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ORIGINAL PAPER

# Measuring the extent, depth, and severity of food insecurity: an application to American Indians in the USA

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**Abstract** Within the extensive food insecurity literature, little work has been done regarding (a) the depth and severity of food insecurity and (b) the food insecurity of American Indians. This paper addresses both these topics with data from the 2001 to 2004 Core Food Security Module of the Current Population Survey. To measure food insecurity, three axiomatically derived measures of food insecurity are used. As expected, given the worse economic conditions facing American Indians, their food insecurity levels are generally higher than non-American Indians. However, the magnitude and significance of these differences differ depending on the choice of food insecurity measure.

**Keywords** Food insecurity · American Indian · Poverty

**JEL** I31 · I32

## 1 Introduction

Food insecurity in the USA has become a well-publicized issue of concern to policymakers and program administrators. In 2004, for example, 11.9% of the population suffered from food insecurity (i.e., these households were uncertain of having, or unable to acquire, enough food for all their members because they had insufficient money or other resources), and 3.9% of the population suffered from food insecurity with hunger (i.e., at least some household members were hungry, at least some time during the year, because they could not afford enough food). In response to the burgeoning interest in food insecurity, in the past decade, an

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extensive literature has been developed that examines the determinants and consequences of food insecurity in the USA (for recent work, see e.g., Bhattacharya et al. 2004; Bitler et al. 2005; Borjas 2004; Dunifon and Kowaleski-Jones 2003; Furness et al. 2004; Gundersen and Kreider 2007; Gundersen et al. 2003; Laraia et al. 2006; Ribar and Hamrick 2003; Slack and Yoo 2005; Stuff et al. 2004; Van Hook and Balistreri 2006). Largely missing from this literature, however, are analyses of the depth and severity of food insecurity in the USA and examinations of the food insecurity status of American Indians at a national level.

In virtually all cases, food insecurity (or, more broadly, food hardship) is measured with binary variables reflecting whether someone is food secure or food insecure. In some comparisons, three categories are also employed—food secure, food insecure, and food insecure with hunger. When these broad categories are used, however, a great deal of information is being suppressed. In particular, information is not being utilized when broad categories are created from the 18-item Core Food Security Module (CFSM), which is used in a wide variety of surveys including the Current Population Survey (CPS). Within the CFSM, a household with children responding affirmatively to three or more questions is deemed food insecure and a household responding affirmatively to eight or more questions is deemed food insecure with hunger. As an example, consider two households, one responding affirmatively to 8 questions and one responding affirmatively to 18 questions. Both are treated as food insecure with hunger; yet, arguably, the latter household has a higher level of food insecurity. In this article, I use a series of axiomatically derived measures that portray the extent, depth, and severity of food insecurity. Along with utilizing more of the information contained in the CFSM, the series of measures used in this article allow one to ascertain the robustness of comparisons of food insecurity between groups.

Being able to portray the depth and severity of food insecurity may be especially relevant for the second major topic being analyzed in this article, the food insecurity status of American Indians. The economic status of Native Americans is substantially worse than the rest of the USA. This status is reflected in per capita incomes, which are 40% less than the entire population (Leichenko 2003), and the large numbers of Native Americans with earnings in the lower end of the income distribution (Gregory et al. 1997). These economic hardships are also reflected in the lower average incomes in counties with a high proportion of Native Americans (Leichenko 2003; Table 2). Given the close connection between economic hardships and food insecurity (Nord et al. 2004; Table 3), one may also expect the food insecurity status of American Indians to also be substantially worse than the general population. While there have been numerous studies on individual reservations examining the extent of food insecurity and other nutrition-deprivation problems (for a summary, see American Indian Studies Programs 2000; Tiehen 2003a,b), to date there have not been any analyses regarding food insecurity among American Indians on a national basis.

I begin this article with background on the development of the food insecurity measures used in the USA. I then turn to the methodology employed in this paper to describe the extent, depth, and severity of food insecurity in the USA, followed by a description of the data set used to apply this methodology—the CPS. With this methodology and data set, I consider baseline cases for the food insecurity rates, the

food insecurity gap, and the squared food insecurity gap, which use the same set of questions employed by the US Department of Agriculture (USDA). These baseline cases are followed by analyses using alternative subsets of questions from the CFSM that have been employed in other papers and one new subset of questions based on suggestions from other work. Following these results under these baseline and other cases, I turn to results from multivariate models and some concluding remarks.

The ordering of food insecurity between American Indians and non-American Indians is as expected: With a few exceptions, food insecurity and food insecurity with hunger are higher among American Indians. However, the magnitudes of the differences differ markedly by choice of food insecurity measure and by choice of subset of food insecurity questions. These differences are especially relevant for households without children. These findings are further confirmed in a multivariate framework.

## 2 Background

### 2.1 History of measure

The official measurement of food insecurity by the US government began in 1995 with the addition of a food security supplement to the CPS. Based on the results from this survey and subsequent annual surveys, a report has been issued by the USDA, which portrays the current status of food insecurity in the USA. The issuance of this report is reported extensively in the media and is followed closely by policymakers inside and outside of the USDA. Along with being on the CPS for purposes of these reports and other research, the CFSM is also on numerous other surveys including the National Health and Nutrition Examination Survey (NHANES) and the Panel Study of Income Dynamics (PSID).

The development of the methods of food security measurement that underlie these reports began in the early 1980s when policymakers began to ask for a better description of what was meant by poverty-related hunger in the USA. As part of this drive, an expert panel was convened, which established definitions for "food security," "food insecurity," and "hunger" (Anderson 1990). Using these definitions, the National Nutrition Monitoring and Related Research Program (established by a 1992 Act of Congress) began to operationalize these concepts within a survey framework. The culmination of these efforts led to the current methods of measuring food insecurity.

If food insecurity were completely determined by other measures of constrained resources (e.g., poverty), the work of establishing the measurement of food insecurity would be largely irrelevant. However, research at the time and later showed that income-based measures and other measures of well being were not highly correlated with food insecurity and hunger[1]. While the food insecurity measures provide a distinct look at food insecurity and hunger in the USA, one should be aware of several things these measures do not do. First, unless the

[1] For a broader discussion of why direct indicators of well being and income measures may deviate, see Mayer and Jencks (1989). For more on why, in particular, measures of food insecurity may diverge from income-based measures see, e.g., Gundersen and Gruber (2001).

household consists of one individual (for adult only households) or one adult and one child (for households with children), information on individuals within the household are not available. Second, households are defined as food insecure if they face financial constraints. The structure of the questions, however, is such that households with inadequate food intakes due to, say, limited mobility that prevents travel to purchase food would not be counted as food insecure unless they also perceived their food inadequacy as being due to inadequate financial resources. Third, a respondent's answer to some of the food insecurity questions will depend on the respondent's perception of what constitutes a particular acceptable level of food intake. This perception may differ from what constitutes some notion of an "objective" acceptable level of food intake (for more on the subjective nature of the food insecurity measure see Gundersen and Ribar 2005).

### 2.2 Construction of food security scale

To calculate the official rates of food insecurity and food insecurity with hunger in the USA, a food security scale is constructed using a set of 18 questions if the household has children or 10 if it does not. Some of the conditions people are asked about include "I worried whether our food would run out before we got money to buy more," (the least severe item), "Did you or the other adults in your household ever cut the size of your meals or skip meals because there wasn't enough money for food," "Were you ever hungry but did not eat because you couldn't afford enough food," and "Did a child in the household ever not eat for a full day because you couldn't afford enough food" (the most severe item for households with children). (A complete list of questions is found in Appendix Table 10.) Each of these questions is qualified by the proviso that the conditions are due to financial constraints. As a consequence, persons who have reduced food intakes due to, say, fasting for religious reasons or dieting, would not be responding affirmatively to these questions.

These 18 questions are taken from a larger set of questions that were asked on the first CFSM in 1995. To narrow the set of questions, questions that were deemed to be a poor fit with other questions were dropped from the scale. Conversely, questions that were deemed to be redundant with other questions were dropped from the scale. Along with being a good fit with the other questions and not being redundant, the 18 questions are considered to be a unidimensional representation of food insecurity (for more on how the 18 questions were ultimately chosen and the justifications for these choices, see Hamilton et al. (1997), especially Chapter 2)[2].

Using the full set of 18 questions, the USDA delineates households into the categories of food secure, food insecure without hunger, and food insecure with hunger. The idea underlying the use of multiple questions is that no single question

[2] Given the differences between households with and without children and the differences in questions being asked (as noted above, the former are asked 18 questions, the latter 10), one may question whether the scales being used are unidimensional. In response, I use two sets of food insecurity scales used by previous authors—one that is restricted to the ten questions relevant for households without children and one that is restricted to the eight questions only asked of households with children. The results from these estimations are discussed below.

can accurately portray the concept of food insecurity.[3] To map the 18 questions into food insecurity categories, the USDA first employs a Rasch model, a model emerging out of the broader class of Item Response Theory models [for more on Rasch scoring methods, see, e.g., Andrich (1988)]. The results from estimating the Rasch model yield a value for each number of affirmative responses. These values can be seen as a reflection of the underlying severity of food insecurity facing a household responding affirmatively to a particular number of questions.

The results of this Rasch score modeling for the official USDA measures can be seen in columns 2 and 4 in Appendix Table 10. These values range from 0 to 13.03 for households with children and from 0 to 11.05 for households without children. As seen, more affirmative responses to these questions are associated with higher Rasch scores and, thus, higher levels of food insecurity. To draw a parallel with income measures, more affirmative responses are equivalent to lower levels of income. In interpreting the values, one should note that the values are unique up to a linear transformation. Thus, the relative differences between the values matter, not the absolute differences. As an example, for households with children, responding affirmatively to ten rather than nine questions raises the Rasch score by 0.56, while responding affirmatively to three rather than two questions raises it by 0.85. This would then imply that the severity of food insecurity increases more as one moves from two to three responses than from nine to ten responses.

These Rasch scores are then used to establish the thresholds for (a) food security, (b) food insecurity without hunger, and (c) food insecurity with hunger.[4] Households responding affirmatively to two or fewer questions are food secure; those responding to three to seven questions are defined as food insecure without hunger (three to five questions for households without children); and those responding to eight or more questions are defined as food insecure with hunger (six or more for households without children). Consistent with the language employed in the literature, a household responding affirmatively to three or more questions is identified as food insecure, with or without hunger. [For a thorough discussion of the construction of the food insecurity measure and how it can be implemented on surveys, see Bickel et al. (2000)].

## 3 Methodology

Given the creation of a household food insecurity index, the next step is to formulate an aggregate measure of food insecurity. While the current partitioning of food security into three categories—food secure, food insecure without hunger, food

[3] An analogy can be drawn with the educational testing literature where the Rasch model is often used. In that case, it would be presumed that no one question can reflect a student's knowledge of, say, a particular subject, but rather a series of questions are needed to accurately portray his or her knowledge.

[4] A household is said to be food secure if all household members had access at all times to enough food for an active, healthy life. Households are said to be food insecure if they were uncertain of having, or unable to acquire, enough food for all household members because they had insufficient money and other resources for food. Households are said to be food insecure with hunger if one or more household members were hungry, at least some time during the year because they could not afford enough food (Nord et al. 2004).

insecure with hunger—may be helpful for some purposes, it neglects to take full advantage of the information contained in the 18 questions; the following discussion demonstrates how one can utilize more fully the richness of the 18 questions. The theoretical framework utilized in this study is based on similar constructions within the income poverty literature (e.g., Atkinson 1987; Foster et al. 1984; Foster and Shorrocks 1991; Pattanaik and Sengupta 1995; Sen 1976). For more on the particular application to food insecurity used here, see Dutta and Gundersen (2007). This section contains a general description of the methodology. Below, this methodology is then applied to the measurement of food insecurity in the USA.

### 3.1 Notation and concepts

Let $N=\{1,...,n\}$ denote the set of all households under consideration, $n$ being the total number of households in the set. For all $i\in N$, let $s_i$ denote the food indicator (FI) for household $i$ where a higher value of $s_i$ indicates a more unfavorable food situation for household $i$. I assume that for every $i\in$N, $s_i$ lies in the interval $[0, z]$, where the value 0 denotes the complete absence of any unfavorable circumstance relating to food, and $z$ denotes the most unfavorable situation with respect to food. As described below, the value of $z$ can vary by household composition.

Let $e$ be the benchmark such that a household $i$ is considered food insecure if and only if $s_i>e$. Thus, $e$ is akin to a poverty line in the income poverty literature. For every household $i$, the food insecurity index (FII) for $i$ is defined to be 0 if $s_i\leq e$, and it is defined to be $(s_i-e)$ if $s_i>e$. This implies that the food security status of food secure households is not reflected in the food security measures; this is akin to how the incomes of those above the poverty line are not reflected in poverty measures. The FII of a household is a measure of the degree to which the household is food insecure; it is analogous to the notion of an individual's "shortfall" from the poverty line, used in the literature on poverty measurement. The normalized food insecurity index (NFII) denoted by $d_i$, is then obtained via

$$d_i=\frac{s_i-e}{z-e} \text{ if } s_i>e;\ d_i-0 \text{ otherwise} \tag{1}$$

Let $d$ denote the degree of food insecurity suffered by the group, $N$, of all households. I assume that $d$ is a (real valued) function of $d_1,...,d_n$. This function is a rule for aggregating household food insecurity levels. Thus, this aggregation rule is a function $D:[0,1]^n \rightarrow R^n$. Define $d$ as $d=D(d_1,...,d_n)$.

### 3.2 Form of the aggregation rule D

What form should one assume for the function $D$ that aggregates the food insecurity levels, $d_1,...,d_n$, of the households to arrive at the index, $d$, of food insecurity at a higher level of aggregation? The properties of similar rules for aggregating deprivation levels have been discussed extensively in the literature on income poverty. Some of the familiar properties that one may wish to impose on $D$ are:

Normalization: For all $(d_1,...,d_n)\in[0, 1]^n$, [if $d_i=0$ for all $i\in N$, then $d=0$] and [if $d_i=1$ for all $i\in N$, then $d=1$].

Anonymity: For all $(d_1,...,d_n)$, $(d'_1,..., d'_n)\in[0, 1]^n$, and for all $i, j\in N$, if $[d_i=d'_j]$, $[d_j=d'_i]$ and [for all $t\in N-\{i,j\}$, $d_t=d'_t$], then $d=d'$.

Monotonicity: For all $(d_1,...,d_n)$, $(d'_1,..., d'_n)\in[0, 1]^n$, and for all distinct $i, j\in N$, if $[d_i\geq d'_i$ for all $i\in N]$ and $[d_i>d'_i$ for some $i\in N]$, then $d>d'$, where $d=D(d_1,...,d_n)$ and $d'=D(d'_1,...,d'_n)$.

Transfer: For all $(d_1,...,d_n)$, $(d'_1,..., d'_n)\in[0, 1]^n$, and for all distinct $i, j\in N$, if [(for all $p\in N-\{i, j\}$, $d_p=d'_p$) and $(d_i>d_j>0)$ and for some $\delta>0$, $d'_i=d_i+\delta$ and $d'_j=d_j-\delta>0$) and (for all $p, q\in N$, $d_p\geq d_q$ if and only if $d'_p\geq d'_q$)], then $d'>d$.

Normalization, which requires that $d$ be 0 when the NFII is 0 for all households and $d$ should be 1 when the NFII is 1 for all households, is an innocuous property. Its justification lies in the convenience it ensures. Anonymity requires that, other things remaining the same, if the NFII of two households are interchanged, then the food insecurity index for the society remains unaffected. Thus, anonymity demands that the households be treated by the aggregation rule in a symmetric fashion. In a framework based on the aggregation of individual deprivation levels, symmetric treatment of individuals is a compelling property. However, in this framework, where $D$ aggregates the NFII's of households to arrive at the measure of overall food insecurity for $N$, the symmetric treatment of the households may be a less compelling property, insofar as households differ in size. Monotonicity requires that, other things remaining the same, an increase in the NFII of a household leads to a rise in the value of the food insecurity index of the society as a whole. The transfer property stipulates that any transfer from one food insecure household to another household with a higher level of food insecurity must lead to an increase in the aggregate level of food insecurity.

In this paper, I use three different aggregation rules for the function $D$. Let $n$ denote the number of households in a society. The different aggregation rules all can be expressed by varying $\alpha$ through the following construction from Foster et al. (1984):

$$d^{\alpha}=\frac{\sum_{i=1}^{n}(d_i)^{\alpha}}{n} \tag{2}$$

When $\alpha=0$, $d$ defines the food insecurity rate; when $\alpha=1$, $d$ defines the food insecurity gap; and when $\alpha=2$, $d$ defines the squared food insecurity gap. These are the three measures used in this article. The food insecurity rate (i.e., the most commonly used measure of food insecurity) satisfies the normalization and anonymity axioms, but it does not satisfy either of the other two axioms; this is one of the reasons for dissatisfaction with the measure. The food insecurity gap satisfies the first three axioms but not the transfer axiom. The squared food insecurity gap measure satisfies all four axioms.

## 4 Data

For this article, I use data from the 2001 through 2004 December Supplements from the CPS, a monthly survey of approximately 50,000 households. Along with being

the official data source for official poverty and unemployment rates, in this supplement the CPS has the CFSM. The CFSM has been in at least 1 month in the CPS in every year since 1995. To avoid issues of seasonality and changes in various other things (e.g., the screening questions), only the four most recently available December Supplements are used in this article. Multiple years are used for this analysis due to the limited sample size of American Indians in any given year. In general, a household is observed in 2 successive years in the CPS. As multiple years are being used in this paper, to ensure that no household is included more than once, households observed for the second time in 2001 through 2003 are included in the sample and all households observed in 2004 are included in the sample.

In terms of defining who is American Indian, on the 2001 and 2002 CPS, there were four questions used to establish race. In households where the respondent answered "American Indian, Aleut, or Eskimo," the household is defined as American Indian. Beginning in the 2003 CPS, persons were allowed to report multiple races. The possible combinations that lead to a designation of American Indian for this article are "American Indian or Alaskan," "white and American Indian," "black and American Indian," "American Indian and Asian," "white, black, and American Indian," "white, American Indian, and Asian," and "white, black, American Indian, and Asian." This change resulted in a decrease in the percentage of persons who reported that they were only American Indian, but overall, an increase in the percentage of persons who reported that they were at least part American Indian. Insofar as it is unlikely that there was an increase in the percentage of the population that is American Indian, the increase is presumably due to persons who may have identified, say, as "black" before but now identify as "black-American Indian." In this article, I define anyone in 2003 and 2004 who reported that they were at least part American Indian as "American Indian." I also consider how the results may differ if an alternative definition of American Indian is used for 2003 and 2004.

Figures 1 and 2 display the percent of households responding affirmatively to each of the possible number of affirmative responses. These are further broken down by whether a household is headed by an American Indian or a non-American Indian. For households with children (in Fig. 1), the number varies from 1 to 18, and for households without children (in Fig. 2), it varies from 1 to 10.[5] Consistent with the work being done below, these percentages are for the four years combined. The graphs delineate the thresholds for food secure, food insecure without hunger, and food insecure with hunger.

As seen, American Indians are more likely than non-American Indians to respond affirmatively to a given number of questions across all the possible values (with the exception of 18 questions—no American Indians responded affirmatively to all questions). One further difference between the two groups is that for households with children, there is a monotonic decline in the number of affirmative responses for non-American Indians, but for American Indians, households are more likely to

[5] The percent of households responding affirmatively to zero questions is suppressed in the figures. If these values were included, in Fig. 1, 54.7% of American Indians responded affirmatively to zero questions and 74.8% of non-American Indians responded affirmatively to zero questions. In Fig. 2, the respective values are 71.5 and 85.9%.

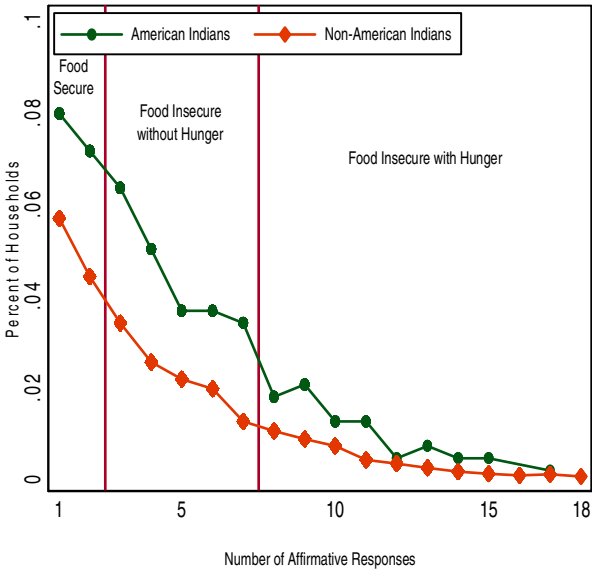


**Fig. 1** Food insecurity responses by AI status, households with children

respond affirmatively to 9 than 8 questions and 13 than 12 questions. For households without children, the number of affirmative responses is generally decreasing for non-American Indians (with slight increases from five to six responses and from nine to ten responses) but American Indians are more likely to respond affirmatively to six questions than five or four questions, are more likely to respond affirmatively

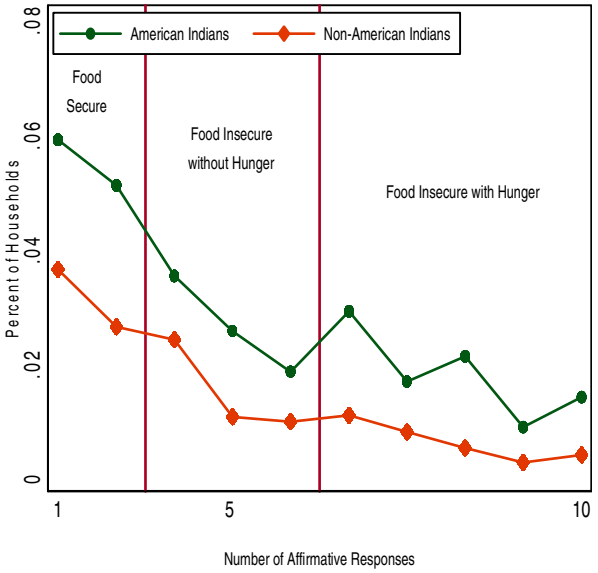


**Fig. 2** Food insecurity responses by AI status, households without children

to eight questions than seven or five questions, and are more likely to respond affirmatively to ten questions than nine questions.

One common argument for why distribution sensitive measures like those employed in this paper are used is because rates do not portray differences, in this case, in levels of food insecurity. Why this argument matters for food insecurity can be seen in these figures. As an example from Fig. 1, 255 households with children responded affirmatively to ten questions. These households would be categorized as food insecure with hunger, just like the 378 households with children responding affirmatively to eight questions. Or, if food insecurity was being analyzed, these households responding to ten questions would be treated the same as households responding affirmatively to three questions—1,276 in the case of households with children. These households would be treated equally despite the fact that according to the Rasch scoring methods, households responding affirmatively to more questions should be treated as more food insecure.

For illustrative purposes, I used the counts of affirmative responses in Figs. 1 and 2. For the results below, however, I use the values established by the Rasch scoring method above. The value of $s_i$ is thus a latent variable of food insecurity. I set $z$ equal to 13.03 for households with children and 11.05 for households without children. A value of $e$ is also needed. Recall that households are food insecure if they respond affirmatively to more than two questions. This cutoff corresponds to a value of $e$ of 2.56 for households with children and 3.10 for households without children. For food insecure with hunger, the relevant values of $e$ are 6.02 for households with children and 6.16 for households without children.

The values of $d_i$ and, subsequently, $d$ are therefore established based on values obtained by the Rasch scoring method. In the case of $\alpha=0$, whether one uses the Rasch scoring method or some other method (say, a count of affirmative responses) the food insecurity rate will be the same, just so long as the same thresholds (as determined by the relevant number of affirmative responses) are used. In the cases of $\alpha=1$ and 2, however, the values will differ depending on the Rasch scores.

## 5 Results

### 5.1 Comparisons of food insecurity and food insecurity with hunger

The top panel of Table 1 has the food insecurity results under each of the three measures among American Indians and non-American Indians for the years 2001 to 2004 for households with children. These are further broken down for all income levels and for households with incomes below 185% of the poverty line (low-income sample). This is also the income cutoff for the Special Supplemental Nutrition Program for Women, Infants, and Children (WIC) and for reduced price meals through the National School Lunch Program and National School Breakfast Program. The results are weighted by household size. Across all three measures for the all-income sample, food insecurity is higher among American Indians than among non-American Indians, and these differences are statistically significant. For the low-income sample, the difference between American Indians and non-American Indians is also significant for all three measures except the differences are now significant at the 95

**Table 1** Food insecurity for American Indians and non-American Indians

| Food insecurity measure | All households | | | Households with incomes below 185% of the poverty line | | |
|---|---|---|---|---|---|---|
| | American Indians (1) | Non-American Indians (2) | Ratio of columns (1) and (2) (3) | American Indians (4) | Non-American Indians (5) | Ratio of columns (4) and (5) (6) |
| Households with children | | | | | | |
| Food insecurity rate ($\alpha$=0) | 0.280[a] | 0.157 | 1.783 | 0.417[b] | 0.348 | 1.198 |
| | (0.020) | (0.002) | | (0.030) | (0.005) | |
| Food insecurity gap ($\alpha$=1) | 0.077[a] | 0.041 | 1.878 | 0.120[b] | 0.093 | 1.290 |
| | (0.007) | (0.001) | | (0.011) | (0.002) | |
| Squared food insecurity gap ($\alpha$=2) | 0.030[a] | 0.015 | 2.000 | 0.047[b] | 0.035 | 1.343 |
| | (0.004) | (0.0004) | | (0.006) | (0.001) | |
| Unweighted sample size | 1,143 | 58,703 | | 646 | 18,746 | |
| Number of respondents with at least one affirmative response | 524 | 14,718 | | 404 | 9,866 | |
| Households without children | | | | | | |
| Food insecurity rate ($\alpha$=0) | 0.163[a] | 0.078 | 2.090 | 0.305[a] | 0.191 | 1.597 |
| | (0.013) | (0.001) | | (0.026) | (0.003) | |
| Food insecurity gap ($\alpha$=1) | 0.081[a] | 0.031 | 2.613 | 0.158[a] | 0.080 | 1.975 |
| | (0.008) | (0.001) | | (0.017) | (0.002) | |
| Squared food insecurity gap ($\alpha$=2) | 0.053[a] | 0.018 | 2.944 | 0.105[a] | 0.047 | 2.234 |
| | (0.006) | (0.0003) | | (0.013) | (0.001) | |
| Unweighted sample size | 1,702 | 124,679 | | 748 | 32,926 | |
| Number of respondents with at least one affirmative response | 480 | 17,102 | | 336 | 10,275 | |

Data are from the 2001–2004 Current Population Survey. Standard errors are in parentheses.

[a] Used in columns (1) and (4) if the p value of the difference between columns (1) and (2) and columns (4) and (5) are less than 0.01

[b] Used in columns (1) and (4) if the p value of the difference between columns (1) and (2) and columns (4) and (5) are less than 0.05

rather than 99% confidence level. In the bottom panel of Table 1, the results for the sample of households without children are displayed. For both the sample of all incomes and the low-income sample, American Indians have higher food insecurity rates than non-American Indians. Thus, the orderings (i.e., whether American Indians or non-American Indians have higher levels of food insecurity) are robust to at least these three food insecurity measures.

Along with considering the orderings across the three measures, one may also wonder whether the magnitude of the differences is similar across the measures. One way to consider this is by taking the ratio of the food insecurity measures for American Indians to non-American Indians. These results are in columns 3 and 6 of Table 1.

For the sample of households with children, the ratios are quite similar across all three measures for both all households and for the low-income sample. For the sample of households without children, however, the ratios differ markedly as more weight is placed on the food insecurity of those with higher food insecurity levels (i.e., as the value of $\alpha$ increases.) For the all-income sample of households without

children, the ratio is 2.09 when $\alpha$=0, and it is 2.94 when $\alpha$=2. For the low-income sample, the figures are 1.60 and 2.23. Therefore, in households with children, the conclusions one draws regarding differences between American Indians and non-American Indians depend on the choice of food security measure.

In Table 2, the results for food insecurity with hunger are displayed in a manner similar to Table 1. For the full sample, as was the case with food insecurity, food insecurity with hunger is higher among American Indians than among non-American Indians under all three measures. For the low-income sample, in contrast to the food insecurity results, there is no statistical distinction between food insecurity with hunger between American Indians and non-American Indians among households with children. Turning to households without children, food insecurity with hunger is higher among American Indians for both the full sample and the low-income sample. As with food insecurity, the results are robust to choice of food insecurity measure.

To again give some sense of the magnitude of the differences between American Indians and non-American Indians, the results for the food insecurity with hunger results are displayed in columns 3 and 6 of Table 2. As for the food insecurity measure, the ratio between American Indians and non-American Indians for households without children in the all-income sample is increasing in $\alpha$—the ratio

**Table 2** Food insecurity with hunger for American Indians and non-American Indians

| Food insecurity measure | All households | | | Households with incomes below 185% of the poverty line | | |
|---|---|---|---|---|---|---|
| | American Indians (1) | Non-American Indians (2) | Ratio of columns (1) and (2) (3) | American Indians (4) | Non-American Indians (5) | Ratio of columns (4) and (5) (6) |
| Households with children | | | | | | |
| Food insecurity rate ($\alpha$=0) | 0.071[a] (0.010) | 0.038 (0.001) | 1.868 | 0.117 (0.018) | 0.090 (0.003) | 1.300 |
| Food insecurity gap ($\alpha$=1) | 0.021[a] (0.004) | 0.010 (0.000) | 2.100 | 0.033 (0.006) | 0.023 (0.001) | 1.435 |
| Squared food insecurity gap ($\alpha$=2) | 0.008[b] (0.002) | 0.003 (0.000) | 2.667 | 0.013 (0.003) | 0.009 (0.001) | 1.444 |
| Unweighted sample size | 1,143 | 58,703 | | 646 | 18,746 | |
| Households without children | | | | | | |
| Food insecurity rate ($\alpha$=0) | 0.091[a] (0.011) | 0.032 (0.001) | 2.844 | 0.185[a] (0.023) | 0.083 (0.002) | 2.229 |
| Food insecurity gap ($\alpha$=1) | 0.047[a] (0.006) | 0.014 (0.000) | 3.357 | 0.095[a] (0.013) | 0.039 (0.001) | 2.436 |
| Squared food insecurity gap ($\alpha$=2) | 0.032[a] (0.005) | 0.009 (0.000) | 3.556 | 0.067[b] (0.012) | 0.026 (0.001) | 2.577 |
| Unweighted sample size | 1,702 | 124,679 | | 748 | 32,926 | |

Data are from the 2001–2004 Current Population Survey. Standard errors are in parentheses.

[a] Used in columns (1) and (4) if the $p$ value of the difference between columns (1) and (2) and columns (4) and (5) are less than 0.01

[b] Used in columns (1) and (4) if the $p$ value of the difference between columns (1) and (2) and columns (4) and (5) are less than 0.05

is 2.84 when $\alpha$=0, 3.36 when $\alpha$=1, and 3.56 when $\alpha$=2. For the low-income sample, however, the increase is much smaller—the respective figures are 2.23, 2.44, and 2.58. For households with children, the ratios are similar across all three measures.

## 5.2 Alternative specifications of the food insecurity measure

In the analyses of the previous section, I employed the same methods used in official measures of food insecurity and food insecurity with hunger in the USA. In particular, I used (a) the Rasch values established for each number of affirmative responses, (b) the set of 18 questions for households with children and the set of 10 questions for households without children, and (c) the cutpoints established to ascertain if a household was food secure, food insecure, or food insecure with hunger. To check the robustness of the results above, I now turn to two alternative specifications of the food insecurity scales found in recent papers and one additional alternative specification. The first two alternative specifications address the potential that the food insecurity scale is not unidimensional, especially when the same sets of questions are applied to households with and without children. The third alternative specification addresses the lack of independence between some of the questions on the CFSM.

The first specification uses the same set of questions for households with and households without children. In other words, the eight questions used for households with children are not considered in establishing food insecurity and food insecurity with hunger for households with children. The cutpoints for food insecurity and food insecurity with hunger are then the same for all households—a household with more than two affirmative answers is food insecure and a household with more than five affirmative answers is food insecure with hunger. This use of the same set of questions for households with and without children and the subsequent choices of similar cutpoints is suggested by Wilde (2004) to more consistently estimate the food insecurity of households with and without children. As a subset of questions is being asked, I establish a new set of Rasch scores, which are available upon request from the author. The results of this alternative measure are found in Table 3. As seen in a comparison of Tables 1 and 3, the proportion of food insecure households with children counted as food insecure declines from 0.290 to 0.219 for American Indians and from 0.157 to 0.124 for non-American Indians. Despite this change and the changes in the values of the other food insecurity measures, the ratios of food insecurity rates between American Indians and non-American Indians are relatively similar under the different sets of food insecurity questions used in Table 3 and in Table 1.[6]

The second specification considers food insecurity among households with children when only the food insecurity questions for children are used. This is the method employed in Casey et al. (2006). Now, only the eight child-specific questions are used, and I construct the Rasch scales using these questions. Consistent with the definition of Casey et al. (2006), a household is defined as food insecure if

[6] The results for food insecurity with hunger are available from the author upon request.

**Table 3** Food insecurity for American Indians and non-American Indians, same questions for households with and without children

| Food insecurity measure | All households | | | Households with incomes below 185% of the poverty line | | |
|---|---|---|---|---|---|---|
| | American Indians (1) | Non-American Indians (2) | Ratio of columns (1) and (2) (3) | American Indians (4) | Non-American Indians (5) | Ratio of columns (4) and (5) (6) |
| Households with children | | | | | | |
| Food insecurity rate ($\alpha$=0) | 0.219[a] | 0.124 | 1.766 | 0.338[b] | 0.274 | 1.234 |
| | (0.018) | (0.003) | | (0.029) | (0.005) | |
| Food insecurity gap ($\alpha$=1) | 0.078[a] | 0.040 | 1.95 | 0.127[b] | 0.090 | 1.411 |
| | (0.009) | (0.001) | | (0.015) | (0.021) | |
| Squared food insecurity gap ($\alpha$=2) | 0.045[a] | 0.021 | 2.143 | 0.076[b] | 0.048 | 1.583 |
| | (0.007) | (0.001) | | (0.011) | (0.002) | |
| Unweighted sample size | 1,143 | 58,703 | | 646 | 18,746 | |
| Number of respondents with at least one affirmative response | 497 | 13,944 | | 385 | 9,396 | |
| Households without children | | | | | | |
| Food insecurity rate ($\alpha$=0) | 0.163[a] | 0.078 | 2.090 | 0.305[a] | 0.191 | 1.597 |
| | (0.013) | (0.001) | | (0.026) | (0.003) | |
| Food insecurity gap ($\alpha$=1) | 0.078[a] | 0.030 | 2.600 | 0.149[a] | 0.075 | 1.987 |
| | (0.008) | (0.001) | | (0.015) | (0.002) | |
| Squared food insecurity gap ($\alpha$=2) | 0.052[a] | 0.017 | 3.059 | 0.100[a] | 0.046 | 2.174 |
| | (0.006) | (0.0004) | | (0.013) | (0.001) | |
| Unweighted sample size | 1,702 | 124,679 | | 748 | 32,926 | |
| Number of respondents with at least one affirmative response | 480 | 17,102 | | 336 | 10,275 | |

Data are from the 2001–2004 Current Population Survey. Standard errors are in parentheses.

[a] Used in columns (1) and (4) if the $p$ value of the difference between columns (1) and (2) and columns (4) and (5) are less than 0.01

[b] Used in columns (1) and (4) if the $p$ value of the difference between columns (1) and (2) and columns (4) and (5) are less than 0.05

more than one question is answered affirmatively. The results are in Table 4.[7] In comparison to Table 1, the ratios are more similar across the three measures, for both all households and the low-income sample in comparison to the results using the full set of food insecurity questions.

The final alternative specification emerges from a suggestion that only questions that do not depend on a household's responses to the other questions should be used to establish the Rasch scores. (National Research Council 2005; Chapter 5). The argument is that questions that depend on one's responses to other questions would lead to a violation of conditional statistical independence, which is needed to estimate the Rasch model. As seen in the Appendix Table 10, some questions are only asked if someone responds affirmatively to a precursor. As an example, one can only respond affirmatively to question number 8 regarding how often adult(s)

[7] Because a different set of questions are being used than in Table 1, the absolute values for $\alpha$=0 are not directly comparable across the two tables.

**Table 4** Food insecurity for American Indians and Non-American Indians, questions specific to children

| Food insecurity measure | All households | | | Households with incomes below 185% of the poverty line | | |
|---|---|---|---|---|---|---|
| | American Indians (1) | Non-American Indians (2) | Ratio of columns (1) and (2) (3) | American Indians (4) | Non-American Indians (5) | Ratio of columns (4) and (5) (6) |
| Food insecurity rate ($\alpha$=0) | 0.297[a] (0.021) | 0.166 (0.002) | 1.789 | 0.431[b] (0.031) | 0.361 (0.005) | 1.194 |
| Food insecurity gap ($\alpha$=1) | 0.206[a] (0.015) | 0.114 (0.002) | 1.807 | 0.300[b] (0.022) | 0.254 (0.003) | 1.181 |
| Squared food insecurity gap ($\alpha$=2) | 0.158[a] (0.013) | 0.087 (0.002) | 1.816 | 0.231 (0.020) | 0.198 (0.002) | 1.167 |
| Unweighted sample size | 1,143 | 58,703 | | 646 | 18,746 | |
| Number of respondents with at least one affirmative response | 362 | 9,142 | | 284 | 6,515 | |

Data are from the 2001–2004 Current Population Survey. Standard errors are in parentheses.
[a] Used in columns (1) and (4) if the *p* value of the difference between columns (1) and (2) and columns (4) and (5) are less than 0.01
[b] Used in columns (1) and (4) if the *p* value of the difference between columns (1) and (2) and columns (4) and (5) are less than 0.05

skipped meals if one had previously responded affirmatively to question number 5, which asks if adult(s) had ever skipped meals. Once questions that depend on responses to previous questions are eliminated, the total number of questions asked of households without children is 8 and the total number of questions asked of households with children is 15. I re-estimate food insecurity under each of the measures in Table 5[8]. As the threshold value does not include any of the three deleted questions, I have kept the threshold at more than two affirmative responses. The results in the top panel of Table 5 for households with children are quite similar to those in Table 1. For households without children (in the bottom panel), however, the results do differ quite markedly. For the case of $\alpha$=0, when the sample includes all households, the proportion of food insecure households drops from 0.163 to 0.129 for American Indians and from 0.078 to 0.049 for non-American Indians. For the low-income sample, the declines are, respectively, 0.305 to 0.242 and 0.191 to 0.124. Another difference with Table 1 is that the ratios of food insecurity between American Indians and non-American Indians are much more similar in Table 5 (see columns 3 and 6). Thus, the restriction of the sample such that all variables that depend on responses to other variables does make a difference.

### 5.3 Multivariate analyses

The differences between food insecurity among American Indians and non-American Indians may be due to many factors. For example, as seen in Appendix

[8] As done in the previous two alternative specifications, I estimate a new set of Rasch scores. These are available from the author upon request.

**Table 5** Food insecurity for American Indians and non-American Indians, questions independent of previous questions

| Food insecurity measure | All households | | | Households with incomes below 185% of the poverty line | | |
|---|---|---|---|---|---|---|
| | American Indians (1) | Non-American Indians (2) | Ratio of columns (1) and (2) (3) | American Indians (4) | Non-American Indians (5) | Ratio of columns (4) and (5) (6) |
| Households with children | | | | | | |
| Food insecurity rate ($\alpha$=0) | 0.279[a] | 0.157 | 1.777 | 0.416[b] | 0.346 | 1.202 |
| | (0.020) | (0.002) | | (0.030) | (0.005) | |
| Food insecurity gap ($\alpha$=1) | 0.066[a] | 0.035 | 1.886 | 0.103[b] | 0.079 | 1.304 |
| | (0.006) | (0.001) | | (0.010) | (0.002) | |
| Squared food insecurity gap ($\alpha$=2) | 0.026[a] | 0.013 | 2.000 | 0.041 | 0.030 | 1.367 |
| | (0.003) | (0.0003) | | (0.006) | (0.001) | |
| Unweighted sample size | 1,143 | 58,703 | | 646 | 18,746 | |
| Number of respondents with at least one affirmative response | 524 | 14,718 | | 404 | 9,866 | |
| Households without Children | | | | | | |
| Food insecurity rate ($\alpha$=0) | 0.129[a] | 0.049 | 2.633 | 0.242[a] | 0.124 | 1.952 |
| | (0.124) | (0.001) | | (0.025) | (0.003) | |
| Food Insecurity gap ($\alpha$=1) | 0.076[a] | 0.027 | 2.815 | 0.145[a] | 0.070 | 2.071 |
| | (0.008) | (0.001) | | (0.016) | (0.002) | |
| Squared food insecurity gap ($\alpha$=2) | 0.054[a] | 0.018 | 3.000 | 0.104[a] | 0.047 | 2.213 |
| | (0.007) | (0.0004) | | (0.014) | (0.001) | |
| Unweighted sample size | 1,702 | 124,679 | | 748 | 32,926 | |
| Number of respondents with at least one affirmative response | 480 | 17,102 | | 336 | 10,275 | |

Data are from the 2001–2004 Current Population Survey. Standard errors are in parentheses.

[a] Used in columns (1) and (4) if the $p$ value of the difference between columns (1) and (2) and columns (4) and (5) are less than 0.01

[b] Used in columns (1) and (4) if the $p$ value of the difference between columns (1) and (2) and columns (4) and (5) are less than 0.05

Table 11, over nearly every characteristic one may associate with higher rates of food insecurity, American Indians are worse off. For example, lower income households have higher probabilities of food insecurity; the average income-to-poverty ratio of American Indians in households with children is 2.25, while for non-American Indians, the ratio is 3.08.

To consider the influence of being in a household headed by an American Indian, net of other factors, I therefore estimate the following model for each food insecurity measure, for food insecurity and food insecurity with hunger, and for the full sample and the low-income sample:

$$d_i = \theta \text{AmericanIndian}_i + \delta \text{Nonmetro}_i + \boldsymbol{\beta}\mathbf{X}_i + \boldsymbol{\gamma}\mathbf{Y}_i + \zeta\mathbf{Z}_i + \tau\mathbf{S}_i + e_i \quad (3)$$

where AmericanIndian=1 if a household is headed by an American Indian, 0 otherwise; Nonmetro=1 if a household lives in a nonmetro area, 0 otherwise; **X** is a vector of variables reflecting non-economic characteristics of the household (marital status, education, age); **Y** is a vector reflecting economic characteristics of the

**Table 6** Effect of American Indian status on food insecurity and on food insecurity with hunger

| | All households | | | Households with incomes below 185% of the poverty line | | |
|---|---|---|---|---|---|---|
| | Food insecurity rate ($\alpha$=0) (1) | Food insecurity gap ($\alpha$=1) (2) | Squared food insecurity gap ($\alpha$=2) (3) | Food insecurity rate ($\alpha$=0) (4) | Food insecurity gap ($\alpha$=1) (5) | Squared food insecurity gap ($\alpha$=2) (6) |
| Food insecurity | | | | | | |
| Households with children | | | | | | |
| American Indian | 0.075[a] | 0.023[a] | 0.010[a] | 0.067[a] | 0.023[a] | 0.011[a] |
| | (0.013) | (0.004) | (0.002) | (0.023) | (0.008) | (0.004) |
| Households without children | | | | | | |
| American Indian | 0.064[a] | 0.038[a] | 0.026[a] | 0.089[a] | 0.059[a] | 0.044[a] |
| | (0.008) | (0.004) | (0.003) | (0.018) | (0.009) | (0.007) |
| Food insecurity with hunger | | | | | | |
| Households with children | | | | | | |
| American Indian | 0.024[a] | 0.007[a] | 0.003[b] | 0.027[b] | 0.009[b] | 0.004 |
| | (0.007) | (0.002) | (0.001) | (0.014) | (0.004) | (0.003) |
| Households without children | | | | | | |
| American Indian | 0.047[a] | 0.026[a] | 0.019[a] | 0.078[a] | 0.045[a] | 0.034[a] |
| | (0.006) | (0.003) | (0.003) | (0.013) | (0.007) | (0.006) |

Data are from the 2001–2004 Current Population Survey. Standard errors are in parentheses. The other coefficients in this model are suppressed. A listing of the variables can be found in Appendix Table 11. Year and state fixed effects are also included.

[a] Used if the $p$ value of the difference from zero for the coefficient is less than 0.01

[b] Used if the $p$ value of the difference from zero for the coefficient is less than 0.05

household (income, homeownership status); **Z** is a vector of year fixed effects; **S** is a vector of state fixed effects; and $e$ is an error term.

Before turning to the results, two comments are in order about the specification of Eq. 3. First, for each measure of food insecurity, the vast majority of observations take on the value of zero. Clearly, there are different degrees of food security among those households, differences that may lead one to use an estimation method like a tobit. In the case here, however, all food secure households are treated identically so models like the tobit would not be appropriate. A parallel with the poverty literature can be drawn where the incomes of non-poor households are irrelevant (Bourguignon and Fields 1997). Second, when $\alpha$=0, Eq. 3 could be estimated with a limited dependent variable model (e.g., a probit). To maintain consistency, however, I use the same estimation method for all three measures.

The results for the food insecurity measure are in the top panel, and the results for the food insecurity with hunger measure are in the bottom panel of Table 6. These are further broken down by whether or not children are in the household. The effect of being an American Indian on the probability of being food insecure is positive and significant for all three measures for the all-income and the low-income sample of households with children.[9] In other words, even net of other factors, American

[9] The coefficients on the other variables, the year fixed effects, and the state fixed effects are suppressed in Table 6 and subsequent tables but are available from the author upon request. These variables are of the expected sign and statistical significance.

Indians are more likely to be food insecure. A similar result holds for the sample of households without children. A key difference in the results is the relative size of the coefficients across the different values of $\alpha$. One way to portray the magnitude of the effects is to divide the coefficient on the American Indian variable by the average value for each $\alpha$. For the all-income sample in households with children, as one moves from $\alpha$=0 to $\alpha$=2, this ratio increases from 0.49 to 0.67. In contrast, as one moves from $\alpha$=0 to $\alpha$=2 in households without children, this ratio increases from 0.88 to 1.56.

For the food insecurity with hunger measure in households with children for the full sample and the low-income sample, all else equal, American Indians are more likely to be food insecure with hunger in comparison to non-American Indians. For the low-income sample, however, this holds for the values of $\alpha$=0 and $\alpha$=1 but not for $\alpha$=2. In households without children, the effect of being American Indian is positive and statistically significant. As with the food insecurity measures, the magnitude of the effect of being American Indian (as determined in the manner described above) is increasing in $\alpha$. In a manner similar to the earlier results, the importance of using multiple measures manifests itself in the multivariate models.

### 5.4 Alternative specifications of the multivariate model

I now consider two further specifications of the multivariate model. The first specification changes the definition of who is American Indian in 2003 and 2004. As noted above, in 2001 and 2002 (and previous years), persons were allowed to place themselves in one and only one racial category in the CPS, but in 2003 and after, persons were allowed to select multiple categories. To see how this expansion affects the results, I keep the American Indian/non-American Indian distinction the same in 2001 and 2002, but for 2003 and 2004, I now limit the group of persons defined as American Indian to those who declared themselves only American Indian on the CPS. In doing so, there is greater consistency in the definition across years. Moreover, those who self-identify as only American Indian may be different than those who self-identify multiple races. This limitation for the definition of American Indian in 2003 and 2004 reduces the number of households headed by an American Indian by over half and increases the number of households headed by a non-American Indian by less than 1%. As seen in Table 7, the estimation of Eq. 2 for households without children is essentially the same as in Table 6. While the coefficients on the American Indian variable are, in general, slightly smaller, the choice of how one defines American Indian in this context does not seem to matter to a large extent. However, for households with children, the change in definition of American Indian does matter in the low-income sample. Now, across all three measures, American Indians no longer have a higher probability of food insecurity.

The second alternative specification allows one to consider whether American Indians living in nonmetro areas (many of whom live on reservations) differ from those living in metro areas (in the CPS, a metro area is defined as a county with a population of 50,000 or more, a county with an urbanized area, or a county with economic ties to a metro area (Jolliffe 2003; Office of Management and Budget 2000). Nonmetro areas are then defined as areas not meeting any of these criteria). As seen in Appendix Table 11, American Indians are much more likely to live in

**Table 7** Effect of American Indian status on food insecurity and on food insecurity with hunger, alternative definition of American Indian

| | All households | | | Households with incomes below 185% of the poverty line | | |
|---|---|---|---|---|---|---|
| | Food insecurity rate ($\alpha$=0) (1) | Food insecurity gap ($\alpha$=1) (2) | Squared food insecurity gap ($\alpha$=2) (3) | Food insecurity rate ($\alpha$=0) (4) | Food insecurity gap ($\alpha$=1) (5) | Squared food insecurity gap ($\alpha$=2) (6) |
| Food insecurity | | | | | | |
| Households with children | | | | | | |
| American Indian | 0.051[a] | 0.017[a] | 0.008[a] | 0.035 | 0.012 | 0.006 |
| | (0.016) | (0.005) | (0.003) | (0.028) | (0.009) | (0.005) |
| Households without children | | | | | | |
| American Indian | 0.064[a] | 0.036[a] | 0.024[a] | 0.073[a] | 0.050[a] | 0.037[a] |
| | (0.011) | (0.006) | (0.004) | (0.023) | (0.012) | (0.009) |
| Food insecurity with hunger | | | | | | |
| Households with children | | | | | | |
| American Indian | 0.020[b] | 0.006[b] | 0.003 | 0.015 | 0.005 | 0.003 |
| | (0.009) | (0.003) | (0.002) | (0.017) | (0.005) | (0.003) |
| Households without children | | | | | | |
| American Indian | 0.041[a] | 0.022[a] | 0.015[a] | 0.063[a] | 0.035[a] | 0.025[a] |
| | (0.008) | (0.004) | (0.003) | (0.016) | (0.009) | (0.008) |

Data are from the 2001–2004 Current Population Survey. Standard errors are in parentheses. The other coefficients in this model are suppressed. A listing of the variables can be found in Appendix Table 11. Year and state fixed effects are also included.

[a] Used if the $p$ value of the difference from zero for the coefficient is less than 0.01

[b] Used if the $p$ value of the difference from zero for the coefficient is less than 0.05

nonmetro areas than non-American Indians. For households with children, 29.2% of American Indians live in nonmetro areas vs 17.9% of non-American Indians and for households without children, the figures are 29.1 and 19.3%. The differences are even larger for households with incomes less than 185% of the poverty line. A central reason for the larger percentage of American Indians living in nonmetro areas is that most Reservations are in nonmetro areas.

To see whether the living in a nonmetro area has a differential influence upon the probability of food insecurity for American Indians, Eq. 2 is estimated with an interaction term between AmericanIndian and Nonmetro. The results are found in Table 8. Under both the food insecurity and food insecurity with hunger measures, for all three-food-insecurity measures, the interaction term is statistically insignificant for households with children. For the full sample of households without children, however, the effect of being an American Indian in a nonmetro area is positive and statistically significant across all three measures of food insecurity. Insofar as living on a reservation confers one access to social capital and social capital has been shown to alleviate food insecurity (e.g., Martin et al. 2004), the findings of no effect of living in a nonmetro area for households with children and a positive correlation between food insecurity and living in nonmetro areas for households without children may be counterintuitive.

In Table 9, I replicate the results of Table 6 for food insecurity for each of the measures of food insecurity in Tables 3, 4, and 5. The signs and significance of the

**Table 8** Effect of American Indian status on food insecurity and on food insecurity with hunger, inclusion of non-metro interaction term

| | All households | | | Households with incomes below 185% of the poverty line | | |
|---|---|---|---|---|---|---|
| | Food insecurity rate ($\alpha$=0) (1) | Food insecurity gap ($\alpha$=1) (2) | Squared food insecurity gap ($\alpha$=2) (3) | Food insecurity rate ($\alpha$=0) (4) | Food insecurity gap ($\alpha$=1) (5) | Squared food insecurity gap ($\alpha$=2) (6) |
| Food insecurity | | | | | | |
| Households with children | | | | | | |
| American Indian | 0.069[a] | 0.023[a] | 0.011[a] | 0.092[a] | 0.035[a] | 0.018[a] |
| | (0.017) | (0.006) | (0.003) | (0.033) | (0.011) | (0.006) |
| In nonmetro area | −0.022[a] | −0.008[a] | −0.004[a] | −0.034[a] | −0.015[a] | −0.007[a] |
| | (0.005) | (0.001) | (0.001) | (0.009) | (0.003) | (0.002) |
| American Indian in nonmetro area | 0.013 | −0.001 | −0.002 | −0.049 | −0.024 | −0.014 |
| | (0.026) | (0.008) | (0.004) | (0.045) | (0.016) | (0.009) |
| Households without children | | | | | | |
| American Indian | 0.043[a] | 0.025[a] | 0.016[a] | 0.067[a] | 0.042[a] | 0.029[a] |
| | (0.011) | (0.005) | (0.004) | (0.025) | (0.013) | (0.010) |
| In nonmetro area | −0.002 | −0.002 | −0.002 | 0.004 | −0.001 | −0.001 |
| | (0.002) | (0.001) | (0.001) | (0.006) | (0.003) | (0.003) |
| American Indian in nonmetro area | 0.050[a] | 0.031[a] | 0.026[a] | 0.042 | 0.033 | 0.029[b] |
| | (0.017) | (0.008) | (0.006) | (0.035) | (0.018) | (0.014) |
| Food insecurity with hunger | | | | | | |
| Households with children | | | | | | |
| American Indian | 0.021[a] | 0.009[a] | 0.004[a] | 0.040[a] | 0.016[a] | 0.008[a] |
| | (0.010) | (0.003) | (0.002) | (0.020) | (0.006) | (0.004) |
| In nonmetro area | −0.012[a] | −0.003[a] | −0.001[b] | −0.022[a] | −0.007[a] | −0.003[b] |
| | (0.003) | (0.001) | (0.000) | (0.006) | (0.002) | (0.001) |
| American Indian in nonmetro area | 0.006 | −0.003 | −0.003 | −0.026 | −0.014 | −0.009 |
| | (0.015) | (0.004) | (0.002) | (0.028) | (0.009) | (0.005) |
| Households without children | | | | | | |
| American Indian | 0.029[a] | 0.014[a] | 0.009[a] | 0.058[a] | 0.028[a] | 0.018[a] |
| | (0.007) | (0.004) | (0.003) | (0.018) | (0.010) | (0.009) |
| In nonmetro area | −0.001 | −0.002 | −0.002 | 0.004 | −0.001 | 0.002 |
| | (0.002) | (0.001) | (0.001) | (0.005) | (0.003) | (0.002) |
| American Indian in nonmetro area | 0.037[a] | 0.025[a] | 0.021[a] | 0.028 | 0.026 | 0.024[b] |
| | (0.011) | (0.006) | (0.005) | (0.025) | (0.014) | (0.012) |

Data are from the 2001–2004 Current Population Survey. Standard errors are in parentheses. The other coefficients in this model are suppressed. A listing of the variables can be found in Appendix Table 11. Year and state fixed effects are also included.

[a] Used if the $p$ value of the difference from zero for the coefficient is less than 0.01

[b] Used if the $p$ value of the difference from zero for the coefficient is less than 0.05

results for being in a household headed by an American Indian in Table 9 are the same as those in Table 6. Turning to relative magnitudes across the measures in a manner similar to above (i.e., by dividing the coefficient on the American Indian variable by the average value for each $\alpha$), for households with children, the differences across the measures are slightly more muted than in Table 6. For example, for the low-income sample when the questions specific to households without children are asked, the ratios moving from $\alpha$=0 to $\alpha$=2 increase from 0.17 to 0.20, while in the baseline case of Table 6, the ratios increase from 0.19 to 0.31.

**Table 9** Effect of American Indian status on food insecurity, alternative sets of questions

| | All households | | | Households with incomes below 185% of the poverty line | | |
|---|---|---|---|---|---|---|
| | Food insecurity rate ($\alpha$=0) (1) | Food insecurity gap ($\alpha$=1) (2) | Squared food insecurity gap ($\alpha$=2) (3) | Food insecurity rate ($\alpha$=0) (4) | Food insecurity gap ($\alpha$=1) (5) | Squared food insecurity gap ($\alpha$=2) (6) |
| Use of same questions for households with and without children | | | | | | |
| Households with children | | | | | | |
| American Indian | 0.068[a] | 0.023[a] | 0.013[a] | 0.066[a] | 0.027[a] | 0.017[a] |
| | (0.012) | (0.005) | (0.004) | (0.022) | (0.010) | (0.008) |
| Households without children | | | | | | |
| American Indian | 0.064[a] | 0.037[a] | 0.026[a] | 0.089[a] | 0.058[a] | 0.043[a] |
| | (0.008) | (0.004) | (0.003) | (0.018) | (0.009) | (0.007) |
| Based on questions specific to children | | | | | | |
| Households with children | | | | | | |
| American Indian | 0.077[a] | 0.056[a] | 0.046[a] | 0.063[a] | 0.047[a] | 0.040[a] |
| | (0.013) | (0.010) | (0.009) | (0.024) | (0.018) | (0.017) |
| Based on questions independent of previous questions | | | | | | |
| Households with children | | | | | | |
| American Indian | 0.073[a] | 0.020[a] | 0.008[a] | 0.067[a] | 0.020[a] | 0.009[a] |
| | (0.013) | (0.004) | (0.002) | (0.023) | (0.008) | (0.004) |
| Households without children | | | | | | |
| American Indian | 0.059[a] | 0.037[a] | 0.027[a] | 0.091[a] | 0.058[a] | 0.043[a] |
| | (0.007) | (0.004) | (0.003) | (0.015) | (0.009) | (0.008) |

Data are from the 2001–2004 Current Population Survey. Standard errors are in parentheses. The other coefficients in this model are suppressed. A listing of the variables can be found in Appendix Table 11. Year and state fixed effects are also included.

[a] Used if the $p$ value of the difference from zero for the coefficient is less than 0.01

[b] Used if the $p$ value of the difference from zero for the coefficient is less than 0.05

For households without children, the relative magnitude of the effect of being American Indian in the case of $\alpha$=0 increases sharply when the questions are limited to questions that are independent of previous questions (the results in the final panel). In comparison to Table 6 where the ratios are 0.82 and 0.47 for the all income and low income sample, the ratios are 1.20 and 0.73 in Table 9.

## 6 Conclusion

This article has described a method of measuring food insecurity that allows researchers and policymakers to move beyond just looking at simple breakdowns of food secure vs food insecure and food secure and food insecure without hunger vs food insecure with hunger. In other words, through the use of the measures in this article, the richness of the 18 questions in the CFSM can be more fully utilized, enabling pictures of the extent, depth, and severity of food insecurity and analyses of robustness of conclusions regarding food insecurity.

I have applied this theoretical framework to a consideration of the food insecurity of American Indians. As expected, in general, American Indians have higher levels

of food insecurity than non-American Indians, but the magnitude of the differences depends on the choice of measure and on the set of food insecurity questions being asked. These differences carry over to multivariate considerations of differences between American Indians and non-American Indians. Therefore, along with a slew of negative consequences arising from limited economic opportunities for American Indians—including high rates of obesity, high prevalences of diabetes, high rates of tooth decay, and low rates of breastfeeding—one can now conclude with a high degree of robustness that American Indians also face higher levels of food insecurity, even after controlling for other factors. These higher levels of food insecurity and food insecurity with hunger are especially prominent for households without children.

I conclude with some suggestions for future research. First, this paper provides a framework to examine the extent, depth, and severity of food insecurity. This leads to a relevant policy question: Does the depth and severity of a household's food insecurity matter for various outcomes? As an example, one may wish to consider whether the negative health outcomes associated with food insecurity[10] are more pronounced for households with greater depths of food insecurity or whether once one is food insecure, greater depths of food insecurity do not matter. Second, this article has made a comparison between American Indians and non-American Indians, but there are many other groups with higher than average food insecurity rates (e.g., single parents with children), which are in need of greater study with richer food insecurity measurement frameworks akin to those of this paper. Third, this analysis has used the CPS, but a wide array of other data sets has used the CFSM and the theoretical framework of this article could be fruitfully utilized there. In particular, there are numerous data sets with information on American Indians, some of which have the CFSM (for more on these data sets, see Feingold et al. 2005). Fourth, in this article, I have created food insecurity measures based on the income poverty measures of Foster et al. (1984). More generally, there are numerous other income poverty measures that may be justifiable as food insecurity measures.

In terms of topics specific to American Indians, there are at least two issues worthy of future research. First, there is little evidence of protection against food insecurity in nonmetro areas for American Indians, and in fact, there is some evidence that living in nonmetro areas makes things worse. To further explore this, one may wish to more finely compare American Indians living on reservations with American Indians living off reservations. Unfortunately, this is not possible with the CPS, as residence is not disaggregated to the reservation-level due to confidentiality reasons. Other data sets, in conjunction with CPS, may allow for answers to this issue. Second, at least part of the differences between American Indians and non-American Indians may be due to cultural differences in the ways American Indians respond to food insecurity questions. As an example, if the definition of household is larger for American Indians in comparison to non-American Indians, this may increase the probability of responding affirmatively to food insecurity questions.

[10] For recent work, see, e.g., Vozoris and Tarasuk (2003), Che and Chen (2001), Adams et al. (2003), Pheley et al. (2002), and Stuff et al. (2004).

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## Appendix

**Table 10** Questions on the core food security module and respective Rasch scores

| Food security question associated with the modal number of affirmative responses | Households with children | | Households without children | |
|---|---|---|---|---|
| | Number of affirmative responses | Rasch score | Number of affirmative responses | Rasch score |
| Worried food would run out | 1 | 1.30 | 1 | 1.72 |
| Food bought did not last | 2 | 2.56 | 2 | 3.10 |
| Respondent did not eat balanced meals | 3 | 3.41 | 3 | 4.23 |
| Child fed few, low-cost foods | 4 | 4.14 | | |
| Adult(s) cut/skip meals | 5 | 4.81 | 4 | 5.24 |
| Child not fed balanced meals | 6 | 5.43 | | |
| Respondent ate less than should | 7 | 6.02 | 5 | 6.16 |
| Adult(s) skipped meals for 3 or more months | 8 | 6.61 | 6 | 7.07 |
| Child not eating enough | 9 | 7.18 | | |
| Respondent hungry but did not eat | 10 | 7.74 | 7 | 8.00 |
| Respondent lost weight | 11 | 8.28 | 8 | 8.98 |
| Child's meal size cut | 12 | 8.79 | | |
| Adult(s) did not eat for whole day | 13 | 9.31 | 9 | 10.15 |
| Child was hungry | 14 | 9.84 | | |
| Adult(s) did not eat for whole day for 3 or more months | 15 | 10.42 | 10 | 11.05 |
| Child skipped meal | 16 | 11.13 | | |
| Child skipped meal(s) for 3 or more months | 17 | 12.16 | | |
| Child did not eat for whole day | 18 | 13.03 | | |

**Table 11** Summary statistics

| | All households | | Households with incomes below 185% of the poverty line | |
|---|---|---|---|---|
| | American Indians | Non-American Indians | American Indians | Non-American Indians |
| Households with children | | | | |
| Income/poverty | 2.253 (0.083) | 3.076 (0.012) | 1.062 (0.033) | 1.15 (0.006) |

**Table 11** (continued)

| | All households | | Households with incomes below 185% of the poverty line | |
|---|---|---|---|---|
| | American Indians | Non-American Indians | American Indians | Non-American Indians |
| Less than high school degree | 0.220 | 0.124 | 0.329 | 0.267 |
| Married | 0.661 | 0.729 | 0.591 | 0.547 |
| Homeowner | 0.535 | 0.693 | 0.373 | 0.429 |
| In nonmetro area | 0.292 | 0.179 | 0.343 | 0.148 |
| Age | 36.082 | 38.173 | 34.627 | 35.608 |
| | (0.426) | (0.056) | (0.562) | (0.099) |
| Households without children | | | | |
| Income/poverty | 3.089 | 3.890 | 1.106 | 1.185 |
| | (0.091) | (0.012) | (0.030) | (0.004) |
| Less than high school degree | 0.210 | 0.147 | 0.376 | 0.323 |
| Married | 0.361 | 0.437 | 0.282 | 0.271 |
| Homeowner | 0.583 | 0.687 | 0.462 | 0.521 |
| In nonmetro Area | 0.291 | 0.193 | 0.395 | 0.259 |
| Age | 50.980 | 52.931 | 53.978 | 56.887 |
| | (0.631) | (0.082) | (1.048) | (0.167) |

Data are from the 2001–2004 Current Population Survey. Standard errors are in parentheses.

## References

Adams E, Grummer-Strawn L, Chavez G (2003) Food insecurity is associated with increased risk of obesity in California women. J Nutr 133:1070–1074

American Indian Studies Programs (2000) Bibliography of resources related to food assistance and health of North American Indians and Alaska Natives. University of Arizona, American Indian Studies Programs

Anderson S (1990) Core indicators of nutritional state for difficult-to-sample populations. J Nutr 120:1559S–1600S

Andrich D (1988) Rasch models for measurement. Sage, Newbury Park, CA, USA

Atkinson A (1987) On the measurement of poverty. Econometrica 55(4):749–764

Bhattacharya J, Currie J, Haider S (2004) Poverty, food insecurity, and nutritional outcomes in children and adults. J Health Econ 23:839–862

Bickel G, Nord M, Price C, Hamilton W, Cook J (2000) Guide to measuring household food security: revised 2000. US Department of Agriculture, Food and Consumer Service, Office of Analysis and Evaluation

Bitler M, Gundersen C, Marquis G (2005) Are WIC non-recipients at less nutritional risk than recipients? An application of the food security measure. Rev Agric Econ 27:433–438

Borjas G (2004) Food insecurity and public assistance. J Public Econ 88:1421–1443

Bourguignon F, Fields G (1997) Discontinuous losses from poverty, generalized $P_\alpha$ measures, and optimal transfers to the poor. J Public Econ 63:155–175

Casey P, Simpson P, Gossett J, Bogle M, Champagne C, Connell C, Harsha D, McCabe-Sellers B, Robbins J, Stuff J, Weber J (2006). The association of child and household food insecurity with childhood overweight status. Pediatrics 118:1406–1413

Che J, Chen J (2001) Food insecurity in Canadian households. Health Rep 12(4):11–21

Dunifon R, Kowaleski-Jones L (2003) The influences of participation in the National School Lunch Program and food insecurity on child well-being. Soc Serv Rev 77:72–92

Dutta I, Gundersen C (2007) Measures of food insecurity at the household level. In: Guha-Khasnobis B, Acharya S, Davis B (eds) Food security indicators, measurement, and the impact of trade openness: series: WIDER studies in development economics. Oxford University Press, Oxford (in press)

Feingold K., Pindus N, Wherry L, Nelson S, Triplett T, Capps R (2005) Background report on the use and impact of food assistance programs on Indian reservations. US Department of Agriculture, Economic Research Service, Contractor and Cooperator Report 4

Foster J, Shorrocks A (1991) Subgroup consistent poverty indices. Econometrica 59:687–709
Foster J, Greer J, Thorbecke E (1984) A class of decomposable poverty measures. Econometrica 52:761–766
Furness B, Simon P, Wold C, Asarian-Anderson J (2004) Prevalence and predictors of food insecurity among low-income households in Los Angeles County. Public Health Nutr 7:791–794
Gregory R, Abello A, Johnson J (1997) The individual economic well-being of Native American men and women during the 1980s: a decade of moving backwards. Popul Res Policy Rev 16:115–145
Gundersen C, Gruber J (2001) The dynamic determinants of food insufficiency. In: Andrews M, Prell M (eds) Second food security measurement and research conference, volume II: papers. US Department of Agriculture, Economic Research Service Food Assistance and Nutrition Research Report 11-2, 92–110
Gundersen C, Kreider B (2007) Food stamps and food insecurity: what can be learned in the presence of nonclassical measurement error? J Hum Resour (in press)
Gundersen C, Ribar D (2005) Food insecurity and insufficiency at low levels of food expenditures. Institute for the Study of Labor (IZA) Working Paper No. 1594
Gundersen C, Weinreb L, Wehler C, Hosmer D (2003) Homelessness and food insecurity. J Hous Econ 12:250–272
Hamilton W, Cook J, Thompson W, Burn L, Frongillo E, Olson C, Wehler C (1997) Household food security in the United States in 1995: technical report of the food security measurement project. US Department of Agriculture, Food and Consumer Service, Office of Analysis and Evaluation
Jolliffe D (2003) On the relative well-being of the nonmetropolitan poor: an examination of alternative definitions of poverty during the 1990s. South Econ J 70:295–311
Laraia B, Siega-Riz A, Gundersen C, Dole N (2006) Psychosocial factors and socioeconomic indicators are associated with household food insecurity among pregnant women. J Nutr 136:177–182
Leichenko R (2003) Does place still matter? Accounting for income variation across American Indian tribal areas. Econ Geogr 79(4):365–386
Martin K, Rogers B, Cook J, Joseph H (2004) Social capital is associated with decreased risk of hunger. Soc Sci Med 58(12):2645–2654
Mayer S, Jencks C (1989) Poverty and the distribution of material hardship. J Hum Resour 24:88–114
National Research Council (2005) Food insecurity and hunger in the United States: an assessment of the measure. National Academies Press, Washington, DC, USA
Nord M, Andrews M, Carlson S (2004) Household food security in the United States, 2003. US Department of Agriculture, Economic Research Service, Food Assistance and Nutrition Research Report 42, Washington, DC, USA
Office of Management and Budget (2000) Standards for defining metropolitan and micropolitan statistical areas. Fed Regist 65:82228–82238
Pattanaik PK, Sengupta M (1995) An alternative axiomatization of Sen's poverty measure. Rev Income Wealth 41(1):73–80
Pheley A, Holben D, Graham A, Simpson C (2002) Food security and perceptions of health status: a preliminary study in rural Appalachia. J Rural Health 18(3):447–454
Ribar D, Hamrick K (2003) Dynamics of poverty and food sufficiency. US Department of Agriculture, Economic Research Service, Food Assistance and Nutrition Research Report 33, Washington, DC, USA
Sen A (1976) Poverty: an ordinal approach to measurement. Econometrica 44(2):219–231
Slack K, Yoo J (2005) Food hardship and child behavior problems among low-income children. Soc Serv Rev 79(3):511–536
Stuff J, Casey P, Szeto K, Gossett J, Robbins J, Simpson P, Connell C, Bogle M (2004) Household food insecurity is associated with adult health status. J Nutr 134:2330–2335
Tiehen L (ed) (2003a) Food assistance and nutrition research small grants program: executive summaries of 2002 research grants. US Department of Agriculture, Economic Research Service, Food Assistance and Nutrition Research Report No. 38
Tiehen L (ed) (2003b) Food assistance and nutrition research small grants program: executive summaries of 2001 research grants. US Department of Agriculture, Economic Research Service, Food Assistance and Nutrition Research Report No. 37
Van Hook J, Balistreri K (2006) Ineligible parents, eligible children: food stamps receipt, allotments, and food insecurity among children of immigrants. Soc Sci Res 35(1):228–251
Vozoris N, Tarasuk V (2003) Household food insufficiency is associated with poorer health. J Nutr 133(1):120–126
Wilde P (2004) Differential response patterns affect food-security prevalence estimates for households with and without children. J Nutr 134:1910–1915