Title page

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Title: Validity of individual short food questionnaire items to measure intake in children and adolescents: a systematic review

Short title: Short food questions measuring children's (0-18y) intake

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Authors:

Rebecca K Golley¹ Rebecca.Golley@unisa.edu.au

Lucinda K Bell² Lucy.bell@flinders.edu.au

Gilly Hendrie³ Gilly.Hendrie@csiro.au

Anna Rangan⁴ Anna.Rangan@sydney.edu.au

Alison Spence⁵ a.spence@deakin.edu.au

Sarah A. McNaughton⁵ s.mcnaughton@deakin.edu.au

Emily Amezdroz⁶ emily.amezdroz@unimelb.edu.au

Lauren Carpenter⁶ lmca@unimelb.edu.au

Margaret Allman-Farinelli⁴ margaret.allman-farinelli@sydney.edu.au

Andrea de Silva⁶ andrea.desilva@dhsv.org.au

Tim Gill⁴ tim.gill@sydney.edu.au

Clare Collins⁷ clare.collins@newcastle.edu.au

Helen Truby⁸ Helen.truby@monash.edu

Victoria M Flood⁴ vicki.flood@sydney.edu.au

Tracy Burrows⁷ Tracy.burrows@newcastle.edu.au

1. University of South Australia

2. Flinders University

3. CSIRO

4. University of Sydney

5. Deakin University

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6 University of Melbourne

7 University of Newcastle

8 Monash University

The authors are members of the Food and Nutrition stream of the Australian Child and Adolescent Obesity Research Network (ACAORN).

Corresponding author:

Dr Rebecca Golley

School of Pharmacy and Medical Sciences, Division of Health Sciences, University of South Australia

P1-19 Playford Building City East Campus

Postal address: GPO Box 2471 Adelaide SA 5000 IPC CEA 19

T:+61 8 8302 2440 F:+61 8 8302 2389

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Abstract

Short food questions (SFQ) are appealing to measure dietary intakes. A review of studies published between 2004 and 2016 was undertaken and included if: they reported on a question or short item questionnaire (≤ 50 items, data presented as ≤ 30 food groups) measuring food intake or food-related habits, in children (aged 6mo-18 years) and reported question validity or reliability. Thirty studies met the inclusion criteria. Most questions assessed foods or food groups ($n=29$), with the most commonly assessed: fruit ($n=22$) or vegetable intake ($n=23$), dairy foods and discretionary foods ($n=20$ studies each). Four studies assessed food habits, with the most common being breakfast and meal frequency ($n=4$ studies). Twenty studies assessed reliability, and 25 studies determined accuracy and were most commonly compared against food records, and evaluation of question performance relied on statistical tests such as correlation. This review identified valid and reliable questions for the range of key food groups of interest to public health nutrition. SFQ questions were more likely to be reliable than accurate, and relatively few questions were both reliable and accurate.

This paper reviews has identified gaps in repeatable and valid short food questionnaires which will provide direction for future tool development.

Keywords: Validity, food intake, short food question, child, adolescent

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32 **Introduction**

33 A growing amount of evidence suggests that a nutrient-centric approach may lose valuable evidence
34 about the relationship between food, dietary patterns and protection from disease. In recent years food-
35 based dietary guidelines and compliance with recommended food intakes requires monitoring. The shift
36 in guideline focus away from being nutrient-based has led to increased interest in dietary assessment
37 methods that accurately and reliably measure food intake. Such methods provide the capacity for rapid
38 reporting of food intake, particularly to monitor population dietary intake, compliance with dietary
39 guidelines and changes in population intake ^(1, 2).

40 . Short questionnaire-style dietary assessment methods, often called short food
41 questionnaires/surveys/screeners, or checklists are an appealing brief dietary assessment method. Short
42 food questionnaires (SFQ) can be tailored to the research question or dietary outcome(s) of interest by
43 selecting a tailored combination of relevant items. While no standard definition exists, they are usually
44 around 50 items in length and ‘Questionnaire-style’ i.e. ask about the frequency or servings (portions) of
45 discrete food or beverage items or groups. Unlike food records, 24-hour dietary recalls and traditional
46 Food Frequency Questionnaires (FFQ) that aim to capture the total diet, short instruments assess limited
47 aspects of the diet. They are also quick to administer in a variety of formats (e.g. hard copy, via
48 telephone, via technology such as the internet or mobile devices), have low respondent burden, can be
49 self-completed, and can be pre-coded to aid in data entry and analysis ⁽³⁾.

50

51 Like any dietary assessment method, the performance of SFQ needs to be examined in terms of both
52 reliability and accuracy. Traditional questionnaires that measure diet such as Food Frequency
53 Questionnaires (FFQ) are often lengthy and commonly used for their ranking ability, and to derive valid
54 estimates of energy or nutrient intake. In contrast, SFQs need to be evaluated in terms of the performance
55 (validity and reliability) of individual questions (items) to assess food intake. Understanding how SFQs
56 perform in different populations, including children and adolescents, and via different reporting methods
57 (i.e. in person or online) is important. Food intake patterns, portion sizes and cognitive processes differ
58 between adults and children, and the performance of SFQ needs to be demonstrated in different
59 population groups (e.g. age groups, genders, ethnicities).

60 To date, evaluation of studies testing the validity of SFQ is limited to unpublished reports in order to
61 recommend the inclusion of SFQ items in national monitoring surveys. ^(2, 4) A now outdated 2010 report
62 identifying tools internationally appropriate for use in large populations found eleven tools with
63 validation studies, six measuring children’s intake ⁽⁵⁾ To our knowledge, no recent or published

systematic review of the international scientific literature has been undertaken. The aim of this systematic review is to identify and critique validation studies evaluating the performance of individual SFQ items to measure food intake in children and adolescents.

Methods

A systematic literature search was performed to identify published validation studies evaluating the performance of individual SFQ items estimating food intake or food habits of children and adolescents using a priori specified inclusion and exclusion criteria.

Inclusion and exclusion criteria

Types of studies: Studies reporting on the reliability or relative validity of individual food group questions (items) that estimate food intake or habits were included. Studies evaluating cognitive processes (e.g. accuracy of portion size estimation) were excluded.

Types of participants: Studies assessing dietary intake of healthy children (free of disease) and adolescents (6 months to 18 years) were included. Studies were excluded if infants were exclusively breastfed or formula fed, or no sub-group analysis was reported for the age range of interest. Studies involving samples of preterm infants, children with disabilities, pregnant or lactating females, health conditions (e.g. asthma, cystic fibrosis), behavioural/learning difficulties and clinical samples were also excluded.

Type of dietary assessment tools: Short questionnaire-style dietary assessment methods such as FFQs, surveys, screeners, questionnaires or checklists were included. For the purpose of this review 'short' was defined as being no more than 50 dietary questions/items (e.g. yoghurt, cheese, milk) in length ⁽⁶⁾ AND reporting food intake on no more than 30 food groups (e.g. dairy) (i.e. food group intake estimated from no more than a few short food questions that could stand alone). 'Questionnaire-style' was defined as including items that ask about the frequency or servings (portions) of discrete food or beverage items or groups. Questions/items could be qualitative, semi-quantitative or quantitative in relation to portion or serving size. Dietary assessment methods such as 24-hour recalls, diet histories or food diaries/records were excluded as they are not considered short tools.

97 Types of outcome measures: Studies reporting on the reliability or relative validity of questions
98 estimating food (e.g. yoghurt, cheese, milk), food group (e.g. dairy) or food habits (breakfast
99 consumption, meal frequency) were included. Studies reporting only nutrient intake, diet quality (e.g.
100 index or dietary pattern scores), supplementation, infant feeding practices (e.g. breastfeeding/formula
101 feeding, complementary feeding practices), eating behaviours (e.g. eating in absence of hunger, food
102 neophobia), food preferences, other non-food intake outcomes (e.g. food allergies, disordered eating,
103 body image, food security, behavioural outcomes), or parental food intake were excluded.

105 Other criteria: Studies included were limited to those published 2004- March 2016 in the English
106 language. This time frame was selected as previous reviews have reviewed studies until 2004 and this is
107 when food-based guidelines begun to arise in the literature and be used in National recommendations.
108 Studies published in abstract or thesis format only were excluded.

110 **Search and selection of included articles**

111 A comprehensive and systematic search was undertaken of the following eight databases: CINAHL,
112 Medline, Medline in Process, EMBASE (Excerpta Medica Database), Web of Science, Scopus, TROVE
113 and PsycINFO. Dietary assessment methodology repositories and Google Scholar were searched to
114 identify any relevant tools or papers in the grey literature. These were cross-checked with the published
115 literature. Search terms were pilot tested, refined and tailored to each database by an information
116 technologist expert. Keywords were searched within four categories (using 'OR') and then combined
117 (using 'AND'): 1) population (e.g. infant, toddler, preschool, child, boy, girl OR adolescent), AND 2)
118 dietary assessment tool/data collection method (e.g. questionnaire, diet surveys, record, checklist OR
119 screener/screening), AND 3) dietary outcome (e.g. food, diet, beverages, meal/s, eat OR snack), AND 4)
120 type of study (e.g. validity, reliability, reproducibility, OR performance). The search strategy specific
121 terms used in each database can be found in Supplementary Table). After searching, duplicates were
122 removed and lists of all identified studies were screened for additional studies. The title and abstract of
123 each study was screened independently against the inclusion/exclusion criteria by two reviewers. Full
124 texts of remaining articles were then screened against the review criteria by two reviewers. Where
125 disagreements were identified, a third reviewer made a final decision.

127 **Data extraction and analysis**

128 Data from each included study was extracted and checked by two reviewers into standardized
129 tables. Data extracted included sample characteristics (age, ethnicity, weight status), dietary assessment
130 methodology details (tool type, foods captured, response variable, recall period, administration method),

as well as reliability and relative validity data for individual SFQ. Two reviewers independently scored the validation study methodology quality using the tool described in Serra-Majem 2009⁽⁷⁾ which has been used previously⁽⁸⁾ but was adapted for the current review as described below. Scores range from 0 (poorest quality) to a maximum of 7 (highest quality) with components including: sample and sample size (max 1 point), type of statistics used to assess validity (3 points), administration method (0.5 points), food grouping detail provided (1.0), frequency scale and portion size consideration (1.0 point), and consideration of seasonality (0.5 points). A summary score of the components was calculated. The maximum score was seven and studies were rated as: poor (≤ 2), acceptable (≥ 2.5 - < 3.5), good (≥ 3.5 - < 5) or excellent (≥ 5.0). Any discrepancies were resolved by a third reviewer.

Data were assessed and synthesized based on the interpretation of a range of statistics to evaluate the performance of individual SFQ in terms of reliability (i.e. tool reproducibility or repeatability using a test-retest procedure^(9, 10)) and relative validity (i.e. the ability to accurately measure food consumption data that represents the true intake of the individual^(10, 11), determined by comparison with an already validated tool/method). Each SFQ was coded using standardised criteria which was determined by an expert consensus at the annual meeting of the Food and Nutrition Stream of the Australasian Child and Adolescent Obesity Research Network. Tool items were coded as reliable and/or accurate (i.e. performed well) based on the following three criteria: (1) non-significant difference between measures if a p value of > 0.05 or a confidence interval that include 1.0 in mean or median intakes between repeated measures of a tool or between two methods; (2) adequate association with a Pearson or Spearman correlation of > 0.5 ⁽¹²⁾; and (3) adequate agreement demonstrated by an Intra-Class Correlation (ICC) of > 0.5 ⁽¹³⁾ or Kappa statistic > 0.6 (Table 1). Where possible the strength of agreement was interpreted as poor (kappa $\leq .20$), fair (kappa = .21-.40), moderate (Kappa = .41-.60), good (kappa = .61-.80) or very good (kappa = .81-1.0). Bland Altman and percent agreement analyses were also considered as tests of agreement between methods. However these data are interpreted in text where available as no critique criteria could be identified for these statistics. Data were then summarized according to common food groups. Food groups included 'core' foods and beverages (e.g. fruits; vegetables; cereals [e.g. bread, rice, pasta, noodles]; meat and alternatives [e.g. fish, eggs, nuts]; dairy; fats and oils; water); and/or discretionary (energy-dense, high added saturated fat/sugar/sodium, low nutrient) foods^(14, 15). For some of the mentioned food groups several questions were separated out, these included: juice intake, legume intake, wholegrains and artificially sweetened (diet) versions of sweetened drinks. Where food groups were based on several items, the intake estimate was considered reliable and/or accurate (i.e. performing well) if $> 50\%$ of items for that food group met the criteria outlined above.

164 **Results**

165 Study characteristics

166 Thirty articles met the review criteria (Figure 1) and are described in Table 2. The majority of studies
167 were conducted in the United States (n=12) and Australia (n=8). Study sample size ranged from 35 ^(16, 17)
168 to 4487 ⁽¹⁾, with the majority (n= 18 studies) having a sample size of n>100. The majority of samples
169 were of Caucasian (European) ethnicity, with studies from the United States tending to include multi-
170 ethnic samples. Child age within study samples ranged between 1-18 years, with five studies focusing on
171 children <5years, 13 studies in 5-11year olds and eight studies in 12⁺year olds. Scoring against a
172 validation study methodology quality tool ⁽⁷⁾ showed eight studies were rated as poor, four as acceptable,
173 11 as good and seven as excellent quality. In addition, 11 studies reported on study sample weight status.
174 Of those described as percentage overweight or obese (n=7), participants ranged from 16%
175 overweight/obese ⁽¹⁸⁾ to 100% overweight/obese ⁽¹⁷⁾. Indicators of socio-economic status were rarely
176 reported (data not shown).

177 Dietary assessment tool characteristics

178 The tools were described as (short) food frequency questionnaires (n=11), short food questions/surveys
179 (n=6), screeners (n=4) or questionnaires (n=9) (Table 2). The majority of tools were designed to self-
180 report intake; 21 used child-report and nine used parents as a proxy (6/8 were for children <6yrs).
181 Twenty-six tools were administered in paper format, with only four studies administered via computer,
182 with a tendency for these being published 2008 onwards. Response options were most commonly
183 qualitative frequencies (n=24), with some tools also utilising serves/portions (n=8) or food category
184 (n=4). The dietary recall period ranged from 1 day to 1 year. Information regarding average completion
185 times was rarely reported. The mean number of questions per tool was 19.

186 Description of individual questions/items

187 Most questions assessed individual foods or food group intake (n=29). The food groups most frequently
188 assessed were fruit (n=22) or vegetable (n=23) intake. Questions on dairy foods (n=20) and discretionary
189 foods (n=20) were the next most common (Table 3). One study included questions relating to all the nine
190 food and beverage (including water) groups ⁽¹⁹⁾, with a further five studies assessing seven food and
191 beverage groups apart from water ^(18, 20-23). Fruit juice was assessed in 13 studies and two studies asked
192 specifically about wholegrains. The most popular food habits assessed were meal frequency (n=4) and
193 breakfast (n=4) followed by the use of vitamin supplements and snacking (n=2 studies each).

194
195 Tool performance

Tools were assessed in terms of their ability to reliably and/or accurately estimate food/beverage or food group intake.

Reliability

Twenty-one studies assessed reliability, with the period between repeat administrations ranging from 1-2 hours to 1-12 weeks (Table 2). The statistical approach varied between studies, but most commonly utilised tests of association (e.g. Pearson or Spearman correlation), and/or tests of agreement (e.g. Intraclass correlations or Kappa statistic) (Supplementary tables 1 and 2). Table 4 and Table 5 identify studies where the estimate of food or beverage group intake was considered reliable based on the interpretation of one or more statistical test. For core food groups, analyses based on t-tests or tests of association tended to suggest reliable tool performance (Table 4). Similar results are described for categories of discretionary foods (Table 5). However, questions asking about discretionary foods or sugar-sweetened beverages as a generic category of food products tended to perform reliably across all statistical testing reported.

Accuracy/relative validity

Twenty eight studies assessed accuracy, specifically relative validity. A range of reference standards were used as the comparison tool (n=13 24-hour recalls; n=12 3-7-day food records/pre-coded diary; n=1 long form FFQ; n=1 direct observation; n=1 interviewer diet history). No studies utilised any biomarkers to test validity. The statistical approach varied between studies, but most commonly utilised t-tests to assess group differences and/or testing of association (Supplementary tables 4 and 5). Only 14 studies utilised tests of agreement between methods, with five of these performing Bland-Altman analyses^(18, 22, 24-26).

Tools were assessed in terms of their ability to accurately estimate food/beverage or food/beverage group intake based on the interpretation of one or more of the statistical tests presented (Table 4 and 5). No tools performed well across all statistical analyses undertaken, although for each food group there were examples of questions that could be considered accurate (Table 4). Similar results were found for categories of discretionary foods (Table 5), although a number of tools were considered to provide accurate estimates of discretionary foods or sugar sweetened beverages as a generic group.

To assess the agreement between SFQ and their comparative method, four studies utilized Bland -Altman plots^(18, 22, 24, 26). While kappa statistics were reported there was limited formal evaluation of the agreement between the two measures. The plots illustrated in these studies limits the determination of absolute agreement values which limits the direct comparisons that could be made. Hendrie et al. 2014⁽¹⁸⁾ reported 84% agreement for the SFQ when compared to the dietary guidelines index. Additionally this

study reported a Kappa of 0.76 classifying it as good agreement. The studies by Flood et al.⁽²⁴⁾ and Lim et al.⁽²⁶⁾ did not report Kappa statistics while Antonogeorgos et al.⁽²²⁾ reported very good agreement (Kappa values of 0.9 or above) for food groups of refreshments/ juices, starchy products, fish and fruit.

Reliability and relative validity

Eighteen studies assessed both reliability and validity/accuracy. No tool could be considered both reliable and accurate across the range of food groups they assessed (Supplemental tables). The Belgium tool reported by Huybrechts and colleagues (2009) performed consistently across both the range of food groups and statistical analysis performed⁽²³⁾. Three Australian tools (Flood 2014⁽²⁴⁾; Hendrie 2014⁽¹⁸⁾; Magarey 2009⁽²⁵⁾) have been rigorously evaluated and perform well across the range of food groups assessed in this review. The US tools developed by Penkilo and colleagues⁽²⁷⁾ and Fahlman and colleagues⁽²⁸⁾ also show promise for the majority of food groups assessed.

Discussion

This review identified 30 validation studies which evaluated the reliability and accuracy of individual SFQ items used to estimate food intake in children and adolescents. While study samples were relatively homogenous, variation in study quality, period between administration to test reliability, reference standard to test relative validity and statistical analysis hindered direct comparison between studies. This review has identified valid and reliable questions for the range of key food groups of interest to public health nutrition for use in Europe⁽²³⁾, North America^(27, 28) and Australia^(18, 24, 25). However, SFQ questions were more likely to be reliable than accurate, and relatively few questions were both reliable and accurate.

Questions measuring intake of fruit and/or vegetables, discretionary food/beverages and dairy foods were the most common SFQ assessed. This is likely to reflect the public health nutrition importance of these food groups and being a proxy for other healthy foods, particularly given the recent focus on child obesity. SFQ asking about meat and alternatives, grain-based foods, water and fats were less common, and also tended to perform poorly when compared with their reference method. This may reflect the range of foods and eating contexts (e.g. eaten as part of mixed dishes and/or low daily frequency of meat and alternatives) of these food groups. While these food groups might be difficult to measure using these existing tools, it is important that valid questions are available to enable assessment of overall dietary intake, particularly to monitor population intake against food-based dietary guidelines. As discussed further below, cognitive testing of these SFQ to understand how respondents interpret and process these questions is likely to aid improvement of their performance.

260 Of the included studies, the SFQ tools that provided the most comprehensive set of questions which can
261 be compared against dietary guidelines included: Huybrechts 2009 ⁽²³⁾ which assessed seven food groups
262 + juice (total of 8), all which performed well against pre-defined criteria; Hendrie 2014 ⁽¹⁸⁾ which
263 assessed seven food groups of which six (four core food groups and 2 discretionary questions) performed
264 well and; Flood 2014 ⁽²⁴⁾ which assessed seven food groups (+ juice and diet beverages) with a more
265 comprehensive breakdown of discretionary food choice and inclusion of 2 additional items on breakfast
266 and dinner consumption, performed well on 5 categories of food/beverage assessed. When considering
267 individual items from within the included studies, Fahlman et al 2012 ⁽²⁸⁾ and Leatherdale et al. 2013 ⁽²⁹⁾
268 had questions which performed well for fruit and vegetables, meat/alternatives and grains and Penkilo et
269 al. 2008 ⁽²⁷⁾ provided assessment of discretionary choices.

271 The information examined in this review is timely given the increased focus on food-based dietary
272 guidelines and recommendations internationally. Specifically, it has been nearly 10 years since the
273 performance of SFQ's in Australian children has been comprehensively assessed, particularly for SFQ
274 other than those relating to fruit, vegetables consumption or type of milk. National Australian data
275 suggests there are some food groups which the population are continuing to consume inadequately i.e.
276 vegetables and legumes ⁽²⁾, as such there is an increasing need to track intakes of such food groups
277 between surveys as extended periods of time may elapse before national surveys are recompleted.

279 Strengths and limitations of the current literature

280 Assessment of the study methodology quality based on the tool described by Serra-Majem ⁽⁷⁾ indicated
281 that study quality was variable, with just over half deemed as good or excellent. Most studies were
282 conducted in samples greater than 100 as recommended in the literature ⁽³⁰⁾ and were well described.
283 While a number of studies utilized multiple statistical tests to comprehensively characterize the validity
284 performance of the SFQ evaluated, this remains the key area for improvement in this body of literature.
285 Very few studies provided explanations of how mixed dishes were handled which has relevance for
286 groups such as vegetables as they may often be components of meals rather than consumed solely on their
287 own. There was a reliance on use of correlations which test association but not agreement. Only three
288 included studies used Bland Altman methods and within those only plots were reported, rather than
289 agreement using Kappa values, which made comparison difficult ⁽³¹⁾. An improvement in the reporting of
290 weight status and socio-demographics in dietary studies would aid in an improved understanding of the
291 population in which the SFQ has been tested, as several sub-groups such as those who are overweight

292 have been identified to be more prone to misreporting⁽³²⁾. Additionally the validity/reliability across these
293 groups need further work as the results may vary.

294 Strengths and limitations of the review methodology

295 Central to the review aim was the intent to interpret the data extracted to provide guidance and
296 recommendations on SFQ items to use in future research. However recommendations of that nature
297 require consensus on cut-offs or criteria for assessing acceptable reliability and validity. While this review
298 used existing and published criteria, these may be considered arbitrary. In addition, they may be
299 considered lenient, and therefore the recommendations of this review may be considered a “best-case”
300 scenario. Further consensus is required on requirements for acceptable reliability and validity.

301 Furthermore, it is acknowledged that the choice of reference standard will influence the results observed.
302 Two important considerations in evaluating relative validity are i) that both the test method and reference
303 method must measure the same underlying concept over the same time period^(10, 33) and ii) that the
304 measurement error from the test method and from the reference method should be uncorrelated⁽¹⁰⁾. It is
305 often very difficult to design validation studies where the test and reference method comparison meet
306 these two considerations, and many of the studies reviewed here did not. This review was limited to
307 English language studies published since 2004 and did not include thesis. The heterogeneity of the
308 studies reviewed made comparisons across studies difficult, limited the ability to conduct sub-analysis by
309 reference standard and was challenging to incorporate into the synthesis of results.

310 A particular challenge faced while developing the review protocol related to the definition of a ‘short
311 food question’. Preliminary scoping identified a lack of validated individual questions that measured child
312 or adolescent food intake and therefore the focus of the review broadened to include short questionnaire-
313 style dietary assessment methods where the intent was to estimate intake of a food group in a few
314 questions. A previously reported definition of a ‘short’ food question was adopted⁽⁶⁾ and the focus was on
315 identifying studies where data were reported on the individual food items or food groups as compared to
316 evaluation of energy or nutrient intake which tends to be the outcome of interest in more traditional
317 validation studies. The results of this review provide an understanding of the validity of short dietary
318 assessment tools and more generally highlight some food groups which are easier or harder to measure as
319 can be assessed by alternate methods. This is useful in explaining and directing the development of
320 dietary assessment methods to estimate energy and nutrient intakes.

321 Conclusions

322 Recommendations for future studies

323 The review highlights a number of areas for further development and testing in future studies. Evaluation
324 of SFQ in terms of responsiveness or sensitivity to change is urgently needed to ensure the valid and
325 accurate monitoring of population trends in food intake, particularly following public health nutrition
326 interventions. Furthermore, a closed SFQ structure achieved through limited response categories is ideal,
327 but requires understanding of the range and distribution of responses to be expected. This has been
328 evaluated in very few tools (e.g. Gwynn et al. 2011 ⁽¹⁹⁾), but should be tested more in the future to
329 minimize respondent and researcher burden, but maximize accuracy by omitting ‘unexpected’ responses.
330 However this approach makes it difficult to identify change within intervention studies if individuals fall
331 within the same response category. Finally, SFQ may benefit from a range of cognitive testing including:
332 provision of memory cues, assessment of frequencies or portion size, tools designed to enhance cognitive
333 processing in order to improve our understanding of whether SFQ are clearly understood particularly in
334 relation to food group definition and serving size estimation. This type of testing is likely to prove most
335 useful in refining SFQ so that they perform better in terms of reliability and validity.

336 Recommendations for future studies considering use of SFQ in research should consider use of
337 technology to assist in administration, which could include prompts of 3D visual aids and portion sizes to
338 increase accuracy. In this review only eight studies utilised parents to report food intake and this tended to
339 be for children less than 5 years. Recent studies have shown that differences exist in dietary reporting
340 depending on who is being asked to report or record dietary or food intake. Traditionally in research
341 studies it is the mother who is asked to report however when compared to the child and father, mothers
342 have been shown to be least accurate when compared to gold standard methods of doubly labelled water
343 ⁽³⁴⁾.

344 Guidance in selecting questions that measure children’s food intake

345 The ideal set of questions to measure children and adolescent’s food intake will depend on the study
346 sample and research question of interest. However the findings and practical tables of this review can be
347 used to guide this process. For example, Table 3 aids validity data critique presented in tables 4 and 5,
348 researchers can choose a single or a tailored combination of valid questions relevant to their research
349 questions. Finally, the review findings can also enable researchers to develop new sets of short food
350 questions (i.e. short food tools) that may improve the validity of short dietary assessment tools that can
351 comprehensively measure total diet, energy and nutrient intake. This is only possible through the
352 improved understanding of the properties of individual items.

353 **Figure 1** Quorum flow diagram⁽³⁵⁾. Validation studies assessing children's food intake using short food
354 questions.

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Table 1: Criteria for interpretation and coding of reliability and accuracy data

Statistical approach	Statistical tests considered	Criteria indicating adequate performance
Group differences between administrations (reliability) or between methods (accuracy)	T tests	$P > 0.05^a$ or confidence interval (CI) includes 1.0 ^a
Tests of association between administrations (reliability) or between methods (accuracy)	Pearson or Spearman correlation	$r > 0.5$
Tests of agreement between administrations (reliability) or between methods (accuracy)	Intraclass correlation (ICC)	$ICC > 0.5$
	Kappa statistic	Kappa > 0.6

^aAdequate performance where no significant difference between repeated measures of a tool or between two methods is observed

Table 2: Study sample characteristics and questionnaire details of included studies

Study	Questionnaire details	Administration method	Population	Reliability	Validity	Study Quality ^a
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Authors (Year), Country	Tool type: number of items ^b	Response variables	Recall period	Respondent or interviewer: paper or computer assisted	Intake reported by:	Sample size; Ethnicity ^c	Age range mean±SD	Gender	Weight status	Period between repeat administ- ration	Reference method	Score (/7)
Antonogeorgos (2013), Greece ⁽¹⁾	FFQ: 63	Fq	Usual	Respondent: Paper	parent	n=124; NR	10-12y 10.9±1.2y	37% M	27% ow/ob	NA	3DFR	4
Bell (2014), Australia ⁽²⁾	FFQ: 19	Fq & portion size	7d	Respondent: Paper	parent	n = 111	12-36mo 23.0±6.9mo	54% F	NR	1-11.9 wks (3.2±1.8)	FFQ	2.5
Bennett (2009), Australia ⁽³⁾	Q: NR	no. serves	1d	Respondent: Paper	parent	n=90	2-5y 3.98±0.98y	56% F	NR	NA	1x24HDR	1.5
Bjelland (2014) Norway ⁽⁴⁾	Q44	Fq	Usual	Respondent: Paper	child	n=440	14.3±0.6; 91% Norwegian	52% F	NR	10-14 dys	NA	4
Davis (2009), USA ⁽⁵⁾	Screeners: 22	Fq & no. times	1mo	Respondent: Paper	child	n=35, Latino	14-17y NR	100% F	100% ow/ob	7-14 dys	3DFR	2
Eaton (2013), USA ⁽⁶⁾	SFS: 14	Fq & no. cups	7d & 1d & usual	Respondent: Paper	child	n=610; Multi- ethnic	14-18y NR	51% F	NR	NA	1x24HDR	2
Economos (2008), USA ⁽⁷⁾	SFQ: 8	yes/no variable	1d	Interviewer; Paper	child	n=84	6-9y 8.3 ± 1.1y	54% F	NR	1-2 hrs	observation	2
Fahlman (2012), USA ⁽⁸⁾	SFS: 20	no. times	1d	Respondent: Paper	child	n=387; Multi- ethnic	NR 13 ± 0.4-1y	52% F	NR	5 hrs	1x24HDR	3.5
Flood (2014), Australia ⁽⁹⁾	FFQ: 17	Fq & servings &	1y	Interviewer: Phone	parent	n=77 (reliability),	2-5y 3.6±0.94y	NR	NR	2 wks	3DFR	5.5

		no. cups				n=64 (validity)						
Guldan, (2015), China ⁽¹⁰⁾	Q: 17	Fq+2	NR	Respondent; paper	Child	n=1301 (reliability), n=357 (validity)	11.6±0.7 y (reliability), 11.5±0.6 y (validity)	54% M (reliability) , 55% M (validity)	NR	2 wks	3x24HDR	3
Gwynn (2011), Australia ⁽¹¹⁾	FFQ: 28	Fq & food type	Usual	Respondent: Paper	child	n=241 (reliability) n=205 (validity); included indigenous	10-12y 10.8±0.7y	42% M	NR	2 wks	1x24HDR	4.5
Haraldsdottir (2005), Europe ⁽¹²⁾	FFQ:6	Fq	Usual	Respondent: Paper	child	n=60-74 (reliability) n=43-60 (validity)	11-12y NR	39-69% F	NR	7-12 dys	7DFR	5
Hendrie (2013), Australia ⁽¹³⁾	SFS: 3	no. serves & food type	Usual	Respondent: Computer assisted	Parent (2-8y); Child (9- 16y)	n=4487	2-16y NR	50% M	27.2% ow/ob	NA	1x24HDR	5
Hendrie (2014), Australia ⁽¹⁴⁾	SFS: 38	no. serves & no. cups & no. times	Usual	Respondent: Computer assisted	parent	n=63	4-11y 7.1±2.1y	56% M	15.9% ow/ob	1 wk	1x24HDR	6
Huybrechts (2009), Belgium ⁽¹⁵⁾	FFQ:6	Fq	1y	Respondent: Paper	parent	n=650 (validity) n=124	2.5-6.5y NR	NR	NR	5 wks	3DFR	6

						(reliability)						
Leatherdale (2013), Canada (16)	Q: 4	servings	1d	Respondent: Paper	child	n=178	14-15y NR	53% F	NR	7 dys	7DFR (online)	4
Lillegaard (2012), Norway (17)	FFQ: 21	glasses/mo , week or day & Fq /mo, week or day	1y	Respondent: Paper	child	n=733 (9yrs) n=904 (13yrs)	9 y 8.9±0.3y 13y 12.9±0.3y	50-52% F	NR	NA	4-d precoded FR	3.5
Lim (2015), USA (18)	Q: 2	Cups per day`	Most days	Respondent: paper	Child	n= 100; multi- ethnic	3 rd grade	50% M	NR	NA	24HDR	5.5
Magarey (2009), Australia (19)	Q: 28	variety & Fq	1wk or 1d	Interviewer/ Respondent; Paper	parent	n=193 (validity) n=116 (reliability)	4-16y NR	NR	16% ow	10 d (5- 57d)	7d food checklist	4
Nelson (2009), USA (20)	Screener: 22	Fq & portion size & no. times/mo, week or day	1mo	Respondent: Paper	child	n=59 (validity) n=33 (reliability)	11-18y NR	45% M	NR	2-21d (most 7- 14d)	3x24HDR	2
Neuhouser (2009), USA (21)	FFQ:19	Fq	1wk	Respondent: Paper	child	n=46	7th grade 12.7y	61% F	NR	4-6 wks	4DFR	1
Olsen (2014), USA (22)	SFS: 7	no. times or no.	7d	Respondent: Paper	child	n=610; Multi- ethnic	grade 9-12 NR	51% F	NR	NA	3x 24HDR	4

		glasses										
Penkilo (2008), USA ⁽²³⁾	Q: 43	Fq	1d	Respondent: Paper	child	n=322; Multi- ethnic	9-12y 9.71y	52% F	NR	2 hrs	NA	1.5
Prochaska (2004), USA ⁽²⁴⁾	Screeners: 2	no. serves	Usual	Respondent: Paper & computer assisted	child	n=138; Multi- ethnic	NR 12.1±0.9y	65% F	NR	0d-1mo	3DFR	5.5
Randall Simpson (2008), Canada ⁽²⁵⁾	Screeners: 17	Fq	NR	Respondent: Computer assisted	parent	n=140; Multi- ethnic	3-5y NR	94% F	NR	2-4 wks	Interviewer DH	3
Thiagarajah (2008), USA ⁽²⁶⁾	FFQ: 54	Fq	1d	Respondent: Paper	child	n=110; Multi- ethnic	9-11y 10.31±0.5y	53% F	NR	NA	1x24HDR	3.5
Vandevijvere (2013), Europe ⁽²⁷⁾	FFQ: 15	Fq	1d	Respondent: Paper	child	n=390	12.5–17.5y 14±1y	42% M	NR	NA	2 x 24HDR	1.5
Vereecken (2008), Belgium Italy ⁽²⁸⁾	FFQ: 14	Fq	Usual	Respondent: Paper	child	n=112 Flemish, n= 114 Italian	11-12y 11±0.5	36-52% M	NR	1wk	7DFR	4.5
Wilson (2011), Australia ⁽²⁹⁾	Q: 14	Fq	1d & 7d	Respondent: Paper	child	n=134 (reliability), n=117 (validity)	10–12y NR	62% F	20% ow/ob	8-36d	7DFR	3.5
Wright (2011), USA ⁽³⁰⁾	Q: 19	Fq & food type & yes/no	1mo	Respondent: Paper	child	n=35; 54% Hispanic, 34% black	7-16y 11.8±2.3y	63% M	43% ow/ob	1-4 wk	1x24HDR	2.5

Austria, Belgium, France, Germany, Greece, Hungary, Italy, Spain and Sweden

Abbreviations: 24HDR, 24 hour dietary recall; 3DFR, 3 day food record; CA, computer assisted; DH, diet history; F, female; FFQ, food frequency questionnaire; I, interviewer; M, male; NA, not assessed; NR, not reported; no. , number; Fq, frequency of intake; P, paper; R, respondent; Q , questionnaire; SFS, short food survey; NS, national survey; nw, normal weight; ob, obese; ow, overweight; uw, underweight; d, direct; d, day; wk, week; mo, month

^aStudy quality assessed using an adapted version of the study quality scoring tool described in Serra-Majem 2009 ⁽³¹⁾

^bShort food survey defined as ≤50 dietary questionnaire items and ≤30 food groups.

^cEthnicity, as stated by authors

Table 3. A summary of food groups assessed by a SFQ within the included studies.

Reference	Fruit	Vegetables	Fruit & vegetables	Meat & alternatives	Grains & starchy foods	Dairy foods	Discretionary foods	SSB	Water	Fats ^a	Habits
Antonogeorgos (2013)	✓ J	✓ L		✓	✓	✓	✓				
Bennett (2009)	✓ J	✓				✓	✓ P	✓	✓		
Bell (2014)	✓	✓		✓	✓	✓	✓	✓		✓	
Bjelland, (2015)		✓						✓			✓ MF
Davis (2009)						✓	✓ P	✓ D	✓		
Eaton (2013)	✓ J	✓									
Economos (2008)	✓	✓									
Fahlman (2012)	✓	✓ L		✓	✓ WG		✓	✓			
Flood (2014)	✓ J	✓		✓		✓	✓	✓ D	✓		✓ BF, Dinner
Guldan (2015)	✓ J	✓				✓	✓	✓			✓ BF
Gwynn (2011)	✓ J	✓ L		✓	✓	✓	✓ P	✓	✓	✓	
Hendrie (2013)	✓	✓				✓					
Hendrie (2014)	✓	✓		✓	✓	✓	✓	✓		✓	
Haraldsdottir (2005)	✓ J	✓	✓								
Huybrechts (2009)	✓ J	✓		✓	✓	✓	✓	✓			

Magarey (2009)			✓			✓	✓	✓		
Nelson (2009)						✓	✓ P	✓ D	✓	
Lillegaard (2012)	✓ J	✓		✓	✓ WG	✓	✓ P	✓ D		
Lim (2015)	✓	✓								
Leatherdale (2013)			✓	✓	✓	✓				
Neuhouser (2009)			✓				✓			
Olsen (2014)	J					✓		✓ D	✓	
Penkilo (2008)	✓ J	✓ L				✓	✓	✓ P		✓ BF, MF, S, Vit
Prochaska (2004)			✓							
Randall Simpson (2008)	✓	✓			✓	✓	✓	✓ P	✓	
Thiagarajah (2008)	✓ J	✓ L			✓	✓	✓	✓ P	✓	✓ BF, MF, S, Vit
Vandevijvere (2013)	✓	✓		✓						
Vereecken (2008)	✓	✓			✓	✓	✓ P	✓ D		
Wilson (2011)	✓	✓					✓	✓	✓	
Wright (2011)	✓ J	✓				✓	✓	✓	✓	✓ MF

BF: breakfast, D: Separate questions available superficially on Diet versions of SSBs; J: Separate question(s) available about juice intake, L: Separate question(s) available about legume intake, MF: meal frequency, P: Partially assessed, S: snack, SSB: Sugar Sweetened Beverages, Vit: vitamin pill, WG: Separate question(s) available about wholegrain intake
^ae.g. butter, margarine

Table 4: A summary of the reliability and validity results of short food questions in the included studies for core food groups.

	Fruit	Fruit juice	Vegetables	Legumes	Fruit & vegetables	Meat & alternatives	Grains & starchy foods	Whole grains	Dairy products	Water	Eating habits
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Reliability^b

Group	yes	3 ^(14, 15, 29)	1 ⁽¹⁵⁾	3 ^(14, 15, 29)	0	0	3 ^(14, 15)	2 ^{(14) (15)}	0	3 ⁽¹⁵⁾	0	0
Association	no	0	0	0	0	0	0	0	0	0	1	0
	yes	9 ^(8, 12, 15, 23, 28)	7 ^(12, 15, 23)	15 ^(8, 12, 15, 23, 28, 32)	2 ^(8, 23)	7 ^(12, 16, 21)	2 ^(8, 15)	6 ^(8, 15, 16, 23, 25)	1 ⁽⁸⁾	7 ^(5, 15, 16, 20, 23, 28)	0	3 ^(23, 32)
Agreement	no	1	0	0	0	0	1	0	0	0	0	2
	yes	4 ^(9, 14, 15, 29)	3 ^(11, 15, 23)	6 ^(9, 14, 15, 23, 25, 29)	2 ^(11, 23)	2 ^(16, 19)	4 ^(8, 11, 14, 15)	5 ^(8, 9, 14-16)	1 ⁽⁸⁾	6 ^(2, 9, 15, 16, 19, 23)	5 ^(5, 9, 11, 20, 29)	2 ^(23, 33)
Summary	Yes all measures	1 ⁽¹⁵⁾	1 ⁽¹⁵⁾	1 ⁽¹⁵⁾	-	-	1 ⁽¹⁵⁾	1 ⁽¹⁵⁾	-	1 ⁽¹⁵⁾	-	-

Accuracy^{cd}

Group	yes	6 ^(3, 6, 12, 14)	1 ⁽³⁾	6 ^(3, 9, 11, 12, 29)	0	2 ⁽¹²⁾	1 ⁽⁹⁾	2 ^(14, 15)	0	3 ^(3, 9, 28)	2 ^(11, 29)	0
Association	no	9	11	9	0	2	3	2	1	4	3	0
	yes	6 ^(8, 9, 12, 15, 18)	2 ^(12, 15)	6 ^(8, 9, 12, 15, 18)	2 ^(8, 26)	4 ^(12, 16, 19, 21)	2 ⁽⁸⁾	4 ^(8, 26, 28)	0	4 ⁽¹⁵⁻¹⁷⁾	0	1 ⁽²⁶⁾
Agreement	no	9	2	10	1	4	6	3	1	6	4	0
	yes	1 ⁽⁸⁾	0	2 ⁽⁸⁾	2 ⁽⁸⁾	1 ⁽¹⁶⁾	2 ⁽⁸⁾	1 ⁽⁸⁾	0	1 ⁽¹⁶⁾	0	0
Summary	Yes all measures	-	-	-	-	-	-	-	-	-	-	-

- The number represents the total number of studies that meet that criteria and the corresponding number in square brackets represents the reference number of the study. A '-' Indicates that no studies met this criteria

Yes = question performs well based on criteria in Table 1 (does not include Bland altman)

No = question did not perform well based on criteria in Table 1

^bn=8 studies did not assess reliability of questions

^cn=2 studies did not assess validity of questions

^dstudies assess association and/or agreement

Table 5: A summary of the reliability and validity results of short food questions in the included studies for discretionary choices.

		Discretionary choices	Confectionary	Cakes/biscuits	Dairy desserts	Savoury snacks	Potatoes Fries	Processed meats	Composite / takeaway foods	SSB	SSB diet varieties	Fats
Reliability^b												
Group difference	Yes	3 ^(14, 15, 29)	0	0	0	0	0	0	0	3 ^(14, 15, 29)	0	0
	no	0	0	0	0	0	0	0	0	0	0	0
Association	Yes	3 ^(8, 15, 21)	3 ^(23, 28)	1 ⁽²³⁾	1 ⁽²³⁾	0	4 ^(15, 23, 28)	1 ⁽⁸⁾	4 ^(20, 23, 28)	3 ^(5, 8, 20, 28, 32)	4 ^(5, 20, 28)	0
	no	0	0	0	0	0	0	0	0	2	0	0
Agreement	Yes	4 ^(8, 14, 15, 19)	2 ^(9, 23)	3 ^(5, 9, 23)	1 ⁽²³⁾	2 ^(9, 11)	4 ^(9, 11, 23, 28)	1 ⁽⁸⁾	2 ^(9, 23)	8 ^(2, 8, 9, 14, 15, 19, 20, 29)	2 ^(9, 20)	4 ^(2, 11)
	no	1 ⁽¹⁵⁾	5	4	1	6	4 ⁽¹⁵⁾	6	5	5 ⁽¹⁵⁾	1	0
Summary	Yes all measures		-	-	-	-		-	-		-	-
Accuracy^{cd}												
Group difference	Yes	2 ⁽¹⁵⁾	2 ^(3, 9)	1 ⁽³⁾	0	3 ^(3, 9, 17)	3 ^(9, 11, 15)	0	3 ^(11, 17)	6 ^(3, 9, 11, 15, 22, 28)	4 ^(9, 17, 22, 28)	0
	no	1	2	1	0	2	4	1	3	6	1	0
Association	Yes	3 ^(8, 21)	0	0	0	0	1 ⁽²⁶⁾	2 ⁽⁸⁾	0	5 ^(8, 15, 19, 28)	1 ⁽⁹⁾	0

	no	3	6	2	1	4	7	2	4	8	4	0
Agreement	Yes	2 ⁽⁸⁾	0	0	0	0	0	2 ⁽⁸⁾	0	3 ^(5, 8)	0	0
	no	2	1	1	1	0	1	1	1	3	1	0
Summary	Yes all measures	-	-	-	-	-	-	-	-	-	-	-

Yes = question performs well based on criteria in Table 1

No = question did not perform well based on criteria in Table 1

^atotal number of samples in which that food group had a question assessed (>number studies as some had multiple samples in same paper)

^bn=8 studies did not assess reliability of questions

^cn=2 studies did not assess validity of questions

^dstudies assess association and/or agreement

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Figure 1 Quorum statement flow diagram. Validation studies assessing children's food intake using short food questions.

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Author/s:

Golley, RK;Bell, LK;Hendrie, GA;Rangan, AM;Spence, A;McNaughton, SA;Carpenter, L;Allman-Farinelli, M;de Silva, A;Gill, T;Collins, CE;Truby, H;Flood, VM;Burrows, T

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