

## ORIGINAL ARTICLE

# Psychometric properties of a modified US-household food security survey module in Campinas, Brazil

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**Objective:** To assess the internal validity of a multiple-item measure of household food security in Brazil using statistical methods based on the single-parameter logistic (Rasch) measurement model.

**Subjects/Methods:** Sample of the non-institutionalized civilian population living in the municipality of Campinas selected using stratified cluster sampling. Of the 1000 households randomly chosen, 847 responded to the interview. Responses to each of the 15 questions were coded into dichotomous items indicating whether the specific food-insecure condition had occurred (other than in just 1 or 2 days) during the 3 months before the survey. Scaling analyses were conducted separately as well as jointly for adult/household-related items and child-related items. Item-fit statistics were examined to determine the extent to which the items appear to measure the same underlying phenomenon, and item severity scores were compared with those of equivalent items in the US Current Population Survey.

**Results:** Except for one item, infit statistics were within a range considered adequate (0.80–1.2), indicating a common phenomenon being measured with approximately equal discrimination. The relative severities of the items in the Campinas survey were generally similar to those of equivalent items in the US Current Population Survey. Analysis of all 15 items together indicates a higher severity level for child-related items compared with equivalent adult-related items.

**Conclusions:** This analysis will serve as the prototype for confirming the psychometric validity of a food insecurity scale at a national level.

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## Introduction

As stated in the Rome Declaration on World Food Security, food security 'exists when all people, at all times, have

physical and economic access to sufficient, safe and nutritious food to meet their dietary needs and food preferences for an active and healthy life' (United Nations Food and Agriculture Organization, 1996). In that declaration, the leaders from 185 countries attending the 1996 World Food Summit committed to achieve 'food security for all and to an ongoing effort to eradicate hunger in all countries, with an immediate view to reducing the number of undernourished people to half their present level no later than 2015.' Nowadays, less than 10 years away from the Millennium Development Goals deadline, efforts are being made by several national and international, governmental and non-governmental institutions to reduce hunger using various approaches and means available. The Brazilian government launched and financed the program *Fome Zero* (Zero Hunger) as its main public policy and strategy to alleviate hunger and food insecurity. Since 2003, *Fome Zero*

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**Contributors:** HRM-Q led the data analysis, as well as the writing of the article; MN was senior analysis advisor in the Rasch modeling, giving major advice contributions to the interpretation of results; RP-E is a co-Principal Investigator in the validation research on the food security scale in Campinas, playing a major role in the discussion of the findings; AMS-C was the principal investigator in the food security scale validation study in Campinas, giving crucial advice in the interpretation of the results within the Brazilian context. The views expressed in this article may not be attributed to the Economic Research Service or the US Department of Agriculture.

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programs and actions have been implemented with strong social control and participation of several non-governmental agencies, research institutions, social organizations, labor unions and experts working on food security issues all over the country (Projeto Fome Zero, 2001).

In response to the need for valid and reliable tools to assess food insecurity, to improve the targeting of the social programs, as well as to evaluate its impact across time, researchers at the Campinas University in Brazil and the University of Connecticut in the USA conducted a study to assess the validity of an adapted version of the US household food security survey module (US HFSSM) (Perez-Escamilla *et al.*, 2004). This instrument takes into consideration the overall food insecurity experience and categorizes this phenomenon by its severity (Bickel *et al.*, 2000; Nord, 2004). Research conducted in the US has confirmed the validity of the US HFSSM as an easy to use method for measuring and analyzing household food insecurity in a diversity of settings and population groups (Radimer *et al.*, 1990; Wolfe *et al.*, 1998; Frongillo, 1999; Rose, 1999; Derrickson *et al.*, 2000; Kaiser *et al.*, 2002; Kaiser and Melgar-Quinonez, 2003; Melgar-Quinonez *et al.*, 2003).

Researchers have evaluated the suitability of adaptations of the US HFSSM to assess food insecurity in many countries, showing the suitability of such instruments in a wide range of geographic and socio-economic contexts (Welch *et al.*, 1998; Grosh and Glewwe, 2000; Studdert *et al.*, 2001; Lorenzana and Mercado, 2002; Frongillo *et al.*, 2003; Coates *et al.*, 2004; Gulliford *et al.*, 2004, 2005; Parás and Pérez-Escamilla, 2004; Johnson *et al.*, 2005; Melgar-Quinonez *et al.*, 2005; Alvarez *et al.*, 2006; Coates *et al.*, 2006; Frongillo and Nanama, 2006; Melgar-Quinonez *et al.*, 2006).

The US HFSSM includes questions about food-related behaviors, experiences and conditions that are known to characterize households having difficulty meeting their food needs. The questions cover a wide range of severity of food insecurity ranging from worrying about running out of food to not eating for a whole day. This supports reliable classification of households into three categories of food security status: food secure, food insecure without hunger and food insecure with hunger (Recently, USDA has introduced new labels for these categories, disaggregating food secure in to 'high food security' and 'marginal food security,' and renaming 'food insecure without hunger' as 'low food security' and 'food insecure with hunger' as 'very low food security'). The questions were developed from ethnographic and case study research conducted in low-income households to discover the natural language low-income respondents use to describe food-access problems.

Internal validation of a multiple-indicator measure is based on an assessment of the extent to which relationships among the observable indicator items are consistent with assumptions about the relationships between each observable indicator item and the unobserved underlying phenomenon measured by the set of items. The statistical methods used to develop and assess the US and Campinas food

security measures are based on the Rasch measurement model. The Rasch model and related Item-Response-Theory models are used extensively in educational testing applications, in which a set of binary responses (correct/incorrect) to problems across a range of difficulty are combined to assess academic performance.

The Rasch model assumes that the relationships between indicator items and underlying phenomenon have the following characteristics:

(1) The higher the severity of the item, the lower the likelihood of its being answered affirmatively; (2) the greater the severity of food insecurity of the respondent, the more likely he/she will respond affirmatively to each question; (3) the specific mathematical form of these relationships is logistic – that is, the odds of a household with severity  $h$  responding affirmatively to an item with severity  $i$  is equal to the exponentiation of  $(h-i)$ ; (4) items discriminate equally sharply; and (5) items are independent for respondents with the same level of severity of food insecurity. Assessment of national food security data in the US has indicated that the items in the US HFSSM are sufficiently consistent with these assumptions to justify use of the Rasch measurement model. In addition to its application for the assessment of a national food security tool in the US, Rasch scaling analysis has been used to evaluate the validity and reliability of the US HFSSM and adaptations of it in different population groups (Derrickson *et al.*, 2000; Opsomer *et al.*, 2003; Connell *et al.*, 2004; Wilde, 2004).

Rasch-model software programs use maximum-likelihood methods to estimate the household and item severity scores that are most consistent with the observed responses under Rasch assumptions. The resulting severity scores for respondents (i.e. households) constitute an interval-level scale across the range of severity represented by the items. However, the size of the interval between households that denied all items and those that affirmed one item cannot be determined statistically unless additional assumptions are made with regard to the form of the distribution of food insecurity in the population.

Rasch analysis also generates 'fit' statistics to assess how well each item and each household conforms to the assumptions of the model. The most commonly used fit statistic is the 'item-infit,' an information-weighted statistic that compares the discrimination of each item with the average discrimination of all items. Item-infit is calculated as follows: After estimating household and item severity scores, the probability of an affirmative response in each cell of the household-by-item matrix is calculated (Nord and Bickel, 2002).

Infit values result from comparing the responses given by the households to the probabilistically expected responses in each cell of the matrix. As infit is an 'information-weighted' statistic, it is sensitive to responses by households with severity scores in the range near the severity level of the particular item and is calculated as follows:

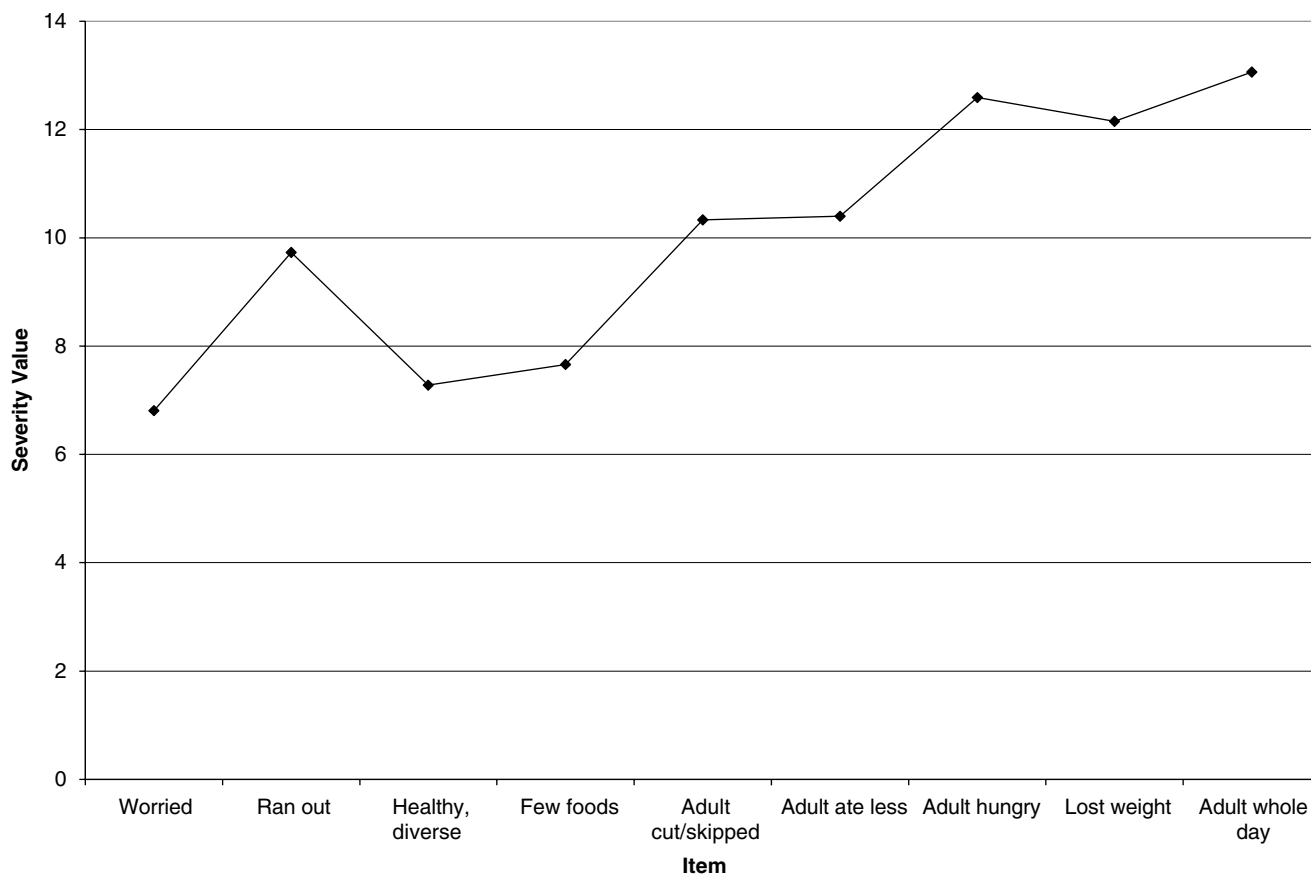
$$\text{INFIT}_i = \text{SUM} [(X_{i,h} - P_{i,h})^2] / \text{SUM} [P_{i,h} - P_{i,h}^2]$$

where:  $X_{i,h}$  is the observed response of household  $h$  to item  $i$  (1=yes, 0=no)  $P_{i,h}$  is the probability of an affirmative response by household  $h$  to item  $i$ . Item infit statistics measure how strongly and consistently each item is associated with the latent trait (food insecurity) compared with the average of all items. The expected value is 1.0 (i.e., the average of all items). These statistics might more appropriately be called 'item misfit' statistics because higher values indicate weaker associations with the underlying construct. An item-infit statistic above 1.0 indicates a weaker association than expected between that item and the underlying condition of food insecurity. That is, a disproportionate share of households with severity scores lower than that of the item affirm the item or a disproportionate share of households with severity scores higher than that of the item deny the item (Connell *et al.*, 2004). An item infit statistics below 1.0 implies a stronger than expected association between that item and the underlying condition of food insecurity. The Rasch model assumes that all items discriminate equally, so infit values that are too high or too low challenge the suitability of the respective item for inclusion in the scale. Infit values in the range of 0.8–1.2 are generally considered to meet the Rasch assumption of equal discrimination of items.

As part of the research being conducted in Brazil to develop a food security tool that is suitable for administration at the national level, this study uses statistical methods

**Table 1** Proportions of households that responded affirmatively to each item in the Campinas-HFSSM, and proportions with each raw score on the combined adult/household/child scale ( $n = 847$ )

Adult/household items	%	Raw score	%
Worried	37.2	0	49.7
Healthy, diverse	33.8	1	11.5
Few foods	30.9	2	10.7
Ran out	16.5	3	6.7
Adult cut/skipped	13.2	4	5.8
Adult ate less	12.9	5	3.7
Lost weight	6.4	6	3.1
Adult hungry	5.1	7	2.0
Adult whole day	4.4	8	2.0
Children items	%	9	2.0
Child healthy, diverse	30.7	10	0.5
Child quantity	13.4	11	0.6
Child cut size	9.9	13	0.8
Child skipped	6.6	14	0.2
Child hungry	3.5	15	0.1
Child whole day	0.4		



**Figure 1** Relative item severity for adult/household related items in the Campinas-HFSSM.

based on the single-parameter logistic Rasch measurement model to examine the internal validity of a locally adapted version of the US HFSSM (from now on Campinas-HFSSM). This analysis contributes to the development of an analytical methodology for a better understanding of the performance of this tool in the Brazilian context, enhancing the knowledge about its usefulness and applicability. Furthermore, this paper will serve as the prototype for assessing the psychometric validity of the recent application of the Brazilian Food Insecurity Scale (EBIA) at a national level (Instituto Brasileiro de Geografia e Estatística, 2004).

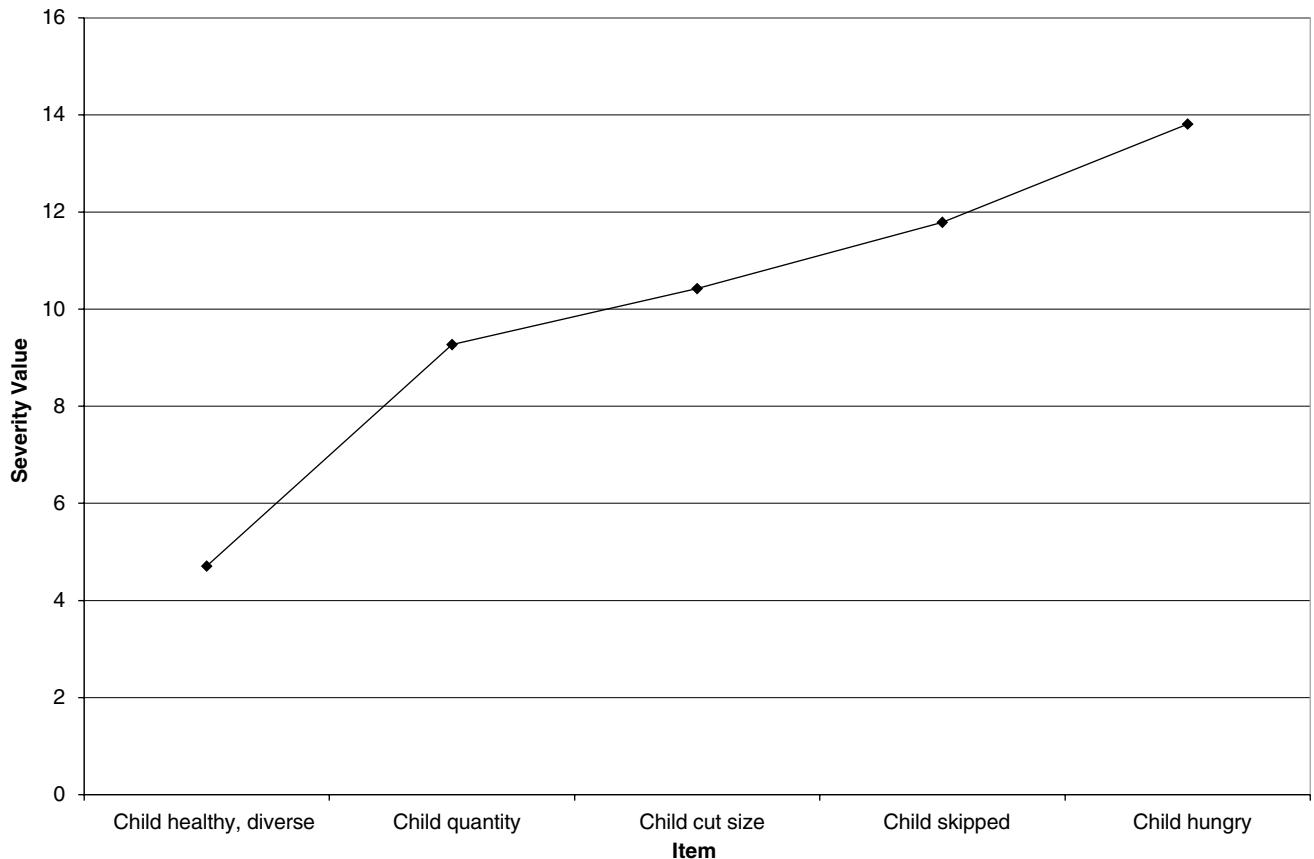
## Statistical methods

This study was approved by the Human Subjects Review Committee of The University of Campinas and The Ohio State University.

After in-depth assessment for content and face validity, the Campinas-HFSSM was applied in a representative sample ( $n = 847$ ) of the non-institutionalized civilian population living in urban areas in the municipality of Campinas, Brazil. The sample was selected in two stages using the census tracts as the primary sampling units and the households as the

secondary units. Further details on this stratified cluster sampling design were published elsewhere (Perez-Escamilla *et al.*, 2004).

The Campinas-HFSSM included 15 'stem' questions about food-insecure conditions and experiences of various levels of severity that occurred during the previous three months. The 15 stem questions were the end product of an in-depth multi-state project of adaptation and validation of the US food insecurity scale to the Brazilian context using qualitative and quantitative research methods (Perez-Escamilla *et al.*, 2004). Nine of the questions include statements referred to the situation of the household as a whole or to the adults in the household (adult/household-related items). The other six items (child-related items) describe conditions related to the children ( $\leq 18$  years of age) in the household. Interviewees who responded affirmatively to any of the 'stem' questions were asked a follow-up question about the frequency of occurrence of the condition. This applied to all the questions in the Campinas-HFSSM with the exemption of one question related to the loss of weight. Response options to the follow-up questions were: (1) *almost every day*; (2) *on just a few days*; (3) *on only 1 or 2 days*. Detailed information about the Campinas-HFSSM was presented in a previous publication that includes a list of each of the



**Figure 2** Relative item severity for children related items in the Campinas-HFSSM.

questions (Perez-Escamilla *et al.*, 2004). In this paper, items are labeled using identifiers that relate to the main event stated in each item.

Responses to the 'stem' questions were coded into two separate dichotomous variables as follows: responses were coded 1 (affirmative) only in case the condition occurred 'almost every day' or 'on just a few days'. Negative responses to stem questions were coded 0, as well as affirmative responses to the 'stem' question followed by a response 'on only 1 or 2 days' to the follow-up question. The item asking about losing weight was coded 1 if the 'stem' question response was affirmative and zero if the response was negative. The dichotomously coded variables were fit to the single-parameter logistic Rasch model using the software WINSTEPS version 3.52. (Winsteps 3.52, Chicago, IL, USA) Item-infit statistics were examined to assess the extent to which all of the items in the Campinas-HFSSM measure the same underlying phenomenon in the Campinas population. Item severities were compared with those from the US Current Population Survey to assess the extent to which the phenomenon measured by the two modules is the same. WINSTEPS generated logit values of relative item severity were rescaled adjusting the mean to a value of 10 to express the whole extent of food insecurity measured by the

Campinas-HFSSM with a scale in a positive range of severity values.

Scaling analysis was conducted separately for adult/household and children related items. With regard to child-related items, the most severe item ('Children ever go without food for a whole day') was excluded from the analysis because it was affirmed by only one household. In addition, all 15 items were analyzed together to assess the severities of child-related items compared with those of equivalent adult/household-related items. Severity values for all 15 items in the Campinas-HFSSM were plotted for comparison with equivalent items in the US HFSSM using data from the US Current Population Survey (CPS) 1998. To make the scales comparable, the Campinas severity values were adjusted by a linear transformation so as to equate the mean and s.d. of item scores to those of the equivalent items in the US CPS.

### Results

Table 1 presents the percentages of affirmative responses to each of the items in the Campinas-HFSSM and the percentages of households in each raw score group. (Raw score is the number of items affirmed by a household.) The

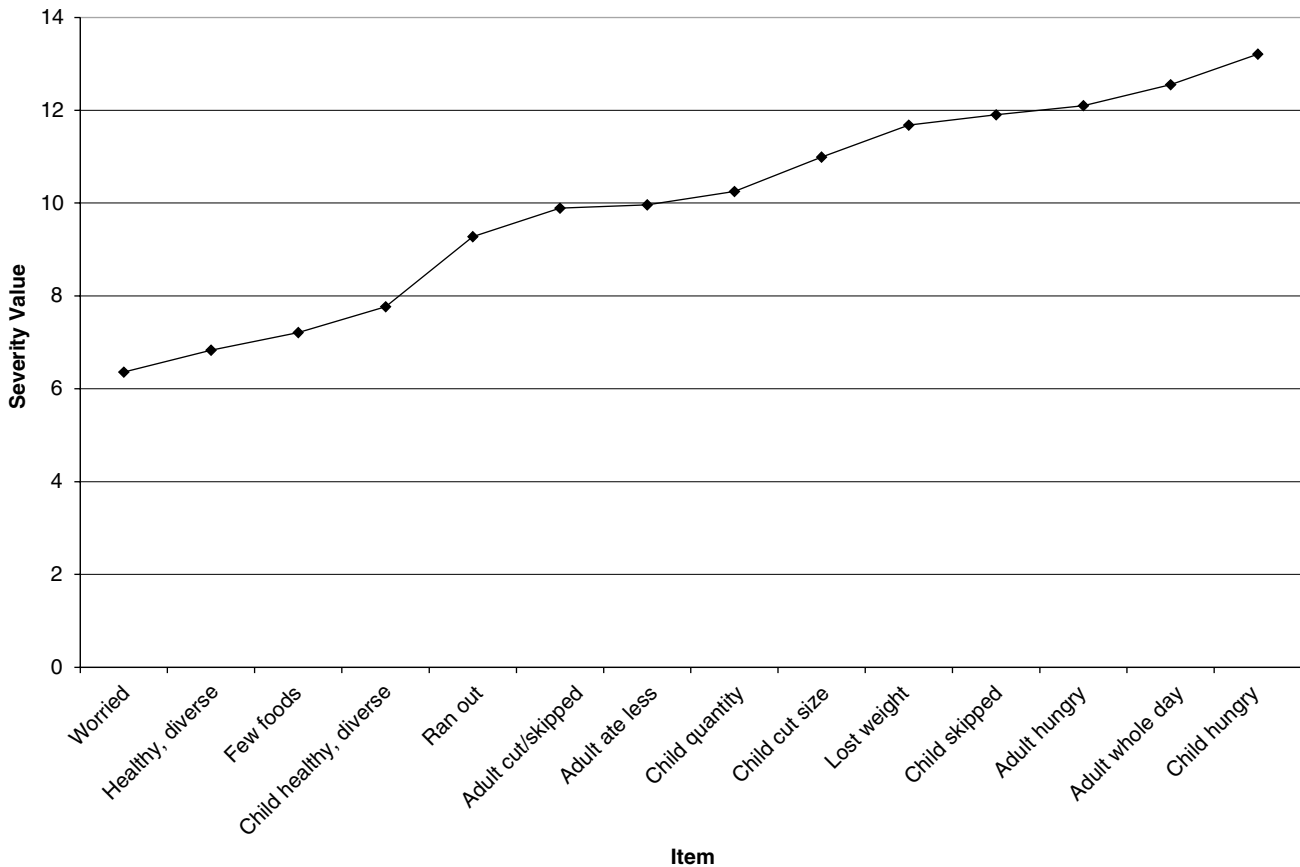


Figure 3 Relative item severity for all 15 Campinas-HFSSM items.

items are ordered by the level of severity of food insecurity indicated by the item. Questions that are conceptually less severe (e.g. 'worried that you would run out of food before being able to buy or receive more food') show a higher proportion of positive response than those conceptualized as more severe (e.g. 'Adult or child go without food for a whole day'). The distribution of households across raw scores indicates that the measurable range of the Campinas-HFSSM comprises about half of the municipality's households and that the density of the distribution generally declines with increasing severity across the measurable range.

Figures 1 and 2 show relative item severity values for adult/household-related items and for child-related items, respectively. Severity values increase monotonically as the conceptual severity level of the items increases.

Figure 3 illustrates how severity values for child-related items relate to those for adult/household-related items. For pairs of items that represent equivalent conditions among adults and children, the child-related item always has a higher severity score than the adult/household item. For example, *children/adolescents ever hungry is about one logistic unit more severe than adult ever feel hungry*.

Figures 4 and 5 present infit values for adult/household related items and children related items, respectively. All of

the items had infit statistics lower than 1.2, which is generally considered an acceptable upper limit. One item (Adult hungry) had an infit statistic somewhat lower (0.74) than 0.8, which is generally considered a lower limit to meet the Rasch model assumption that all items discriminate equally well. Including this item in the scale is not problematic, but the information it contributes is somewhat undervalued in the Rasch-based scale score, which weights all items equally.

The child-related items conform very closely to the Rasch-model assumption of equal discrimination having item infit values between 0.92 and 1.05.

Figure 6 compares item severity values for the Campinas-HFSSM with item severity for items from the US Current Population Survey. Two of the Campinas-HFSSM items ('ran out' and 'few foods') were omitted from this comparison because they have no equivalent item in the US-HFSSM. With regard to the Campinas-HFSSM 'healthy diverse' item, it was compared to the US-HFSSM 'balanced meals' item, as both are intended to represent the same behavior. This figure shows that some of the items had very similar or even identical severity scores in both countries (e.g. 'worried' or 'Child quantity'). On the other hand some items had in Brazil considerably higher (e.g. 'Ran out' or 'Adult hungry'), whereas

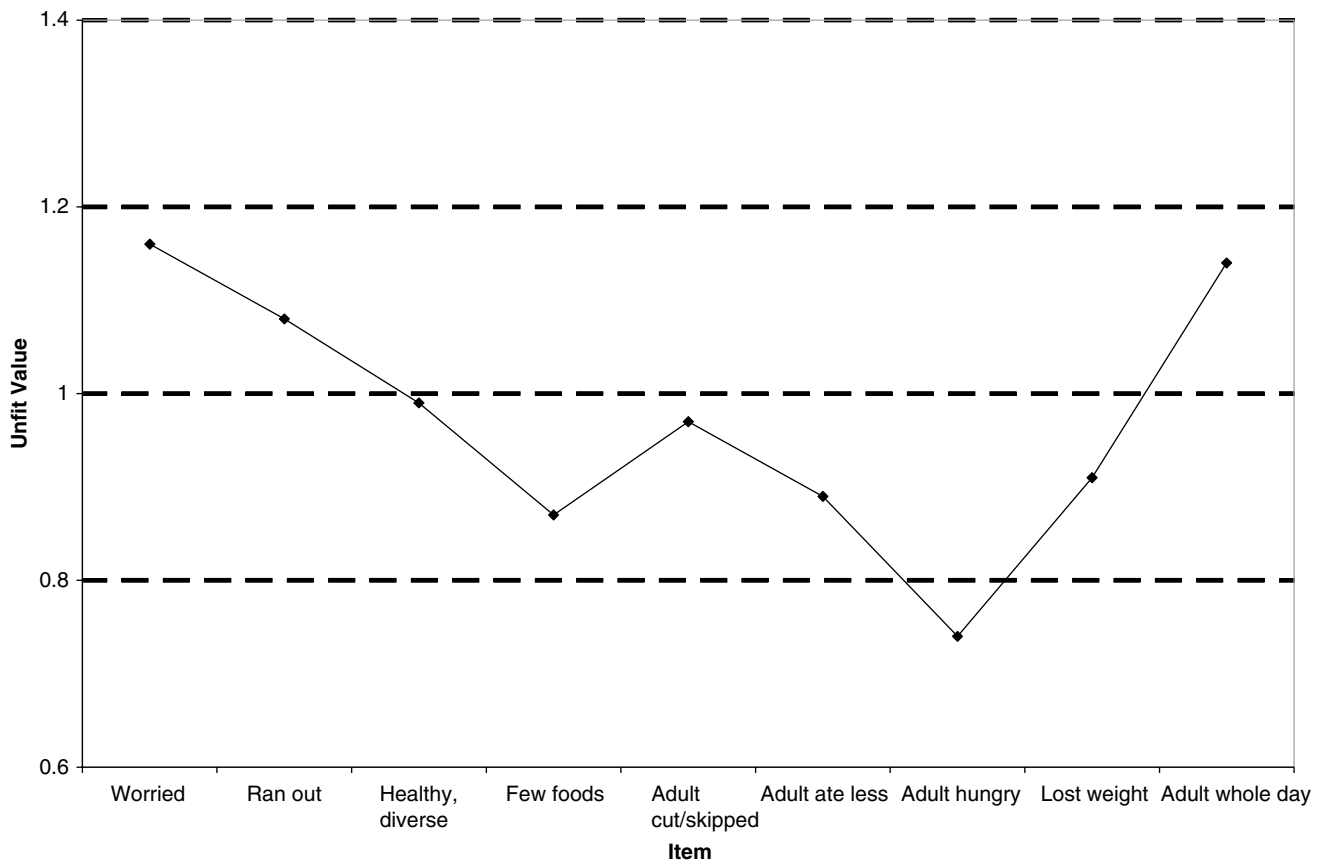


Figure 4 Item infit values for adult/household related items in the Campinas-HFSSM.

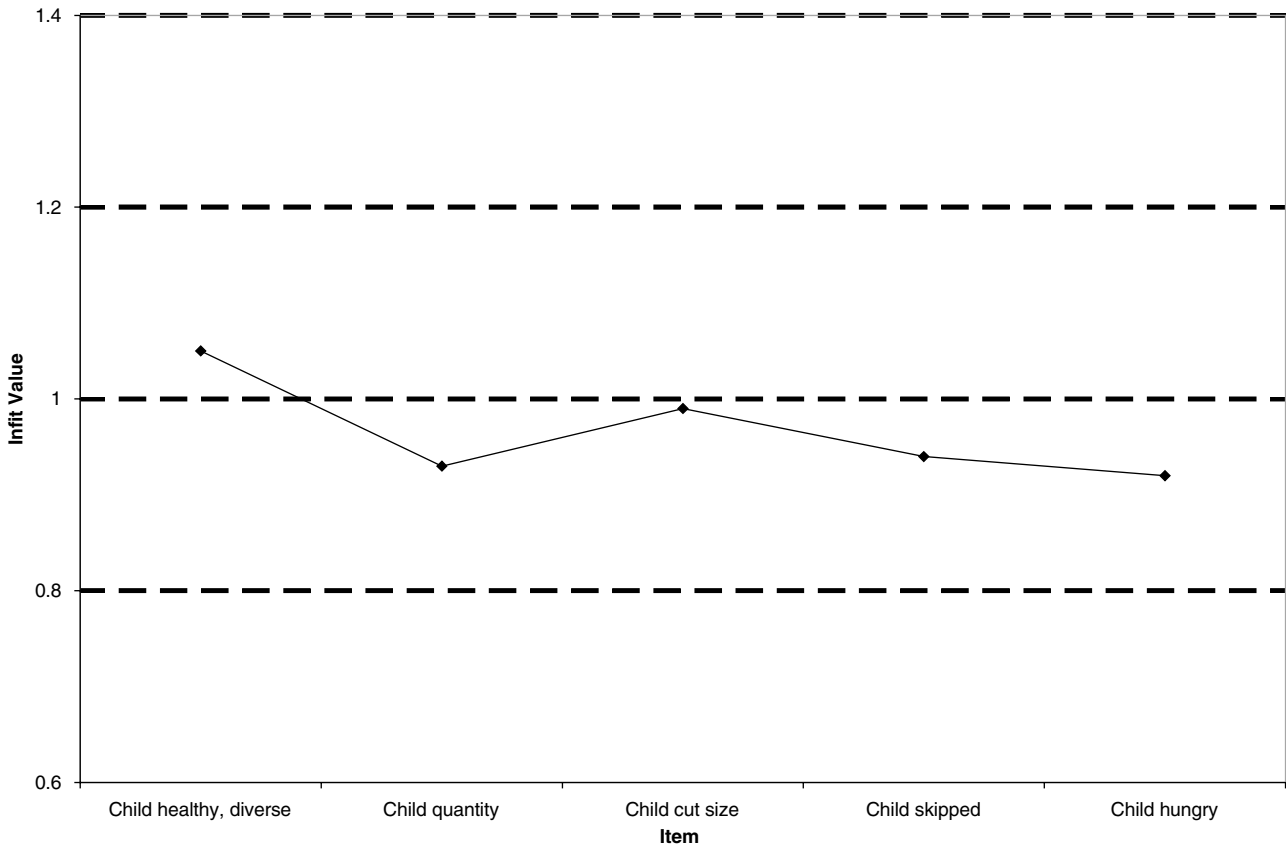


Figure 5 Item infit values for children related items in the Campinas-HFSSM.

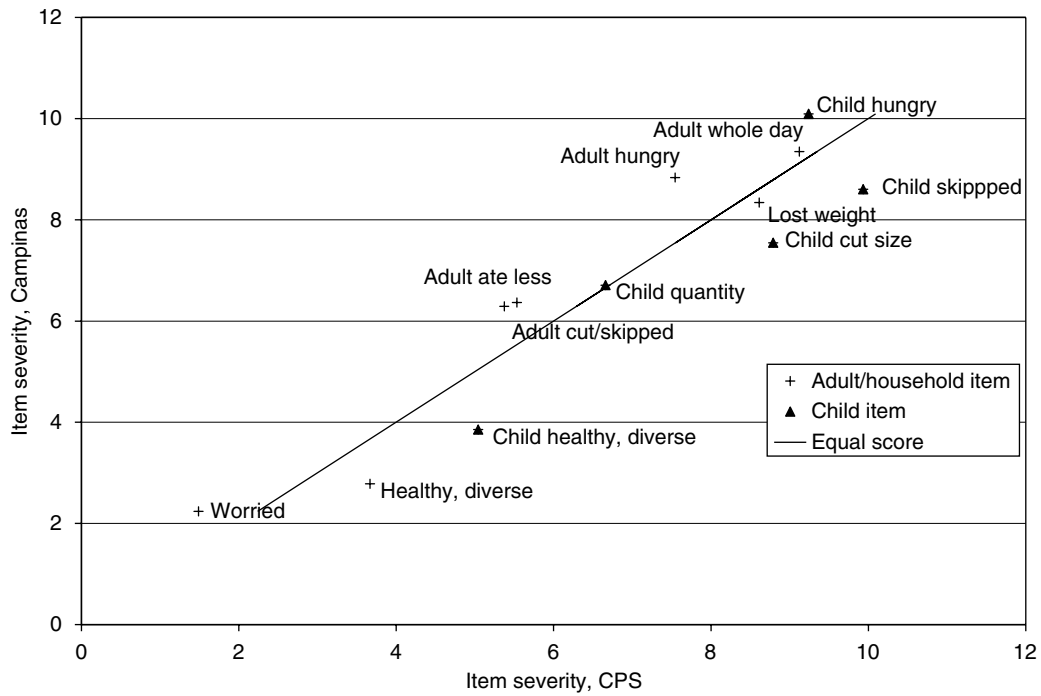


Figure 6 Comparison of item relative severity values between Campinas-HFSSM, and US Current Population Survey data.

others had a lower severity score (e.g. 'Child healthy, diverse' or 'Child cut size'). Nevertheless, a similar trend in terms of the relative severity of the items is observed for both countries.

## Discussion

This analysis establishes the internal validity of adult and child scales based on the Campinas-HFSSM for measuring food security in the Campinas population. After this initial research in Campinas, the assessment of the proposed Campinas-HFSSM has extended nationally, replicating the validation methodology in other urban areas and rural areas in several states of Brazil. These analyses generated results that were consistent with those reported in this paper. Brazilian researchers therefore proposed for this module to be included in several surveys with nationally representative population samples (Perez-Escamilla *et al.*, 2004). The Brazilian government has accepted this recommendation and as a first step it included the scale derived from this work (EBIA) in the 2004 National Household Survey (PNAD). Indeed, for the first time Brazil has generated nationally and regionally representative household food insecurity estimates. EBIA was also included in the recently completed Brazilian Demographic and Health Survey (DHS). Thus, the analytical approach developed in this paper has major implication for assessing the psychometric behavior of EBIA and confirming its validity at a national level, with potential dissemination throughout Latin America.

Although some of the items in the Campinas-HFSSM were modified in response to previous cognitive research, a comparison of relative item severities with equivalent items from the US CPS showed strong similarities between the two modules. They are clearly measuring essentially the same phenomenon in the two surveys. Given that similarity, approximate equivalence could be established between the two measures. Equivalence would, however, be only approximate, as some items intended to represent the same objective conditions in the two modules differ substantially in severity level. Discrepancies in severity scores might be related to actual differences in the segments of the food insecurity construct being measured by the individual items. To compare prevalence rates between the two surveys, equivalent thresholds would need to be established because each scale includes unique items that are not in the other scale. Recently conducted studies using item response theory models in Trinidad and Tobago are consistent with this finding as well (Gulliford *et al.*, 2006).

As suggested by Coates *et al.*, 2004 when comparing household food security measures in several countries with differing cultures and languages, important commonalities in the experience of food insecurity related to insufficient food quantity, inadequate food quality, and uncertainty and worry about food exist across cultures. In spite of that, generalization across countries must be taken with caution

as important differences might also exist, especially with regard to the level of severity at which food insecurity is experienced by diverse populations. In other words, at this moment it is not possible to determine whether universal cutoff points can be used across countries to convert the scale scores into discrete food security/insecurity categories. Even within the same country and especially in countries with substantial cultural or linguistic diversity, differences in the way the questions are interpreted and responded might weaken the validity and reliability of the measure. Therefore, despite the already available versions of the US-HFSSM in other languages, the lack of adaptation and modification of this tool to the specific local language uses and cultural values might have negative impacts in the quality of the collected food security data. As shown by a study conducted by Melgar-Quinonez *et al.* (2006) in three countries, the differences in time and resources available for the initial qualitative assessment of proposed tool for its subsequent adaptation and modification to the local culture might have generated dissimilarities in the psychometric characteristics of the measurements.

Analysis by region of nationally representative data should be conducted to further assess the validity of the measure across the diverse populations of Brazil and to assess the extent to which food security statistics will be comparable across these populations. As 'Fome Zero' evolves as a national program to assist those at a higher risk of food insecurity and hunger, the need for a national tool to monitor and evaluate its impact at the household level is becoming more crucial. The results and analytical methodology presented in this paper will be used for assessing the validity of EBIA at a national level and improving it for future applications.

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