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Internal validity and reliability of experience-based household food insecurity scales in Indian settings

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Abstract

Background: Experience-based household food insecurity (HFI) scales are not included in large-scale Indian surveys. There is limited evidence on which experience-based HFI scale or questions within a scale are most relevant for India. Between 01 June and 31 August 2015, we reviewed 19 published and unpublished studies, conducted in India between January 2000 and June 2015, which used experience-based HFI scales. As part of this exercise, internal validity and reliability of the scale used in these studies was examined, field experiences of 31 researchers who used experience-based HFI scales in India were gathered and psychometric tests were conducted where raw data were available.

Results: Out of the 19 studies reviewed, HFI prevalence varied depending on the type of experience-based HFI scale used. Internal reliability across scales ranged between 0.75 and 0.94; however certain items ('balanced meal', 'preferred food', 'worried food would run out') had poor in-fit and out-fit statistics. To improve this, the following is suggested, based on review and experience of researchers: (1) cognitive testing of quality of diet items; (2) avoiding child-referenced items; (3) rigorous training of enumerators; (4) addition of 'how often' to avoid overestimation of food-insecure conditions; (5) splitting the cut and skip meal item and (6) using a standardized set of questions for aiding comparison of construct validity across scales.

Conclusions: An evidence-based policy dialogue is needed in India for contextualizing and harmonizing the experience-based HFI scales across multiple surveys to aid comparability over time, and support policy decision making.

Keywords: Food security, Hunger, Validity, Reliability

Background

Nearly 40% of Indian children under 5 years of age (~47 million) are chronically undernourished, with over half (51%) of children in the poorest wealth quintiles being affected [1]. Household food insecurity (HFI) is a key determinant of chronic undernutrition in Indian children, particularly for those living in income-insecure households. HFI is defined as the inability of a household to acquire or consume adequate quantity or quality of food. As severity of HFI increases, steps taken by the household to cope with it become more intense, starting

from adjusting the food budget to adults reducing their food intake and experiencing hunger, and finally the children experiencing reduced food intake and hunger [2].

Measurement of HFI experiences is not routinely included in large-scale demographic Indian surveys. The National Sample Survey Organization (NSSO) survey includes only one question on household daily access to food, which is inadequate to comprehensively capture the intensity of HFI [3]. The National Family Health Survey (NFHS) measures diet diversity, but not HFI.

Globally, there are four composite validated questionnaires available for measuring HFI experiences of households as reported by respondents. The first is the 18-item scale developed by Hamilton et al. [4], which served as

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a model for subsequent experience-based HFI scales. It captured four types of HFI experiences: (1) uncertainty and worry about food; (2) inadequate food quality; (3) insufficient food quantity for adults; and (4) insufficient food quantity for children. It supported differentiation of four categories of HFI across diverse settings: high food security, marginal food insecurity, low food insecurity and very low food insecurity. The 18-item scale was followed by a 6-item sub-set developed by Blumberg et al. [5] that differentiated three categories of HFI experiences faced by adults—high or marginal food security, low food security and very low food security, but did not measure the most severe range of adult food insecurity, in which children's food intake is likely to be reduced. In 2000, the Food and Nutrition Technical Assistance (FANTA) project adapted the 18-item scale to developing country contexts and came up with the 9-item Household Food Insecurity Access Scale (HFIAS) (hereafter called the 9-item scale). The 9-item scale captured four categories of HFI experiences: food secure, mildly food insecure, moderately food insecure and severely food insecure [6]. The fourth and latest addition is the 8-item Food Insecurity Experience Scale (FIES) (henceforth called the 8-item scale) to measure individual food insecurity (FI) developed by the Food and Agriculture Organization of the United Nations (FAO) and tested for use globally through Gallup surveys. The 8-item FIES can identify four categories of individual FI, but can be modified to measure HFI as well. While FIES recommends each country to arrive at FI categorization meaningful to its context, it does provide a raw score-based categorization for researchers who find it beneficial. These are high food security (raw score 0), marginal FI (raw score 1–3), moderate FI (raw score 4–6) and severe FI (raw score 7–8) [7]. Items (i.e. questions) included in the above-mentioned HFI scales are detailed in Table 1.

The Rasch model helps detect internal validity and internal reliability of the experience-based measures of HFI [8]. The Rasch model has its roots in psychometry and Item Response Theory, wherein the construct of interest is 'experience-based HFI' and the items representing the underlying phenomenon are arranged along a continuum of 'severity' [9]. The internal validity is established through face validity, fit statistics, item residual correlation and differential item functioning (DIF). Face validity compares a concept as understood by the target audience with the operational definition of the concept [10]. Item fit statistics help verify whether each item comprising the scale is associated equally strongly with successive stages of HFI [9] and in-fits between 0.7 and 1.3 are acceptable [11]. DIF helps examine whether items are behaving differently for particular subgroups of determined respondents, i.e. by race, sex or ethnicity.

The underlying cause of DIF could be either that those respondents in two subpopulations understand the question differently, or they experience or manage FI differently [12]. Cronbach's α and point bi-serial correlations are helpful to ascertain internal reliability; however, they have several limitations [13] and Rasch reliability can be used instead. External validation that can be established by associating experience-based HFI measures with factors considered to be determinants or outcomes, such as income, nutrition status and food expenditure, is done, and this is termed as construct validation [4].

There is limited evidence on which of the above globally recommended and validated experience-based HFI scales and/or questions in these scales are suitable for India. To fill this information gap, this paper maps the use of experience-based HFI scales in India and reviews their internal validity and reliability, with the aim to inform policy decisions on inclusion of suitable experience-based HFI questions in the large-scale national Nutrition or Demographic Health Surveys in India.

Methods

The study's geographic scope is India (rural, tribal, urban). It uses a mix of analytic methods including desk review of published/unpublished studies on HFI in India; mapping and interviewing researchers contributing to these studies to record their experiences; and future recommendations and psychometric analyses for studies where raw data were available.

For the desk review, a literature search of HFI in India, conducted between 2000 and 2015, was undertaken. Studies written in English were included. Search engines, including PubMed, Web of science, Medline and Scopus, were used. Search terms applied were 'experience-based', 'experiential', 'food insecurity', 'hunger', 'Rasch model', 'food security scales', 'food security measurement' and 'India'. The search period was 1 June–31 August 2015.

To gain access to grey literature (papers/reports), a contact list was generated of 31 researchers who have conducted relevant work in India (14 from non-governmental organizations and 17 from academia). Subsequently, an email questionnaire was sent to the identified 31 researchers. Of these, 22 responded affirmatively and provided information to at least three of the four questions and also shared their reports/papers: (1) Which questions have been the most applicable in your context?; (2) which questions have been the most difficult to understand for the respondents in your context?; (3) concern(s) with translating the questions in local language; and (4) any feedback regarding future application of the scale?

From the 31 researchers contacted and from search across various Boolean operators during the search

Table 1 Food security scale questionnaire: various scales

Items	18-item US HFSSM	6-item short form US HFSSM	9-item HFIAS	8-item FIES
Recall period	12 months	12 months	30 days	12 months
Worried food would run out/not have enough food	✓	×	✓	✓
Food bought just didn't last/household ran out of food	✓	✓	×	✓
Couldn't afford to eat balanced meals/healthy/nutritious food	✓	✓	×	×
Cut the size or skip meals	✓	✓	×	×
Did you ever eat less than you felt you should	✓	✓	×	×
Hungry but didn't eat	✓	✓	×	×
Lose weight because there wasn't enough money for food	✓	×	×	×
Not eat for a whole day because there wasn't enough money for food?	✓	×	×	×
Relied on only a few kinds of low-cost food to feed child/the children	✓	×	×	×
Couldn't feed child/the children a balanced meal	✓	×	×	×
Child/children not eating enough	✓	×	×	×
Cut size of child's meals	✓	×	×	×
Child/children ever skip meals	✓	×	×	×
Child/children ever hungry	✓	×	×	×
Child/any children not eat for a whole day	✓	×	×	×
Not able to eat preferred foods	×	×	✓	×
Eat limited variety of foods/few kinds of foods	×	×	✓	✓
Eat some foods you really did not want to eat	×	×	✓	×
Eat a smaller [meal] than you felt you needed	×	×	✓	×
Eat [fewer meals in a day]/ate less	×	×	✓	✓
No food to eat of any kind in your household because of lack of resources to get food?	×	×	✓	×
Sleep at night hungry	×	×	✓	×
Whole day and night without eating anything/went without eating for a whole day	×	×	✓	✓
Skip a meal	×	×	×	✓
Hungry but did not eat	×	×	×	✓
Any of the children younger than 5 years old: did not eat healthy and nutritious foods	×	×	×	✓
Any children younger than 5 years old was not given enough food	×	×	×	✓

period, 19 studies were identified that had their survey instrument tested for at least one of the measures of internal validity and internal reliability. For each of the 19 studies, an excel spreadsheet was prepared, listing study objective, study setting, sample size, period of survey, study population, survey respondents, recall period, type of scale used and information on scale's reliability statistics (Cronbach's α , point bi-serial correlation, Rasch reliability, classification reliability), and validity statistics (face validity, conceptual validity, fit statistics, residual correlations and DIF) (Table 2). Cross-cultural validity for equally worded items across studies was compared by four domain areas: (1) worry/anxiety related to food budget/food supply; (2) perceptions of inadequate food quality or quantity; (3) reported instances of reduced

food intake or its consequences for adults; (4) reported instances of reduced food intake or its consequences for children. To evaluate the external validity of the HFI scales across 19 studies, information was collated on bivariate or multivariate association of HFI status with respect to its determinants and consequences.

Results

In total, 19 experience-based HFI studies in Indian settings were identified during the study period. All studies were household-based and cross-sectional (Table 2).

Experience-based HFI scales used in Indian settings

The *18-item scale* and its adaptations have been used across six studies. In urban Vellore [14], they used the

Table 2 Summary of published/unpublished work on experiential household food security scales, India, 2000–2015

ID	Authors	Setting	Period of study	Sample size	Study population	Respondent	Language	Type of scale	Recall period	Internal reliability/validity	Food security status
1	Nord et al. [11] ^a	Rural Orissa	2000–2001	282	All adults and children in the household	–	Oriya	9-item scale adapted from 18-item US HFSSM ^b	30 days	In-ft: 0.75–1.11 High out-fit: balanced meal, ate less and cut-skip meal	Food secure: 8.0% Food insecure: 92.0% (with 57.0% food insecure with hunger)
2	MSF [23]	Chittagong Hill Tracts Sajek Union bordering Bangladesh and Mizoram, India	March–April 2008	151 households from 34 villages	Children aged 1–5 years	Adult females/males in the household.	Bengali	9-item FANTA HFIAS version 3	30 days	–	Food secure: 4.0% Mildly food insecure: 4.6% Moderately food insecure: 11.9% Severely food insecure: 79.5%
3	Agarwal et al. [21]	Slum in north-east Delhi	June–July 2008	410	All adults in household	Adult female involved in cooking/purchasing food	Hindi	4-item scale adapted from 6-item shorter version of US HFSSM ^c	12 months	Cronbach's α : 0.8 In-ft: 0.77–1.07 High out-fit: cut meal/skip meal	Food secure: 9.0% Food insecure: 51% (with 27.1% food insecure without hunger and 23.9% food insecure with hunger)
4	Agarwal et al. [22]	75 slums of Meerut city	October 2007–March 2008	40,016	Women of reproductive age (WRA)	Adult female	Hindi	4-item scale adapted from 6-item shorter version of US HFSSM ^d	12 months	Point bi-serial correlation: 0.43–0.59 Cronbach's α : 0.725 In-ft - 0.52–1.11 High out-fit: nutritious food	Food insecure: 74.2% (with 31.5% food insecure without hunger and 42.7% with hunger)
5	Pasricha et al. [24]	Rural Karnataka	–	415	Children aged 12–23 months	Mothers of children	Kannada	9-item FANTA HFIAS version 3	30 days	–	Food secure: 42.0% Food insecure: 58.0%
6	Gopichandran et al. [14]	Tamil Nadu, Vellore (urban)	May/June 2009	130	All adults and children in household	Head of household/housewife	Tamil	18-item USHFSSM	12 months	–	Food secure: 25.4% Food insecure with hunger: 61.5% Food insecure without hunger: 13.1%

Table 2 continued

ID	Authors	Setting	Period of study	Sample size	Study population	Respondent	Language	Type of scale	Recall period	Internal reliability/validity	Food security status
7	Mukhopadhyay et al. [18]	Bankura-1 CD block district, West Bengal	July–August 2009	267 tribal households	All adults in household	Head of household/responsible adult family member, preferably a woman	Bengali	A validated Bengali version of the US 6-item short form food security scale	12 months	$\kappa > 0.84$ Cronbach's α : 0.82	47.2% households had high or marginal food security, whereas 29.6% and 23.2% had low and very low food security, respectively. The prevalence of low and very low food security was higher among households having children aged under-five (31.2 and 24.3%, respectively) compared to households without children under-five (24.6 and 20.0%, respectively)
8	Mukhopadhyay and Biswas [19]	Bankura-1 CD block district, West Bengal	July–August 2009	188 tribal households	Tribal children aged 24–59 months	Mothers of the children	Bengali	A validated Bengali version of the 6-item shorter version of US HFSSM	12 months	Same as above	High/marginal food security: 46.8% Low food security: 28.7% Very low food security: 26.5%
9	Chatterjee et al. [25]	Three slums in north-west Mumbai	January–March 2010	283	All adult members	Adult female	Marathi	9-item FANTA HFIAS	30 days	–	Food secure: 23.7% Severely food insecure: 59.7% Mild to moderate food insecure: 16.6%
10	Chinnakali et al. [26]	A resettlement colony in south Delhi		250	All adult members	Females aged 18–50 years	Hindi	9-item FANTA HFIAS	30 days	–	Food insecure: 77.2% (with 49.2% households being mildly food insecure, 18.8% households moderately food insecure and 9.2% households severely food insecure)

Table 2 continued

ID	Authors	Setting	Period of study	Sample size	Study population	Respondent	Language	Type of scale	Recall period	Internal reliability/validity	Food security status
11	Maitra [30]	15 slums in Kolkata Metropolitan Corporation (KMC) area	April 2010–January 2011	500	All adults and children	Head of household/adult female in charge of kitchen	Bengali	9-item adult scale and 5-item child scale adapted from 18-item US HFSSM ^e	30 days	9-item adult scale Cronbach's α : 0.85 Rasch reliability: 0.75 Sensitivity: 0.83 Specificity: 0.97 Positive predictive value: 0.85 In-ft: 0.7–1.3 High out-fit: never cooked rich meal	9-item adult 'ever' scale Food insecure: 15.4% (with 12.8% moderately food insecure and 2.6% severely food insecure) Food secure: 84.6% (with 76.2% highly food secure and 8.4% marginally food secure) 5-item child scale Food insecure: 20.4% households Highly food secure: 70.7% households (with 7.9% households having children who were marginally food secure)
12	UHRC [15]	Slum in north-east Delhi	June–July 2011	232	Children aged below 5 years	Adult female aged ≥ 18 years involved in cooking and purchasing food	Hindi	8-item child food security scale based on US HFSSM	30 days	5-item child scale Rasch reliability: 0.94 Sensitivity: 0.87 Specificity: 0.97 Positive predictive value: 0.89 In-ft: 0.63–1.25 High out-fit: child could not eat three square meals	Households where children are food secure: 0.4% Marginally food secure: 8.6% Food insecure without hunger: 27.6% Food insecure with hunger: 63.4% Food secure: range 45.0–81.0% Low food insecurity: range 18.0–49.0% Very low food insecurity: range 1.0–15.0% Food insecure: 38.1% of children
13	Gupta et al. [16]	Four Delhi slums	August 2011–October 2012	446	WRA (15–45 years) with children (6–35 months)	Mothers involved in cooking and purchasing food	Hindi	8-item child scale based on 18-item USHFSSM	12 months		
14	Gupta et al. [17]	Four Delhi slums	2012	446	WRA (15–45 years) with children (6–36 months)	Mothers involved in cooking and purchasing food	Hindi	8-item child scale based on 18-item USHFSSM	12 months		

Table 2 continued

ID	Authors	Setting	Period of study	Sample size	Study population	Respondent	Language	Type of scale	Recall period	Internal reliability/validity	Food security status
15	Nord and Cafero [29]	Rural/urban India	2012 Gallup World Poll Survey	2540	Adult men and women aged 15+ years, children aged <15 years	Randomized adult (aged 15+) in household	Multiple: Hindi (n = 1480), Marathi (n = 280), Bengali (n = 230), Telegu (n = 210), smaller numbers of Gujarati, Kannada, Malayalam, Tamil, Oriya, Punjabi and Assamese	FIES ^f 8 adult items 7 child items	12 months	Adult scale In-fits: 0.7–1.3 except item 'ran out' (1.38) Rasch reliability: 0.72 Child scale (6 items) In-fits: acceptable range 0.7–1.3 Combined adult-child scale In-fits: acceptable range 0.7–1.3	Not available
16	IIPS-UNICEF [28]	Maharashtra state — aggregate/rural/urban	February–April 2012	2630	Household with children below 2 years of age	Household member, primarily involved in the food preparation	Marathi/English	FANTA 9-item HFIA5	30 days	Maharashtra basic dichotomous (yes/no) scale Cronbach's α : 0.91 Rasch reliability: 0.818 In-fits: 0.62–1.29 High out-fits: worried (4.50), preferred food (5.99), hungry (7.04) and whole day (11.54) Maharashtra polytomous scale Rasch reliability: 0.807 In-fits: 0.77–1.45 In-fit for worried is high High out-fit: worried, hungry and whole day	Food secure: 57.0% Mildly food secure: 17.0% Moderately food secure: 13.0% Severely food insecure: 14.0%

Table 2 continued

ID	Authors	Setting	Period of study	Sample size	Study population	Respondent	Language	Type of scale	Recall period	Internal reliability/validity	Food security status
17	Wright and Gupta [20]	A slum from north-east Delhi	2010	105	Convenience sample of members in families receiving care at health centres and clinics	WRA (18–45 years) who were responsible for food procurement	Hindi	6-item shorter version of US HFSSM	12 months		Food insecure: 57.0%
18	Nord and Cafiero [29]	Rural/urban India	2014 World Poll Survey	3000 (nationally representative sample)	Men and women aged 15+ years	Randomized adult (aged 15+ years) in household	Multiple. Hindi (n = 1480), Marathi (n = 280), Bengali (n = 230), Telugu (n = 210), smaller numbers of Gujarati, Kannada, Malayalam, Tamil, Oriya, Punjabi and Assamese	Extended FIES 8 adult items (plus 2 child items if child aged under-five lived in the household) ⁹	12 months	In-fit: 0.7–1.3 for 8 items and excellent for 7 (0.8–1.2) Rasch reliability: 0.72 Extended FIES (hungry and whole day trichotomous) All Rasch-Thurstone in-fit statistics were in an excellent range 0.8–1.2 Overall item in-fit statistics good for all 8 items (0.7–1.3) Rasch reliability: 0.82	Not yet released
19	IFPRI [27]	Odisha	2015	–	–	–	–	9-item FANTA HFIAS	30 days	In-fits: 0.92–1.36 (high in-fit—preferred food) High out-fit: preferred food	Not available

All studies are household-based cross-sectional studies

^a The survey and initial adaptation of the 18-item US HFSSM in rural Odisha was undertaken by Nikhil Raj and Anup Satpathy. Dr. Mark Nord joined the project at a later stage to undertake the psychometric assessment of the scale. The original paper is cited as: Raj and Satpathy [34]

^b The items 'adult/child cut size-skip meal' have the follow-up question 'how often'

^{c,d} Three items have the follow-up question 'how often'. Only 'slept hungry' had no follow-up

^e All items except 'did you get rich food' and 'did adult/child lose weight' were followed by frequency of occurrence

^f No follow-up question 'how often'

⁹ Extension was to include 'how often' follow-up questions to the two most severe questions (hungry and whole day). Response options: 'only once or twice', 'in some months but not every month', 'almost every month'. Partial credit Rasch model analysis. Child items were for research purposes and not included in the scale

original 18-item scale that combines the adult–child item. In the Kolkata slum study, Maitra [30] used nine adult items and five child items. In rural Odisha [11], researchers adapted the 18-item scale to construct a 9-item adult–child combined scale. Three Delhi-based slum studies used only the eight child items as they intended to assess child FI [15–17]. Five studies used the 6-item scale. Bankura district studies [18, 19] and a north-east Delhi slum study [20] used the original version of the 6-item scale. Delhi [21] and Meerut [22] slum studies shortened it to a 4-item scale. The 9-item *FANTA* scale has been used in six studies: rural Mizoram [23], Karnataka [24] Mumbai slums [25], Delhi urban resettlement colony [26], rural Odisha [27] and state-wide Maharashtra nutrition survey [28]. The 8-item *FIES* scale has been used in the nationwide Gallup World Poll (GWP) 2014 survey and its 2012 feasibility study [29].

Six studies were in rural settings [11, 18, 19, 24, 27], and the remaining ten were urban slums/resettlement colonies. Sample size varied from 130 [14] to 40,000 [30]. The GWP 2014 survey and Maharashtra survey sampled between 2000 and 3000 households and were representative for nation and state, respectively [28, 29]. The survey tool was locally adapted in all studies.

The respondents were mostly women of reproductive age, except in five studies [12, 16, 17, 26, and 27] where respondents were head of household or any responsible adult family member, preferably a woman. For two studies [11, 27], information on respondents was not available.

Studies using the 9-item scale used a 30-day recall period, and those studies using *FIES* and the 6-item scale or its adaptations used a 12-month recall period. The Kolkata slums and rural Odisha studies reported using a 30-day recall period while using the 18-item scale for recall accuracy [11, 30] although a 12-month recall period is recommended. Only one of the three studies that used the child-referenced items of the 18-item scale [15] reported experiencing difficulty with a 12-month recall period and, hence, used a 30-day recall period.

All studies that used the 9-item scale used standard frequency of occurrence options. The 18-item version of the scale has frequency of occurrence questions for selected items. These options were followed in the Vellore study [14] and child food security studies in Delhi slums [15–17]. However, the Kolkata slum study incorporated a frequency of occurrence question after every ‘occurrence’ question except the questions on ‘eating rich food’ and ‘losing weight’ and tweaked the frequency of response options to: ‘often’ (a few times most weeks), ‘sometimes’ (1 or 2 weeks but not every week) and ‘rarely’ (only a few days in a month/1 or 2 days) [30].

Studies using the 6-item scale have used the standard frequency of occurrence options with minor variations—for example, while the Delhi survey [21] defined ‘often’ as ‘10–12 months’ or ‘almost every month’ and ‘sometimes’ as ‘3–9 months’, the Meerut survey [22] worded ‘often’ as ‘few times in most months’ or ‘almost every month’ and ‘sometimes’ as ‘6–12 times past year’. The rural Odisha survey [11] did not use any frequency of occurrence response. India is among the few countries of the GWP 2014 survey in which affirmative responses to the two most severe questions ‘hungry’ and ‘whole day’ were followed up with frequency of occurrence options [29] such as ‘only once or twice’, ‘in some months but not every month’ and ‘almost every month’.

Prevalence thresholds used across experience-based HFI scales

Fifteen of the nineteen studies used standard recommended raw score thresholds for classifying HFI. The rural Odisha study [11], Delhi slum studies [21], Agarwal et al. [22] and Kolkata slum study [30] used locally meaningful cut-off for raw scores to capture local context. Not surprisingly, HFI prevalence varied depending on the type of scale used and geographic context (Table 2).

Internal reliability and validity

For nine studies with information on psychometric analysis, the item and household severity parameters have been reported (Table 2). For studies using the 18-item scale [11, 30], in-fits were in acceptable range for adult items (0.7–1.13) and out-fits were high for ‘balanced meal’ (4.96), ‘ate less’ (3.07), ‘child cut size-skip meal’ (1.95) in the Odisha study [11] and for ‘rich meal’ (5.00) in the Kolkata study [30].

The adapted 6-item scale into four-items was administered in Delhi and Meerut slums [21, 22] with in-fits ranging from 0.52 to 1.11 and variant out-fits (0.63–11.22), particularly for ‘cut size-skip meal’ and ‘nutritious meal’.

Using the 9-item scale, the Odisha study [27] reports item in-fits of 0.84–1.36, with high in-fit (1.36) and out-fit (1.47) for the item ‘preferred food’. In Maharashtra study [28], in-fits were variant (0.62–1.29), largely owing to erratic responses for the items ‘worried’, ‘preferred food’, ‘hungry’ and ‘whole day’. The residual correlation between ‘smaller’ and ‘fewer’ is excessive (0.63) (Table 2).

GWP 2014 survey results [29] on internal validity are available for the dichotomous 8-item scale and the extended trichotomous 8-item scale with ‘hungry’ and ‘whole day’ (i.e. followed up by ‘how often’ questions with three response options), all Rasch–Thurstone in-fit statistics were acceptable (0.7–1.3), and Rasch reliability was 0.82.

All nine studies reported consistency in ordering of items corresponding to anxiety and quality of food (e.g. 'worried', 'preferred food', 'limited variety') being at the lower end of the scale and the items relating to drastic reduction in adult intake (e.g. 'hungry' and 'whole day') being at the higher end of the scale. In between lie the questions on graduated reduction in quality or intake ('food not want' or 'smaller meal'). Occasional overlaps in ordering of responses to some of the questions are noted, the most striking result being the item 'lost weight' (adult-referenced), while 'personally eating less' and 'rich food' having very low severity in the Kolkata slum study [30] and the item 'preferred food' having relatively lower severity than expected in the rural Odisha study [11].

Cross-cultural validity

For most items, severity of equally worded items was comparable for domains pertaining to reducing quantity of food reduced food intake, but not those relating to worry/anxieties related to food budget and perceptions of inadequate food quality (Table 3).

External validation

There was a positive linear relation that children from food-insecure households have poor nutritional status in studies where construct validity was established [19, 21, 28].

Discussion

Low in-fits for selected items across scales

In-fit statistics for one or more items in seven of the nine studies where fit statistics were reported were not in the expected range of 0.7–1.3, owing to either low in-fits or extremely high out-fits on selected items [11, 21, 22, 27–30]. Variant out-fits/in-fits were particularly noted for items such as 'worried', 'balanced meal', 'preferred food', 'rich meal', 'adult/child cut-skip meal', 'nutritious meal'. These results show either poor interviewee or interviewer understanding of the questions, proper wording of items and, hence, a need for more robust pre-testing and contextualization. A rephrasing of and elaboration of the questions to arrive at suitable answers may help improve the in-fits. Evidence on the 'uncertainty and anxiety' items is mixed, demonstrating weak association of the item with the underlying latent trait of experience-based HFI in India and an indication that worrying about food is not a common concept in all cultures and redundancy of some 'worry/anxiety' items for deprived environments [31].

Quality-related items are problematic

Major concerns emerge on items/questions related to the 'inadequate food quality' domain, adult or child specific.

First, the 'balanced meal' item may be speculated to be not applicable in the Indian low-income zones unless accompanied by relevant and suitable examples, due to lack of equivalent expression for the phrase in the Indian context. Attempts to replace the expression 'balanced meal' by expressions such as 'healthy and varied diet' (child-referenced) or 'nutritious meal' (adult-referenced) have also met with problems in some studies indicating the need for care during translation in a well-understood language. Additionally, including relevant indicators from FAO dietary diversity score is suggested to help understand (1) access to food and nutrient adequacy and (2) capture information on source of meals. It is an important step, since 'balanced meal' itself as a question leads to deviant out-fits. Also, the score provides perspective on agriculture–nutrition linkages, which are important in rural areas.

Second, the item 'preferred food' is also problematic based on both psychometric evidence and the researchers' feedback, since the concept of 'preferred' food is likely to vary according to culture and geographic origin of people and also between adults and children. Third, an attempt to capture the quality through items such as 'rich food' did not prove meaningful. Items such as 'lost weight', 'personally eating less food' in scales seem to contradict the essence, and it would be useful to avoid them.

Severe forms of food insecurity are uniformly cross-cultural

The items in the domain of 'inadequate food quantity' perform more or less consistently across all settings and all scales and were unacceptable fit-statistics ranges (0.70–1.30) in most cases, providing evidence that the most severe forms of FI are uniform across all cultures and also easier to relate to by respondents.

A challenging item across scales was 'adult cut-skip meal', and researchers [11, 22] have advised to split the item for future applications, since the two behaviours are supposedly different in practice. Similar results have been reported by Derrickson for Hawaii [10] where the item 'cut size-skip meal' has been tested for inclusion on the national scale and reported poor in-fit statistics.

Problematic child food insecurity items

There is limited psychometric evidence in the domain of child food inadequacy and its consequences [32]. However, the consensus that emerges from literature and personal feedback of researchers who participated in the online survey is that child FI may not always represent severe FI since reduction in children's meals is possible for reasons other than FI.

Nord and Cafiero [29] also caution against using both child and adult items in the same scale unless child items

Table 3 Food insecurity themes and corresponding items, India, 2000–2015

Study	Setting	Language	Item (abbreviation)	% yes	Severity (s.e)	In-fit	Out-fit
Anxiety relating to food budget or food supply							
Nord [11]	Odisha/rural	Oriya	Food bought didn't last (<i>food no last</i>)	75.9	2.79 (0.16)	0.75	0.16
Agrawal et al. [21, 22]	Delhi/urban	Hindi	Food did not last and no money for more	51.7	4.80 (0.4)	0.77	0.56
	Meerut/urban	Hindi	Food did not last and no money for more	74.5	5.25 (0.03)	0.60	1.11
Chatterjee et al. [25]	Mumbai/urban	Hindi	Worried household wouldn't have enough food	61.1 ^a	–	–	–
Maitra [30]	Kolkata/urban	Bengali	Worried food would run out	23.0	5.53 (0.21)	1.05	0.75
Maitra [30]	Kolkata/urban	Bengali	Food stored ran out	18.8	6.44 (0.22)	1.30	0.46
Chinnakali et al. [26]	Delhi/urban	Hindi	Worried household would not have enough food	2.0 ^a	–	–	–
IIPS-UNICEF [28]	Maharashtra State (yes/no)	Marathi, English	Worried household would not have enough food	42.1	3.24 (0.11)	1.29	4.50
	Polytomous scale No = 0, rarely = 1, sometimes/ often = 2	Marathi, English	Worried household would not have enough food	–	–	1.56	1.78
IFPRI [27]	Odisha	Oriya	Worried household would not have enough food	34.1	3.80 (0.19)	0.92	0.89
Perceptions of inadequate food quality or quantity							
Nord et al. [11]	Odisha/rural	Oriya	Couldn't afford to eat balanced meals (<i>balanced meal</i>)	77.3	2.94 (0.17)	1.00	4.96
	Odisha/rural	Oriya	Eat less than you felt you should (<i>ate less</i>)	48.2	5.50 (0.14)	1.11	3.07
	Odisha/rural	Oriya	Child couldn't have a balanced meal (<i>child balanced</i>)	56.7	3.56 (0.17)	0.94	0.24
Pasricha et al. [24]	Rural Karnataka	Kannada	Same as above	–	–	–	–
Agarwal et al. [21]	Delhi/urban	Hindi	Could not afford to eat balanced meal	65.8	2.25 (0.46)	1.00	0.31
Agrawal et al. [22]	Meerut/urban	Hindi	Could not afford to eat nutritious meal (<i>nutritious</i>)	84.2 ^a	3.63 (0.03)	1.11	11.22
UHRC [15]	Delhi/urban	Hindi	Relied on only a few kinds of low-cost food to feed children	99.5 ^a	–	–	–
			Could not afford children a balanced meal	89.7 ^a	–	–	–
			Children not eating enough	83.6 ^a	–	–	–
Chatterjee et al. [25]	Mumbai/urban	Hindi	Eat the same foods daily	60.1 ^a	–	–	–
			Have to eat any type of food that you did not want (<i>undesirable food</i>)	57.6 ^a	–	–	–
Gupta et al. [17]	Delhi/urban	Hindi	Relied on only a few kinds of low-cost food to feed children	39.7	–	–	–
			Could not feed children a balanced meal	40.4	–	–	–
			Children not eating enough	30.9	–	–	–
Maitra [30]	Kolkata/urban	Bengali	Did you cook <i>bhalo mondo</i> ('rich food' such as <i>shemai, paish</i> or <i>polao</i>) (not as part of a festival day) (<i>rich food</i>)	81.6	0.48 (0.41)	1.02	5.00
			Could not give children their preferred food and had to rely on only a few kinds of low-cost food (<i>child preferred food—low-cost food</i>)	16.4	5.36 (0.30)	0.96	2.02
			Children could not be given a varied and healthy diet (<i>varied and healthy</i>)	38.5	3.94 (0.35)	1.04	0.86
Chinnakali et al. [26]	Delhi/urban	Hindi	Children were not eating enough food	11.3	8.90 (0.33)	0.63	0.29
			Not able to eat the kinds of foods you preferred	1.6	–	–	–
			Have to eat a limited variety of foods	0.4	–	–	–
			Have to eat some foods that you/they really did not want to eat	0.4 ^a	–	–	–

Table 3 continued

Study	Setting	Language	Item (abbreviation)	% yes	Severity (s.e)	In-fit	Out-fit
IIPS-UNICEF [28]	Maharashtra state (only yes/no)	Marathi, English	Not able to eat the kinds of foods you preferred	36.6	4.25 (0.09)	0.88	5.99
IIPS-UNICEF [28]	Polytomous scale No = 0, rarely = 1, sometimes/ often = 2	Marathi, English	Not able to eat the kinds of foods you preferred	–	–	1.05	1.01
IIPS-UNICEF [28]	Maharashtra state (only yes/no)	Marathi, English	Have to eat a limited variety of foods	31.4	5.19 (0.09)	0.85	0.85
IIPS-UNICEF [28]	Polytomous scale No = 0, rarely = 1, sometimes/ often = 2	Marathi, English	Have to eat a limited variety of foods	–	–	0.91	0.90
IIPS-UNICEF [28]	Maharashtra state (only yes/no)	Marathi, English	Have to eat some foods that you really did not want to eat	25.5	6.08 (0.09)	0.94	0.87
IIPS-UNICEF [28]	Polytomous scale No = 0, rarely = 1, sometimes/ often = 2	Marathi, English	Have to eat some foods that you really did not want to eat	–	–	0.91	0.84
IFPRI [27]	Odisha	Oriya	Not able to eat the kinds of foods you preferred	40.5 (65.5) ^a	3.16 (0.19)	1.36	1.47
IFPRI [27]	Odisha	Oriya	Have to eat a limited variety of foods	26.5 (67.8) ^a	4.59 (0.19)	0.88	0.74
IFPRI [27]	Odisha	Oriya	Have to eat some foods that you really did not want to eat	25.2 (63.2) ^a	4.74 (0.19)	0.97	0.89
Reported instances of reduced food intake or its consequences for adults							
Nord et al. [11]	Odisha/rural	Oriya	Adults in your household ever cut the size of your meals or skip meals (<i>adult cut/skip</i>)	43.3	6.30 (0.12)	0.76	0.32
Nord et al. [11]	Odisha/rural	Oriya	Hungry but didn't eat (<i>hungry</i>)	31.9	7.00 (0.11)	0.98	1.11
Agrawal et al. [21]	Delhi/urban	Hindi	Cut meal size or skipped meal	23.9	8.97 (0.52)	1.07	4.63
Agrawal et al. [21]	Delhi/urban	Hindi	Hungry but couldn't afford food	14.7	11.98 (0.72)	1.00	0.19
Agrawal et al. [21]	Meerut/urban	Hindi	Cut meal size or skipped meal	43.5	8.14 (0.03)	0.52	0.63
Agrawal et al. [21]	Meerut/urban	Hindi	Slept hungry but did not eat	20.7	11.98 (0.04)	1.03	6.43
Chatterjee et al. [25]	Mumbai/urban	Hindi	Eat less than you felt you should	46.3 ^a	–	–	–
			Adult in your household cut the size of your meals	48.4 ^a	–	–	–
			Skip some of your daily meals (<i>skip meal</i>)	30.1 ^a	–	–	–
			Food didn't last and no money to buy more (<i>no food</i>)	34.0 ^a	–	–	–
			Hungry and you did not eat a meal	49.8 ^a	–	–	–
			Not eat for a whole day	19.1 ^a	–	–	–
Maitra [30]	Kolkata/urban	Bengali	Adults in your family couldn't eat at least two square meals (full stomach meals) a day (<i>two square meals</i>)	16.4	6.90 (0.22)	0.80	0.62
Maitra [30]	Kolkata/urban	Bengali	Personally eat less food so that there would be more for the rest of the family (<i>ate less</i>)	20.0	6.15 (0.22)	0.88	0.95
Maitra [30]	Kolkata/urban	Bengali	Adults in your family skip entire meals	3.8	9.74 (0.30)	0.89	1.11
Maitra [30]	Kolkata/urban	Bengali	Hungry but didn't eat	2.4	10.87 (0.44)	1.05	0.26
Maitra [30]	Kolkata/urban	Bengali	Adult lost weight	20.6	6.03 (0.22)	0.78	0.42
Maitra [30]	Kolkata/urban	Bengali	Adults in your family not eat for a whole day	2.2	10.87 (0.44)	0.70	0.16

Table 3 continued

Study	Setting	Language	Item (abbreviation)	% yes	Severity (s.e)	In-fit	Out-fit
Chinnakali et al. [26]	Delhi/urban	Hindi	Have to eat a smaller meal than you felt you needed	0.4 ^a	–	–	–
			Have to eat fewer meals in a day	0.8 ^a			
			No food of any kind to eat in your household	2.0 ^a			
			Go to sleep at night hungry	0.4 ^a			
			Go a whole day and night without eating anything	0.0 ^a			
IIPS-UNICEF [28]	Maharashtra State (yes/no) Polytomous scale No = 0, rarely = 1, sometimes/ often = 2	Marathi, English	Have to eat a smaller meal than you felt you needed	20.3	6.90 (0.09)	0.62	0.37
			Have to eat a smaller meal than you felt you needed	–	–	0.67	0.52
IIPS-UNICEF [28]	Maharashtra state (yes/no) Polytomous scale No = 0, rarely = 1, sometimes/ often = 2	Marathi, English	Have to eat fewer meals in a day	18.2	7.35 (0.09)	0.63	0.47
			Have to eat fewer meals in a day	–	–	0.68	0.53
IIPS-UNICEF [28]	Maharashtra State (yes/no) Polytomous scale No = 0, rarely = 1, sometimes/ often = 2	Marathi, English	No food of any kind to eat in your household	12.2	8.65 (0.10)	0.86	0.92
			No food of any kind to eat in your household	–	–	0.92	0.72
IIPS-UNICEF [28]	Maharashtra State (yes/no) Polytomous scale No = 0, rarely = 1, sometimes/ often = 2	Marathi, English	Go to sleep at night hungry	7.7	9.97 (0.13)	0.85	7.04
			Go a whole day and night without eating	4.5	11.37 (0.18)	1.09	11.54
IIPS-UNICEF [28]	Polytomous scale No = 0, rarely = 1, sometimes/ often = 2	Marathi, English	Go a whole day and night without eating	–	–	1.19	2.10
IFPRI [27]	Odisha	Oriya	Have to eat a smaller meal than you felt you needed	23.3 (59.8)	4.96 (0.19)	0.86	0.78
			Have to eat fewer meals in a day	19.6 (51.7)	5.45 (0.19)	0.88	0.76
			No food of any kind to eat in your household	13.9 (47.3)	6.37 (0.20)	0.84	0.66
			Go to sleep at night hungry	12.1	6.75(0.20)	1.13	0.90
			Go a whole day and night without eating	11.1 (31.8)	7.00	1.19	0.93
Nord et al. [11]	Odisha/rural	Oriya	Cut the size of any of the children's meals/or ever skipped meals of children (<i>child cut/skip</i>)	14.2	8.04 (0.12)	0.86	1.95
			Children ever not eat for a whole day (<i>child whole day</i>)	4.96	9.04 (0.16)	1.10	0.73
Nord et al. [11]	Odisha/rural	Hindi	Cut the size of children's meals	64.7 ^b	–	–	–
			Children ever hungry but you just could not afford more food	63.4 ^b			
UHRC [15]	Delhi/urban	Hindi	Children ever skip meals	34.1 ^b			
			Frequency of skipping meals	31.1 ^b			
			Child not eat for a whole day	0.0 ^b			

Table 3 continued

Study	Setting	Language	Item (abbreviation)	% yes	Severity (s.e)	In-fit	Out-fit
Gupta et al. [17]	Delhi/urban	Hindi	Cut the size of children's meals	8.5	–	–	–
			Children hungry but could not afford food	5.6	–	–	–
			Children ever skip meals	2.9	–	–	–
			Frequency of skipping meals	1.6	–	–	–
			Child not eat for a whole day	1.3	–	–	–
Maitra [30]	Kolkata/urban	Bengali	Children in your family could not eat at least three square meals (full stomach meals) a day (<i>child 3 square meals</i>)	9.1 ^c	9.66 (0.39)	1.25	5.37
Maitra [30]	Kolkata/urban	Bengali	Skip child's/any of the children's meals	1.1 ^c	–	–	–
Maitra [30]	Kolkata/urban	Bengali	Child/children hungry but you just couldn't afford more food	1.5 ^c	–	–	–
Maitra [30]	Kolkata/urban	Bengali	Children in the household lost weight/felt weak (<i>child lost weight</i>)	20.0 ^c	7.14 (0.28)	0.71	0.46
Maitra [30]	Kolkata/urban	Bengali	Child did not eat a whole day	0.75 ^c	–	–	–
Nord and Cafero [29] ^d	India	Multiple	Child not given enough food because of lack of money or other resources	–	–	–	–

^a Percentage of affirmative responses to combined 'sometimes + often' follow-ups. All questions are followed by phrases such as 'because of a lack of money or other resources' or 'because you didn't have enough money to buy food/more'. The item 'run out of food/run out/food no last' to be included in the domain of 'worry/anxiety' in US HFSSM (18 or 6-item scale) and FIES GWP 2012; however, it represents a more severe food insecurity condition in the HFAS and FIES GWP 2014

^b The GWP 2014 had extended FIES (eight adult items) where the extension was to include 'how often' follow-up questions to the two most severe questions ('hungry' and 'whole day')

^c The GWP 2012 data for FIES included seven questions that asked about food conditions among children aged 0–14 years in the household

^d The GWP 2014 had two child items if child aged under-five lived in the household. Child items were for research purposes and not included in the scale. No child items are included in the GWP 2015 survey

refer only to much younger children under the age of five due to the potential threat of the presence of a strong second dimension differentiated by adult versus child items. This explains why the child-referenced questions were removed in the 8-item FIES.

Inclusion of follow-up questions should be based on pre-testing stage

In the 4-item Delhi and Meerut slum studies [21, 22] including the follow-up question 'how often' after the combined item 'cut size-skip meal' served to improve the validity of the scale. The Delhi study [21] also recommended adding 'how often' follow-up questions to the item 'hungry'. Similar suggestions were proposed by the Kolkata study [30].

Other researchers interviewed suggested that including 'how often' responses may increase respondent burden and greatly complicate analysis. It can thus be suggested that it may be useful to include such follow-up questions in a research survey to explore the temporal patterns of FI or it may be useful to include such follow-ups to the most severe questions in order to extend the range of measured severity upward. However, the final decision to include follow-up items should be based on pre-testing.

Mixed evidence on cross-cultural validity

Items in domains of uncertainty and quality reduction, such as 'worried', 'balanced meal', 'preferred food', 'no food to eat', have different severities across different scales and settings. Nonetheless, the 8-item FIES tested across various settings and subpopulations in India did find cross-cultural comparability, indicating that its prevalence rates will have little bias. However, the question of equivalence of different scales remains unanswered due to lack of adequate data.

Relevance of construct validity

Construct validation is relevant only if internal validity and reliability is robust and a standardized set of characteristics are defined for use across studies and only nine studies have established the same. Reporting poor association of experience-based HFI scales (with poor internal validity) will misrepresent the information on construct validity. Although the respondent in the majority of studies reviewed was an adult female member in the household, possible sources of bias in the surveys may affect the validity of the scales, such as sex of respondent, period of survey and choice of recall period, thereby reducing comparability [32].

Recall period: 12 months or 30 days?

The survey period is also an important consideration in eliminating risk of response bias due to seasonality and

subsequent change in food habits, especially during festivities [30]. The shorter reference period may improve recall. It is a good option when differences in food security between the different seasons need to be studied. Difference in recall periods should also be kept in mind when comparing HFI prevalence using experience-based HFI scales. In surveys conducted over a longer period, like National Surveys, a 12-month recall period is better since it reduces seasonality effects and improves comparability across different parts of the country. A 12-month recall period may be more relevant in those settings where averaging out seasonal differences is necessary. If experience-based HFI is transient or occasional for a substantial proportion of those who are food insecure, then the difference between the 12-month and 30-day recall period may be substantial. Based on the objective of the study, the reference period should be decided.

Conclusions

This paper reviewed the internal reliability and validity of 19 studies using experience-based HFI in the India. The following conclusions are based on this analysis:

First, experience-based HFI scales used in the Indian context are internally reliable. To improve validation, the following actions are suggested: (1) cognitive testing of quality of diet items; (2) avoid child-referenced items (FAO guidelines state 'additional child centric questions may be added to describe the context of FI among children, but will not be used in the analysis of the 8-item FIES scale' [7]); (3) rigorous training of enumerators; (4) addition of 'how often' to avoid overestimation of food-insecure conditions; (5) split the 'cut and skip' meal item; (6) use a standardized set of questions for aiding comparison of construct validity across scales; and (7) apart from evaluating the Rasch assumption of equal item discrimination, examine the assumption of conditional item independence to eliminate the threat of redundant items and of a second dimension in the data, such as households with and without children.

Second, the survey recall period may be decided according to the survey purpose and based on pre-testing and duration of FI periods.

Third, it is critical to establish external validity of experience-based HFI scales with nutritional (anthropometric) indicators.

Fourth, equivalence of the scales across diverse settings should be established to ensure comparability of prevalence estimates across subpopulations, with similar questions, scale and recall periods. FAO [33] provides a method to compare this. The 8-item FIES, tested psychometrically, for cross-cultural validity may be included in large-scale Indian surveys that collect nutrition information to further establish and test this equivalence.

However, for the exploratory/pre-testing phase in India, we do recommend including ‘How often’ follow-up questions to all items; using standard thresholds for categorization of raw scores and testing whether last 30 days/12 months recall period works best for Indian settings. This will help to finally arrive at an FIES that is most suitable to the Indian context—with the most relevant questions, recall period and items requiring follow-up questions, for inclusion in the DHS, after expert opinion from a good representation of nutritionists and related policy and advocacy groups under the aegis of a nationally recognized body. Finally, India is signatory to reporting progress against the agreed indicators of the sustainable development goals (SDG). SDG indicator 2.1.2, i.e. prevalence of moderate or severe FI in the population, is based on the eight-item FIES. It is, therefore, critical and timely for India to start an evidence-based policy dialogue by including FIES in India’s national surveys and invest. This should be preceded by harmonizing the HFI scales and/or questions within the scale across multiple surveys (NSSO, NFHS) to aid comparability over time, to effectively support policy decision making as well as SDG reporting.

Abbreviations

HFI: household food insecurity; NSSO: National Sample Survey Organization survey; NFHS: The National Family Health Survey; FANTA: Food and Nutrition Technical Assistance; HFIAS: Household Food Insecurity Access Scale; FIES: Food Insecurity Experience Scale; FAO: Food and Agricultural Organization; FI: food insecurity; DIF: differential item functioning; SDG: sustainable development goals.

Authors’ contributions

VS conceptualized, contributed to analysis, drafted the manuscript and critically revised the manuscript. CM, SU and RA contributed to acquisition, analysis, or interpretation and critically revised the manuscript. SB contributed to conception or design and critically revised the manuscript. All authors read and approved the final manuscript.

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Competing interests

The authors declare that they have no competing interests.

Disclaimer

Any opinions stated or errors herein are those of the authors and are not necessarily representative of or endorsed by the designated organizations.

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References

1. Ministry of Women and Child Development. Annual report 2014-2015. Government of India. 2015. <http://www.wcd.nic.in/sites/default/files/AR2014-15.pdf>.
2. Radimer KL, Olson CM, Campbell CC. Development of indicators to assess hunger. *J Nutr*. 1990;120:1544–8.
3. National Sample Survey Organization. Nutritional intake in India 2011-12. Report no 560. National Statistical Organization, Ministry of Statistics and Program Implementation. 2013. <http://www.indiaenvironmentportal.org.in/files/file/nutritional%20intake%20in%20India%202011-12.pdf>.
4. Hamilton WL, Cook JT, Thompson WW, et al. Household food security in the United States in 1995: technical report. Resource document. Washington, DC: US Department of Agriculture Food and Consumer Service. 1997. http://www.fns.usda.gov/sites/default/files/TECH_RPT.PDF. Accessed 12 Apr 2016.
5. Blumberg SJ, Bialostosky K, Hamilton WL, Briefel RR. The effectiveness of a short form of the household food security scale. *Am J Public Health*. 1999;89(8):1231–4.
6. Coates J, Swindale A, Bilinsky P. Household Food Insecurity Access Scale (HFIAS) for measurement of household food access: indicator guide (v. 3). Resource document. Washington, DC: Food and Nutrition Technical Assistance Project, Academy for Educational Development. 2007. http://www.fantaproject.org/sites/default/files/resources/HFIAS_ENG_v3_Aug07.pdf. Accessed 10 May 2016.
7. Ballard TJ, Kepple AW, Cafiero C. The food insecurity experience scale: development of a global standard for monitoring hunger worldwide. Rome: Food and Agriculture Organization. 2013. http://www.fao.org/fileadmin/templates/ess/voh/FIES_Technical_Paper_v1.1.pdf. Accessed 25 May 2016.
8. Bond TG, Fox CM. Applying the Rasch model: fundamental measurement in the human sciences. 2nd ed. London: Routledge; 2007.
9. Fisher AG. The assessment of IADL motor skills: an application of many-faceted Rasch analysis. *Am J Occup Ther*. 1993;47(4):319.
10. Derrickson JP, Fisher AG, Anderson JE. The core food security module scale measure is valid and reliable when used with Asians and Pacific Islanders. *J Nutr*. 2000;130(11):2666.
11. Nord M, Satpathy AK, Raj N. Comparing household survey-based measures of food insecurity across countries: case studies in India, Uganda and Bangladesh. Discussion Paper No. 7. Friedman School of Nutrition Science and Policy, Tufts University. 2002. http://nutrition.tufts.edu/sites/default/files/fpan/wp07-comparing_measures.pdf. Accessed 10 Feb 2016.
12. Nord M. Assessing potential technical enhancements to the U.S. household food security measures—Technical Bulletin No 1936. US Department of Agriculture, Economic Research Service, USA. 2012. <http://www.ers.usda.gov/media/978956/tb-1936.pdf>. Accessed 11 Jan 2016.
13. Cronbach LJ. Coefficient alpha and the internal structure of tests. *Psychometrika*. 1951;16(3):297–334.
14. Gopichandran V, Claudius P, Baby LS, et al. Household food security in urban Tamil Nadu: a survey in Vellore. *Natl Med J India*. 2010;23(5):278–80.
15. Urban Health Resource Centre. Coping strategies and levels of child food insecurity among urban-poor food insecure households living in urban slums of Seelampur, Delhi—a report. New Delhi: Urban Health Resource Centre. 2011 (unpublished, personal communication).

16. Gupta P, Singh K, Seth V. Food insecurity among the young children (6–35 months) in urban slums of Delhi, India. *Indian J Matern Child Health*. 2013;15(4):1–6.
17. Gupta P, Singh K, Seth V, et al. Association of Food Insecurity and Malnutrition among young children (6–36 months). *Indian J Nutr Diet*. 2014;51(3):293–305.
18. Mukhopadhyay D, Mukhopadhyay S, Biswas A. Enduring starvation in silent Population: a study on prevalence and factors contributing to household food security in the tribal population in Bankura, West Bengal. *Indian J Public Health*. 2010;54(2):92–7.
19. Mukhopadhyay DK, Biswas AB. Food security and anthropometric failure among tribal children in Bankura, West Bengal. *Indian Pediatr*. 2011;48(4):311–4.
20. Wright L, Gupta P. Coping strategies adopted by urban poor to ameliorate food insecurity: case of United States, Belize and India. *J Food Secur*. 2015;3(2):40–6.
21. Agarwal S, Sethi V, Nord, M. Levels and predictors of experiential household food insecurity among urban poor of North India. 2009 (unpublished presentation, personal communication).
22. Agarwal S, Sethi V, Gupta P, Jha M, Nord M. Experiential household food insecurity in an urban underserved slum of North India. *Food Secur*. 2009;1(3):239–50.
23. Medecins Sans Frontieres (MSF). Food security assessment report, Chitragong Hill Tracks Sajek Union. Bangladesh: MSF; 2008.
24. Pasricha SR, Vikaykumar V, Prashant NS, et al. A community based field research project investigating anaemia amongst young children living in rural Karnataka, India: a cross sectional study. *BMC Public Health*. 2009; doi:10.1186/1471-2458-9-59.
25. Chatterjee N, Fernandes G, Hernandez M. Food insecurity in urban poor households in Mumbai, India. *Food Secur*. 2012;4(4):619–32.
26. Chinnakali P, Upadhyay RP, Shokeen D, et al. Prevalence of household-level food insecurity and its determinants in an urban resettlement colony in North India. *J Health Popul Nutr*. 2014;32(2):227–36.
27. International Food Policy Research Institute. Delivering for nutrition in Odisha: insights from a study on the state of essential nutrition interventions. Report. New Delhi: IFPRI. 2015. <https://www.ifpri.org/cdmref/p15738coll2/id/129277/filename/129488.pdf>.
28. International Institute for Population Sciences-United Nation Children's Fund. Comprehensive nutrition survey of Maharashtra Report. Mumbai: IIPS. 2013. http://www.iipsindia.org/IIPS-UNICEF_report.htm. Accessed 10 Apr 2016.
29. Nord M, Cafiero C. Experiential food security measures in nationally representative surveys in India: psychometric analysis. Rome: Hungry, Food and Agricultural Organization of the United Nations. 2015 (unpublished, personal communication).
30. Maitra C. Going beyond calories—looking at experiential food insecurity in urban slum households in Kolkata. Discussion paper 523. Brisbane: School of Economics, University of Queensland. 2014. <http://www.uq.edu.au/economics/abstract/523.pdf>. Accessed 01 Apr 2016.
31. Deitchler M, Ballard TJ, Swindale A, et al. Validation of a measure of household hunger for cross-cultural use. Resource document. Washington, DC: Food and Nutrition Technical Assistance Project, Academy for Educational Development. 2010. http://www.fantaproject.org/sites/default/files/resources/HHS_Validation_Report_May2010_0.pdf. Accessed 26 Apr 2016.
32. Coates J. Experience and expression of food insecurity across cultures: practical implications for valid measurement. Resource document. Washington, DC: Food and Nutrition Technical Assistance Project, Academy for Educational Development. 2004. <http://www.fantaproject.org/sites/default/files/resources/Experience-Expression-Food-Insecurity-Apr2004.pdf.pdf>. Accessed 23 Apr 2016.
33. FAO. Methods for estimating comparable rates of food insecurity experienced by adults throughout the world. Resource document. Rome: Food and Agriculture Organization. 2016. <http://www.fao.org/3/a-i4830e.pdf>. Accessed 1 May 2016.
34. Raj N, Satpathy AK. Household food insecurity and child labour: some evidences from rural Orissa, chap 14. In: Ramachandran N, Massum L, editors. *Coming to grips with rural child work*. IHD: New Delhi; 2002.

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