and eating patterns, only the details of nationally representative studies could be given in Table 1; however, all identified studies are represented in the summary of findings below.

Overall low diet quality

Disparities in overall dietary patterns and quality have been described according to age[40,42-44], sex[40,43], ethnicity/race[40,41,43,44] and markers of SES[40,41,43]. One example of these studies calculated the Healthy Eating Index 2010 (HEI-2010) score for all child and adolescent participants who completed dietary recalls as part of the National Health and Nutrition Examination Survey over the years 1999 to 2012[40]. The nationally representative results showed that there was population-level improvement over time in diet quality, but that overall diet quality remained poor (mean score: 50·9 of 100 points) in 2012 and improvements were not equal across population subgroups[40]. Results showed that older children and adolescents had consistently lower HEI-2010 scores than preschool-aged children, and non-Hispanic Black children and adolescents had consistently lower scores than those who identified with other ethnic/racial groups. There was also evidence that low-SES participants who were enrolled in the Supplemental Nutrition Assistance Program had lower scores than non-participants after the 2003–2004 assessment year[40].

Markers of poor diet: underconsumed dietary components

Disparities in children's intake of healthful dietary components have been identified and differences described according to age[2,45,46,60,61,63,68,69,73,75,76,78,80,86], sex[2,45-48,68,71,73,78,80,85,86],

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Table 1. Patterns in dietary intake, meal frequency and snacking behaviours of nationally representative US paediatric samples (2–19 years) according to age, sex, ethnic/racial minority composition, markers of socio-economic status and rural–urban location*

Reference	Setting and sample	Study design	Measures of dietary intake	Key findings regarding differences in eating patterns across population subgroups
Thomson *et al.* (2019)[44]	Nationally representative sample of 9000 children aged 2–18 years	Survey data for the years 2009–2014 included a household interview and an in-person dietary recall	HEI-2015 scores based on 24 h recalls conducted with a parent (2–5 years), parental assistance (6–11 years) or participant (12–18 years)	The youngest participants had higher HEI-2015 scores compared with participants aged 6–11 and 12–18 years Non-Hispanic Black participants had lower HEI-2015 scores than participants of Mexican American, other Hispanic and other racial backgrounds Non-Hispanic White participants had lower HEI-2015 scores than participants who identified as Mexican American
Wang *et al.* (2018)[98]	Nationally representative sample of 3345 children aged 0–4 years who were not being breastfed	Cross-sectional survey data collected in 2009–2014	A single, in-person 24 h recall with the primary caregiver	Child intake of SSB, added sugars and Na increased whereas intake of saturated fat decreased as age increased Sugary beverages (SSB and 100 % fruit juices) contributed a greater percentage of total energy among children of non-Hispanic Black ethnicity/race than among non-Hispanic White children Children from the highest household income group consumed less of their total energy intake from sugary beverages in comparison with children from the medium- and lowest-income households
Welker *et al.* (2018)[59]	Nationally representative sample of 600 children aged 2–4 years	Cross-sectional survey data collected in 2016	A single 24 h recall telephone survey with the primary caregiver	A higher percentage of non-Hispanic White 2- to 4-year-olds consumed cows' milk compared with non-Hispanic Black children. Among cows' milk consumers, a higher percentage of non-Hispanic White children consumed skimmed milk in comparison with non-Hispanic Black children A higher percentage of non-Hispanic Black 2- to 4-year-olds consumed cereal that was not whole grain rich in comparison with non-Hispanic White and Hispanic children. Non-Hispanic Black children were less likely to consume whole grain-rich breads, rolls, biscuits, bagels and tortillas More non-Hispanic Black 2- to 4-year-olds consumed SSB than did non-Hispanic White and Hispanic children. Among consumers of SSB, non-Hispanic Black children consumed more energy from any SSB and fruit-flavoured drinks than did non-Hispanic White and Hispanic children
Bailey *et al.* (2018)[60] and Jun *et al.* (2018)[62]	Nationally representative sample of 799 children, birth to 4 years	Cross-sectional survey data collected in 2016	Two 24 h recall telephone surveys with the primary caregiver	Among toddlers and preschoolers, excessive intakes of vitamin A and Zn were evident, often paired with low intakes of fibre, vitamin D and vitamin E Participants in the Special Supplemental Nutrition Program for WIC had better intakes of saturated fat (aged 24–47·9 months) and vitamin D (all ages) WIC preschoolers had lower compliance with Na and added sugar guidelines than higher-income non-participants. WIC toddlers had a higher risk of inadequate Ca and excessive Na than non-participants and were more likely than non-participants to exceed added sugar guidelines

Table 1. (*Continued*)

Reference	Setting and sample	Study design	Measures of dietary intake	Key findings regarding differences in eating patterns across population subgroups
Herrick *et al.* (2018)[68]	Nationally representative sample of children aged 2–19 years	NHANES survey data from 2013–2016	A single 24 h recall was used to assess intake of milk, soft drinks, 100 % juice, and other beverages	Water accounted for a smaller percentage of total beverage consumption among males compared with females; milk accounted for a larger percentage of total beverages among males compared with females The contributions of milk and 100 % to total beverage intake were found to decrease with age; intake of water, soft drinks, and other beverages were found to increase with age In comparison with children of other ethnic/racial backgrounds, children of non-Hispanic Black race were found to have lower intake of milk and higher intake of soft drinks as a percentage of total beverage consumption In comparison with children of other ethnic/racial backgrounds, non-Hispanic Black and Hispanic children were found to have higher intakes of 100 % juice as a percentage of total beverage consumption
Demmer *et al.* (2018)[69]	Nationally representative sample of 2445 children aged 0–5 years; sample included 1514 children aged 2–5 years	NHANES survey data from 2011–2014	A single 24 h recall was used to assess intake of 100 % juice, water, milk, diet beverages, SSB, and coffee and tea	Sugar-sweetened beverage consumption was found to increase with age whereas intake of milk and 100 % juice declined after 2–3 years of age. Children of non-Hispanic Black ethnicity/race consumed the most 100 % juice from 2–3 years of age and up, and across all groups, consumed the least milk and most SSB The percentage of children who consumed Ca amounts below the Estimated Average Requirement was found to increase with age
Demmer *et al.* (2018)[67]	Nationally representative sample of 2431 children aged 0–5 years; sample included 1511 children aged 2–5 years	NHANES survey data from 2011 to 2014	A single 24 h recall was used to assess intake of nutrients and MyPlate food groups. Primary caregivers reported for their children	Children of non-Hispanic Black ethnicity/race had lower intakes of dairy products and more protein foods, and accordingly were more likely to have inadequate intakes of Ca and vitamin D in comparison with their peers of non-Hispanic White and Hispanic ethnicity/race Children of non-Hispanic Black ethnicity/race were less likely to have inadequate intake of vitamin E when compared with children of non-Hispanic White and Hispanic ethnicity/race Children of Hispanic ethnicity/race consumed significantly less added sugars than their peers of non-Hispanic White and Black ethnicity/race at ages 4–5 years The percentage of children with intakes below recommendations was higher among those aged 4–5 years *v.* 2–3 years
Vercammen *et al.* (2018)[66]	Nationally representative sample of 1576 children, 2–4 years	NHANES survey data from 2009 to 2014	A single 24 h recall was used to assess intake of 100 % fruit juice, whole fruits and vegetables. Primary caregivers reported for their children	In comparison with income-eligible non-participants, participants in WIC had higher intakes of 100 % fruit juice but no higher intake of whole fruit or total vegetables WIC participants were more likely than non-participants to exceed the age-specific recommended maximum intake for juice

Table 1. (*Continued*)

Reference	Setting and sample	Study design	Measures of dietary intake	Key findings regarding differences in eating patterns across population subgroups
Dunford & Popkin (2018)[93]	Nationally representative sample of 50 072 children, 2–18 years	Repeated cross-sectional survey data collected from 1977 to 2014	A single 24 h recall was used to assess intake of energy and snacks	Adolescents had the highest intake of SSB from snacks compared with other age groups Non-Hispanic Black children had the largest secular increase in energy deriving from foods as a snack and the highest energy intake from SSB in 2011–2014 The largest secular increase in salty snack intake occurred in Hispanic children with more than a fourfold increase over time The largest secular increases in intake from snacks were observed among children in the lowest poverty level and the lowest household educational attainment groups
Kann *et al.* (2018)[86]	Nationwide, public (state) and private school-based sample of adolescents in grades 9–12	Cross-sectional survey data collected as part of the Youth Risk Behavior Surveillance System, 2017	Past 7 d intake of fruit, vegetables, milk, sugar-sweetened soda, sports drinks, water and breakfast	Examples of observed disparities: The prevalence of having eaten vegetables 3+ times/d was higher among males than females and higher among students who identified as Black than those of White race The prevalence of not having drunk SSB was higher among female than male students and higher among Hispanic than Black students
Dunford *et al.* (2017)[87]	Nationally representative sample of 50 072 children, 2–18 years	Repeated cross-sectional survey data collected from 1977 to 2014	A single 24 h recall was used to assess intake of snacks and Na	The groups to experience the largest secular increase in Na from snacks over time were those with the lowest household educational attainment, of non-Hispanic Black ethnicity/race, and with the lowest household incomes
Quader *et al.* (2017)[101]	Nationally representative sample of 3020 children aged 2–19 years and 5047 adults	NHANES survey data from 2013 to 2014	A single 24 h recall was used to assess intake of Na	Among children, mean Na density was lowest among those aged 2–5 years (1534 mg/1000 kcal (4184 kJ)) Children aged 6–11 years (1574 mg/1000 kcal (4184 kJ)) and 12–19 years (1706 mg/1000 kcal (4184 kJ)) had higher Na densities as well as absolute intakes
Rosinger *et al.* (2017)[88]	Nationally representative sample of children aged 2–19 years	Survey data for the years 2011–2014 included a household interview and dietary recall	Intake of SSB was estimated using 24 h recall data	A higher percentage of males than females consumed at least one SSB on a given day and males consumed more energy from SSB across all age groups, with the exception of those aged 2–5 years Mean energy from SSB and the percentage of total energy consumed from SSB on a given day increased with age Among females, non-Hispanic Black children compared with children of other ethnic/racial backgrounds consumed the highest percentage of total energy from SSB
Gu & Tucker (2017)[40]	Nationally representative sample of 38 487 children aged 2–18 years	Survey data for the years 1999–2012 included a household interview and at least one dietary recall	HEI-2010 scores based on 24 h recalls conducted with a parent (2–5 years), parental assistance (6–11 years) or in-person (12–18 years)	Young participants had higher HEI-2010 scores compared with those of older participants at each assessment Mexican American participants had the highest HEI-2010 scores and non-Hispanic Black participants had the lowest scores Higher-income children did not have consistently higher HEI-2010 scores over time, but children in the highest income category experienced greater improvement over time

Table 1. (*Continued*)

Reference	Setting and sample	Study design	Measures of dietary intake	Key findings regarding differences in eating patterns across population subgroups
Deming *et al.* (2017)[119]	Nationally representative sample of 2891 young children (6–47 months) and their parent/ caregiver; included children aged 24–35 months (*n* 736) and 36–47 months (*n* 725)	Telephone interviews and dietary recalls were collected as part of the Feeding Infants and Toddlers Study 2008	The 24 h dietary recall was used to estimate child percentage of energy coming from meals and snacks, number of snacks per d, nutrient intake from snacks, and the most commonly consumed snacks	About 95 % of children aged 24–35 and 36–47 months consumed at least one snack on a given day and snacks provided an average of 25 % of total energy intake for both age groups Snacks provided nearly 20 % of daily Fe and nearly 25 % of daily Ca and fibre intakes among children in both age groups Salty snack intake increased with age; on a given day 14·5 % of 24- to 35-month-olds and 18 % of 36- to 47-month-olds had a salty snack
Kann *et al.* (2016)[47]	Nationwide, public (state) and private school-based sample of adolescents in grades 9–12	Cross-sectional survey data collected as part of the Youth Risk Behavior Surveillance System, 2015	Past 7 d intake of fruit, vegetables, milk, sugar-sweetened soda, sports drinks, water and breakfast	Examples of observed disparities: The prevalence of having eaten vegetables 3+ times/d was higher among male than female students, higher among Hispanic than White students, and higher among 12th grade than 10th grade students The prevalence of not having drunk SSB was higher among female than male students, higher among White than Black and Hispanic students, and higher among 12th-grade than 10th-grade students
Haughton *et al.* (2016)[50]	Nationally representative sample of 967 children aged 6–11 years and 987 adolescents aged 12–19 years	NHANES survey data from 2011–2012	Dietary recalls completed by a parent (for those <16 years) or an adolescent (16–19 years) were used to assess intake of fruit, vegetables and SSB	Among children, just 3 % met the recommendation for fruits and vegetables and 9 % met the recommendation for SSB Among adolescents, just 4 % met the recommendation for fruits and vegetables and 17 % met the recommendation for SSB Asian young individuals were most likely to meet the fruit and vegetable target when comparisons were made among those 6–11 years and most likely to meet the SSB target among those 12–19 years After accounting for age, sex, BMI, parental marital status and income differences between ethnic/racial groups, it was found that Asian young individuals (6–19 years) were more likely to meet the SSB target than non-Hispanic Whites
Rehm & Drewnowski (2016)[120]	Nationally representative sample of 12 378 children aged 4–18 years	NHANES survey data from 2003–2010 included two dietary recalls	Data from a single 24 h recall were used to determine energy intakes from fast food restaurants and intakes of solid fats, added sugars and Na with a fast food restaurant source	Fast food restaurants contributed more energy to the diets of adolescents (12–19 years; 13·5 %) as compared with younger children (4–11 years; 9·4 %) in the year 2010 Similar patterns of differences across age were observed but not tested for solid fats, added sugars and Na
Powell *et al.* (2016)[100]	Nationally representative samples of children aged 2–18 years and adults aged 19+ years	NHANES survey data from 1977 to 2012	Data from a single 24 h recall were used to determine intake of added sugar	The likelihood of being in the highest quintile of energy consumed from added sugars was lower for females than for males The likelihood of being in the highest quintile of energy consumed from added sugars was lower among children of non-Hispanic Black ethnicity/race and those who identified as Mexican American compared with non-Hispanic White children

Table 1. (*Continued*)

Reference	Setting and sample	Study design	Measures of dietary intake	Key findings regarding differences in eating patterns across population subgroups
Wang *et al.* (2016)[121]	Nationally representative sample of 3647 children aged 4–13 years	NHANES survey data from 2009 to 2012	Snacking behaviours and intake of foods and beverages as part of self-defined snacking occasions were based on 2 d of 24 h recall data obtained from the child and/or a caregiver proxy	Foods and beverages consumed at snacking occasions provided 25 % of daily energy intake for children aged 4–8 years and children 9–13 years. No differences by sex In both age groups, the afternoon and evening snacks contributed substantially to total energy intake For morning snacks, the density of added sugar was higher and the densities of protein and vitamin D were lower among children aged 9–13 years *v.* 4–8 years Compared with children aged 4–8 years, children aged 9–13 years were less likely to consume foods from the milk and dairy category in all snacking periods
Storey & Anderson (2016)[71]	Nationally representative sample of 3020 children aged 1–3 years	NHANES survey data from 2009 to 2012	A single 24 h recall was used to assess intake of total vegetables, white potatoes, and nutrients	There were few significant differences by sex in nutrient intake; however, boys consumed more total energy and vitamin E than did girls There were no significant ethnic/racial group differences in intake of protein, dietary fibre, K or vitamin A. Fat intake was lower among non-Hispanic Black children than among Mexican American children Ca intake was adequate among non-Hispanic Black children but lower than among children in other ethnic/racial groups Average Na intakes of all children were higher than the Adequate Intake, but non-Hispanic Black children had the highest intake across ethnic/racial groups The only observed difference in vegetable intake across ethnic/racial groups was the finding that non-Hispanic Black children had higher intake of white potatoes
Banfield *et al.* (2016)[42]	Nationally representative sample of 8390 children aged 4–18 years	NHANES survey data from 2005 to 2010 included two dietary recalls	Dietary recall data were used to determine HEI- 2010 scores and adherence to the Dietary Guidelines for Americans	Young children (4–8 years) had the highest overall diet quality scores; the aspects of diet that contributed to higher scores were total fruit, whole fruit, dairy products and whole grains Young children also had the highest scores for Na, refined grains and 'empty calories' Fatty acid and total vegetable scores were highest for children aged 14–18 years
Papanikolaou *et al.* (2015)[55]	Nationally representative sample of 2855 children aged 4–18 years	NHANES survey data from 2007 to 2010 included two dietary recalls	Dietary recall data were used to determine mean intakes of Ca, Mg, and vitamins A, C and D	Mean usual intake of Ca, P, Mg, vitamin A and vitamin D were significantly lower among non-Hispanic Black children than non-Hispanic Whites A greater percentage of non-Hispanic Black children relative to non-Hispanic Whites had intakes below the Estimated Average Requirement for Ca, Mg, vitamin A and vitamin D
Wang *et al.* (2015)[53]	Nationally representative sample of 6453 students grades 1–12	NHANES survey data from 2003–2008	Dietary recalls were used to determine intake of energy, vegetables, SSB and added sugar	Lower-income children did not have 'less healthy' dietary patterns than higher-income students during summer breaks Being male and being older were associated with higher consumption of energy, SSB and added sugar Lower-income elementary school students consumed more total vegetables than higher-income students but there was no difference by income in consumption of vegetables other than potatoes

Table 1. (*Continued*)

Reference	Setting and sample	Study design	Measures of dietary intake	Key findings regarding differences in eating patterns across population subgroups
Watowicz *et al.* (2015)[75]	Nationally representative sample of 9169 children aged 2–18 years	NHANES survey data from 2005–2010 included at least one dietary recall	Day 1 dietary recalls were used to determine intake of water, milk, 100 % fruit and vegetable juice, coffee and tea, fruit drinks and ades, sugar-sweetened soda and reduced-energy diet drinks	Young children (2–5 years) were nearly 2-fold more likely to drink milk and 100 % fruit juice in comparison with adolescents (12–18 years) Mean energy from milk among consumers was similar across age categories; in contrast, for 100 % fruit juice the consumer-only mean average intake was highest among adolescents aged 12–18 years The proportion of children consuming sugar-sweetened soda and the proportion consuming coffee and tea were greater in each ascending age group Mean energy from sugar-sweetened soda and from coffee and tea among consumers was significantly higher among adolescents as compared with children aged 2–5 years
Herrick *et al.* (2015)[76]	Nationally representative sample of 3129 children aged 2–19 years	Cross-sectional survey data were collected as part of the 2011–2012 NHANES	Dietary recalls were used to determine intake of whole fruit, 100 % fruit juices, mixed fruit dishes and total fruit servings	Children aged 2–5 years consumed significantly more fruit as 100 % juice and significantly less fruit as whole fruit in comparison with children aged 6–11 years. Intake of fruit from mixed fruit dishes was found to increase with age Children of non-Hispanic Black ethnicity/race consumed more fruit as 100 % juice and less fruit as whole fruit in comparison with children of non-Hispanic White, Asian and Hispanic ethnicity/race
Vikraman *et al.* (2015)[123]	Nationally representative sample of children aged 2–19 years	Cross-sectional NHANES survey and dietary recall (one per participant) data from the years 1999–2000 and 2009–2010	Dietary recalls were used to determine intake of energy from fast food restaurants	Adolescents reported higher energy intake from fast food restaurants in comparison with children aged 2–11 years Reported energy intake from fast food restaurants was lower for children who identified as non-Hispanic Asian when compared with the intake of children with non-Hispanic White and non-Hispanic Black ethnic/racial identities Energy intake from fast food restaurants was not found to differ by sex or poverty status
Bleich & Wolfson (2015)[96]	National sample of 14 092 children aged 2–19 years	Cross-sectional survey data were collected as part of the 2003–2010 NHANES	Energy from SSB and sweet and salty snacks were based on 24 h dietary recalls data	Trends over time showed declines in energy intake from SSB and snacks but different patterns were observed among groups defined by ethnicity/race and weight status For example, among children 2–5 years, significant declines in the amount of energy from SSB were observed only among White and Hispanic children at a healthy weight and Hispanic children who were overweight Similarly, declines in energy from sweet snacks were observed only among 2- to 5-year-old White children at a healthy weight
Keim & Branum (2015)[74]	National sample of 2496 children aged 12–60 months	NHANES survey data from 2003–2008 included at least one dietary recall	Day 1 dietary recalls reported by a parent/caregiver were used to determine intake of PUFA and fish	In comparison with children of Mexican American heritage, children of non-Hispanic White ethnicity/race had lower intakes of DHA and arachidonic acid Children of non-Hispanic Black ethnicity/race were more likely than non-Hispanic White children to have consumed fish No age differences in fish or DHA intake were observed; the oldest children had higher EPA and arachidonic acid intakes

Table 1. (*Continued*)

Reference	Setting and sample	Study design	Measures of dietary intake	Key findings regarding differences in eating patterns across population subgroups
Masters *et al.* (2014)[113]	National sample of young individuals aged 6–19 years	Cross-sectional data collected as part of the 2007–2010 NHANES	Meal preparation and eating patterns of families were reported by one adult per household	High-income homes had significantly lower mean levels of the number of times someone cooked dinner at home compared with low- and middle-income homes High-income homes had significantly higher mean levels of money spent on eating out per 30 d than low-income families Across income groups, the mean number of times someone cooked dinner at home and the number of meals eaten together cooked at home over a 7 d period were significantly lower for Black homes compared with Hispanics and Whites Middle- and high-income Black homes spent significantly less money on eating out per 30 d compared with middle- and high-income White and Hispanic homes
Storey & Anderson (2014)[80]	Nationally representative sample of children aged 2–19 years	Cross-sectional NHANES survey and dietary recall (one per participant) data from 2009–2010	Dietary recalls were used to determine intake of dietary fibre	Hispanic males consumed more dietary fibre than non-Hispanic Black males; however, there was no difference in mean dietary fibre intake among female children and adolescents Female children at 131 to 185 % of the poverty threshold had significantly lower intakes of dietary fibre than did female children at more than 185 % of the poverty threshold; however, there were no similar differences observed among male children
Kim *et al.* (2014)[78]	Nationally representative sample of 12 459 children aged 2–18 years	Cross-sectional NHANES survey and dietary recall (one per participant) data from years 2003–2010	Dietary recalls were used to determine cup-equivalent servings of fruit and cup-equivalent servings of vegetables per 1000 kcal (4184 kJ)	Children aged 2–5 years consumed significantly more fruit in CEPC than older children Females consumed more total vegetables in CEPC than males Children aged 12–18 years consumed more vegetables in CEPC than younger children Mexican American children consumed more vegetables in CEPC than non-Hispanic Black children
Watowicz & Taylor (2014)[79]	Nationally representative sample of 1963 children aged 2–4 years	Cross-sectional NHANES survey and dietary recall (one per participant was reported by parent/caregiver) data from years 2005–2010	Dietary recalls were used to determine intake of water, milk, 100 % juice, fruit drinks and ades, soda and low-energy/diet drinks	A higher percentage of WIC participants consumed milk than did low-income non-participants and WIC participants had the highest percentage of 100 % juice consumers Higher-income non-participants were less likely than WIC participants and lower-income non-participants to consume fruit drinks and soda Participants in WIC consumed significantly more 100 % juice, fruit drinks and soda as a proportion of total energy intake

Table 1. (*Continued*)

Reference	Setting and sample	Study design	Measures of dietary intake	Key findings regarding differences in eating patterns across population subgroups
Moore *et al.* (2014)[46]	Nationally representative sample of 6226 children (1–18 years)	Cross-sectional data collected as part of the 2007–2010 NHANES	Dietary recalls in combination with dietary supplement use questionnaires were used to determine intakes of vitamin D	High-income homes had significantly lower mean levels of the number of times someone cooked dinner at home compared with low- and middle-income homes High-income homes had significantly higher mean levels of money spent on eating out per 30 d than low-income families Across income groups, the mean number of times someone cooked dinner at home and the number of meals eaten together cooked at home over a 7 d period were significantly lower for Black homes compared with Hispanics and Whites Middle- and high-income Black homes spent significantly less money on eating out per 30 d compared with middle- and high-income White and Hispanic homes
Kenney *et al.* (2014)[57]	Nationally representative sample of 8363 adolescents in grades 6–10	Data were collected as part of the 2005–2006 US Health Behavior in School-Aged Children survey	Days per week of high-energy snack food consumption, SSB, fruit and vegetables and milk products	As compared with young individuals living in metropolitan areas and those who identified their ethnicity/race as Hispanic or non-Hispanic White, non-metropolitan young individuals who identified as non-Hispanic Black had the highest rate of consuming high-energy snack foods on 2+ d/week
Mendez *et al.* (2014)[90]	Nationally representative sample of 12 909 children aged 2–18 years	NHANES survey data from 2003–2004, 2005–2006, 2007–2008 and 2009–2010	The 24 h recall data were used to determine usual intakes of energy; intakes at the median and extremes of the distribution were examined	After an initial decline in energy intake across all age groups to 2007–2008 (159–240 kcal/d (665–1004 kJ/d) at the median), there were significant increases of approximately 90 kcal/d (377 kJ/d) at the median among adolescents in 2009–2010. Intakes in younger children remained steady Among adolescent males, the increase in 2009–2010 led to intakes exceeding those in 2007–2008 and was larger at the 90th percentile than at the median. For females, intakes returned to 2005–2006 levels Intake trends did not vary by parental education or ethnic/racial group; across ethnic/racial groups, intakes were similar at the upper end of the distribution
Carriquiry *et al.* (2013)[102]	Nationally representative sample of 34 916 individuals aged $\geq$1 year	NHANES survey data from 2003 to 2010, including up to two dietary recalls	Dietary recalls were used to determine Na intake, Na density and prevalence of excess Na intake	Small declines in the prevalence of excess Na intake occurred during 2003–2010 for children aged 1–13 years; no decline was observed among adolescents Na density did not change significantly over time except among young individuals aged 14–18 years, for whom Na density increased slightly

Table 1. (*Continued*)

Reference	Setting and sample	Study design	Measures of dietary intake	Key findings regarding differences in eating patterns across population subgroups
Hiza *et al.* (2013)[43]	Nationally representative sample of 3286 children aged 2–17 years	NHANES survey and dietary recall (one per participant) data from 2003–2004	Dietary recalls were used to assess overall diet quality based on the HEI-2005	Females had higher dietary quality scores than males; component scores of females were higher for total fruit, whole fruit and total vegetables Children aged 2–5 years had higher overall diet quality scores than those 6–11 or 12–17 years Children aged 2–5 years also had higher scores than older children for the component scores total fruit, whole fruit, milk, and energy from solid fats, alcoholic beverages and added sugars Hispanic children had higher dietary quality scores than children of non-Hispanic Black ethnicity/race, but comparable with the scores of White children Children in the highest income group had higher dietary quality scores than children in the second lowest income group
Drewnowski *et al.* (2013)[73]	Nationally representative sample of 4766 children aged 4–13 years	Cross-sectional NHANES survey data, including up to two dietary recalls per participant. Data from the years 2005–2006, 2007–2008 and 2009–2010 were analysed	Dietary recalls were used to determine intakes of water, plain and flavoured milk, 100 % fruit juice, soda/soft drinks, fruit drinks, sport drinks, coffee, tea and energy drinks	There was no group of US children that came close to satisfying the Dietary Recommended Intakes for total water intake Intake of plain water tended to be associated with higher income Older children (9–13 years) drank more plain water than young children (4–8 years), but there was no difference observed by sex Children of non-Hispanic White ethnicity/race drank more plain water than children of Mexican American and non-Hispanic Black ethnic/racial backgrounds Milk was the leading source of energy from beverages for all children; fruit juices were the second leading source for children aged 4–8 years and soda was the second leading source for children aged 9–13 years
Kant & Graubard (2013)[124]	Nationally representative sample of 39 822 children aged 2–19 years	NHANES survey and dietary recall (one per participant) data from the years 1971–1974 to 2003–2008	Dietary recalls were used to determine intake of energy from snack episodes, breakfast skipping, energy density of food choices, energy density of beverages, energy density of nutritive beverages (for example, milk, 100 % juice)	Higher education predicted lower energy density in all age groups Higher family poverty income ratio predicted a higher number of eating occasions among children aged 6–11 years Higher education predicted lower energy intake from snack occasions Breakfast frequency was associated with higher parental educational attainment and higher family poverty income ratio
Slining & Popkin (2013)[105]	Nationally representative sample of 17 268 children aged 2–18 years	Continuing Survey of Food Intakes by Individuals and NHANES survey and dietary recall data from the years 1994–1996 to 2009–2010	Dietary recalls were used to determine intake of solid fats and added sugars	Intake of solid fats and added sugars declined over this period; decreases began earlier among preschool-age children, females, Mexican American children, and low-income groups such that intake was lower in 2005–2006 than in 1994–2004. For other groups intake was significantly lower only in the periods 2007–2008 and 2009–2010

Table 1. (*Continued*)

Reference	Setting and sample	Study design	Measures of dietary intake	Key findings regarding differences in eating patterns across population subgroups
Han & Powell (2013)[106]	Nationally representative samples of 8627 children aged 2–11 years and 8922 adolescents aged 12–19 years	NHANES survey and dietary recall (one per participant) data for the years 1999–2000 to 2007–2008	Dietary recalls were used to determine intake of SSB	Over the period 1999–2008, heavy SSB consumption (≥500 kcal/d; ≥2090 kJ/d) was found to increase among children and decrease among adolescents Black children and adolescents were more likely to report heavy fruit drink consumption Low-income children were more likely to report heavy SSB consumption and had higher energy intake from total SSB and fruit drinks than high-income children Adolescents whose parents had less formal education were more likely to report heavy SSB consumption and had higher energy intake from total SSB and soda
Ervin & Ogden (2013)[104]	Nationally representative sample of children aged 2–19 years	Cross-sectional NHANES survey and dietary recall (one per participant) data from the years 1999–2000 and 2009–2010	Dietary recalls were used to determine intake of energy and macronutrients	Energy intakes decreased over the 12-year period for boys 2–5 and 6–11 years as well as for girls 12–19 years. Energy was not found to decline for boys 12–19 years or girls aged 2–5 or 6–11 years The percentage of energy from saturated fat was found to decrease over the same period for Mexican American boys and girls aged 2–19 years. No other trends in total or saturated fat were observed for other ethnic/racial groups
Wallace *et al.* (2013)[45]	Nationally representative sample of 8364 children aged 4–18 years	NHANES survey data from 2001–2002, 2003–2004, 2005–2006 and 2007–2008	Dietary recalls were used to determine intake of Ca and vitamin D from food, beverages and supplements taken in the past 30 d	Examples of observed disparities: Children aged 4–8 years were the most likely group to meet the 2010 Dietary Guidelines for Americans recommendation for consumption of low- or fat-free dairy products Males of all ages had higher usual intakes of dairy products *v.* females Children aged 9–13 and 14–18 years had the greatest prevalence of not meeting Estimated Average Requirements for Ca compared with other age groups Children aged 4–8 years had the highest intakes of vitamin D Children who identified as White had higher Ca and vitamin D intakes and were more likely to meet their Estimated Average Requirements targets as compared with Black or Mexican children Children with high household income had higher Ca and vitamin D intakes as compared with children in low- and middle-income households
Dodd *et al.* (2013)[51]	Sample of 2314 students in grades 1–12 at a nationally representative sample of 287 public (state) schools participating in the National School Lunch Program	Student dietary recalls and interviews with parents as part of 2004–2005 School Nutrition Dietary Assessment Study	Dietary recalls were used to determine intake of beverages, including soda, other SSB, 100 % fruit juice, flavoured milk, unflavoured milk, diet drinks and water.	Examples of observed disparities: Across all school levels, non-Hispanic White students were significantly more likely to consume unflavoured, low-fat milk (1 % or skimmed) at home than both non-Hispanic Black and Hispanic students A higher percentage of non-Hispanic Black elementary students consumed SSB other than soda at home compared with non-Hispanic White and Hispanic students

Table 1. (*Continued*)

Reference	Setting and sample	Study design	Measures of dietary intake	Key findings regarding differences in eating patterns across population subgroups
Saavedra *et al.* (2013)[63] and Fox *et al.* (2010)[64]	Nationally representative sample of 3273 young children (0–47 months) and their parent/ caregiver	Telephone interviews and dietary recalls were collected as part of the Feeding Infants and Toddlers Study 2008	The 24 h dietary recall was used to estimate child intake of energy, macronutrients, fruit, vegetables, milk, sweets and SSB	Sweets (desserts, cookies, candy) were consumed by 68 % of 2-year-olds and 74 % of 3-year-olds on a given day SSB intake was also slightly less prevalent among 2-year-olds (44 %) than among 3-year-olds (48 %) on a given day Fruit and vegetable intakes were similarly low among children aged 2–3 years Most children aged 2–3 years consumed whole or reduced-fat milk and very few consumed fat-free or low-fat milk. The proportion of children consuming whole milk was lower among 3-year-olds (27 %) than among 2-year-olds (34 %)
Fulgoni & Quann (2012)[107]	Nationally representative sample of 3998 children from birth to 5 years	NHANES survey and dietary recall (one recall per participant) data for the years 1976–1980, 1988–1994 and 2001–2006	The first 24 h recall was used to estimate consumption of milk, 100 % fruit juice, fruit drinks, soft drinks, tea and soya beverages	A higher percentage of children consumed soft drinks with increasing age (29 % at 2 years, 38 % at 3 years, 41 % at 4 years, and 45 % at 5 years based on the 2001–2006 survey) Whole milk intake declined with increasing age. The 2001–2006 survey data indicate reduced-fat milk was consumed in almost equivalent amounts by age 5 years
Ervin *et al.* (2012)[108]	Nationally representative sample of children aged 2–19 years	NHANES survey and dietary recall data for the years 2005–2008	The first 24 h recall was used to estimate consumption of added sugar	Males consumed a greater percentage of energy per d from added sugars than females Percentage of energy from added sugars increased linearly with age among males and females Non-Hispanic White children and adolescents consumed a larger percentage of energy from added sugars than Mexican American children and adolescents There was no observed difference in added sugar consumption by income
Powell *et al.* (2012)[125]	Nationally representative sample of children aged 2–11 years and adolescents aged 12–19 years	NHANES survey and dietary recall data for the years 2003–2008	The first 24 h recall was used to estimate frequency of eating foods from fast food restaurant sources and average energy intake from fast food	Adolescents were the most prevalent fast food consumers and had the highest daily energy intake from fast food Adolescent boys had higher daily energy intake from fast food compared with adolescent girls The likelihood of restaurant consumption did not differ between younger (2–5 years) and older children (6–11 years); however, among consumers, energy intake was higher among older children Black adolescents were more likely to consume fast food when compared with their White counterparts Among children 2–11 years, higher parental education (college *v.* less than a high school degree) and income was associated with a lower likelihood of fast food consumption
Liu *et al.* (2012)[58]	Nationally representative sample of 14 332 children aged 2–19 years (2771 rural, 13 766 urban)	NHANES survey data for the years 1999–2006	The first 24 h recall was used to estimate intake of SSB, dairy products, fruit, vegetables, whole grains and energy	Among children 2–11 years, those living in rural areas consumed 90 kcal/d (377 kJ/d) more on average and were more likely to consume the recommended 2–3 cups/d of dairy products Among adolescents 12–19 years, those living in rural areas were less likely to consume any fruit or meet the recommendation of 2 cups/d of fruit No other dietary differences were observed among young individuals in either age group

Table 1. (*Continued*)

Reference	Setting and sample	Study design	Measures of dietary intake	Key findings regarding differences in eating patterns across population subgroups
Kirkpatrick *et al.* (2012)[1]	Nationally representative sample of 7212 children aged 2–18 years	NHANES survey data for the years 2001–2004 included a household interview and dietary recall	The 24 h recall data were used to estimate dietary intake of food groups, whole grains, oils, solid fats and added sugars	Examples of observed disparities: In comparison with the highest-income group, fewer middle-income children met the minimum recommendations for whole fruit and whole grains and smaller proportions of children in the lowest income group met the minimum recommendation for milk Fewer non-Hispanic Black children met the minimum recommendations for whole fruit and milk compared with non-Hispanic White children; more Mexican American children met minimum recommendations for fruit compared with non-Hispanic White and Black children
Davis *et al.* (2011)[56]	National sample of 7882 young individuals aged 2–18 years	Data from the 2003–2004 and 2005–2006 NHANES were used to assess for differences by rurality	Dietary recalls were used to estimate mean daily intake of fruits/vegetables, SSB, dairy products, fried foods, meat, added fats and sweets	There were no urban–rural differences in mean intakes of any of the dietary intake categories Children who were at an obese weight status were more likely to drink more SSB in both rural and urban areas
Poti & Popkin (2011)[111]	Nationally representative sample of 29 217 children aged 2–18 years	Cross-sectional survey data collected in four waves over the period 1977 to 2006	2 d of dietary recall and food record data were used to estimate energy intake and define food source	The largest contributor to foods prepared way from home was fast food for all age groups Preschoolers ate the smallest (8 %) and adolescents ate the highest percentage (17 %) of energy from fast food
Piernas & Popkin (2011)[89]	Nationally representative sample of 31 337 children aged 2–18 years	USDA cross-sectional survey data collected in four waves over the period from 1977 to 2006	Dietary recall and food record data were used to estimate energy intake and portions of SSB, salty snacks, desserts, fried potatoes, burgers, pizzas and Mexican fast foods	Examples of observed disparities: Total energy intake increased over time for all age groups, but increased most over time for young children 2–6 years Results suggested adolescents are most susceptible to increased portion sizes and corresponding increases in energy intake at meals Adolescent boys consumed larger portion sizes of the selected foods and higher energy intakes at meals for all periods in comparison with girls
Kant & Graubard (2011)[91]	Nationally representative sample of 24 131 children aged 2–19 years	NHANES survey data from 1988–1994, 1999–2002 and 2003–2008	Dietary recall data were used to assess secular changes in reported energy, amount of foods and beverages, and eating occasions	The secular increase in mean number of eating occasions was significant in all age and ethnic/racial groups Among non-Hispanic Black and Mexican American 2- to 5 and 12- to 19-year-olds, the increase in number of eating occasions, and in non-Hispanic Black 12- to 19-year-olds, the percentage of energy from all beverages or non-nutritive beverages was greater relative to non-Hispanic White children In children aged 2–5 years, the decline in dietary fibre intake was greater in children who identified as non-Hispanic Black relative to other ethnic/racial groups

Table 1. (*Continued*)

Reference	Setting and sample	Study design	Measures of dietary intake	Key findings regarding differences in eating patterns across population subgroups
Kant & Graubard (2010)[85]	Nationally representative sample of 3978 children aged 2–19 years	NHANES survey and dietary recall data collected in 2005–2006	Dietary recalls were used to determine intake of total water, energy and fat, along with the energy density of food and overall meal patterns	More males than females reported intakes of at least the Adequate Intake of total water The percentage of beverage moisture contributed by nutritive beverages did not differ by sex and total water intake (g) in relation to dietary energy intake (kcal/kJ) was higher among females Beverage moisture was highest among non-Hispanic White and Mexican American children The percentage of total water intake from plain water increased with age Plain water intake was inversely associated with intake of beverage moisture and the energy density of food intake
Reedy & Krebs-Smith (2010)[109]	National samples of children and adolescents (2–18 years) in 2003–2004 (*n* 3553) and 2005–2006 (*n* 3778)	NHANES survey and dietary recall (one per participant) data for the years 2003–2004 and 2005–2006	Dietary recalls were used to determine dietary sources of energy, solid fats and added sugars	Non-Hispanic Black and White young individuals consumed more energy from SSB than from milk whereas Mexican American children consumed more energy from milk Non-Hispanic Black young individuals consumed more added sugars from fruit drinks and less from soda than other groups Younger children obtained a greater share of their solid fats from both whole and reduced-fat milk whereas adolescents got more from fried potatoes
Krebs-Smith *et al.* (2010)[2]	National sample of young individuals aged 2+ years	Cross-sectional analysis of data collected as part of the 2001–2004 NHANES	Meeting federal recommendations based on 24 h recalls for fruits, vegetables, milk, grains, meats, fats and added sugars	A large majority of the population did not meet the minimum recommendations for every one of the food groups except total grains and meats and beans. However, 2- to 3-year-olds had the lowest rates of inadequacy for nutrient-rich foods Rates of inadequacy tended to be highest among young individuals aged 14–18 years, and were particularly high for milk, total grains, and meats and beans among female adolescents
Piernas & Popkin (2010)[110]	National sample of 31 337 children and adolescents (2+ years)	Food intake surveys in 1977–1978, 1989–1991, 1994–1996 and 2003–2006	Snacking behaviours were defined based on 2 d of 24 h recall data obtained from the child or a caregiver	The percentage of children consuming at least one snack in 2003–2006 was greater than 97 % across each sociodemographic grouping; however, males, non-Hispanic Whites, children with high household incomes, and high household education were most likely to snack Children aged 2–6 years reported the highest number of snacks per d and the largest increase from 1977 to 2006 The largest increase over time in grams consumed per snack occurred among children aged 13–18 years

HEI-2015, Healthy Eating Index 2015; SSB, sugar-sweetened beverages; WIC, Women, Infants and Children; NHANES, National Health and Nutrition Examination Survey; HEI-2010, Healthy Eating Index 2010; CEPC, cup-equivalents per 1,000 calories; HEI-2005, Healthy Eating Index 2005; USDA, United States Department of Agriculture.

* The studies identified in this Table represent peer-reviewed publications that were published or made publicly accessible between January 2009 and January 2019.

Table 2. Patterns in parent feeding practices of relevance to US paediatric populations (2–19 years) according to age, sex, ethnic/racial minority composition, markers of socio-economic status and rural–urban location*

Reference	Setting and sample	Study design	Measures of feeding practices	Key findings regarding differences in feeding patterns across population subgroups
Berge *et al.* (2018)[126]	Parent–child dyads (*n* 150, children aged 5–7 years) were recruited through family physicians in the Minneapolis–St Paul metropolitan area of Minnesota	Ecological momentary assessment surveys were completed in 2015–2016	Restriction and pressure-to-eat feeding practices, foods pressured or restricted	Parents identifying as Hmong had the highest likelihood of engaging in pressure-to-eat feeding practices relative to Black, Hispanic, Native American and Somali parents Parents identifying as Black had the highest likelihood of pressuring children to eat meat protein foods; White, Hmong and Native American parents were also more likely to pressure their children to eat meat protein foods when compared with Somali parents There were no overall differences in restrictive feeding practices across ethnic/racial groups; however, Native American and Hmong parents were most likely to restrict meat proteins
Ruzicka *et al.* (2018)[127]	Parents of adolescents aged 12–17 years (*n* 54) were recruited at community events in Northeast Ohio	Survey measures were completed at two in-person study visits	Parent restriction and pressure-to-eat feeding practices were assessed using the Child Feeding Questionnaire	Adolescents living in low-income households were more likely to experience parental pressure to eat Household income was not related to parent use of restrictive feeding practices
Larson *et al.* (2015)[118]	School-based sample of 2374 adolescents and their parents that were recruited from twenty secondary schools in Minneapolis–St Paul, Minnesota	Cross-sectional, classroom surveys collected in 2009–2010 as part of the Project Eating and Activity in Teens study	Home availability of healthy and unhealthy food, parent encourages healthy eating, parent models healthy food choices, healthy foods served at meals, home meal planning and preparation	Most characteristics of the home food environment were found to vary by ethnicity/race; however, there was not a consistent pattern in terms of the overall home food environment being more or less supportive of healthy eating for any one group Scores for serving healthy foods at meals were highest for White, East African and Asian families and somewhat lower for African American, mixed/other race, Hispanic and Native American families Similarly, scores for healthy food modelling were highest for White and East African families and somewhat lower for Asian, African American, mixed/other race, Hispanic and Native American families
Ranjit *et al.* (2015)[52]	School-based sample of 8th-grade students (mean age 13·2 years; *n* 2502) within five districts serving mostly low-income youth in Austin, Texas	Cross-sectional, classroom surveys collected in 2009 as part of the Coordinated Approach to Child Health Middle School intervention	Home availability of healthy and unhealthy food at home, parent support for healthy eating, family meals, breakfast consumed at home	For each of the home food environment characteristics, non-Hispanic White children had significantly better environments than children of Hispanic and Black ethnic/racial backgrounds Non-Hispanic White children reported greater availability and accessibility of healthy foods at home, greater parental support for healthy eating, and higher frequency of consuming breakfast at home
Loth *et al.* (2013)[128]	Parents (*n* 3709) of a school-based sample of adolescents who were recruited from twenty public (state) middle and high schools in metropolitan Minneapolis–St Paul, Minnesota	Cross-sectional, mailed surveys collected in 2009–2010 as part of the Project Families and Eating and Activity among Teens study	Controlling food-related parenting practices (restriction, pressure-to-eat)	Use of controlling food-related parenting practices were particularly common among parents in ethnic/racial minority subgroups, parents with less than a high school education, and parents with a low household income Specifically, restriction scores and pressure-to-eat feeding scores based on parent report were highest among the Asian, Hispanic and African American subgroups

Table 2. (*Continued*)

Reference	Setting and sample	Study design	Measures of feeding practices	Key findings regarding differences in feeding patterns across population subgroups
Weatherspoon *et al.* (2013)[65]	Toddlers and mothers of African American (*n* 199) and Non-Hispanic White (*n* 200) ethnic/racial backgrounds who were enrolled in Early Head Start Programs in a mid-Western state	Cross-sectional, in-home surveys and observations	Mothers completed the Toddler and Parent Mealtime Behavior Questionnaire, which assessed television viewing during mealtime, supervision over meals, controlling practices, toddler involvement in mealtime, social interaction during mealtime, and mothers' mealtime distress	In comparison with reports of mothers identifying as non-Hispanic White more exertion of pressure over toddler meals was reported by mothers identifying as African American African American mothers were also more likely than non-Hispanic White mothers to allow television watching during mealtimes
Huang *et al.* (2012)[130]	Parents (*n* 158) of Chinese American and non-Hispanic White children (2–12 years) who attended community health centres in New York state, West Virginia and Maryland	Interviews with parents were completed in 2004–2005	Controlling food-related parenting practices (restriction, pressure-to-eat, monitoring)	Parents identifying as Chinese American reported higher levels of restriction for children of all ages and higher levels of monitoring for children aged 2–5 years
Ding *et al.* (2012)[129]	Adolescents (12–18 years), parents of adolescents and parents of children (5–11 years) in San Diego, CA, Boston, MA, and Cincinnati, OH (*n* 458)	Cross-sectional survey conducted in 2005	Home food availability of healthy and less healthy foods	Family income (range $60 000–69 000) was associated with availability of more healthful food in the home across all samples, but was not associated with availability of less-healthful food Families with adolescent girls reported fewer less-healthful food items available and a higher, more-healthful:less-healthful food ratio compared with families with adolescent boys
Taveras *et al.* (2010)[97]	A sample of 1212 mother–child pairs enrolled during the prenatal period and followed to child age of 2–4 years	Longitudinal analysis practices and reported by the mother	Maternal control over feeding (restriction and pressure to eat)	Children of Black and Hispanic ethnicity/race were more likely to experience maternal restrictive feeding practices

* The studies identified in this Table represent peer-reviewed publications that were published or made publicly accessible between January 2009 and January 2019.

Table 3. Patterns in disordered eating behaviours in US paediatric populations (2–19 years) according to age, sex, ethnic/racial minority composition, markers of socio-economic status and rural–urban location*

Reference	Setting and sample	Study design	Measures of disordered eating	Key findings regarding differences in disordered eating across population subgroups
Rodgers *et al.* (2017)[135]	Students at forty-seven middle schools in Massachusetts (*n* 16 978)	Cross-sectional 2005 survey of students was completed in school classrooms	Dieting and disordered eating (vomiting, laxatives, diet pills) in the past 30 d	Among girls who were overweight, there was no difference in the prevalence of dieting across ethnic/racial groups; however, girls who identified as an 'other' ethnicity/race were more likely to report disordered eating than their White counterparts. Similar patterns of elevated disordered eating were observed among non-Hispanic Black and Latina overweight girls, but differences were not statistically significant Among boys who were overweight, compared with their White counterparts, non-Hispanic Black and Latino boys were more likely to report dieting (but not at a statistically significant level). In addition, boys who were overweight and who identified as non-Hispanic Black and Latino were more likely to report disordered eating than their White counterparts; a similar but non-significant pattern was observed for Asian boys
Lee-Winn *et al.* (2016)[136]	Nationally representative sample of adolescents aged 13–18 years (*n* 9336)	National Comorbidity Survey-Adolescent Supplement, 2001–2004	Binge eating symptoms were assessed using a modified version of the WHO Composite International Diagnostic Interview	Females in comparison with males reported more indicators of loss of control; distress in relation to binge eating; guilt, depressive symptoms, and worry in relation to binge eating; and fear of weight gain while binge eating When compared with non-Hispanic White adolescents, there was a higher prevalence of lifetime recurrent overeating among non-Hispanic Black and Hispanic adolescents. Additional ethnic/racial differences were identified regarding feelings of guilt/upset/depressive symptoms after binge eating and fear of weight gain while binge eating
Gonsalves *et al.* (2014)[131]	Statewide sample of public (state) school children in middle and high school grades within the state of Massachusetts	Cross-sectional data from the 2009 and 2011 Youth Health Survey was combined	Disordered eating (fasting, vomiting, diet pills, laxatives) in the past 30 d	Among middle school and high school students, females were more likely than males to report disordered eating Among middle school students, Black, Hispanic and other ethnicity/race groups were more likely than White non-Hispanic students to report disordered eating
Arcan *et al.* (2014)[49]	Students at twenty public (state) secondary schools in Minneapolis–St Paul, Minnesota (*n* 1672)	Cross-sectional 2009–2010 survey of students was completed in school classrooms	Any past-year dieting or unhealthy weight-control behaviour (fasting, eating little food, diet pills, vomiting, laxatives, diuretics, food substitutes, skipping meals and smoking more cigarettes)	In comparison with non-Hispanic White students, a higher percentage of Hmong and Somali students engaged in unhealthy weight-control behaviours Body satisfaction was also lower for Hmong adolescents and a higher percentage of the youth dieted to lose weight as compared with White students There were no significant differences for dieting or unhealthy weight-control behaviours between White and Hispanic students
Neumark-Sztainer *et al.* (2012)[132]	Adolescent students in Minneapolis–St Paul, Minnesota middle and high schools in 1999 (*n* 3072) and 2010 (*n* 2793)	Repeated, cross-sectional analysis of surveys completed by students in school classrooms	Any past-year dieting or unhealthy weight-control behaviour (fasting, eating little food, diet pills, vomiting, laxatives, diuretics, food substitutes, skipping meals and smoking more cigarettes)	Prevalences of binge eating, using any unhealthy weight-control behaviours, and using any extreme weight-control behaviours were higher among females than among males at both time points. There were significant secular decreases in unhealthy and extreme weight-control behaviours only among females There were no meaningful ethnic/racial group differences in secular trends for weight-control behaviours or binge eating

Table 3. (*Continued*)

Reference	Setting and sample	Study design	Measures of disordered eating	Key findings regarding differences in disordered eating across population subgroups
Eaton *et al.* (2012)[133]	Nationwide, public (state) and private school-based sample of adolescents in grades 9–12	Cross-sectional survey data were collected in 2011 as part of the Youth Risk Behavior Surveillance System	Disordered eating was assessed by asking about whether each of three behaviours were done with the goal of losing or preventing weight gain: fasting; taking diet pills, powders or liquids; vomiting or taking laxatives	The prevalence of fasting was higher among females than males, higher among 9th-grade females than 12th-grade females, and higher among 11th-grade males than 9th-grade males The prevalence of taking diet pills/powders/liquids was higher among females than males, higher among Hispanic than White and Black students, and higher among 11th-grade than 9th-grade and 10th-grade students The prevalence of vomiting/laxatives was higher among females than males and higher among White and Hispanic than Black students
Austin *et al.* (2011)[134]	Students at forty-seven middle schools in Massachusetts (*n* 16 978)	Cross-sectional 2005 survey of students was completed in school classrooms	Disordered eating (vomiting, laxatives, diet pills) in the past 30 d	Disordered eating behaviour was elevated 2–10 times in most ethnic groups relative to Whites. The prevalence of disordered eating behaviour was highest among Hawaiian/Pacific Islander young individuals Overall and within each ethnicity group, females and males did not significantly differ in percentage reporting disordered eating behaviour except within the American Indian or Alaskan Native group

* The studies identified in this Table represent peer-reviewed publications that were published or made publicly accessible between January 2009 and January 2019.

ethnicity/race[1,41,46,47,49-52,55,59,65,67-74,76-78,80,82-86] and markers of SES[1,41,46,48,53,54,62,66,72,73,76,79,80]. This evidence comes from forty-one studies that were cross-sectional in design or examined trends over time; twenty-nine studies were nationally representative[1,2,45-47,50,51,53,55,59-64,66-69,71,73-76,78-80,85,86] (Table 1), eight represented local/regional populations[41,48,49,52,54,72,77,83] and four were convenience samples[65,70,82,84]. More than half of the studies made use of dietary recalls[1,2,45,46,50,51,53,55,59-64,66-69,71,73-76,78-80,83,85], five studies assessed dietary intake with a FFQ[41,49,65,70,82], seven studies used brief survey measures[47,48,52,54,77,81,86] and two studies made use of food records[72,84]. The combined evidence base most consistently identifies adolescents, females and young individuals from lower-SES households as at risk for poor intake of milk and nutrients of public health concern (i.e. Ca, vitamin D). There is also evidence that younger children and those from higher-SES households tend to consume more fruit and vegetables[2,48,75,78]. Although a number of studies examined ethnic/racial differences, the findings have been mixed. As only four other studies were found to have examined rural–urban differences in intake of commonly underconsumed dietary components[56-58,81], the findings are not summarised here in detail.

Age and sex disparities. Existing studies addressing age and sex disparities have focused on intake of water[73,75,85,86], fruit[2,47,63,64,67,72,76,78,86], vegetables[2,47,63,64,67,71,72,78,86], dairy products[2,45,47,61,63,64,67-69,73,75,86] and other nutrient-dense foods[2,61,64], along with fibre and nutrients of public health concern (i.e. Ca, vitamin D)[45,46,60,67,69,71,80]. For example, national data based on the collection of dietary recalls show that young children (2–3 years) are more likely than all other age groups to consume adequate amounts of fruit, orange vegetables, legumes and milk[2,75,78]. National data show that adolescent females tend to have the poorest intake of milk, grains, and meats and beans[2,47]. Analyses focused on Ca and vitamin D have aligned with such findings in showing that these key nutrients provided by milk are more often underconsumed by young individuals aged 9–18 years than children 4–8 years; the percentage of children with inadequate intake tends to increase with age[45,46,69]. In regards to water consumption, older children consume a greater volume but there is mixed evidence regarding sex differences[73,75,85].

Socio-economic disparities. The evidence base suggests that intakes of plain water, milk, fruit, vegetables, whole grains, fibre, Ca and vitamin D tend to be poorer among young individuals with fewer household resources[1,41,45,46,48,53,54,72,73,79,80]. National data show that the Special Supplemental Nutrition Program for Women, Infants and Children (WIC) is protective for these young children. Toddlers and preschool-age children who participate in WIC tend to have higher intake of milk and a lower risk of inadequate vitamin D intake when compared with low-income non-participants[62,66,79]. A recent analysis of dietary recall data provided by 1542 adolescents in Northern New England confirmed the finding that fruit and vegetable intake is positively related to household income[48]. However, just as WIC is protective for young children, the results further showed that being provided meals at school may mitigate income-related disparities for adolescents[48].

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Among adolescent participants who received school meals there was very little difference in fruit and vegetable intake by household income[48]. The results instead highlighted that adolescents' average intake of fruit and vegetables was low regardless of income[48].

Ethnic/racial disparities. Less consistent evidence has identified ethnic/racial differences in intakes of milk, water, fruit, vegetables, whole grains, PUFA, fibre and nutrients of public health concern (i.e. Ca, vitamin D)[1,47,49-52,55,59,65,67-71,73,74,76-78,80,82-86]. At least nine studies have reported that non-Hispanic White children tend to have higher milk intakes than Black children[1,47,51,59,67-69,82,86], but evidence regarding differences in intake between Hispanic and non-Hispanic children is inconsistent[49,52,67,82]. There is similarly inconsistent evidence regarding differences in intake between White and Asian children. Some evidence suggests that Asian children tend to have higher intakes of fruit and vegetables than White children[41,50] whereas other findings have indicated Asian girls who identify as Hmong tend to have low vegetable intake[49]. One study found that non-Hispanic Black children consumed more fruit as 100 % juice and less fruit as whole fruit in comparison with non-Hispanic White, Asian and Hispanic children[76]. There is also some evidence that non-Hispanic White children consume more plain water, on average, as compared with Mexican American and non-Hispanic Black children[73,85]. Total beverage moisture was found to be highest among non-Hispanic White and Mexican American children[85].

Markers of poor diet: overconsumed dietary components

There is much evidence of disparities according to age[53,60,61,63,64,86,88,89,93,98,102-109], sex[47,53,86,88-90,95,98,103-105,108], ethnicity/race[1,47,49-52,59,65,77,82-84,86-88,91-93,96-98,103-106,108,109] and markers of SES[62,79,87,92-95,98,99,103,105,106] in children's intake of dietary components that tend to be consumed in excess. This evidence is based on thirty-seven cross-sectional analyses[1,47,49-53,59-61,63-69,71,72,75,77,79,82-84,86,88,94,95,97-99,101,103,108,109] and thirteen studies of secular trends over time[87,89-93,96,100,102,104-107]; thirty-six studies were nationally representative (Table 1)[1,47,50,51,53,59-61,63,64,66-69,71,75,79,86-91,93,96,98,100-102,104-109], eight represented local/regional populations[49,52,72,77,83,92,94,97] and six studies enrolled convenience samples[65,82,84,95,99,103]. More than half of the studies made use of dietary recalls[1,50,51,53,59-64,66-69,71,75,79,83,87-91,93,96,98,100-102,104-109], five studies assessed dietary intake with a FFQ[49,65,82,92,97], eight studies used brief survey measures[47,52,77,86,94,95,99,103] and two studies made use of food records[72,84]. The studies identified for the present review suggest that adolescents and males are most likely to report overconsumption of energy-dense, nutrient-poor foods and beverages and excess Na consumption[75,86,102]. Similarly consistent evidence suggests that young individuals from lower-SES households and individuals who identify their race as Black are most likely to report a high intake of sugar-sweetened beverages[47,51,59,72,79,83,86,88,91,93,94,97,98,106,109]. An additional three cross-sectional studies were found to have used national data to examine and report on mixed evidence of rural–urban differences in patterns of overconsumption[56-58]. Two of the three studies that examined rural–urban differences were based on dietary recall data[56,58], and one used brief survey measures to assess intake[57]. One study showed that young individuals (2–11 years) in rural areas consume more total energy on average than their urban counterparts[58]. In contrast, another study compared adolescents living in an inner-city area with those in a suburban area and found no differences in dietary pattern[95].

Age and sex disparities. Research on age and sex disparities has addressed intakes of sugar-sweetened beverages, sweet and salty snack foods, added sugars, Na, saturated fats and total energy. National data indicate that low-nutrient, energy-dense sweets and sugar-sweetened beverages are commonly consumed at a young age and the percentage of young individuals who consume them on a given day is directly related to age[59,61,63,64,68,69,72,75,103,107]. One national study found that 41 % of 2-year-olds and 49 % of 3-year-olds consumed a sugar-sweetened beverage on a given day[59]. Adolescents have the highest mean energy consumed from sugar-sweetened beverages and highest percentage of total energy consumed from sugar-sweetened beverages[75,88,109]. Adolescents also have the highest prevalence of excess dietary Na intake and, in contrast with young children, consume more solid fats from fried potatoes than from milk[102,109]. Existing studies consistently show males as compared with females tend to report higher intake of sugar-sweetened beverages, added sugars and total energy[47,53,86,88,89,100,104,108]. National surveillance data based on dietary recalls with adolescents suggest that this difference may be in part due to males consuming larger portions and more energy at meals than females[89]. The 2011–2014 national surveillance data additionally indicate that a slightly higher percentage of males than females (64·5 *v.* 61·3 %) consumed at least one sugar-sweetened beverage on the given day of their dietary recall[88]. These same data show that males consumed more energy from sugar-sweetened beverages compared with females across all age groups, with the exception of children aged 2–5 years[88]. One notable contradiction to these findings came from a study in a convenience sample of Black adolescents and indicated that females consumed foods higher in fat and energy than males[95].

Socio-economic disparities. A growing number of studies have provided evidence of differences in dietary patterns according to SES markers. Most existing evidence suggests that sugar-sweetened beverage, juice and added sugar consumption tends to be higher among young individuals with fewer household resources[62,66,72,79,94,98,99,106], but that those with limited household resources have lower or comparable intakes of sweets and solid fats[1]. There is also some evidence that recent trends in snacking may lead to changes in SES-related patterns of disparities. An analysis of national trends in Na intake based on dietary recalls found that there was an increase from 1977 to 2014 in the proportion of Na intake derived from snacks among all sociodemographic groups, but that young individuals (2–18 years) in the lowest-household education (less than high school) and lowest-household income (less than 185 % of the Federal Poverty Level) groups

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had the largest increases in Na intake from snacks over time[87]. It was notable that children in the lowest-income compared with the highest-income group had significantly lower Na intakes from snacks in 1977–1978 whereas there was no difference in Na intakes between these groups in 2011–2014[87]. National data further indicate that toddlers and preschoolers enrolled in WIC have a higher risk of excessive Na intake than higher-income non-participants[62].

Ethnic/racial disparities. Research on ethnic/racial differences in intake of overconsumed dietary components has found a similarly mixed pattern of disparities. Several studies suggest that intake of sugar-sweetened beverages is higher among children of Black race and lower among children of Asian race than among non-Hispanic White children[47,49-51,59,68,69,82-84,86,88,91,93,98,106,109]; however, some evidence suggests that intake of sugar-sweetened beverages varies across Asian subgroups[77]. A small number of studies have found that Black children consume more Na and unhealthy foods such as desserts, chips (crisps) and other energy-dense snacks[52,65,71,83,92]. Among young children (2–4 years), nationally representative data suggest that more non-Hispanic White children consume some forms of sugary snack foods on a given day in comparison with non-Hispanic Black (for example, ice cream, pudding) and Hispanic children (for example, candy)[59]. National survey data also suggest that non-Hispanic White children are less likely than Hispanic children to meet recommendations for limiting intake of solid fats and added sugars and have higher intakes of solid fats and added sugars in comparison with Black children[1,67,100,104,108]. Non-Hispanic Black children had the largest recent secular increases in Na intake from snacks out of all ethnic/racial groups[87]. National surveillance data for 2011–2014 showed that, based on dietary recalls, Black children had the highest mean Na intake from snacks, representing more than a doubling in mean Na intake from 1977 to 2014[87].

Unhealthy meal and snack patterns

There is growing evidence that disparities in certain eating patterns such as the frequent skipping of main meals, infrequent eating with other household members as part of family meals, and frequent consumption of meals and snacks prepared away from home may be important contributors to disparities in dietary quality[139,140]. Whereas little research has examined rural–urban differences in the eating patterns of children, several studies have documented disparities according to age[86,92,110,111,115-117,119-123,125], sex[47,86,92,93,116,117,125], ethnicity/race[41,47,49,77,82,86,91-94,97,112,113,115-117,123,125] and markers of SES[41,92,93,112-114,116,117,124,125]. The existing evidence summarised here is based on eighteen cross-sectional analyses[41,47,49,77,82,86,94,97,113-115,117-119,121-123,125] and nine studies of secular trends over time[91-93,110-112,116,120,124]; thirteen studies were nationally representative (Table 1)[47,86,91,93,110,111,113,119-121,123-125], eleven represented local/regional populations[41,49,77,92,94,97,112,116-118,122], and three were conducted within intervention and clinic-based samples[82,114,115]. Among these studies, eating patterns were assessed by a mix of assessment tools, including 24 h recalls[91,93,110,111,119-121,123-125], food records[111], FFQ[41,49,92] and brief survey measures[47,77,82,86,94,97,112-118,122]. The evidence base collectively suggests that these problematic eating patterns are most prevalent among adolescents, young individuals from low-SES backgrounds, and young individuals who identify with an ethnicity/race other than non-Hispanic White. Meal skipping tends to be most common among adolescent females[86,92,141].

Age and sex disparities. National survey data indicate that young children (2–5 years) have the greatest number of snacks on a given day and the proportion of total energy intake contributed by snacks is highest for this age group[93,119,142]. In contrast, national survey data show that the prevalence of skipping one or more main meals is highest among adolescents (39 % of males, 45 % of females) and females[86,141]. Having two or more snacks per d is common among adolescents who skip meals[141]. Young children participate in family meals more frequently than older children[122]. Population-based research among adolescents in Minnesota has further provided evidence that middle adolescence is a period when young individuals are particularly likely to have infrequent family meals and skip meals, with females being at greatest risk[92,116,117]. Among the 2540 young individuals who were surveyed in the 2009–2010 school year, only 37 % of high school students and 36 % of females reported eating each main meal (breakfast, lunch, dinner) on five or more days a week as compared with 45 % of middle school students and 46 % of males[92]. Likewise, the Minnesota survey data suggest that high school students tend to obtain meals and late-night snacks from fast food restaurants more often than middle school students[92,112]. National survey data show that food and beverages obtained from fast food restaurants contribute more energy to the diets of adolescents compared with younger children and adolescent males have higher daily energy intake from fast food compared with females[120,123,125]. The likelihood of eating at a restaurant on a given day does not differ between younger (2–5 years) and older (6–11 years) children[125].

Socio-economic and ethnic/racial disparities. Several studies on SES and ethnic/racial differences in eating patterns have focused on adolescent populations[41,47,49,86,92,112], but a growing number of studies have also assessed patterns among younger children[77,82,94,123-125]. Despite evidence of some overall secular improvement in the frequency of eating main meals, national survey data and Minnesota survey data similarly show that skipping breakfast occurs more often among adolescents from low-SES backgrounds and those who identify as non-Hispanic Black or Native American[47,86,92,125,143,144]. Secular trend data also show that significant decreases in the frequency of eating food from fast food restaurants have occurred among most groups of Minnesota adolescents but not among those from the lowest-SES backgrounds and young individuals who identify as non-Hispanic Black or Native American[112]. Likewise, among adolescents in Minnesota, secular trend data showed that weekly family meal frequency decreased from 4·0 times in 1999 to 3·6 times in 2010 among adolescents from the lowest-SES backgrounds and conversely increased from 4·2 times in 1999 to 4·5 times in 2010 among adolescents from the high-middle-SES group[116]. The

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results of this study also showed a secular decrease in family meal frequency among adolescents of Asian race[116], but findings in regards to ethnic/racial disparities in family meals have been mixed across other studies[52,117,118].

One study on ethnic/racial disparities among 15 902 preschool-aged and school-aged children (2–11 years) in California found that low-income children were less likely to have consumed food from a fast food restaurant in the past week and evidence that Latino children and Asian children were more likely than non-Hispanic White children to consume food from a fast food restaurant[94]. Preschool-age Latino and non-Hispanic Black children born in Massachusetts were found to more often consume food from a fast food restaurant in another study[82]. In regards to family meals patterns, a study among 1134 urban households with young children showed that preschool-age children (2–5 years) of non-Hispanic White race had more frequent breakfast family meals compared with non-Hispanic Black children and non-Hispanic multiracial children. However, among the young urban children, no ethnic/racial differences were observed in the frequency of total family meals or eating together as a family at lunch or dinner[115]. Only one other study addressing disparities in family meals among young children (up to age 4 years) was identified[97]. This cross-sectional analysis of data collected from a prospective cohort conversely found that Black children ate fewer meals together with their family as compared with White and Hispanic children[97].

Problematic feeding practices

Demographic patterns in the feeding practices of parents and other caregivers probably also contribute to disparities in dietary quality among young individuals. Recommendations for the promotion of healthy eating patterns include the use of developmentally appropriate feeding practices across the life course from early childhood to adolescence[145-148]. It is important that caregivers are responsive to the hunger and satiety cues of their children, make healthy foods available and accessible at home, eat meals together with their children (see above discussion of family meals) and model the consumption of healthy foods[145,148]. Few studies to date have addressed rural–urban differences or the demographic patterning of feeding practices[137].

Recent research on disparities in the use of feeding practices has addressed parental control over feeding, the types of food made available at home, and parental modelling of healthy food choices among young children[65,97,126,130,149] as well as older children and adolescents (Table 2)[52,113,118,127-130,150]. This research evidence is based on eight cross-sectional analyses[52,65,118,126-130] and one longitudinal analysis[97]; five studies represented local/regional populations[52,97,118,128,129] and four studies involved a convenience sample[65,126,127,130] (Table 2). The research studies have used brief survey and interview tools to assess feeding practices with much variation across studies regarding the number of practices assessed and the measures used to assess specific practices.

The one longitudinal study of young children collected data on feeding practices for 1343 White, 355 Black, and 128 Hispanic mother and child pairs using in-person interviews and mailed questionnaires[97]. Multiple assessments were conducted over the course of development from the prenatal period up to 4 years of age[97]. Analysis of these data showed that Black and Hispanic children were more likely than White children to have experienced maternal control over feeding as defined by the restriction of energy-dense food options and pressuring children to eat[97]. Few studies have addressed parental control over the feeding of adolescents; however, existing evidence for young children and for adolescents suggests that controlling practices are more often used by parents who identify with ethnic/racial minority groups (Hispanic, Asian, Black), parents with less than a high school education and parents with low household incomes[65,126-128,130]. The existing research likewise indicates that young individuals in ethnic/racial minority subgroups and those from lower-SES households tend to have fewer healthful foods available at home than their peers but similar or more limited access to less-healthful foods at home[52,118,129,150].

Disordered eating behaviours

A small number of studies have also examined whether there are sex and ethnic/racial disparities in the prevalence of using unhealthy weight-control behaviours and binge eating (Table 3). The existing evidence on unhealthy weight-control behaviours that is summarised here is based on five cross-sectional analyses[49,131,133-135] and one study of secular trends over time[132]; one study was nationally representative[133], one represented a statewide sample of secondary students in Massachusetts[131], two represented secondary students in urban areas of Minnesota[49,132] and two studies were conducted among students enrolled at baseline of an overweight prevention study in Massachusetts[134,135]. All six of these studies used brief survey tools to assess the use of dieting and three to nine specific unhealthy weight-control behaviours. Four studies focused on unhealthy weight-control behaviours in the past 30 d[131,133-135] and two studies focused on use in the past year[49,132]. Evidence regarding disparities in binge eating was recently summarised as part of an integrative literature review[138] that described six relevant USA-based studies and one more recent study[136] was additionally identified; these studies have made use of heterogeneous measurement tools.

There were no studies identified that had examined rural–urban differences in disordered eating and the existing research focuses solely on adolescent populations. Most studies that have examined sex differences[131-134] found the prevalence of disordered eating to be higher among females than males. Additionally, there is mixed evidence regarding differences in the prevalence of disordered eating between ethnic/racial groups[49,131-135,138].

Ethnic/racial disparities

Studies that have identified ethnic/racial differences in disordered eating have, in general, found evidence that the prevalence is lower among non-Hispanic White adolescents than other groups[49,131,133,134,138]. For example, a large survey of 16 978 middle school students in Massachusetts asked students

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to report on vomiting, use of laxatives and use of diet pills in the past month to lose weight[134]. The prevalence of using any of these extreme weight-control behaviours was elevated two to ten times in most ethnic/racial groups relative to reported use by non-Hispanic White students and observed differences remained after accounting for weight status, self-perceived weight status and neighbourhood poverty[134]. Similarly, a recent literature review identified two studies of binge eating that have found a higher prevalence among Hispanic adolescents, one study that found evidence of a higher prevalence among Black adolescents and one other study that found binge eating to be more common among Native American adolescents; three studies found no evidence of ethnic/racial disparities[138]. Additional research further suggests that ethnic/racial differences in binge eating may vary across symptoms. One illustrative study found that Hispanic adolescents may be more afraid of weight gain while binge eating than non-Hispanic Black adolescents[136]. The interpretation of these studies and others that have not found strong evidence of ethnic/racial disparities should consider that across studies there was variability in the composition of adolescents enrolled, the types of unhealthy weight-control behaviours and characteristics of binge eating explored, and also the measurement tools and definitions established to determine prevalence[138].

There was also variability across the studies regarding accounting for ethnic/racial group differences in weight status. As young individuals who are at a BMI categorised as overweight/obese are more likely to engage in unhealthy weight-control behaviours[151], differences in weight status across groups could at least in part explain observed disparities in disordered eating. Among young individuals at an overweight BMI, Rodgers *et al.* found that non-Hispanic Black and Latino males were more likely to report disordered eating than White males but observed no ethnic/racial differences among overweight females[135]. Further, none of the studies addressed the excess burden of food insecurity among ethnic/racial minority groups and the potential contribution of food insecurity to observed disparities in disordered eating[152,153].

Discussion

The present review described recent evidence of disparities in nutritional problems among US child and adolescent populations (2–19 years) according to age, sex, markers of SES, ethnicity/race and geographic location. The findings identified adolescent females, young individuals from lower-SES households and young individuals of non-Hispanic Black ethnicity/race as particularly vulnerable populations for whom targeted strategies should be developed to address evidence of increased risk in regards to multiple aspects of nutritional wellbeing. There is an urgent need for research to build a more in-depth understanding of these disparities, including the contributions of environmental factors and food insecurity, and to fill a large gap in evidence regarding the potential existence of rural–urban differences. Nutrition and health professionals can use the existing evidence in advising the development of programmes and policies, and to design studies addressing the limitations of this scientific knowledge base. The existing evidence has several limitations relating to the accuracy of self-reported dietary data; the need for standard measures and definitions of disordered eating; the focus on individual dietary components *v.* patterns; the complexities of categorising SES, ethnicity/race and rural and urban areas; and the cross-sectional nature of most research designs. It will be critical for future studies to fulfill standing research needs in order to better inform public health improvement strategies and promote equity in nutritional health.

Adolescent females were identified by the present review as a target population for interventions based on evidence showing a high prevalence of multiple nutritional problems within this demographic subgroup. Adolescents as a group had lower overall diet quality scores than preschool-aged children and higher intake of sugar-sweetened beverages than children at earlier stages of development[40,53,88,93,111]. Female adolescents were also more likely than other demographic groups to report poor intake of milk, grains, and meats and beans[2,45]. The life stage of adolescence is a time when young individuals, especially females, are most likely to have infrequent family meals and to skip meals[86,92,116]. Further, most studies of disordered eating among adolescents have found that prevalences of unhealthy weight-control behaviours and binge eating are higher among females than males[49,131-133,136]. These findings collectively suggest the potential benefit of integrating content that addresses the importance of consuming nutrient-dense foods and avoiding disordered eating behaviours as part of interventions for adolescent females. The school-based programme New Moves is an example of such an intervention that was designed for adolescent females and guided by the philosophy that if girls feel good about their bodies they will want to take care of their bodies through healthy eating, physical activity and self-acceptance[154,155]. Accordingly, the objectives of the New Moves Program were designed to address the nutrition problems of poor diet (i.e. eat at least five servings of fruit and vegetables each day, limit pop and other sweetened beverages), unhealthy meal and snack patterns (i.e. eat breakfast every day, choose fruits and vegetables for snacks, pay attention to portion size and to your body's signs of hunger and fullness), and disordered eating patterns (i.e. avoid dieting and unhealthy weight-control practices) along with body dissatisfaction (i.e. focus on your positive traits)[154]. A 9-month follow-up evaluation of the programme among a sample of ethnically/racially diverse adolescent females demonstrated success by increasing the use of portion-control behaviours, decreasing the use of unhealthy weight-control behaviours, and improving body image[155].

Young individuals from low-SES households were likewise identified as a target population for interventions based on evidence showing a high prevalence of multiple nutritional problems among those who depend on parents/caregivers with limited formal education and income. Overall diet quality and, in particular, intakes of milk, fruit, vegetables, whole grains, Ca and vitamin D tend to be poorer among young individuals

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from low-SES households[1,40,45,54,62,94]. The diets of young individuals from low-SES households are also adversely impacted by having higher intakes of sugar-sweetened beverages and added sugars than their peers with more household resources[62,94,98]. Studies of eating behaviour have further shown that young individuals from low-SES households tend to skip breakfast and purchase food from a fast food restaurant more often than their peers[92,94,112]. The home food environments of young individuals from low-SES households have been found to provide less access to healthy foods and to be characterised by more parental control over feeding when compared with the environments of young individuals with more household resources[127-129]. In addition to these challenges, there is evidence that weight-related concerns and disordered eating are prevalent among paediatric populations in low-income communities[132,152,156-158]. The extent to which food insecurity and parental control over feeding may contribute to the development of disordered eating patterns among lower-income households is an area of ongoing research. Given the elevated prevalence of food insecurity among low-SES households, it may accordingly be important to assess for various weight-related problems (for example, binge eating, unhealthy weight-control behaviours) when intervening with young individuals that have limited household resources[132,157,159]. It is also important that programmes and policies addressing food insecurity are designed to provide diverse young individuals with access to nutrient-dense foods. Research studies evaluating the nutritional quality of foods provided to children through weekend backpack programmes have identified such opportunities for improvement (for example, providing more beans, vegetables and essential fatty acids)[160]. More in-depth discussion of disparities in the prevalence of food insecurity is provided below in line with the likely relevance of this public health problem for feeding practices and disordered eating as well as dietary intake and meal and snack patterns.

Several of the studies included in the present review identified young individuals of non-Hispanic Black ethnicity/race as a population group bearing an excessive burden of one or more nutritional problems. Across studies there is consistent evidence that non-Hispanic Black children and adolescents have diets of poorer overall quality and higher intakes of sugar-sweetened beverages and Na from snacks when compared with young individuals of other ethnic/racial backgrounds[1,40,45,47,51,52,55,57,59,86-88,93,98]. Young individuals of non-Hispanic Black ethnicity/race also tend to skip breakfast and purchase food from fast food restaurants more often than young individuals of other ethnic/racial backgrounds[86,92,112]. When compared with non-Hispanic White children and adolescents, young individuals of non-Hispanic Black ethnicity/race are more likely to experience parental control over feeding (for example, restriction of energy-dense food options, pressuring to eat) and have fewer healthful foods available to them at home[52,97,128]. Although the evidence is mixed with regard to ethnic/racial disparities in the prevalence of binge eating, there is further evidence that adolescents of non-Hispanic Black ethnicity/race are more likely than non-Hispanic White adolescents to use extreme weight-control behaviours and this relationship was particularly evident among male adolescents at an overweight BMI[131,134,135,138]. There is a great need for strategies to address the collective burden of these nutritional problems that are disparately making an impact on non-Hispanic Black young individuals. It is likely that a combination of strategies addressing the root causes of the identified nutritional problems will be most effective in working towards health equity. For example, recent reports have identified the need for strong policies to stop the targeted marketing of sugary drinks and fast foods to individuals of non-Hispanic Black ethnicity/race[161-164]. In alignment with evidence that food-insecure parents are more likely to use controlling or other compensatory feeding practices[165-167], there is also a pressing need to address the excess burden of food insecurity among non-Hispanic Black households and disseminate culturally relevant health promotion messages to parents[159].

Nutrition and health professionals can use the existing evidence in advising the development and monitoring of programmes and policies. In order to promote equity, it is imperative that efforts are made to ensure that the reach of programmes and policies extends to population subgroups with elevated rates of nutritional problems. Further, it is critical that nutrition education messages, programme materials and programme activities be tested to ensure they are culturally and developmentally appropriate for vulnerable population subgroups. There is also a need to monitor and provide technical support as appropriate to ensure full implementation of nutrition policies in settings that serve vulnerable subgroups of children and adolescents. The results of the present literature review demonstrated that nutrition assistance programmes (i.e. programmes designed to increase food security and reduce hunger through access to affordable, healthy food and nutrition education), are vital in addressing socio-economic disparities in nutritional problems; specifically, the WIC Program was found to mitigate income-related disparities in milk intake among young children and the National School Lunch Program (NSLP) was found to likewise mitigate disparities in fruit and vegetable intake for school-age children[48,62,66,79]. Ongoing funding and continuous efforts to monitor the reach of nutrition assistance programmes are clearly essential. In addition, the results of the present literature review demonstrated there may be opportunities as part of these programmes to address nutritional problems that are elevated among programme participants (for example, higher risk of excessive Na intake among WIC participants)[62]. It is similarly important that evidence-based practices be addressed in refining administrative requirements for settings that administer these programmes. For example, secondary schools that offer the NSLP might be required to address elevated rates of disordered eating among adolescent females as part of nutrition education[49,131-133,136].

An extensive and growing body of research has established that there are disparities in food insecurity, participation in nutrition assistance programmes, and several social and physical environmental factors that influence nutritional health and dietary behaviours[159,168]. The research literature on disparities in food security indicates that US children who are born in the country are at lower risk for experiencing household food security when compared with foreign-born children[169]. National

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surveillance data additionally indicate that rates of experiencing food insecurity are higher than the US national average (11 % of households in December 2018) for the following groups: households with incomes near or below the federal poverty line (29 %), all households with children (14 %) and particularly households with children headed by single women (28 %) or single men (16 %), Black- and Hispanic-headed households (21 and 16 %) and households in principal cities of metropolitan areas (13 %)[159]. The prevalence of food insecurity was not found to be significantly higher than the national average in rural non-metropolitan areas (13 %) but was elevated in comparison with the rate in suburbs/exurbs and other metropolitan areas outside principal cities (9 %)[159]. The prevalence of severe food insecurity, involving the reduction of food intake and disrupted eating patterns for one or more household members, was similarly patterned for US households[159].

Along with this evidence of disparities in food insecurity, there are data that indicate that gaps exist in access to nutrition assistance programmes and environmental supports for healthy eating. Just over half of the US households (56 %) that were food insecure in 2018 reported participating in one or more of the three largest federal nutrition assistance programmes (Supplemental Nutrition Assistance Program, WIC, NSLP) in the previous month[159]. Although food-insecure households may also obtain food from emergency providers in their local community, these data suggest that there are gaps in meeting the needs of many households with children. More specific data on the contributions of major nutrition assistance programmes indicate the Supplemental Nutrition Assistance Program (SNAP) provided assistance to 41 % of food-insecure households, children in 28 % of food-insecure households were provided with free or reduced-price meals through the NSLP, and women or children in 8 % of food-insecure households received food vouchers from the WIC Program[159]. National data further indicate that nutrition assistance programmes contribute to the prevention of food insecurity for many low-income households[170]. A large share of the children and adolescents who benefit from the NSLP and School Breakfast Program are children from low-income households who are provided with free or reduced-price meals. Over two-thirds of participants in the NSLP received a free lunch and another 6 % received a reduced-price lunch in 2018[170]. Likewise, in 2018, 80 % of participants in the School Breakfast Program received a free breakfast and another 5 % received a reduced-price meal[170]. Social and physical environmental factors that probably play roles in driving disparities in nutritional problems include unequal local access to healthy food, the targeted marketing of energy-dense food products, resources to prepare food at home, and cultural pressures around eating, body size and body shape. Additional research is, however, needed to clarify the contributions of food insecurity and various environmental factors to disparities, and establish that efforts to improve environments do actually lead to improvements in health equity without having unintended consequences. This research should be guided by a framework that highlights the potential for programmes and policies to have unequal impacts and recognises the importance of ongoing evaluation to identify gaps in implementation and to drive improvements.

To advance the field, several other areas for future research should also be given attention:

(a) There is a need to better understand how problematic eating behaviours and dietary patterns may cluster among population groups. Much of the existing research on nutritional disparities has focused on individual dietary components *v.* patterns and separately addressed multiple, related dietary behaviours. Research that has alternatively examined patterns in dietary behaviours or ranked overall dietary intake quality has been informative and may serve as a useful model for advancing science[40]. For example, Gu & Tucker[40] calculated a HEI-2010 score for all child and adolescent participants in the National Health and Nutrition Examination Survey over the years 1999 to 2012[40]. The HEI-2010 allowed for examining overall dietary quality with attention to ensuring adequate intake of fruit, vegetables, whole grains, dairy products, protein foods and fatty acids as well as moderating intake of refined grains, Na and 'empty calories'. Results of the Gu & Tucker[40] analysis clarified the need for interventions to address the overall lower dietary quality of young individuals that identify as non-Hispanic Black and those who are eligible for public assistance.

(b) Consistent methods for identifying rural and urban areas are needed and should be reported in publications to build understanding of geographic disparities in dietary intake, meal and snack patterns, feeding practices and disordered eating. A prior review of rural–urban disparities in paediatric diet and physical activity patterns described eight different methods of classifying geographic areas[171]. There is a need for consensus on the use of a single nuanced definition of rural to allow for greater comparability across studies.

(c) Attention to variability in dietary patterns and the validity of self-reported data should receive greater attention in the design of future studies. Most existing studies of disparities have relied on reports of dietary intake at a single point in time. Many studies have made use of strong assessment methods, such as 24 h dietary recalls, and the findings produced from these studies have identified important cross-sectional differences and disparate secular trends. However, little is known regarding how disparities track longitudinally over time to allow for understanding whether trajectories of dietary patterns over the course of development may systematically differ across groups. Only a few studies have examined issues such as how disparities in intake may differ by season (for example, during the school year *v.* summer)[53] or for different food subgroups (for example, dark green *v.* starchy vegetables)[1]. It may be informative for more future studies to report on variability in diet as well as more objective measures (i.e. biomarkers such as serum carotenoids) of long-term intake patterns[172].

(d) Finally, the need for additional research to address disparities in disordered eating behaviours is noteworthy. The

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comparability of findings across existing studies of disparities is currently limited by the use of inconsistent definitions. Future studies should pay greater attention to the selection of comparable measures and recognising problematic behaviours that occur before middle adolescence. The few identified studies of disordered eating behaviours among middle school students have indicated that it should be a priority to examine disparities among large, population-based samples of preadolescents and early adolescents[131,132,135].

Review limitations

This narrative review of literature had several limitations. It is likely that some relevant literature was missed as the search was limited to peer-reviewed research published within the past decade. There may be value in additionally reviewing reports outside the peer-reviewed literature to address potential publication bias and evaluating patterns in nutritional disparities over a longer period of time. Further, in contrast to most systematic reviews of the literature, the present review did not use a formal process to evaluate the quality of included studies. The literature search focused on the nutritional problems of poor dietary intake (underconsumed and overconsumed components), problematic eating patterns and feeding practices, and disordered eating among US paediatric populations. In developing research plans, it will also be important for reviews to examine physical signs of malnutrition, upstream determinants of disparities in nutritional problems (for example, local food access) and disparities across sexual orientation groups[173]. Further, it will be important for future reviews to examine these same issues with a broader international perspective.

Conclusion

This review provides important information on disparities in nutritional problems among US child and adolescent populations. The findings may be of international interest as many countries across the globe are working to address nutritional disparities among their paediatric populations[174-176]. However, there is substantial cross-national variation in the magnitude and direction of disparities that must be attended to in developing responsive programmes and policies[174-176]. Whereas the gradient of certain nutritional disparities has been increasing in the USA in recent years, other countries have maintained stable patterns of differences or made progress towards greater equity[174]. Disseminating information on patterns of US disparities may help to guide research based on cross-national comparisons and is critical to building broad support for US programmes and policies. Identified areas of need for future research in US populations include building a greater understanding of how problematic eating behaviours and dietary patterns may cluster among population groups, developing consistent methods for the identification of rural and urban areas, paying more attention to variability in dietary patterns and the reliability of self-reported dietary data, and developing standard methods for identifying disordered eating that are appropriate for epidemiological studies.

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