

Review Article

Measurement of the dimensions of food insecurity in developed countries: a systematic literature review

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Abstract*Objective:* Food insecurity is a salient health issue comprised of four dimensions – food access, availability, utilization and stability over time. The aim of the present study was to conduct a systematic literature review to identify all multi-item tools that measure food insecurity and explore which of the dimensions they assess.*Design:* Five databases were searched (CENTRAL, CINAHL plus, EMBASE, MEDLINE, TRIP) for studies published in English since 1999. Inclusion criteria included human studies using multi-item tools to measure food security and studies conducted in developed countries. Manuscripts describing the US Department of Agriculture Food Security Survey Module, that measures ‘food access’, were excluded due to wide acceptance of the validity and reliability of this instrument. Two authors extracted data and assessed the quality of the included studies. Data were summarized against the dimensions of food insecurity.*Setting:* A systematic review of the literature.*Subjects:* The majority of tools were developed in the USA and had been used in different age groups and cultures.*Results:* Eight multi-item tools were identified. All of the tools assessed the ‘food access’ dimension and two partially assessed the dimensions ‘food utilization’ and ‘stability over time’, respectively. ‘Food availability’ was not assessed by existing tools.*Conclusions:* Current tools available for measuring food insecurity are subjective, limited in scope, with a majority assessing only one dimension of food insecurity (access). To more accurately assess the true burden of food insecurity, tools should be adapted or developed to assess all four dimensions of food insecurity.**Keywords**Nutrition surveys
Epidemiological measurement
Food supply
Food security

Food and nutrition security exists when ‘all people at all times have physical, social and economic access to food, which is safe and consumed in sufficient quantity and quality to meet their dietary needs and food preferences, and is supported by an environment of adequate sanitation, health services and care, allowing for a healthy and active life’⁽¹⁾. The determinants of food insecurity are multifactorial and complex, occur at multiple levels (the individual, social and environmental), and include poverty, social and economic disadvantage, individual characteristics and the political and social environments. Food insecurity can affect all stages of the lifespan^(2–5), resulting in poor dietary intakes and negative health consequences^(6–11). These outcomes place significant burden on health-care systems, thus food insecurity is a significant issue for individuals, households, communities

and nations alike, yet there exists no internationally accepted measurement of individuals’ and households’ food security. Accurate measurement of food security is imperative to understand the magnitude of the issue and to identify specific areas of need, in order to effectively tailor policies and interventions for its alleviation.

The definition encompasses four hierarchical dimensions which are integral to achieve food security. ‘Availability’ refers to a reliable and consistent source of enough quality food for an active and healthy life. At a macro level this has been the primary focus of nation-states; however, simply increasing production is not enough to ensure availability at a household level. The availability of food may include home food production, transport systems to ensure food is available at source points away from where it is grown, and exchange systems for food. Food needs to be available

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in socially acceptable ways, which meet the definition of human dignity. 'Food availability' is realized when people have enough food, of sufficient nutritional quality, available⁽¹²⁾. Availability does not necessarily predict access. 'Access' acknowledges the resources required in order to put food on the table; this could be economic or physical (transport). It refers to the food needed by all household members to meet dietary requirements and food preferences and to achieve and maintain optimal nutritional status. This takes into consideration prioritization of food by the household over other goods and services as well as intra-household distribution of food. 'Food access' requires food availability to be established for it to be achieved, and it is attained when people have adequate economic resources and sufficient physical access to food⁽¹²⁾. 'Utilization' refers to the intake of sufficient and safe food which meets individual physiological, sensory and cultural requirements. It also refers to physical, social and human resources to transform food into meals. It encompasses food safety but also sanitary and hygienic conditions. 'Food utilization' centres on people's ability to choose nutritionally adequate foods and their ability and resources to safely prepare and store them⁽¹³⁾. 'Stability' recognizes that food insecurity can be transitory, cyclical or chronic. 'Stability over time' affects the three aforementioned factors through seasonal and temporary change⁽¹²⁾. Food insecurity therefore may occur when access to or availability of safe, culturally appropriate and nutritious foods is compromised, or when these foods cannot be obtained via socially acceptable means. However, if food security is to exist, then availability, access and utilization need to be stable over time and not be subject to weather variations, food price shifts or civil conflict^(14,15).

The contextual nature and complexity of the issue, combined with the practical considerations of data collection, may make the measurement of food security problematic. Given these complexities, multi-item tools are likely to be able to capture the full extent of the food security spectrum; however, such tools are often long and have significant time and financial implications for data collection, particularly in large-scale monitoring efforts⁽¹⁶⁾. A systematic review by Marques *et al.* in 2014, which searched the literature up to 2011, identified the US Department of Agriculture (USDA) Food Security Survey Module (FSSM) as the only tool in the literature in which psychometric properties had been substantially evaluated, having undergone rigorous testing among a variety of population groups⁽¹⁷⁾. The FSSM measures household food insecurity. It is an eighteen-item measure that assesses the dimension of food access through financial resources, with questions investigating concern about and actually running out of food and instances of reducing amounts and quality of food in a household. The FSSM was developed based on two early instruments: the Community Childhood Hunger Identification Project

(CCHIP) tool and the Radimer/Cornell tool⁽¹⁸⁾. Despite its validity and reliability, the FSSM may not fully capture the extent and magnitude of food security, as its measurement is limited to one dimension of food security^(17,19). In addition, it has not been validated in certain populations, so may not be the most appropriate tool for some groups. There is a need to more fully explore the tools that are available to assess food security, particularly the dimensions they assess.

The present review aimed to update and build on the previous Marques review⁽¹⁷⁾ to identify all reliable and valid multi-item tools, separate to the FSSM, and the dimensions of food security they assess.

Methods

Using the PICO (Population, Intervention, Comparison, Outcome) framework⁽²⁰⁾, the present review aimed to answer the question 'In developed countries, what tools are available for measuring food security, in addition to the USDA FSSM, and what dimensions of food security do they assess?' Describing the prevalence of food insecurity measured by these tools across different countries was beyond the scope of the review.

Eligibility criteria

To avoid unnecessary repetition of the findings of the Marques review⁽¹⁷⁾ that had no search date limit, studies that reported on the FSSM tool were excluded from the present review. Given the variations in both determinants and outcomes of food insecurity between developed and developing countries, and subsequently potential differences in measurement, studies in developing countries were omitted to ensure issues of famine and war did not influence measurement or findings. The authors sought to strengthen generalizability of the findings to the developed country context to support advocacy efforts around monitoring of food insecurity.

Studies were eligible for inclusion if they were conducted in developed countries, as defined by the OECD (Organisation for Economic Co-operation and Development) member countries⁽²¹⁾, and conducted on human subjects. Studies were limited to those published in English as resource limitations prevented article translation. The search was limited to studies published from the year 1999 to current date (June 2014) to ensure newly developed tools were identified. To be included, studies were required to have as their main objectives to measure food insecurity and report on a tool that was multi-item, thus excluding single-item tools which would be unable to assess varying levels of severity of food security. Studies also had to include a tool that assessed food security in at least one of the dimensions (Table 1). All study designs were included, as well studies that measured individual-, household- or community-level food security, to allow a comprehensive scan of the use of tools.

Table 1 Systematic review inclusion and exclusion criteria

Exclusion criteria*	Inclusion criteria
Not a study of interest (NS)	Study of interest
Study conducted in non-humans	Study conducted in humans
Study not related to food insecurity	Study related to food insecurity
Opinion piece, commentary, editorial, conference proceedings, narrative reviews (NS)	Study using scientific method or a review article
Not a population of interest (NP)	Population of interest
People in developing countries, as defined by exclusion from OECD ⁽²¹⁾	People in developed countries as defined by OECD ⁽²¹⁾
Not an outcome of interest (NO)	Outcome of interest
Study does not measure food insecurity	Study does measure food insecurity
Not in English language (Neng)	English language
Not an accessible study (Nacc)	Study accessible
Study not accessible via Monash University library search or Google Scholar Search	Study accessible via Monash University library search or Google Scholar Search
Tool not named or discussed (NT)	Tool named and discussed
Food insecurity measurement may be mentioned, but tool used to measure is not named or discussed	Tool used to assess food insecurity is named and/or discussed
Single-item tool (SIT)	Multi-item tool
Tool used to assess food insecurity contains only one question	Tool used to assess food insecurity contains more than one question
USDA tool (UST)	Not a USDA tool
Tool used to assess food insecurity is the USDA tool	Tool used to assess food insecurity is not the USDA tool
No statistical validity/reliability data (NStat)	Statistical validity/reliability data present and reported
Tool has no statistical validity or reliability data associated with it, or the data are not reported and/or referenced	Tool has statistical validity or reliability data associated with it, and the data are reported in the paper and/or referenced

OECD, Organisation for Economic Co-operation and Development; USDA, US Department of Agriculture.
 *Articles were coded based on first relevant criteria.

Table 2 Systematic literature review search terms and strategy†

Food insecurity	Tool
'food access**	'survey**
'food afford**	'tool**
'food insecure**	'question**
'food poverty**	'measure**
'food secur**	
'food suppl**	
'food sufficien**	
'food insufficien**	
'food desert**	

*Truncation was used at the end of the word in all databases to retrieve all suffix variation.

†The full electronic search strategy for CINAHL database conducted on 1 June 2014 as an example: ('food NEXT access** OR 'food NEXT afford** OR 'food NEXT insecure** OR 'food NEXT poverty** OR 'food NEXT secur** OR 'food NEXT suppl** OR 'food NEXT sufficien** OR 'food NEXT insufficien** OR 'food NEXT desert**) AND ('survey** OR 'tool** OR 'question** OR 'measure**'). Limits: year, >1999; language, English; subjects, human.

Search strategy

The PRISMA (Preferred Reporting Items for Systematic Reviews and Meta-Analyses) protocol, a list of key elements that must be reported when conducting a systematic review⁽²²⁾, was followed. Five databases were searched: CENTRAL, CINAHL plus, EMBASE, Ovid MEDLINE and TRIP, due to their content specificity in health, nutrition and food. Search terms related to the terms, developed countries and tool to assess food security and its dimensions were developed (Table 2). These terms were based on search terms used in the previous systematic review⁽¹⁷⁾ that explored food insecurity measurement. Data were limited to the searching databases with predominantly

peer-reviewed literature; unpublished work or expert opinion was unlikely to contain information about the statistical validity/reliability of the instruments.

Study selection

Studies were identified and subsequently included or excluded through a four-phase screening process. The number of search records and subsequent inclusion and exclusion in each phase are summarized in Fig. 1.

The first phase involved screening the titles and abstracts of articles to determine inclusion and exclusion. All records identified from the search term in each database were filed and handled using EndNote X7TM, and any duplicates were removed. The title and abstract of each article were screened and, based on these, those that were deemed to tentatively meet the inclusion criteria were included; those that did not meet the inclusion criteria were assigned codes indicated in Table 1. Five hundred and fifty articles from the initial search were randomly selected to be cross-checked by two authors (C.P. and S.K.) to ensure concurrence with inclusion and exclusion criteria. Disagreements between the reviewers were discussed and settled by consensus.

The second phase involved reviewing the full text of the articles included from the first phase. In the third phase, remaining studies were divided into categories based on the food security measurement tool they utilized. Papers that used only the USDA tool were excluded (*n* 259). The fourth phase involved excluding studies that did not report any measures of validity or reliability (*n* 45). Those that remained were included in the final analysis.

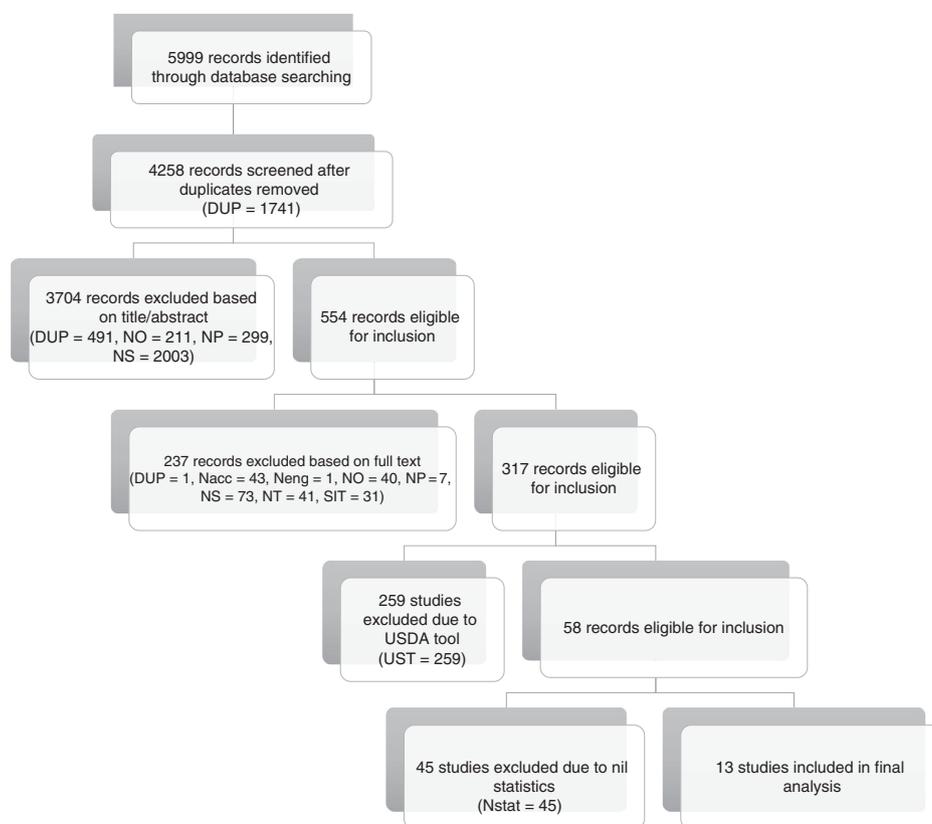


Fig. 1 Systematic literature review study selection flowchart (DUP, duplicate study; NO, not an outcome of interest; NP, not a population of interest; NS, not a study of interest; Nacc, not an accessible study; Neng, not in English language; NT, tool not named or discussed; SIT, single-item tool; UST, US Department of Agriculture (USDA) tool; Nstat, no statistical validity/reliability data)

Data extraction

Data extraction from the selected articles was undertaken independently by two authors, using a spreadsheet that had been designed to answer the research question. The following information was extracted: (i) source of funding/affiliation; (ii) study design; (iii) location/setting of research; (iv) population the tool had been used in; (v) summary of main findings; (vi) name of the tool; (vii) number and type of questions in the tool; (viii) mode of delivery of the tool; (ix) any modifications made to the tool; (x) any statistical measures of reliability, validity, sensitivity or specificity; (xi) level of food security measured; (xii) dimension of food security assessed; (xiii) time period measured; and (xiv) quality of the study and risk of bias as assessed using the American Dietetic Association *Evidence Analysis Manual*⁽²³⁾ based on ten questions related to validity and scoring the study as positive, neutral or negative.

Due to the heterogeneous nature of the included studies, and the need to summarize all available tools as part of the research question, a summary of included studies was prepared⁽²⁴⁾. Differences and commonalities between tools were identified and collated, and described narratively. All studies were weighted equally, despite quality ratings, given that the objective of the study was

to describe all tools that attempted to measure food insecurity with some statistical integrity.

Results

Database searching recovered 5999 records. After exclusion criteria were applied, thirteen studies, describing eight different tools, were included in the final analysis (Fig. 1). The majority of the studies and tools were developed in the USA and had been used in different age groups and cultures (Table 3). The number of items in the tools ranged from two items (Townsend Food Behaviour Checklist and Hager two-item screen) to nine items (CCHIP tool; Table 3).

All of the tools assessed the dimension of food access. The majority of tools (six in total) only assessed food security in accordance with one dimension – food access, including physical and economic resources to access food. Only the Radimer/Cornell tool enquired about anxiety around eating a good meal due to assistance required with preparing food⁽²⁵⁾, and the Kuyper tool attempted to measure stability over time^(26,27). The Radimer/Cornell tool⁽²⁵⁾ also assessed the dimension of food utilization and the Kuyper tool^(26,27) partially assessed the dimension of

Table 3 Characteristics of eight tools that measure food insecurity in developed countries

Instrument	Items	Dimension	No. of items	Food insecurity outcome measurement	Recall period	Instrument integrity (reliability and validity)	Food insecurity level (household or individual)	Quality assessment
Radimer/Cornell ⁽²⁵⁾	<ol style="list-style-type: none"> 1. Do you worry about whether your food will run out before you get money to buy more? 2. Do you worry about whether the food you can afford to buy will be enough? 3. Do you worry about whether you will eat a good meal because you need help with grocery shopping? 4. Do you worry about whether you will eat a good meal because you need help preparing food or feeding yourself? 5. Do you eat the same thing for several days in a row because you only have a few different kinds of food on hand and don't have the money to buy more? 6. Do you run out of the foods you need to put together a meal and don't have money to get more food? 7. Would you say that the food you buy doesn't last and you don't have money to get more? 8. Would you say you are often hungry but don't eat because you don't have enough food? 	Access Food utilization	8	Dichotomous scale: respondents categorized as either 'food secure' or 'food insecure'	Unclear or not measured	Cronbach's $\alpha = 0.94$ Validated for use with diverse, elderly population (no data reported)	Individual	Positive ⁽²⁵⁾
Cornell Child Food Security Measure ⁽⁴³⁾	<p>In the last 3 months:</p> <ol style="list-style-type: none"> 1. Did you worry that food at home would run out before your family got to buy more? 2. Did the food that your family bought run out and your family did not have money to get more? 3. Were you not able to eat a variety of healthy foods at a meal because your family didn't have enough money? 4. Did your meals only include a few kinds of cheap foods because your family was running out of money to buy food? 5. Was the size of your meals cut because your family didn't have enough money for food? 6. Did you have to eat less because your family didn't have enough money to buy food? 7. Did you have to skip a meal because your family didn't have enough money for food? 8. Were you hungry but didn't eat because your family didn't have enough food? 9. Did you not eat for a whole day because your family didn't have enough money for food? 	Access	9	Categorical: four-point scale classifying respondents as 'high food insecurity' (score = 0), 'marginal food insecurity' (score = 1), 'low food insecurity' (score = 2 to 4) or 'very low food insecurity' (score = 5 to 9)	3 months	Cronbach's $\alpha = 0.81$ Tested on a sample of children for face validity Iterative common factors analysis on the nine items identified that one factor (eigenvalue = 3.2) explained 79% of the shared variance	Household	Positive ⁽⁴³⁾

Table 3 *Continued*

Instrument	Items	Dimension	No. of items	Food insecurity outcome measurement	Recall period	Instrument integrity (reliability and validity)	Food insecurity level (household or individual)	Quality assessment
Community Childhood Hunger Identification Project (CCHIP) tool ⁽³⁰⁾	The following questions were asked about the past 12 months: <ol style="list-style-type: none"> 1. Did your household ever run out of money to buy food to make a meal? 2. Did you ever eat less than you felt you should because there was not enough money to buy food? 3. Did you ever tell your parent(s) that you were hungry because there was not enough food in the house? 4. Did you ever go to bed hungry because there was not enough money to buy food? 5. Did you ever cut the size of your meals or did you skip meals because there was not enough money to buy food? 	Access	5	Categorical: three-point scale classifying respondents as 'not hungry' (score = 0), 'at risk of hunger' (score = 1 to 4) or 'hungry' (score = 5)	12 months	Cronbach's $\alpha = 0.77$ Tested a second time on children to test time-to-time reproducibility – Spearman correlation coefficient test (no data reported) Children at the lowest weight percentiles had highest prevalence of risk for hunger ($P = 0.004$)	Household	Negative ⁽³⁰⁾
Hager two-item screen ^(28,29)	Within the past 12 months: <ol style="list-style-type: none"> 1. The food we bought just didn't last, and we didn't have money to get more⁽²⁸⁾ 2. We worried whether our food would run out before we could get more⁽²⁸⁾ Within the past 12 months: <ol style="list-style-type: none"> 1. The food we bought just didn't last, and we didn't have money to get more⁽²⁹⁾ 2. You or others in your household cut the size of your meals or skipped meals because there wasn't enough money for food⁽²⁹⁾ 	Access	2	Dichotomous scale: respondents categorized as either 'food secure' or 'food insecure'	12 months	Sensitivity = 97 % Specificity = 83 % Cronbach's $\alpha = 0.82$ Convergent validity assessed: positive associations with hospitalization, developmental risk, maternal depression; inverse association with mental and physical health, basic needs, parenting and environmental safety ^(28,29)	Household	Positive ^(28,29)
Girard four-point tool ⁽⁶⁾	<ol style="list-style-type: none"> 1. Because of my financial situation, I cannot obtain the products I would like as often as I would like 2. In the last few weeks, you and members of your family have been afraid of running out of food before more money comes in 3. In the last few weeks, you and your family have not had the means to eat a balanced diet 4. In the last few weeks, you have visited a food bank Scale: 'never', 'very seldom', 'seldom', 'quite often', 'very often' and 'always'	Access	4	Dichotomous scale: respondents categorized as either 'food secure' or 'food insecure'	'Last few weeks'	Cronbach's $\alpha = 0.724$ Validity assessed by comparing prevalence of food insecurity identified with previous rates of immigrant food insecurity identified in the Canadian Community Health Survey	Household and individual	Negative ⁽⁶⁾

Table 3 *Continued*

Instrument	Items	Dimension	No. of items	Food insecurity outcome measurement	Recall period	Instrument integrity (reliability and validity)	Food insecurity level (household or individual)	Quality assessment
Kuyper past food insecurity ^(26,27)	<ol style="list-style-type: none"> 1. Do you feel you need to give your child certain food that you didn't have as a child? 2. Did you family eat the same foods every day because there was not enough money or resource for other foods? 3. Were there times of the month or year when your family ran low on food? 4. Did you have to divide very small amounts of meat among family members, because there wasn't enough for everyone? 5. Did you work as a child to earn money to help your family buy food? 6. When you were a child, were there times when your parents did not have enough to eat? 7. When you were a child, were there times when you did not have enough to eat? 	Access Stability over time	7	Dichotomous variable: respondents categorized as either 'past food secure' or 'past food insecure'. Affirmative answers to four or more of the questions included in the tool served to categorize an individual as past food insecure	Retrospectively 'as a child'	Cronbach's $\alpha = 0.84$ Convergent validity assessed: negative correlation between food insecurity and maternal education status; positive correlation with past food insufficiency ⁽²⁶⁾ , childhood ⁽²⁷⁾	Household	Neutral ^(26,27)
Household Food Insecurity Access Scale (HFIAS) ^(8,31,32)	<ol style="list-style-type: none"> 1. Anxiety and uncertainty about food supply 2. Insufficient quality and variety of food 3. Insufficient food intake and its physical consequences 	Access	9	Continuous variable/score (0 to 27): higher score reflects more severe food insecurity. Scores were dichotomized as either 'food secure' or 'food insecure' ⁽⁸⁾ Categorical three-point scale: 'food secure', 'mild/moderately food insecure' or 'severely food insecure' ^(31,32)	Unclear	Cronbach's $\alpha = 0.94$ Validation studies ^(8,31,32) demonstrated that the HFIAS distinguishes food-secure from food-insecure individuals or households across different cultural contexts ⁽³⁰⁾	Individual	Positive ^(31,32) Neutral ⁽⁸⁾
Townsend Food Behaviour Checklist ⁽³³⁾	<ol style="list-style-type: none"> 1. Do you run out of food before the end of the month? 2. Do you worry whether your food will run out before you can buy more? 	Access	2	Four-point categorical scale for each item: 'always' = 1, 'often' = 2, 'sometimes' = 3, 'never' = 4	'Before the end of the month'	Reliability = 0.68 (Q1) Reliability = 0.69 (Q2) Content validation: Q1 inversely correlated with serving of fruit and positively percentage energy from fat Q2 inversely correlated with serving fruit Positive correlation between Q1 and Q2	Individual	Neutral ⁽³³⁾

stability over time. Food availability was not assessed by any tools found in the present review.

Of the eight tools, three assessed individual food security, four assessed household food security and one, the Girard four-point tool, assessed both individual and household food insecurity. No individual instrument was identified that measured community food insecurity (Table 3). All studies used Cronbach's alpha (coefficient of internal consistency) to measure reliability. The tools all yielded moderate to high reliability among the respective samples in which they were used. Only one tool (the Hager two-item screen) was compared with another direct measure of food insecurity (the USDA FSSM) with a reported 97% sensitivity and 83% specificity compared with the USDA FSSM^(28,29). Each of the tools identified had previously been validated among different population subgroups and against different factors known to be associated with food insecurity, with the findings for each tool suggesting satisfactory convergent validity for each respective measure (Table 3). It was however noted that validity was investigated for only one tool (the Cornell Child Food Security Measure). The validity for the remaining tools was based primarily on comparisons with other associated, but separate, factors. All tools relied on self-report and are therefore subjective.

Of the thirteen studies, three were unclear regarding the period of time the respondent was asked to recall, two studies asked for respondents to respond in relation to the past 12 months/past year, two incorporated a recall period spanning the previous 3 months/past few weeks, and one study asked respondents to recall experiences from their childhood. All studies sampled from vulnerable population subgroups that were more likely to be at risk of food insecurity, including older adults, adults with HIV, adults on low incomes and children from low-income families.

Discussion

The present systematic literature review aimed to collate all multi-item tools with statistical integrity that have been used to assess food insecurity in developed countries, separate to the FSSM, and to establish the dimensions of food security assessed by each instrument. The review found that there were eight tools – the Radimer/Cornell tool⁽²⁵⁾, the Cornell Child Food Security Measure, the CCHIP tool⁽³⁰⁾, the Hager two-item screen^(28,29), the Girard four-point tool⁽⁶⁾, the Kuyper past food security tool^(26,27), the Household Food Security Access Scale^(8,31,32) and the Townsend Food Behaviour Checklist⁽³³⁾ – in addition to the FSSM. The main focus of food insecurity measured by these tools was on the food access dimension of food insecurity for individuals and households.

Food access has been comprehensively assessed by the available tools in developed countries, as evidenced by the present systematic review's findings and also a

previous systematic review discussing the FSSM⁽¹⁷⁾. The FSSM provides the most comprehensive assessment of this dimension with regard to economic access to food, and is the most reliable and valid of the available tools to assess food insecurity^(17,19). Using the FSSM, the prevalence of food insecurity in the USA and Canada has most recently been reported as 14.5% and 12.5%, respectively^(34,35). However, despite the initial screening question that provides opportunity to assess across the pillars of food insecurity, the focus of the remainder of the tool (the component used for scoring and classification of food insecurity status) is the limited financial ability to acquire food, which assesses only the food access dimension, leaving the remaining three dimensions unassessed and other elements of the food access dimension unexplored⁽³⁶⁾. Thus it is likely that national monitoring using the FSSM underestimates the true prevalence of food insecurity.

All of the tools identified in the present review focused on the financial constraints associated with acquiring sufficient amounts of food. This is not surprising given the FSSM was developed based on two early instruments, the CCHIP tool and the Radimer/Cornell tool⁽¹⁸⁾, and the fact that access to economic resources is one of the key determinants of food insecurity. By focusing mainly on the experience of running out of food, these tools are likely to identify only those households experiencing more severe levels of food insecurity, subsequently failing to identify those experiencing stress related to acquiring foods, or who may be altering the quality and quantity of foods consumed as coping mechanisms, and as such have not yet actually 'run out of food'. As such, these tools are likely to underestimate the true prevalence of food insecurity⁽³⁷⁾.

Addressing and preventing food insecurity efforts continues to be a challenge in developed countries⁽³⁸⁾. In adopting measures of food insecurity, practitioners and policy makers should aim to incorporate a tool that assesses the spectrum of food insecurity. This should include experiences of anxiety and running out of food, such as measured in the FSSM, and in addition questions that capture utilization, coping mechanisms and stability over time, to ensure more accurate measures of food insecurity.

The focus of the food insecurity assessment and therefore instrument integrity was on vulnerable population subgroups. While there was a range of groups represented by the identified studies, all were considered at high risk of food insecurity. These tools should be applied with caution as tools validated in one country and population will not necessarily be valid in another country or population. Populations were often specific to subgroups, such as the Girard four-point tool, which was tested only with recent immigrants to Canada⁽⁶⁾. The integrity of these tools across higher-income or less-vulnerable populations is not known. As food insecurity is increasingly being reported in higher-income groups^(39,40) there is a need to ensure that the measurement tools used to assess it are valid and

reliable in these populations as well as validated across samples of the general population in developed countries. The focus on food insecurity as only a problem of the poor is evidenced by the studies found in the present review, but needs challenging in light of this emerging new evidence.

The findings of the present review provide insight into short, multi-item tools that policy makers and practitioners alike may consider in the face of limited resources that may restrict the use of the more comprehensive FSSM or its shorter iterations. However, they should be cautioned that these instruments may also underestimate the true prevalence of food insecurity⁽³⁷⁾. To the authors' knowledge there is no evidence to suggest that instruments overestimate the true prevalence of food insecurity. All instruments, despite their limitations, were able to measure food insecurity to some degree, yet the focus was on individuals or households. No individual instrument was identified that measured community food insecurity. This may be due to the fact that multiple methods and instruments, including healthy food basket costs, food outlet mapping and community needs assessment, are recommended to fully understand community-level food insecurity⁽⁴¹⁾. There remains a need to develop a valid and reliable instrument to measure all four dimensions of food insecurity at the household, individual and community levels. Alternatively, in the absence of a comprehensive instrument, other methods may be used to complement these 'food access' assessments, for example food outlet mapping to measure 'availability'.

To our knowledge, the present systematic review is the first using multiple databases and PRISMA guidelines to assess a wide variety of tools, alternative to the FSSM tool, relevant to only developed countries. One limitation of the review was that studies not in English were excluded, potentially omitting food insecurity measurement tools that might have been relevant to the research question, especially in developed countries of South America whose food insecurity issues are significant, and these stories may have strengthened the findings. This may explain why there was a low representation of European countries and tools. However, the focus on developed countries ensured that food insecurity issues of developing countries did not complicate or confuse the findings. In addition, validation studies conducted prior to 1999 would not have been captured in the present review. Another key limitation to our review is that the search terms did not include 'food availability' or 'food utilization' *per se*. The heterogeneous nature of the included studies and the review question meant that combining results and forming a meta-analysis was not possible. Limiting to the review to published work only is a further limitation, potentially omitting new tools in development or those not yet tested. The findings of the present systematic review, in conjunction with previous work by Marques *et al.* (2014)⁽¹⁷⁾ and Keenan *et al.* (2001)⁽⁴²⁾, may be used to

guide decisions by practitioners, researchers and policy makers regarding the measurement and monitoring of food insecurity.

Conclusion

The present systematic literature review aimed to identify and characterize potentially valid and reliable tools, in addition to the FSSM, for the measurement of food insecurity in developed countries and to discuss the underlying dimensions of food insecurity assessed by any tools identified. The findings may provide guidance to practitioners and policy makers in selecting tools to assess food insecurity in situations in which the USDA tool may not be appropriate for use. The review found eight additional tools, shown to have moderate to high internal consistency, and varying levels of validity, among a variety of population subgroups at risk of food insecurity. These tools only measured access to food. There is a need for a valid and reliable instrument to measure all four dimensions of food insecurity at both the household and individual level, as well as to consider accurate measurements of community food insecurity.

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References

1. Food and Agriculture Organization (2012) *Committee on World Food Security. CFS 2012/39 Final Report*. Rome: FAO; available at <http://www.fao.org/3/a-mf115e.pdf>
2. Weinreb L, Wehler C, Perloff J *et al.* (2002) Hunger: its impact on children's health and mental health. *Pediatrics* **110**, e41.
3. Lohman BJ, Stewart S, Gundersen C *et al.* (2009) Adolescent overweight and obesity: links to food insecurity and individual, maternal, and family stressors. *J Adolesc Health* **45**, 230–237.
4. Vijayaraghavan M, Jacobs EA, Seligman H *et al.* (2011) The association between housing instability, food insecurity, and diabetes self-efficacy in low-income adults. *J Health Care Poor Underserved* **22**, 1279–1291.
5. Radermacher H, Feldman S & Bird S (2010) Food security in older australians from different cultural backgrounds. *J Nutr Educ Behav* **42**, 328–336.

6. Girard A & Sercia P (2013) Immigration and food insecurity: social and nutritional issues for recent immigrants in Montreal, Canada. *Int J Migration Health Soc Care* **9**, 32–45.
7. Melchior M, Chastang JF, Falissard B *et al.* (2012) Food insecurity and children's mental health: a prospective birth cohort study. *PLoS One* **7**, e52615.
8. Weiser SD, Bangsberg DR, Kegeles S *et al.* (2009) Food insecurity among homeless and marginally housed individuals living with HIV/AIDS in San Francisco. *AIDS Behav* **13**, 841–848.
9. Lee JS & Frongillo EA Jr (2001) Understanding needs is important for assessing the impact of food assistance program participation on nutritional and health status in US elderly persons. *J Nutr* **131**, 765–773.
10. Bihan H, Castetbon K, Mejean C *et al.* (2010) Socio-demographic factors and attitudes toward food affordability and health are associated with fruit and vegetable consumption in a low-income French population. *J Nutr* **140**, 823–830.
11. Tarasuk VS (2001) Household food insecurity with hunger is associated with women's food intakes, health and household circumstances. *J Nutr* **131**, 2670–2676.
12. Gross R, Schoeneberger H, Pfeifer H *et al.* (2000) The four dimensions of food and nutrition security: definitions and concepts. *SCN News* **20**, 20–25.
13. Barrett CB (2010) Measuring food insecurity. *Science* **327**, 825–828.
14. Ecker O & Breisinger C (2012) *The Food Security System: A New Conceptual Framework*. Washington, DC: International Food Policy Research Institute.
15. Carletto C, Zezza A & Banerjee R (2013) Towards better measurement of household food security: harmonizing indicators and the role of household surveys. *Glob Food Sec* **2**, 30–40.
16. Masters G, Coles-Rutishauser I, Webb K *et al.* (2006) *National Food and Nutrition Monitoring and Surveillance System: A Framework and a Business Case*. Sydney: Nexus Management Consulting.
17. Marques ES, Reichenheim ME, de Moraes CL *et al.* (2015) Household food insecurity: a systematic review of the measuring instruments used in epidemiological studies. *Public Health Nutr* **18**, 877–892.
18. Carlson S, Andrews M & Bickel G (1999) Measuring food insecurity and hunger in the United States: development of a national benchmark measure and prevalence estimates. *J Nutr* **129**, 2S Suppl. 510S–516S.
19. Bickel G, Nord M, Price C *et al.* (2000) *Measuring Food Security in the United States. Guide to Measuring Household Food Security, Revised 2000*. Alexandria, VA: US Department of Agriculture.
20. Moher D & Tricco AC (2008) Issues related to the conduct of systematic reviews: a focus on the nutrition field. *Am J Clin Nutr* **88**, 1191–1199.
21. Organisation for Economic Co-operation and Development (2016) List of OECD Member countries – Ratification of the Convention on the OECD. <http://www.oecd.org/about/membersandpartners/list-oecd-member-countries.htm> (accessed March 2016).
22. Oxford University & Ottawa Hospital Research Institute (2015) Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA). <http://www.prisma-statement.org/> (accessed March 2016).
23. American Dietetic Association (2008) *Evidence Analysis Manual: Steps in the ADA Evidence Analysis Process*. Chicago, IL: American Dietetic Association.
24. Popay J, Roberts H, Sowden A *et al.* (2006) Guidance on the conduct of narrative synthesis in systematic reviews. A product from the ESRC methods programme Version 1. http://www.lancaster.ac.uk/shm/research/nssr/research/dissemination/publications/NS_Synthesis_Guidance_v1.pdf (accessed May 2016).
25. Gollub EA & Weddle DO (2004) Improvements in nutritional intake and quality of life among frail homebound older adults receiving home-delivered breakfast and lunch. *J Am Diet Assoc* **104**, 1227–1235.
26. Kuyper EM, Espinosa-Hall G, Lamp CL *et al.* (2006) Development of a tool to assess past food insecurity of immigrant Latino mothers. *J Nutr Educ Behav* **38**, 378–382.
27. Kuyper EM, Smith D & Kaiser LL (2009) Does food insecurity influence child feeding practices? *J Hunger Environ Nutr* **4**, 147–157.
28. Hager ER, Quigg AM, Black MM *et al.* (2010) Development and validity of a 2-item screen to identify families at risk for food insecurity. *Pediatrics* **126**, e26–e32.
29. Swindle T, Whiteside-Mansell L & McKelvey L (2013) Food insecurity: validation of a two-item screen using convergent risks. *J Child Fam Stud* **22**, 932–941.
30. Jimenez-Cruz A, Bacardi-Gascon M & Spindler AA (2003) Obesity and hunger among Mexican-Indian migrant children on the US–Mexico border. *Int J Obes Relat Metab Disord* **27**, 740–747.
31. Weiser SD, Hatcher A, Frongillo EA *et al.* (2013) Food insecurity is associated with greater acute care utilization among HIV-infected homeless and marginally housed individuals in San Francisco. *J Gen Intern Med* **28**, 91–98.
32. Weiser SD, Yuan C, Guzman D *et al.* (2013) Food insecurity and HIV clinical outcomes in a longitudinal study of homeless and marginally housed HIV-infected individuals in San Francisco. *AIDS* **27**, 2953–2958.
33. Townsend MS, Kaiser LL, Allen LH *et al.* (2003) Selecting items for a food behavior checklist for a limited-resource audience. *J Nutr Educ Behav* **35**, 69–82.
34. Coleman-Jensen A, Nord M & Singh A (2013) *Household Food Security in the United States in 2012: Statistical Supplement. Administrative Publication* no. AP061. Washington, DC: US Department of Agriculture, Economic Research Service.
35. Tarasuk V, Mitchell A & Dachner N (2015) Household Food Insecurity in Canada, 2013. <http://proof.utoronto.ca/resources/proof-annual-reports/annual-report-2013/> (accessed April 2016).
36. Nord M & Hopwood H (2007) Recent advances provide improved tools for measuring children's food security. *J Nutr* **137**, 533–536.
37. Nolan M, Rikard-Bell G, Mohsin M *et al.* (2006) Food insecurity in three socially disadvantaged localities in Sydney, Australia. *Health Promot J Aust* **17**, 247.
38. Burns C, Kristjansson B, Harris G *et al.* (2010) Community level interventions to improve food security in developed countries. *Cochrane Database Syst Rev* issue 12, CD008913.
39. Tarasuk V & Vogt J (2009) Household food insecurity in Ontario. *Can J Public Health* **100**, 184–188.
40. Gundersen C & Garasky S (2012) Financial management skills are associated with food insecurity in a sample of households with children in the United States. *J Nutr* **142**, 1865–1870.
41. Cohen B (2002) *Community Food Security Assessment Toolkit*. Washington, DC: US Department of Agriculture, Economic Research Service.
42. Keenan D, Olson C, Hersey J *et al.* (2001) Measures of food insecurity/security. *J Nutr Educ* **33**, Suppl. 1, S49–S58.
43. Sharkey JR, Nalty C, Johnson CM *et al.* (2012) Children's very low food security is associated with increased dietary intakes in energy, fat, and added sugar among Mexican-origin children (6–11 y) in Texas border Colonias. *BMC Pediatr* **12**, 16.