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Measuring beverage consumption in US children and adolescents: A systematic review

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Abstract

Beverage consumption habits are associated with weight outcomes for children and adolescents. Many studies have examined children's beverage consumption, but little is known about what methods are commonly used to assess youth beverage consumption and whether these strategies are valid and reliable. This study aimed to systematically review articles assessing beverage consumption among children and adolescents. We searched PubMed and SCOPUS for English-language articles published between February 2007 and February 2017 that measured and reported on American youth's (ages 2-18 years) beverage consumption. Searches yielded 17,165 articles, of which 589 articles describing 615 measures were extracted. We examined the types of assessment methods used, characteristics of these methods (e.g., validity, reliability, literacy level), characteristics of study samples, and beverages assessed. The most common assessment methods were questionnaires/screeners (used by 65.4% of articles) and recalls (24.4%). About three-quarters of articles did not address validity (70.5%) or reliability (79.5%) of any measures used. Study populations were diverse: 54.7% of articles included low-income children, and 90.2% included non-White children. The most commonly assessed beverage category was sugar-sweetened beverages. Findings suggest that improved measurement techniques and reporting are both needed to track progress toward a goal of ensuring all youth have healthy beverage consumption.

Keywords

Beverage consumption; dietary intake assessment; children; adolescents; measurement; youth

Introduction

The beverages children consume have important effects on their bodyweight. Randomized trials and prospective studies indicate that consumption of sugar-sweetened-beverages (SSBs) such as sodas, sports drinks, and fruit drinks increases children's risk of obesity.¹⁻³ Some studies have also suggested that consumption of fruit juice is associated with weight gain and adiposity in youth.^{4,5} On the other hand, consumption of healthier beverages can have positive effects. Higher milk consumption has been prospectively linked to lower body fat percentage,⁶ body mass index,⁷ and waist circumference in youth,⁸ and drinking water may help limit excess weight gain.^{9,10}

Because beverage habits are key contributors to childhood obesity, there is considerable interest in measuring children's beverage consumption.¹¹⁻¹³ Accurate measurement of beverage consumption is crucial for assessing population-level trends in beverage consumption over time and for estimating changes in consumption in response to specific interventions. Although beverage consumption is the target of many policies and programs, and the focus of considerable research, measuring beverage consumption can be challenging, and the five most common dietary assessment methods—dietary recalls, diaries, questionnaires and screeners, observations, and direct measurements of weight or volume¹⁴—each have their own limitations.^{15,16} For example, dietary recalls, which assess recent consumption, will typically misrepresent an individual's true long-term dietary behaviors. A single recall is therefore generally not appropriate for estimating distributions of usual intake.¹⁷ Questionnaires and screeners reflect longer-term dietary habits, but are quantitatively imprecise.^{15,18} Diaries, observations, and direct measurements of weight or volume (e.g., as in plate waste studies) may reduce measurement error, but are often too resource-intensive or logistically challenging to be used in large samples or community settings. Assessing beverage consumption specifically among youth presents additional challenges, because children are less able to recall their dietary behaviors, have greater difficulty estimating portion size, and tend to have more variable diets compared to adults.^{16,19,20}

In order to accurately measure beverage consumption among youth, researchers and evaluators need to know what methods are available and to understand the key properties of those methods. Yet to our knowledge, no such unified information exists. In addition, because assessment methods have different strengths and weaknesses, consumers of the scientific literature need to understand what techniques are commonly used to assess beverage consumption in youth, and whether such strategies are valid and reliable.

To address these needs, we systematically reviewed articles measuring beverage consumption in children and adolescents. Our review was guided by four key questions: 1) What assessment methods are used to measure beverage consumption among children and adolescents ages 2-18 years in the United States?; 2) What are the properties of these assessment methods, including their reliability and validity?; 3) What types of beverages are examined by studies measuring beverage consumption in children and adolescents?; and 4) What are the characteristics (age, race/ethnicity, sex, income) of the populations in which these assessment methods have been used?

To address these questions, we reviewed literature published in peer-reviewed journals between 2007-2017 reporting on children's or adolescent's beverage consumption.

Methods

Literature Search

We adhered to the guidelines of the Preferred Reporting Items for Systematic Reviews and Meta-Analyses Statement,²¹ with slight modifications as needed to address the study objectives. To reflect recent trends in beverage consumption assessment, this review assessed peer-reviewed articles that measured beverage consumption in children and adolescents during the past ten years. We selected this ten-year period given how rapidly the marketplace of beverage products changes.^{22,23} In February 2017, we conducted searches in two databases, PubMed and Scopus, using search syntax developed in collaboration with a reference librarian (Exhibit S1). Briefly, our queries included the following terms and all of their cognates and synonyms: beverage AND consumption AND children.

Inclusion and Exclusion Criteria

We included articles that quantitatively measured beverage consumption in free-living children ages 2-18 years. Beverage consumption varies across countries,²⁴⁻²⁶ and the assessment methods used in one country may not be accurate and sensitive in another;²⁷ thus, we focused specifically on U.S. populations. To be included, articles were required to be published in the English language in peer-reviewed journals between February 8, 2007 and February 8, 2017 and to report on beverage consumption as a primary exposure or outcome.²⁸ Studies could use any design (observational, randomized-controlled trial, etc.). We excluded articles if they: 1) did not report on a U.S. population, 2) assessed the wrong exposure or outcome (e.g., only assessed alcohol consumption, breastfeeding, or infant formula consumption, which are not relevant for children ages 2-18); 3) reported on the wrong age group; 4) were not original research (e.g., review articles, policy briefs), 5) were not published in peer-reviewed journals (e.g., dissertations); 6) used a beverage assessment method other than the five major methods (i.e., recall, screener/frequency questionnaire, diary, observation, direct measurement; see Table S1 for descriptions of these methods); 7) did not adequately describe the beverage assessment method used; or 8) directly manipulated beverage consumption (e.g., laboratory studies in which the researcher controlled participants' beverage consumption; these studies are not free-living environments). RCTs that encouraged children to consume particular beverages (e.g., promoted water consumption) but did not have direct control over beverage consumption were included. We excluded exact duplicate publications, but included articles from the same parent study (e.g., publications using data from the same cohort). A full list of inclusion and exclusion criteria are detailed in Table S2.

Article Selection

We conducted initial screening of titles and abstracts using the online software Covidence (Veritas Health Innovation Ltd, Melbourne, Victoria, Australia). For the initial screen, two investigators double-screened all records, and any record included by at least one author was retained for full-text review. During full-text screening, two investigators double-assessed all

texts for eligibility, with disagreements resolved by discussion. Inter-rater agreement for full-text screening was high (Krippendorff's alpha = 0.88).

Data Extraction

Two investigators extracted data in 2017 using REDCap (Vanderbilt University, Nashville, TN).²⁹ We extracted information on study type and design, beverage consumption assessment method, types of beverages measured and reported, psychometric characteristics of assessment methods, and participant characteristics (each expanded upon below). Each article was extracted by one investigator. To ensure the investigators were consistent with one another, we double-extracted a random sample of 5% of included articles (n = 30) and calculated agreement statistics for extracted data. We set a conservative *a priori* cutoff of an average Krippendorff's alpha > 0.80 as suggested by Krippendorff.³⁰ We achieved a high average raw agreement (97.3%), and had a mean Krippendorff's alpha of 0.87 (see Table S3 for full results), above our specified cutoff of 0.80. The data extractors reviewed all discrepancies from the double-extraction, resolved discrepancies via discussion, and refined the codebook to clarify definitions as needed.

Adapting from Glanz et al.,³¹ we recorded the study type and design. Possible study types included intervention or observational, and study designs included cross-sectional, longitudinal, or repeated cross-section/trend.

We also extracted information on the method(s) used for assessing children's beverage consumption. If an article used more than one assessment method, we extracted information on all methods used. We recorded the type of measure used; who reported the child's consumption (for participant-reported measures); the mode of administration; the language of administration; and the average or approximate time to complete in minutes (if reported). For self-administered methods, we also noted whether the instrument was appropriate for low-literacy populations, which we defined as measures that had a reported Flesch-Kincaid³² score ≥ 8 , that were noted as low-literacy by authors, or that were noted as 'age appropriate' for non-adult respondents.

For recalls and questionnaires, we extracted the referent period used, defined as the period of time participants were asked to consider when reporting their beverage consumption. Diaries, observations, and direct measurements were considered to capture consumption in real-time and thus have no referent period.

For questionnaires, we recorded whether the measure was quantitative/semi-quantitative (assessed portion size in some manner) or non-quantitative, and whether the tool assessed recent beverage consumption (e.g., "what did you drink yesterday?") vs. habitual/usual consumption (e.g., "what do you drink during a typical month?"). Finally, for measures known to assess recent consumption (recalls, diaries, questionnaires assessing recent consumption, observations, and direct measures), which may not accurately reflect an individual's usual consumption for episodically consumed items, we assessed whether analyses incorporated more than one measurement event (e.g., analyses used repeated 24-hour recalls). While we extracted information on repeat-measurement for all studies, note that repeated measurement is most important for studies wishing to estimate the distribution

of usual beverage consumption amounts, but is generally not necessary for studies that aim to estimate only mean consumption (and not a full distribution of intakes).

We examined what beverage categories the article assessed (e.g., milk, water, soda) as a key exposure or outcome of interest (excluding beverage categories used only as control variables).

To assess psychometric characteristics of measures used, we extracted whether the article assessed or reported on the validity of one or more measurement techniques, and if so, the type of validity addressed (content or face, criterion or convergent, other).³³ We also extracted whether the article assessed or reported on reliability of one or more of the measurement techniques used, and if so, the type of reliability addressed (test-retest, inter-rater, internal consistency). Given the diversity in methods for assessing and reporting validity and reliability across the method types, we did not synthesize information on the results of psychometric testing for all methods. Instead, we extracted results of validity and reliability testing for questionnaires/screeners only.

Finally, we extracted information on the characteristics of the study participants included in analysis. We examined participants' age, including the sample's mean age and whether the sample included any children in early childhood (2-5years), middle childhood (6-11years), and/or adolescence (12-18years). We also extracted information on the sample proportions of females and in major categories of race/ethnicity. Finally, we assessed whether any non-White children were included, and whether any low-income children were included. 'Low income' was operationalized as the author noting the sample was 'low-income' and/or the presence of children in the sample with characteristics such as being eligible for free or reduced priced meals through the School Breakfast Program or the National School Lunch Program, having household income less than 185% of the Federal Poverty Level (or about \$30,000/year), or participating in a government assistance program.

Results

Article Selection

As detailed in Figure 1, the database search yielded 27,319 records, of which 10,154 were duplicates. After excluding duplicates, 17,165 records remained. During the initial screen, 16,052 records were excluded, leaving 1,113 articles assessed for full-text eligibility. After full-text screening, a total of 589 articles were retained and extracted for inclusion in the review. A reference list of all 589 included articles is shown in Exhibit S2.

Synthesis of Results

Included articles—The included articles used both cross-sectional (63.7%), longitudinal (31.2%) and repeated cross-sectional (7.8%) designs (Table 1). Most (72.3%) were observational. More than a quarter (26.5%) used a common data source, including 79 articles that used data from the National Health and Nutrition Examination Survey, 16 that used data from the Youth Risk Behavior Surveillance Survey and 18 that used data from one or more cohort of Project Eating Among Teens.

Assessment methods used—The most common assessment method used by the included articles was questionnaire/screeners, with nearly two-thirds of articles (65.4%) using this method (Table 1). Approximately one-quarter (24.4%) used recalls, while the other assessment methods (diaries, observation, and direct measurement) were each used by about 4% of articles. Slightly more than 4% of articles used more than one assessment method.

Properties of assessment methods—We extracted information on all methods used in the included articles ($n = 615$; sample size is larger than the number of included articles because some articles used more than one assessment method). We report different characteristics for each type of method, based on what was relevant for that method type.

For recalls, diaries, and questionnaires, it was slightly more common for the child to self-report her consumption (63.7% of measures used child-report) than for a proxy to report the child's consumption (42.9% measures) (Table 2); 13.5% of methods used both child- and proxy-reports (e.g., proxy-report for younger children and self-report for older children). All articles that focused exclusively on 2-to-5-year-olds (i.e., included only children in this age range) used proxy-report, and 44.3% of articles focused on 6-to-11-year-olds used proxy-report. For most recalls, diaries, and questionnaires (79.1%), the article did not report the language of administration. Just 5.0% of recalls, diaries, and questionnaires/screeners were explicitly indicated as being appropriate for low-literacy populations (e.g., had Flesch-Kincaid score of 8 or lower, or authors described measure as appropriate for low-literacy respondents), though for most articles (95.0%), authors did not report any information about the literacy level of the measure.

The most common referent periods used for recalls and questionnaires/screeners was yesterday/past 24 hours (used by 36.8% of reported methods) or the past week/seven days (used by 18.7% by reported methods). Questionnaires assessed recent consumption (40.8% of questionnaires) more often than usual/habitual consumption (36.7% of questionnaires; remainder did not directly report the type of consumption assessed). Only two-fifths (40.3%) of questionnaires in the included articles were described as being quantitative or semi-quantitative. Most of the articles (74.5%) using observations and direct measurements (which almost always assess a single meal) generally used at least two measurements in analysis. In contrast, this figure was only 30.8% for articles using recalls, diaries, and questionnaires assessing recent consumption.

Most articles did not measure or mention the validity (70.6%) or reliability (79.5%) of any of the measures used to assess children's beverage consumption (Table 1). About 23% of articles provided a reference indicating one or more of the assessment methods had been validated, and 6.6% measured and reported the validity of one or more assessment method in the article itself. More recent articles were not more likely to address validity than older publications (p -value for linear time trend = 0.915). Of those that measured and reported validity ($n = 39$), most reported criterion-related or convergent validity (66.7%) or content/face validity (41.0%). Reliability was also not addressed often, with 16.0% of articles providing a reference indicating that one or more of the assessment methods used had been assessed for reliability, and 4.6% measuring and reporting results of reliability testing within

the article itself. These figures did not improve for articles using longer referent periods. Of the articles that measured and reported on reliability in the article itself ($n = 27$), most reported test-retest reliability (55.6%) or inter-rater reliability (37.0%). Additionally, while it may be particularly important to understand the psychometric characteristics of questionnaires and screeners, nearly two-thirds (63.6%) of the 387 articles that used questionnaires/screeners did not mention or assess validity and three-quarters (75.3%) did not mention or assess reliability. Table S4 provides details on the articles ($n = 25$) that reported results of criterion validity or reliability testing for a questionnaire or screener.

Characteristics of study samples—Study samples were diverse. The mean age of youth in included studies ranged from 2.0 to 17.8 years, with a mean of 9.9 years ($SD = 4.4$) (Table 3). Articles' analytic samples were, on average, 54% female (range: 0% to 100% female). Most articles (90.2%) included non-White children, with an average of 41% of study participants being white or Caucasian, 24% black or African American, 26% being Hispanic or Latino, and 4% being Asian. Some articles focused exclusively on a particular racial/ethnicity minority: 3.3% of articles included only African American participants, 2.9% focused on Hispanic/Latino participants, and 1% focused on Native Americans/American Indians/Alaskan Natives. More than half of articles (54.7%) indicated that they included low-income children, 0.3% indicated that their sample included only higher-income children, and the remaining 45.0% did not provide enough information to assess whether there were low-income children in the sample.

Beverage types—The most commonly reported beverage type examined was sugar-sweetened beverages, with 79.6% of articles assessing SSB consumption as a key exposure or outcome of interest (Table S5). Milk was also a commonly examined beverage type (34.3% of articles examined milk), as was 100% juice (31.1%), and water (20.4%).

Discussion

Promoting healthy beverage consumption among children and adolescents is an important obesity prevention strategy. Because different dietary assessment methods are subject to unique limitations that could influence study findings, it is important to understand what assessment methods are typically used in the literature. In particular, characteristics of the assessment method affect measurement error, and in turn, measurement error affects both the accuracy of estimates of children's usual beverage consumption (e.g., mean intake of juice) and the validity of estimates of the association between beverage consumption and other variables (e.g., the relationship between juice consumption and weight outcomes).¹⁴ We examined several features of assessment methods relevant for measurement error. For example, we extracted information on the referent period used to assess consumption. While about one-third of recalls and questionnaires/screeners examined here assessed children's beverage intake over a specific meal or the past 24 hours, more than one in ten measures used a referent period of one month or longer. These measures may not produce accurate estimates of children's beverage intake, as children can report their dietary intake more accurately for short compared to long referent periods.^{34,35} To increase accuracy, future studies might shift toward measures that assess shorter referent periods. However, usual consumption is often of greater public health interest than recent intake; thus, research might

also identify elicitation techniques that improve children's ability to report their usual beverage habits over longer periods.

We also found that nearly one-third of recalls and questionnaires/screeners did not specify any referent period for participants to consider when reporting their consumption, or the article did not provide enough information to determine the period used. Without this information, it is difficult to assess the potential degree of measurement error. Authors should strive to provide sufficient details about measurement (including stating the referent period used) such that readers can make an informed assessment about the potential for measurement error.

We also assessed the types of assessment methods used (e.g., recall vs. questionnaire), as different methods produce different degrees of measurement error. Nearly two-thirds of assessment tools used in the included articles were questionnaires or screeners. Of these, 40% were non-quantitative (did not assess portion size), and another 24% did not provide enough details to determine whether the instrument was quantitative. While questionnaires and screeners have benefits (they are often less costly to administer, and can be used to assess long-term behaviors), these instruments are prone to measurement error, particularly when they are non-quantitative.^{15,16,18} For studies wishing to rank participants' consumption relative to one another, these instruments will suffice; however, if estimates of actual intake amounts are needed, researchers should use more precise methods such as recalls or diaries.¹⁶

Considerable work has gone into validating assessments of total energy intake, particularly in adults,^{16,36–39} but much less is known about the validity and reliability of methods to assess overall beverage consumption or consumption of specific beverages, particularly in children. We found that less than one-third of articles reported on or assessed the validity of the instruments they used. It may be particularly important to assess validity and reliability for questionnaires and screeners, as these instruments can vary considerably from one another in beverage categories assessed, referent period used, mode of administration, etc. However, of the 387 articles that used questionnaires/screeners to assess children's beverage consumption, nearly two-thirds did not mention or assess the validity of the instrument used. Only 39 articles both tested validity of the assessment method used and reported the results of validity testing in the article text. We extracted information on results of this validity testing for questionnaires/screeners. In general, when validity testing was conducted, beverage consumption as assessed via questionnaire/screener was found to be significantly correlated with beverage consumption as assessed via the reference method (e.g., diary, recall, observation). However, some of the reported correlations were weak (e.g., correlation coefficient < 0.2), and some questionnaires systematically over- or under-estimated beverage consumption.

Information on reliability was also lacking, with only one in five articles addressing the reliability of the instrument used. Consumption of most beverages is 'episodic' (i.e., most beverages are not consumed daily by nearly all of the population). For example, milk, juice, and sugar-sweetened beverages are not consumed daily by all children.^{11,12,40} Test-retest reliability may therefore not be relevant for measures with short referent periods, since we

would not assume beverage consumption to be stable day-to-day. However, reliability was not addressed any more often in articles using instruments with longer (10 days or more) referent periods, even though test-retest reliability is a relevant metric for these instruments. As above, we extracted the results of reliability testing for questionnaires/screeners only. There was considerable variation in questionnaire reliability, with some instruments showing good reliability (e.g., test-retest correlations > 0.80) and others showing lower reliability (e.g., test-retest correlations < 0.5).

Because the majority of the included articles simply did not address reliability and validity, it is difficult to assess the extent to which researchers are employing valid and reliable assessment methods. Whenever possible, authors should fully describe the psychometric properties of the measures they use so that readers can weigh whether bias or measurement error could be affecting study results. The STROBE-nut reporting guidelines provide a useful framework for the methodological details authors might wish to include.⁴¹ Further, given the relative paucity of studies validating methods to assess children's beverage intake, more research is warranted to develop valid, reliable measures and to establish the properties of existing instruments.

A large majority of articles examined SSB consumption as the exposure or outcome of interest. This is perhaps not surprising, given that SSB consumption has been linked to a number of important health outcomes, including obesity, diabetes, cardiovascular disease, and dental caries.^{1,42–44} While health promotion efforts have often focused on reducing consumption of unhealthy beverages such as SSBs, emerging work is also examining promotion of healthier beverages, particularly water.^{9,45} Reflecting this trend, about one-fifth of the included articles examined water consumption. However, few articles examined consumption of tap water specifically. Additional research on determinants of tap water consumption may be useful, as tap water is an affordable alternative to bottled beverages, and when fluoridated, can reduce risk of dental caries.⁴⁶

Children's beverage consumption varies considerably with their demographic characteristics,^{11,12,47–51} and thus some assessment methods may be valid in certain populations but not others.²⁷ We found that nearly all articles included non-white children. Some articles focused exclusively on minority children, including 20 that focused specifically on African American children,^{52–71} 19 that focused on Hispanic children,^{72–90} six that focused on Native American, Alaskan Native, or American Indian children,^{91–96} and one that focused on Asian or Asian-American children.⁹⁷ These articles may serve as references to evaluators wishing to assess beverage consumption in these populations, though evaluators should attend to whether the assessment methods described in these articles have been validated specifically for their population of interest.

It is particularly important to tailor questionnaires and screeners to the population in which they are used to ensure that the categories assessed are appropriate.¹⁶ A number of questionnaires have been validated in diverse populations (i.e., at least half of children in the sample were non-white).^{56,77,86,97–102} Research has documented notable disparities in healthy beverage consumption across racial/ethnic and income groups, with minorities and low-income children tending to consume more SSBs and less plain water and unsweetened,

low-fat milk than white and higher-income children.^{11,50,51,103,104} Having beverage intake assessment tools appropriate for diverse populations is crucial to assessing whether interventions and policies reduce these disparities.

This study had limitations. While restricting the review to the past ten years increased the feasibility of the study, we may have missed important articles that were published before 2007, particularly validation studies of some popular questionnaires (e.g., the Youth Adolescent Questionnaire¹⁰⁵). Because beverage products available and beverage consumption can vary across countries and cultures, we focused on articles studying American children and adolescents, and our findings may not generalize to non-U.S. settings. Given the volume of articles included and the variety of validity/reliability outcomes reported, we also did not extract the results of validation or reliability testing for all method types, focusing instead on the reliability and validity of questionnaires and screeners.

Conclusion

The results of this review suggest several fruitful directions for future research. First, given that questionnaires and screeners are a common assessment tool, and can be feasibly implemented in a number of settings, additional work is warranted to establish the psychometric properties of existing instruments and to develop new tools that are scientifically sound. Given that validity and reliability often vary with participant characteristics,^{16,106–108} psychometric analysis should be conducted with children of varying ages and sociodemographic backgrounds. Our review also revealed that many articles did not report key information about how beverage consumption was measured. While space constraints will always limit what details can be reported, future work should be mindful of describing features of assessment techniques that might affect the accuracy of beverage consumption estimates, such as the referent period used, who reported the child's consumption, whether the method has been validated and in what populations, and whether and how portion size was assessed.

Ensuring healthy beverage consumption among children and adolescents remains a public health and policy priority. Improved measurement techniques and reporting will help establish whether progress is being made toward this goal. Given that beverage consumption is an important determinant of childhood weight outcomes, practitioners, clinicians, and researchers focused on obesity prevention should be invested in developing and applying thoughtful measurement techniques to assess beverage intake among children and adolescents.

Supplementary Material

Refer to Web version on PubMed Central for supplementary material.

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Figure 1. PRISMA Flow Diagram

Table 1
Characteristics of Articles Included in the Review (n = 589)

Characteristic	%	N
Sample size, median (IQR)	788	(191, 3991)
Sample size not reported	2.9%	17
Year Published		
2007-2011	36.8%	217
2012-2017	63.2%	372
Used a common data source ^a		
National Health and Nutrition Examination Survey (NHANES) ^b	13.4%	79
Youth Risk Behavior Surveillance Survey (YRBSS)	2.7%	16
Project Eating Among Teens (EAT), any wave or project	3.1%	18
Early Childhood Longitudinal Study – Birth or Kindergarten Cohort (ECLS)	3.9%	23
School Physical Activity and Nutrition Survey (SPAN)	0.5%	3
School Nutrition Dietary Assessment Study (SDNA)	0.8%	5
California Health Interview Survey (CHIS)	2.2%	13
None of these	73.5%	433
Study type		
Observational	72.3%	426
Intervention/Experiment	27.7%	163
Study Design ^a		
Cross-sectional	63.7%	375
Longitudinal	31.2%	184
Repeated cross-section or trend	7.8%	46
Types of Methods Used ^a		
Recall	24.4%	144
Diary	5.3%	31
Questionnaire/screener	65.4%	385
Observation	4.6%	27
Direct measurement	4.2%	25
More than one assessment method used	4.4%	26
Did the article address the validity of any method?		
Measured and reported in this article	6.6%	39
Referenced previous literature	22.8%	134
Not mentioned	70.6%	416
Type of validity addressed by articles reporting validity results ^a (n = 39)		
Content or face	41.0%	16
Criterion-related or convergent	66.7%	26
Other	2.6%	1
Did the article address reliability of any method used?		
Measured and reported in this article	4.6%	27

Characteristic	%	N
Referenced previous literature	16.0%	94
Not mentioned	79.5%	468
Type of reliability addressed by articles reporting reliability results ^a (n = 27)		
Test-retest	55.6%	15
Inter-rater	37.0%	10
Internal consistency	25.9%	7

^aCategories may not sum to 100% because more than one category could apply simultaneously

^bIncludes articles that used Continuing Study of Food Intake in Individuals

Table 2
Characteristics of Methods Used to Assess Beverage Consumption in Children and Adolescents (n = 615 methods)^a

Characteristic	%	N
Recalls, Diaries, and Questionnaires (n = 564)		
When relevant, was repeat measurement taken (n = 335) ^b		
Yes	30.8%	103
No	66.0%	221
Not reported/unable to assess	3.3%	11
Individual who reported child's consumption ^c		
Proxy-reported	42.9%	242
Child-reported	63.7%	359
Reference provided, but no details on who reported	3.5%	20
Not reported/unable to assess	3.5%	20
Mode of administration		
Self-report on paper	13.6%	72
Self-report on computer, tablet, or other electronic device	4.0%	21
Face-to-face interview	21.9%	116
Phone interview	16.0%	85
Text message interview	0.2%	1
Other mode ^d	0.4%	2
Not reported/unable to assess	54.3%	288
Language of administration		
English	19.5%	110
Spanish	13.1%	74
Other ^e	2.5%	14
Not reported/unable to assess	79.1%	446
Time to complete		
Average time to complete, minutes (mean, SD)	32.4	22.6
Not reported/unable to assess	95.0%	536
Literacy(n = 401) ^f		
Authors report that tool is appropriate for low-literacy population	5.0%	22
Reference provided, but no details on literacy level	54.3%	323
Not reported/unable to assess	40.8%	217
Referent period ^g (n = 530) ^h		
Specific meal	1.5%	8
Yesterday or past 24 hours	36.8%	195
Past week / past 7 days	18.7%	99
Past 10-14 days	0.2%	1
Past 30 days or 1 month	6.0%	32
Past 3-6 months	0.9%	5

Characteristic	%	N
Past Year	3.2%	17
Other referent period	0.6%	3
Not reported/unable to assess ⁱ	32.1%	170
Questionnaires only (n = 387)		
Was questionnaire quantitative/semi-quantitative?		
No	35.4%	137
Yes	40.3%	156
Reference provided, but no details about whether quantitative	8.0%	31
Not reported/unable to assess	16.3%	63
Type of consumption assessed		
Recent actual consumption	40.8%	158
Usual or habitual consumption	36.7%	142
Reference provided, but no details on type of consumption	13.7%	53
Not reported/unable to assess	8.8%	34
Observations and Direct Measurements (n = 51)		
Was measurement repeated?		
Yes	74.5%	38
No	21.6%	11
Not reported/unable to assess	3.9%	2

^aSome articles reported on more than one measure; thus, total sample size of measures (615) is larger than the number of included articles (589)

^bApplies only to questionnaires assessing recent actual consumption (vs. usual/habitual consumption), recalls, and diaries

^cDoes not sum to 100% because more than one option could apply (e.g., proxy-report for younger children, self-report for older children)

^dThe other mode used was research staff reading items aloud/presenting items on a projected screen while participants marked responses on their own paper questionnaires

^eOther languages included Cantonese, Mandarin, Korean, Vietnamese, Khmer, Hmong, Haitian Creole, Yup'ik, Somali, and Portuguese

^fSample size of measures is smaller because we did not assess literacy level for questionnaires or recalls administered via interview

^gReferent period refers to the period of time participants were asked to consider when reporting their beverage consumption, rather than the unit of measurement. For example, if a questionnaire asks participants about their soda consumption during the past six months, six months if the referent period.

^hSample size is smaller because referent period was only assessed for recalls and questionnaires/screeners, as the referent period for diaries was considered concurrent/real-time.

ⁱApplies to measures that did not specify the referent period (e.g., simply asked participants about their 'usual' consumption without specifying the timeframe over which to estimate consumption) and to articles that did not specify what referent period the measure used.

Table 3
Characteristics of Study Samples (n = 589 articles)

Characteristic	Mean or %	SD or N	Min	Max
Mean age (years)	9.9	4.4	2.0	17.8
Did not report mean age	40.2%	237	-	-
Age ranges included				
Included children 2-5y	39.9%	235	-	-
Included children 6-11y	47.0%	277	-	-
Included children 12-18y	52.8%	311	-	-
Cannot tell what age ranges included	18.8%	111	-	-
Proportion female	0.54	0.14	0.00	1.0
Did not report proportion female	21.9%	129	-	-
Race/ethnicity of sample				
Included any non-White children?				
Yes	90.2%	531	-	-
No	0.8%	5	-	-
Cannot tell/not reported	9.0%	53	-	-
Proportion in each racial/ethnic category				
White/Caucasian	0.41	0.29	0.00	1.00
Black or African American	0.24	0.25	0.00	1.00
Asian or Asian American	0.04	0.09	0.00	1.00
Hispanic or Latino	0.26	0.27	0.00	1.00
Native American or American Indian	0.02	0.13	0.00	1.00
Pacific Islander or Native Hawaiian	0.00	0.03	0.00	0.64
Multiracial	0.01	0.05	0.00	0.57
Other race as defined by authors ^a	0.05	0.08	0.00	0.69
Racial/ethnic category not listed above ^b	0.01	0.07	0.00	0.61
Did not report any race/ethnicity information	24.1%	142	-	-
Included any low-income children?				
Yes	54.7%	322	-	-
No	0.3%	2	-	-
Cannot tell/not reported	45.0%	265	-	-

^aIncluded categories such as “Other race” and “Other / multiracial” without further definition as well as “Other” with details on which races were included in this category

^bIncluded categories such as “Minorities”, “non-white”, “Somali/Sudanese” and “Asian/Pacific Islander”