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Child age and gender differences in food security in a low-income U.S. inner-city population☆

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ABSTRACT

A long literature in economics studies differential allocations of resources to children within the family. In a study of approximately 1600 very disadvantaged households with children in three cities in the U.S. from 1999 to 2005, significant differences in levels of food allocation, as measured by an indicator of food "insecurity," are found across children of different ages and genders. Using answers to unique survey questions for a specific child in the household, food insecurity levels are much higher among older children than among younger ones, and to be sometimes higher among older boys than among older girls. Allocations are strongly correlated with the dietary needs of the child as well as with household structure and the level of family organization. However, the differences appear only in the poorest households with the lowest levels of money income and household resources in general, and most differences disappear in significance or are greatly reduced in magnitude when resources rise to only modest levels.

1. Introduction

A large and multi-threaded literature has examined parental allocations of resources to different children across a wide variety of areas. The classic Becker and Tomes (1976) study suggesting that parents provide educational resources differently to children with different ability endowments set off a significant strand of literature which is continuing (e.g., Behrman et al., 1982; Cunha and Heckman, 2007; Aizer and Cunha, 2012). Another large strand has studied different parental food and health allocations to children in developing countries, including differences across children by birthweight, other health endowment indicators, and gender (Pitt et al., 1990 is an early study followed by many more). In the U.S., a smaller thread has asked if parental resources are related to child health (e.g., Datar et al., 2010; Del Bono et al., 2012), while a sizeable literature has examined differences in parental allocations by child gender, particularly differences in parental time inputs

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and other variables that might explain gender gaps in test scores, noncognitive traits, education levels, and other outcomes (Lundberg, 2005; Goldin et al., 2006; Raley and Bianchi, 2006; Dahl and Moretti, 2008; Fryer and Levitt, 2010; Bertrand and Pan, 2013; Durante et al., 2015; Autor et al., 2016; Baker and Milligan, 2016).

This article contributes to the literature on differential parental allocations to children by examining whether a child's "food security," a variable correlated with child food consumption, differs by the child's age and gender in low-income families in the U.S. Differential food allocations to children have been thought to be primarily a problem in developing countries, not in a prosperous country like the U.S., yet it is also known that poverty is stubbornly high in the U.S. and that a large fraction of families is extremely poor, living on very meager resources (Edin and Shaefer, 2013). Consequently, differences in food inputs across children may arise among very low-income households. We study whether food security differs across children of different ages and genders in very poor households and whether meager resources impel parents to make difficult food allocation decisions across children.

A sizable literature exists on U.S. food security, where the term is conceptually defined as having "access by all people at all times to enough food for an active, healthy life" (Coleman-Jensen et al., 2015). The converse of food security, food insecurity, is regularly measured by a set of survey questions developed by the U.S. Department of Agriculture (USDA) in 1995 and asked annually since then in the Current Population Survey (CPS). The questions ask if the adults or children in a household have experienced a range of food deprivations in the last twelve months because of a lack of money, ranging from mild conditions of worrying about running out of food to more severe conditions of having to skip eating for an entire day. The USDA has set specific thresholds of food insecurity based on reports of multiple food intake problems in the answers to the survey questions (USDA, 2014). Previous research using the CPS and other surveys that ask food security questions has identified a long list of correlates of food insecurity, including low income, not owning a home, low levels of education, living in a family with an unmarried household head and unmarried status in general, minority race-ethnicity status, living in a household with adults with physical or mental disabilities, the presence of substance abuse in the family, poor child care arrangements, and disadvantageous parenting styles, among other conditions (Gundersen et al., 2011; Gundersen and Ziliak, 2014). Triggering events for food insecurity include shocks to income, job loss, disruption to housing arrangements, and the occurrence of other crises.

This article departs from these studies by making use of a unique survey that measured food insecurity for a specific, randomly selected child in a sample of low-income households, permitting an examination of how insecurity varies at the individual child level. Such an investigation has not been possible heretofore because the standard USDA questions only ask about food insecurity for the children in the household as a whole.[1]

However, while individual food insecurity has not been comprehensively examined in the literature for data reasons, a related issue about intrahousehold allocations has been investigated, namely, whether food insecurity differs between adults as a whole and children as a whole. This can be investigated because the USDA questions are asked separately for adults and for children. Studies of the data on this issue have led to what is known as the "child protection hypothesis," which posits that adults sacrifice their own food security before allowing their children to experience it. Simple evidence for this hypothesis is that, within families, food insecurity levels for adults as a whole are higher than those of the children as a whole (Coleman-Jensen et al., 2015; Kirkendall et al., 2013). The analysis here, measuring food insecurity at the individual child level, can pursue this question further by asking whether adults sacrifice their own food security differentially for children of different ages and genders.

The data set for this study was developed from a survey of very low income households in high-poverty neighborhoods in three large U.S. cities from 1999 to 2005. The sample is a particularly disadvantaged one relative to the general low-income population. The respondents were mostly Black and non-Black Hispanic and hence mostly minority, and the survey over-sampled single-mother households and households on welfare (although sampling weights allow an adjustment for this). While the results presented here cannot be generalized to a nationally representative sample of low-income households, very disadvantaged minority households in U.S. inner cities are a group known to be particularly vulnerable to a variety of deprivations and constitute a population of special policy concern. Future research can determine whether the results found here extend to other groups.

There are several notable findings from the analysis of these data. First, the data are overwhelmingly consistent with the child protection hypothesis, for adult levels of food insecurity are much greater than those of the child. Second, the data show strong evidence that food insecurity is positively correlated with the age of the child, and for both adult and child food insecurity. Third, smaller but noticeable gender differences in food insecurity appear in the data, with the strongest effects for adolescents where insecurity (both child and adult) is higher for boys than for girls. Thus, contrary to the hypothesis in the son preference literature (e.g., Dahl and Morretti, 2008), the data here imply daughter preference. Fourth, a large fraction of the age difference in insecurity is explained by differential food needs, consistent with intuition and with a simple economic model outlined in the article which shows that individuals in the household who have higher and therefore more costly food needs end up with a lower probability of their needs being satisfied. Fifth, age and gender differences are

[1] No existing U.S. survey has the breadth of sample or the depth of questions on individual-level child food security or consumption as the data set we use, including the National Health and Nutrition Examination Survey (NHANES) used by Bhattacharya and Currie (2001) and Nord (2013), or the Child Development Study of the Panel Study of Income Dynamics used by Woodward and Ribar (2012). Woodward and Ribar only analyzed consumption among children aged 10–17 and did not examine younger children; they analyzed children's own reports, rather than parents' reports; and they did not consider interactions of gender and age, which we find to be necessary in our analysis.

strongly correlated with whether the household has cash income below the poverty line or is experiencing some form of financial strain; households with income above the poverty line or not experiencing such strain generally have much smaller, and often insignificant, differences in food insecurity by age and gender of the child.[2] Sixth, differences in food insecurity by age and gender of the child are much stronger for households with unmarried mothers than for those with married mothers, and for those households without established routines like eating together at breakfast and lunch than for households with such routines.

It would be an interesting question to know whether any of these results extend to the UK or European countries. The U.S. differs from European countries in its economic, social, and institutional context. Income inequality (as measured by the Gini coefficient) in the U.S. exceeds that in every other European country but Turkey.[3] The U.S. also has a higher relative poverty rate than every other European country and a higher child poverty rate than most European countries. Since we find that differentials in child food deprivation by age and gender appear only for the lowest income households, European countries may not have many households with such low incomes. In addition, material hardships, including indicators of food hardships, also appear to be considerably lower in Europe than in the U.S. Gábos et al. (2011) estimated that, in 2009, 5.2% of European children were in households that could not afford to feed the children meat or fish daily, 4.7% were in households that could not afford to feed them fruits or vegetables daily, and 1.0% were in households that could not afford to feed them three meals daily. However, these percentages varied widely across countries. For example, 7.2% of children in Bulgaria lived in households that could not afford to provide three meals every day, while only 0.1% of children in the Czech Republic, Denmark, Finland, the Netherlands, and Sweden faced these conditions. More research on cross-country comparisons in this dimension would be useful.[4]

The next section discusses the data and presents the basic patterns in the data. The following section lays out a simple optimizing model of parental behavior to guide thinking about possible causes, particularly the relative roles of parental preferences for different children versus differences in individual production functions. The sections that follow examine a variety of possible explanations for the patterns, including the roles of differential dietary and nutritional needs, household structure and levels of household organization, and level of household resources.

2. Data and initial results

2.1. Data

The Three-City Study (TCS) was a longitudinal survey of approximately 2400 low-income households living in Boston, Chicago, and San Antonio. When they were first surveyed in 1999, each of the households had an income below 200% of the poverty line, had at least one child 0–4 or 10–14 years of age, and was living in a low- or moderate-income neighborhood. The data constitute a random sample of the population with these characteristics. In addition, because the study was intended to focus on the children in low-income households after 1990s welfare reform, one “focal” child in the household in either the 0–4 or 10–14 age range was randomly selected for special data collection. The households were interviewed three times from 1999 to 2005.[5] By the end of the survey, the children who were initially 0–4 had grown to 6–10 and the children who were initially 10–14 had grown to 16–20, thus providing us with an artificial cohort spanning the full age range of children 0–20 (although we only consider children 0–18). The survey collected a wide range of information on employment, income, household structure, welfare participation, characteristics of the focal child’s caregiver (usually the mother), and food security in each of the three waves of interviews. In addition, the interview collected data on several variables, including financial strains, “family routines”, and social networks, not present in most other studies but which will be shown to be related to the main findings. We select a balanced sample of children who were present in all three waves of the data, whose caregiver did not change from wave to wave, and who have non-missing values for all variables used in the analysis. The sample has 1628 unique children and a pooled sample size over all three waves of 4229 children. We conduct sensitivity tests to these sample exclusions below.[6]

[2] Consistent with this is the study by Durante et al. (2015) which found that parents say they would invest and spend more on girls than boys in a low-resource environment, i.e., during a recession.

[3] OECD (2017), “Income inequality (indicator)” <https://data.oecd.org/inequality/income-inequality.htm>, doi:10.1787/459aa7f1-en, accessed 8 December 2017.

[4] Although the impact of social programs on food deprivation is not the focus of this study, the constellation of such programs is the source of other major differences with the U.S. Redistribution in the U.S. relies largely on a patchwork of in-kind assistance programs, including several food assistance programs specifically targeted at children, and less on cash assistance, unlike most European countries.

[5] Children were followed to the extent possible after residential mobility. At each of the first two interviews, households were asked to provide contact information for other family and friends who would know their location. Postcards were sent to households in between interviews to ascertain any change in residential status, and any cards returned with a change-of-address were followed up with either the post office or the contact individuals to determine the respondent household’s new address. There was sample loss to follow-up (see below), but it is not known how much of that was a result of residential mobility.

[6] The original sample of children pooled over all three waves has 6424 child-year observations (there was sample loss to attrition). Of the 6424 observations, 314 were dropped because the child aged out to over 18 by the third wave, 146 were dropped because of a change in caregiver, 765 were dropped because of missing data on one of the variables used in the analysis in a particular wave, and 970 were lost to attrition, leaving our final sample of 4229 observations. While the sample is balanced on caregivers and children, the exclusion of observations missing values of the variables varies from wave to wave, making the final sample unbalanced.

Most of the households were headed by a single mother but a few married heads were sampled as well. The vast majority of the sample was either Hispanic or Non-Hispanic Black and hence heavily minority, reflecting the characteristics of the low-income neighborhoods of the cities.[7] While, as noted above, the income cutoff was a relatively high 200% of the poverty line, the sample was very poor and disadvantaged, with quite low levels of education as well as poor physical and mental health.[8] While the trends in unemployment rates and welfare caseloads in the three states over the period 1999–2005 were similar to those in other states, the findings below should not be generalized to populations other than very disadvantaged, mostly Non-Hispanic Black and Black populations, without further research.

Food insecurity questions and creation of a scale. Since 1995, the USDA has administered an 18-question module as a supplement to the CPS called the Household Food Security Supplement Module (HFSSM). The food security scales, count measures, and indicators from the HFSSM have formed the basis for official reports of food insecurity in the U.S. (see Coleman-Jensen et al. 2015 and earlier reports) and are widely used in research. The measures have been formally validated by the U.S. Department of Agriculture (Bickel et al., 2000) and have been shown to be valid in many other countries, including Canada, Russia, South Korea, and the U.K. (see the review by Melgar-Quinonez and Hackett, 2008). The TCS survey asked caregivers only a subset of 8 of the standard 18 USDA food security questions from the CPS. The 8 questions are shown in Appendix A. The first 4 questions are identical to 4 of those in the adult portion of the USDA battery and were selected to reflect the questions about more severe hardships. The second 4 were drawn from the 8 in the child-related portion of the USDA battery but were modified to ask about hardships of only the focal child in the household rather than of all children. The 4 questions that were chosen were also those concerning more severe hardships. The 8 questions were asked in identical form in all three waves of the TCS survey.

For households with children, the USDA analyzes the answers to its 18 questions by summing the number of positive answers and then creating binary variables for whether the sum is greater than particular cutoffs. The USDA defines "Low Food Security" as answering 3 or more of the 18 questions affirmatively and "Very Low Food Security" (VLFS) as answering 8 or more of the 18 questions affirmatively (Coleman-Jensen et al., 2015). The USDA also creates binary variables for food insecurity among children using the sum of affirmative answers to the 8 children-related questions alone. Here, we take a broader approach to the definitions by using both binary indicators based on cutoffs of the sums of the TCS questions, but also using the sums themselves which are continuous measures of food insecurity. The sums have a larger range than the binary variables, obviously, and hence contain more variation and should contribute more statistical power to the analysis. On the other hand, if there are nonlinearities in the relationship between the covariates and the sums, the binary outcomes might provide more statistical power if the nonlinearity is strong around the cutoff point. We therefore employ both binary and summation measures.

As emphasized earlier, we also distinguish between answers to the four food insecurity questions asked about the adults and the four asked about the focal child. We use six outcome variables in our analysis below, defined with the following acronyms:

1. VLFS: binary variable equal to 1 if 2 or more of the 8 TCS questions are answered affirmatively;
2. VLFSA: binary variable equal to 1 if at least 1 of the 4 adult questions is answered affirmatively;
3. VLFSC: binary variable equal to 1 if at least 1 of the 4 child questions is answered affirmatively;
4. SUM: sum of the affirmative answers to the 8 questions;
5. SUMA: sum of the affirmative answers to the 4 adult questions;
6. SUMC: sum of the affirmative answers to the 4 child questions.

The first variable, VLFS, represents an approximation to the USDA Very Low Food Security binary indicator. We do not examine the less severe USDA Low Food Security indicator because it cannot be distinguished from VLFS with the TCS food hardship items. Our choice of a cutoff of 2 or more for the definition of our VLFS is based on an extensive preliminary analysis using the 18 USDA questions (in their 1999 survey), which we used to determine what cutoff should be used for the 8 TCS questions to classify families into VLFS status most closely to the same way they would be classified if all 18 USDA questions were used. Our analysis, reported in Appendix B, shows that the cutoff of 2 achieves the maximal congruence with the USDA measure.

However, because only 4 questions were asked of the adults and of the focal child, and because the distribution of the answers is concentrated at the lower end of their sum distribution (see below), we define their binary indicators, VLFSA and VLFSC, as answering at least one of the questions affirmatively. Finally, the three SUM variables are simply defined as the sum of the affirmative answers to the 8 questions for the household as a whole, and over the 4 questions for the adults and the focal child, respectively.

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[7] Details of the design can be found in Winston et al. (1999). The design over-sampled certain types of households, so a survey weight which adjusts for the oversampling is used in all data analyses. In addition, there was significant attrition, with only 80% of the children still in the sample by the third wave. The survey weights were adjusted for a few wave 1 observables for this sample loss. In addition, a comparison of the observables used in the analyses below at the first wave among those who later attrited and those who did not show very few differences. Finally, an incentive experiment was conducted which paid a random fraction of the sample a higher payment for participation and had a significant effect on attrition but showed no effect on unobservable attrition in income, poverty rates, and other economic variables as of the second wave (Moffitt, 2004).

[8] Frogner et al. (2009) summarized the findings on the welfare receipt, employment, and income levels of the sample. Studies of food security with these data have been conducted (DePolt et al., 2009; Moffitt and Ribar, 2016) but did not focus on the age and gender characteristics of the child as this study does. Other studies using the data can be found on the project website at http://web.jhu.edu/threecitystudy.

Table 1
Mean values of food security indicators, by focal child age and gender.

	All children	Male	Female
All focal child ages			
VLFS	.078	.080	.076
VLFSA	.121	.120	.121
VLFSC	.039	.037	.041
SUM*	3.38	3.48	3.28
SUMA*	1.99	2.14	1.85
SUMC*	1.79	1.74	1.82
By focal child age			
VLFS			
0–5	.056	.045	.067
6–11	.061	.062	.060
12–18	.115	.138	.096
VLFSA			
0–5	.083	.073	.094
6–11	.110	.126	.093
12–18	.168	.171	.166
VLFSC			
0–5	.012	.012	.012
6–11	.027	.025	.030
12–18	.078	.080	.076
SUM*			
0–5	3.23	3.56	3.01
6–11	3.11	3.39	2.80
12–18	3.57	3.49	3.66
SUMA*			
0–5	2.22	2.28	2.17
6–11	1.81	1.85	1.75
12–18	1.96	2.26	1.71
SUMC*			
0–5	2.05	2.00	2.09
6–11	1.52	1.65	1.41
12–18	1.82	1.73	1.89

$N = 1{,}463$ (first wave only) for All Ages, $N = 4229$ (all three waves) for the By Age means. Note that there were some children who were in the sample at waves 2 and 3 but not in wave 1 because of missing data on variables at wave 1.

* For those with VLFS = 1, VLFSA = 1, and VLFSC = 1, respectively.

Table 1 shows the means of these six measures for our analysis sample as of the first wave of the survey. A little under 8% of all families experienced VLFS, with a slightly higher rate among families in which the focal child was a boy rather than a girl (8% versus 7.6%). Still, the gender difference is statistically insignificant (10% level). But the frequency of food insecurity reports is much higher among adults than for the focal child, with 12% of the former reporting at least one problem but only 3.9% of the latter. This is strongly consistent with the child protection hypothesis cited in the Introduction although, here, the child report is only for one child in the family (more on this below).[9] However, no gender differences appear in either the adult or child binary indicators. For the variables representing the sums of the answers to the questions, only conditional means are shown in the table (the unconditional means are the product of the binary indicator means and the conditional means). Again, the mean number of reports of insecurity is higher for adults than for children, and the gap between whether the focal child is a boy or girl widens for the adult reports, with adults reporting more hardships if the focal child is a boy.

The lower portion of the table shows differences by the age of the child, using three common demarcations of stages of childhood, 0–5, 6–11, and 12–18. The results are broadly consistent across all six of the insecurity outcomes and tend to show that food insecurity, whether for the household as a whole, for adults, or for the focal child, tends to rise with the age of the focal child. But for the binary indicators, the age gradient is somewhat steeper for boys than girls. The increase in adult insecurity with the age of the child is inconsistent with a simple version of the child protection hypothesis, which would suggest that adults protect adolescents less than young children. But it could also be interpreted as suggesting that food insecurity among adolescents would be even greater than it is, were adults not to sacrifice some of their own food consumption. Of course, no other variables have been controlled for yet which might explain the pattern of adult food insecurity with the age of the child in other ways, including the number and types of other children in the family.

[9] The economic model in the next section will reinterpret the child protection hypothesis as a matter of allocating food to the individuals where the marginal product is highest.

Gender differences also appear in these separate age means that were not apparent in the means taken over all ages, but they are not large in magnitude. There is a slight tendency for insecurity reports to be higher for the youngest girls than for the youngest boys but the opposite for adolescent boys and girls. However, this pattern is not present in a consistent way for the conditional SUM measures.

2.2. Initial multivariate results

We estimate random effects probit models for the three binary outcomes (VLFS, VLFSA, VLFSC) and random effects ordered probit models for the three SUM variables (SUM, SUMA, and SUMC), in all cases using the survey weights referred to previously.[10] The typical equation is of the form

$$V_{it}^{*} = C_i\alpha + X_{it}\beta + \mu_i + \varepsilon_{it} \tag{1}$$

where V_{it}^{*} is the latent variable for child i at wave t that generates the discrete binary outcome or ordered discrete outcome, C_i is a vector of the 6 age–gender dummies for the child (3 age groups, 2 genders) and α is its coefficient vector, X_{it} is a vector of control variables for child i at wave t and β is its coefficient vector, μ_i is a random effect for child i, and ε_{it} is the remaining error term. The vector of control variables consists of measures of household characteristics including income and household composition (marital status, presence of other children in the household, etc.), characteristics of the caregiver, measures of participation in relevant welfare programs (more on this below), and fixed effects for city of residence. The exact list of control variables and their means is shown in Supplemental Appendix Tables C-1–C-3.[11]

The main results are shown in Table 2, which shows only the coefficients on the age–gender variables. The coefficients on the control variables are shown in Supplemental Appendix Table C-4.[12] They show that having income below the poverty line and having an unmarried caregiver, for example, increase the probability of experiencing food insecurity, as does having a disabled caregiver.[13] Having more adults in the household also increases the probability while having more other young children in the family decreases it. Being a recipient of SNAP lowers the probability of having VLFS. This result differs from many estimates of positive effects in the literature which are usually thought to occur because of selection bias.[14] The negative sign in this sample suggests that very little if any selection bias is likely present, and this may be, in turn, because of the homogeneous nature of the TCS sample (all from inner city poor neighborhoods, all very disadvantaged, etc.).

Turning to the main results, column (1) of Table 2 shows many significant age and gender differences in overall food insecurity (VLFS) with, for example, an age gradient that was apparent in the raw means still present after controlling for the variables in the X vector. The age gradient is somewhat steeper for those with boys – households with a boy focal child 12–18 have significantly greater probabilities of VLFS than those with a girl focal child in the same age range (probit coefficient = −0.340). Just the opposite is the case for households with very young children, where having a boy focal child 0-5 results in a lower probability of having VLFS than having a girl focal child in the same age range (−0.522 versus −0.835).[15]

The other columns in the upper panel of Table 2 show the coefficient estimates on the age–gender variables from specifications that have the same control variables but estimated for the other five outcome measures. The age gradient is maintained for almost all outcomes, with the exception of girls 6–11 for some of the outcomes. The age gradients for adult food insecurity are generally smaller than the age gradients for child insecurity. The gender gradients are, however, considerably smaller for the adult and child insecurity measures than they were for overall VLFS. The gender gaps at 0–5 and 12–18 are no longer significant, and the gap at 6–11 is only significant for some outcomes.

The implied magnitudes of the differences translated into probabilities of insecurity (i.e., marginal effects) are arguably more relevant and are shown in the bottom portion of the Table.[16] The age gradients are particularly strong for males, with 12–18 males having between 5 and 8 percentage points higher food insecurity than 0–5 boys. Girls 12–18 also have higher food insecurity than younger girls, but the magnitude of the gap is generally smaller with 0–5 girls and generally larger

[10] OLS estimates and alternative methods of clustering are discussed below.

[11] The control variables include counts of the number of other children in the household of each age and gender, so that the coefficients on the age–gender variables for the focal child in these regressions represent their incremental effects on adult and child food insecurity, holding fixed the composition of other children in the family. The mean counts of other children in the family are shown in Supplemental Appendix Table C-3. The mean number of other children is about 2, so the mean total number of children in this sample is only 3, not a large number for a low-income population.

[12] Supplemental Appendix Table C-4 also shows estimates of the effect of child age and gender, uninteracted. Some prior studies (e.g., Nord, 2013) have found insignificant gender effects on total food security; we find the same result but only in the uninteracted specification.

[13] Additional equations were estimated which decomposed both family income and the poverty-status dummy into permanent and transitory components, measured, respectively, by the mean of each variable over the three waves and the family's deviation from the mean in each wave. The results (available upon request) show a significant negative effect of permanent income on food insecurity and significant positive effects of both permanent and transitory poverty status on food insecurity. However, the coefficients on child age and gender were not affected, so these results are not shown.

[14] See the discussion in Gregory et al. (2016). Our result has also been found in previous studies using these data (DePolt et al., 2009).

[15] Any pairwise difference between two age–gender categories which is statistically significant at the 10% level is indicated in the table. Any such comparison with no significance level shown is statistically insignificant at that level.

[16] The marginal effects are calculated in a way appropriate for the effects of a dummy variable rather than a continuous variable (see footnotes to the table). We note that the issue of estimating marginal effects with interactions noted by Ai and Norton (2003) is not directly relevant here because age–gender variables are the direct object of interest, rather than the overall effect of either age or gender. We also note that the more recent literature (Puhani 2012 and the literature following that paper) recommends, in any case, that interaction coefficients be used alone when the variables in question are discrete.

Table 2
Age–gender coefficients and marginal effects from probit and ordered probit estimation of food security models.

Variable	VLFS	SUM	VLFSA	SUMA	VLFSC	SUMC
Coefficient estimates[1]						
Age 0–5 female	−0.522$^{*\wedge}$	−0.451^{*+}	−0.385$^{*+\#}$	−0.383^{*+}	−1.329^{*o+}	−1.225^{*o+}
	(0.170)	(0.132)	(0.130)	(0.125)	(0.284)	(0.272)
Age 6–11 female	−0.626*	−0.472$^{*\wedge}$	−0.348$^{*+\#}$	−0.440$^{*+\#}$	−0.714$^{*+\wedge}$	−0.702^{*+}
	(0.175)	(0.132)	(0.127)	(0.130)	(0.262)	(0.266)
Age 12–18 female	−0.340$^{*\wedge}$	−0.098$^{\wedge}$	−0.044$^{\wedge}$	−0.129$^{\wedge}$	−0.103$^{\wedge\#}$	−0.072$^{\wedge\#}$
	(0.153)	(0.115)	(0.112)	(0.111)	(0.204)	(0.196)
Age 0–5 male	−0.835*	−0.627$^{*\#}$	−0.588$^{*\#}$	−0.563$^{*\#}$	−1.285*	−1.197*
	(0.177)	(0.130)	(0.129)	(0.123)	(0.305)	(0.284)
Age 6–11 male	−0.587*	−0.268*	−0.150	−0.211*	−0.932*	−0.871*
	(0.160)	(0.114)	(0.111)	(0.111)	(0.256)	(0.236)
Marginal effects						
Age differences (Relative to 12–18)						
Male						
0–5	−0.074*	−0.060*	−0.078*	−0.079*	−0.056*	−0.053*
	(0.018)	(0.014)	(0.020)	(0.020)	(0.013)	(0.012)
6–11	−0.061*	−0.034*	−0.027	−0.038	−0.049*	−0.047*
	(0.018)	(0.015)	(0.022)	(0.021)	(0.013)	(0.011)
Female						
0–5	−0.017	−0.037*	−0.052*	−0.039*	−0.048*	−0.048*
	(0.013)	(0.014)	(0.020)	(0.020)	(0.010)	(0.010)
6–11	−0.024*	−0.039*	−0.047*	−0.046*	−0.034*	−0.036*
	(0.013)	(0.013)	(0.019)	(0.018)	(0.011)	(0.010)
Gender differences (Male minus female)						
0–5	−0.019*	−0.010	−0.019	−0.017	.001	.000
	(0.011)	(0.009)	(0.014)	(0.015)	(0.005)	(0.005)
6–11	.002	.018*	.028*	.031*	−0.007	−0.005
	(0.012)	(0.010)	(0.018)	(0.016)	(0.007)	(0.007)
12–18	.038*	.013	.007	.022	.008	.006
	(0.017)	(0.015)	(0.021)	(0.020)	(0.012)	(0.011)

Standard errors in parentheses; survey weights used.
Marginal effects calculated by setting all Control variables to their means, all age–gender variables to zero, and calculating baseline probabilities from predicted values of Prob(VLFS = 1), Prob(VLFSA = 1), Prob(VLFSC = 1), Prob(SUM > 1), Prob(SUMA > 0), and Prob(SUMC > 0). Then, for each age–gender group, the six predicted probabilities are recalculated using the estimated coefficient for that group, and the difference from the baseline probability is the marginal effect. Standard errors are derived by bootstrapping.

* Significant at the 10% level (from the omitted group).
$^{+}$ Significantly different from Age 12–18 female, 10% level.
$^{\wedge}$ Significantly different from Age 0–5 male, 10% level.
$^{\#}$ Significantly different from Age 6–11 male, 10% level.
^{o} Significantly different from Age 6–11 female, 10% level.
[1] Indicator for 12–18 male omitted.

with 6–11 girls than for the same gaps for boys. There is no consistent pattern in whether these age gradients are larger for adult food insecurity than for the focal child, with the adult gradient sometimes larger than for the child but often in the other direction as well. The gender differences are only significant at conventional levels for overall food insecurity and for VLFS for adults and never significant for child measures, implying that any gender effects are manifest more in adult food insecurity differences. Where significant, the gender gradients imply the same reversal from younger ages to older ages, but the magnitudes are largest for the middle, 6–11 age group.[17]

These results will be the basis for the rest of the article. The next section below lays out a simple economic model that can be used to interpret these results. Following that, we explore a number of possible explanations and correlates for these age–gender differences. However, before doing either of those, we subject our results to several sensitivity and robustness tests addressing a range of different issues, summarized in Table 3 for the VLFS outcome variable (results for other outcomes available upon request). First, we address possible concerns with the inclusion of variables for welfare participation in the equation, especially those for participation in school breakfast and lunch programs which, in addition to being potentially endogenous in general, could affect child food insecurity. A simple test is just to exclude those variables from the regression. As the second column shows, this has very little effect on the estimated age–gender differences. Another concern is that the strong finding of greater food insecurity among older children than younger ones could reflect the presence of unobservables

[17] We might note at this point that lack of parental knowledge of whether teenagers are eating if away from home might be contributing to the age gradient results. While this is a possibility, the questions about child food consumption (see Appendix A) are about cutting meals, not eating for a full day, or going hungry, which should not, in principle, generate a positive response if a teenager was simply absent. Also, Nord and Hanson (2012) found that adolescents often report food problems even if their parents do not, which suggests that the age gradient might actually be stronger. In addition, adding an 'Eating at home' dummy (see below) to the regression does not affect the age–gender coefficients.

Table 3
Robustness checks: age–gender coefficients for VLFS.

Variable	Base	No welfare participation variables	No time-varying X variables	Other adults present	Grandparent caregiver variable included[2]	Changing caregiver allowed	Dropping X variables with missing values	OLS
Coefficient estimates[1]								
Age 0–5 female	−0.522	−0.540	−0.459	−0.654	−0.481	−0.507	−0.503	−0.063
	(0.170)	(0.153)	(0.138)	(0.244)	(0.260)	(0.161)	(0.160)	(0.016)
Age 6–11 female	−0.626	−0.697	−0.650	−0.617	−0.602	−0.606	−0.615	−0.071
	(0.175)	(0.169)	(0.154)	(0.255)	(0.228)	(0.150)	(0.170)	(0.016)
Age 12–18 female	−0.340	−0.359	−0.323	−0.497	−0.363	−0.295	−0.318	−0.041
	(0.153)	(0.153)	(0.133)	(0.205)	(0.215)	(0.143)	(0.156)	(0.015)
Age 0–5 male	−0.835	−0.825	−0.739	−1.484	−0.779	−0.781	−0.850	−0.086
	(0.177)	(0.164)	(0.147)	(0.300)	(0.255)	(0.170)	(0.178)	(0.016)
Age 6–11 male	−0.587	−0.620	−0.588	−0.547	−0.537	−0.594	−0.598	−0.065
	(0.160)	(0.158)	(0.140)	(0.241)	(0.221)	(0.154)	(0.161)	(0.015)

Standard errors in parentheses; survey weights used.
[1] Indicator for 12–18 male omitted.
[2] Coefficient and standard error on Grandparent Caregiver variable equal to −0.167 and 0.560, respectively.

correlated with the presence of older versus younger children in the family. While we cannot test for unobservables formally, we can examine the sensitivity of the results to the inclusion or exclusion of variables which markedly change over time as the child ages. These include rising income levels, falling poverty rates, rising rates of home and car ownership, and aging of other children in the household (see Supplemental Appendix Table C-3). The third column of Table 3 shows the effects of excluding all X variables from the equation which change non-trivially over the waves of the data. While the coefficient estimates change to some degree, the general pattern and significance levels do not change.[18]

Another concern might be that there are other adults in the household who are providing assistance to the children's food consumption. The X vector includes a variable for the number of adults in the family (including caregiver and any spouse), whose coefficient is significant and positive (see Supplemental Appendix Table C-4). This is probably because more mouths to feed means higher levels of food insecurity, holding income fixed. But the coefficients on the age–gender dummies could also vary depending on the presence of other adults in the household. The fourth column in Table 3 shows the age–gender coefficients obtained when the sample is restricted to those with adults present in the household other than caregiver and spouse.[19] Once again, the coefficients move around in magnitude to some degree (especially that on the 0–5 boys variable, who have much reduced food insecurity relative to older boys), implying some differences. However, the general pattern and significance of the results remains. Another test we conduct, shown in the next column in the table, is to add a dummy variable to the regression for whether the caregiver is a grandparent. That variable is insignificant but again moves the coefficients slightly around, with generally reduced differences in the age gaps in food insecurity.[20]

The next two columns conduct two sensitivity tests for our sample exclusions. First, we drop the requirement that the caregiver has to be the same across waves, which results in an additional 98 observations over all three periods (net of other sample exclusions). The coefficients again move around slightly but the general pattern remains. We also relax our requirement that all variables in the X vector be non-missing by dropping the six variables with the most missing values. This also has little effect on the general pattern.

Finally, we conduct some tests to the estimation method. One test is to estimate the model with OLS (weighted, random effects) rather than probit. These coefficients, shown in the final column in the table, should be compared to the marginal effects for VLFS in the lower panel of Table 2, although the OLS coefficients for some of the effects have to be differenced for comparability. The OLS results are very close to the marginal effects in Table 2. A second exercise tests the sensitivity of our standard error estimates to methods other than random effects. One is cluster by child instead of using child random effects (clustering is more robust than random effects but less efficient if the random effects assumption is correct) and the other is to cluster both by individual child and by gender of the child. For brevity, the results are shown in Supplemental Appendix Table C-5. Clustering instead of using random effects alters the estimated effects slightly and in one case moves a coefficient slightly below the cutoff for significance at the 10% level, while clustering by child and gender leaves most coefficients that were initially significant still significant except for two coefficients that are moved slightly below that cutoff.[21]

[18] These results reflect a general lack of correlation between the age–gender variables and the X variables in the equation in general. OLS regressions of the 6 age–gender dummies on the X vector yield R^2 statistics ranging only from .03 to .11.

[19] About two-thirds of the households have such other adults present, although almost never more than one.

[20] 196 observations out of the total of 4229 had a grandparent caregiver. We might note at this point that all the caregivers in the analysis sample are female. There were 24 caregivers in the total original sample who were male, but all 24 were eliminated by the requirement for the same caregiver over time (which we test for next).

[21] We also examined the estimates in Table 2 for Bonferroni effects given that two measures of VLFS (adult and child) and two measures of SUM (also adult and child) are used, and the two may be correlated. We use the simplest Bonferroni adjustment, which just uses a p-level of α/k, where k is the number of measures, instead of α (this simple adjustment is known to be conservative in the sense of overadjusting for Type I error). This adjustment does

3. A simple economic model

A simple economic model can help frame these results and help formalize at least some of the possible explanations for the differences in food security across members of the household. One possibility is that adults and children, and children of different ages and genders, have different nutritional needs, which could lead to different quantities of food being required to reach a given level of food well-being.[22] This does not automatically imply differences across household members if households simply allocate additional food to those needing more. A second possibility is that adults and children, and children of different ages and genders, may have different non-food needs. The needs for clothing, housing (e.g., bedroom size), and medical care may all differ for adults and different children and, since all compete for the household dollar, a household may allocate its income differently across different goods for different household members if non-food needs differ. A third possibility is that food consumption for children has important future consequences which may be more important than for adults, and may have consequences for future health, education, and earnings. In addition, the importance of food intake for future outcomes may differ for children of different ages and gender, and early child food intake may have implications for health and well-being at later child ages. A fourth possibility is that a household simply has different preferences for members with different characteristics. A fifth is that the age and gender composition of the children are related to household capabilities and functioning, such as financial management, family organization, and family routines, as will be discussed in more detail below.

There have been a few models in the food insecurity literature which focus on some of these aspects of household decision making (Barrett, 2002; Gunderson and Gruber, 2001; Meyerhoefer and Yang, 2011; the last of these draws on Cawley, 2004). However, none of the frameworks in these studies attempts to model differences between adults and children or between children of different characteristics. The studies cited in the introduction (Becker and Tomes, 1976; Behrman et al., 1982; Aizer and Cunha, 2012) are more relevant because they focus on individual child allocations. But, in all studies, the traditional household production framework is the workhorse model, and that is the same here.[23]

Many of the issues can be seen with a model of a household composed of adults and a single child. Let the household problem be to

$$\underset{F_A,\, F_C,\, O_A,\, O_C,\, H}{\mathrm{Max}} \quad U(S_A, S_C, N_A, N_C, H, Y_C) \tag{2}$$

subject to the constraints

$$S_i = f(F_i; X_i) \quad i = \mathrm{A, C} \tag{3}$$

$$N_i = g(O_i; X_i) \ \ , i = \mathrm{A, C} \tag{4}$$

$$Y_\mathrm{C} = h(S_\mathrm{C}, N_\mathrm{C}; X_\mathrm{C}) \tag{5}$$

$$M = H + p \cdot (F_\mathrm{A} + F_\mathrm{C}) + q \cdot (O_\mathrm{A} + O_\mathrm{C}) \tag{6}$$

where S_A is adult food security, S_C is food security of the child, N_A is adult non-food security (i.e., security arising from non-food consumption, somehow defined), N_C is non-food security of the child, H is public goods consumption within the household, and Y_C is a future outcome (health, education, earnings) of the child. Food security is here assumed to be a continuous measure of food intake which can generate discrete indicators such as those used in the food security literature. Non-food security is set up to parallel food security, solely for the purpose of formality. Both food and non-food security are generated by production functions f and g, with positive first and negative second derivatives, with inputs of the adults' and child's food consumption, F_A and F_C, and non-food consumption, O_A and O_C, respectively. The functions depend on X_A and X_C, the individual characteristics of the adult or child, most prominently age and gender. Future outcomes for the child are affected by food and non-food security and also depend on child characteristics, X. Household income, M, is allocated to current food and non-food consumption to adults and the child, with prices p and q, respectively.

Our interest in this model is in the food allocation to the adults versus the child, which is governed by the marginal condition

$$U_1 f'(F_\mathrm{A}; X_\mathrm{A}) = U_2 f'(F_\mathrm{C}; X_\mathrm{C}) + U_6 h_1(S_\mathrm{C}, N_\mathrm{C}; X_\mathrm{C}) f'(F_\mathrm{C}; X_\mathrm{C}) \tag{7}$$

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not affect the conclusions to be drawn in Table 2 because those parameters which are significant in both adult and child equations have critical values far above the Bonferroni-adjusted ones.

[22] Different nutritional needs could also be traced to differences in the activity levels of adults and children and for different ages and genders of children, which might generate different nutritional intakes to satisfy.

[23] There has been more past work done on gender differences than age differences. See Lundberg (2005) for a conceptual analysis of gender differences which also makes the distinction between preferences and constraints that we make here, and see Raley and Bianchi (2006) for a sociological study which implicitly discusses the importance of production functions. See also the references in the Introduction and in the section below on the relationship between family structure and gender differences in parental inputs.

The term on the LHS and the first term on the RHS show that if either the marginal utilities of increasing food security for the adults and the child differ, or the marginal products of additional food allocations on food security differ, food allocations will also tend to differ. The second term on the RHS shows simply that if food security affects future child outcomes, food allocations will tend to be greater to the child than to the adults even if the production functions and marginal utilities of the adult and the child are the same.[24] Ignoring these future outcomes and just examining the other two terms also clearly shows that even if marginal utilities are the same, more food will be allocated to the child if the marginal product of a given amount of food in the production of food security is higher for the child, which is plausible because children have lower food requirements than adults.

However, note that there is no need in this model for the levels of food security to be equalized between the adults and the child, because it is only the marginal products (weighted by marginal utilities and ignoring future payoffs) that are equalized. At the optimum, adult food security could be greater than, equal to, or less than that of the child. On the other hand, it is plausible (1) that the marginal product of incremental food consumption is higher for the child at low levels of F, (2) but its marginal product declines more rapidly w.r.t. F than for the adults, and (3) that the marginal product of F for adults is greater than that of the child at higher levels of F. In that case, it is plausible that the household first devotes food consumption to the child and then to the adults thereafter, stopping at a point where resources limit further consumption but at a level where S is lower for adults. This would be consistent with the child protection hypothesis.

A model with multiple children speaks more directly to the issues raised by the results reported in the previous section. Now let the model be:

$$\underset{F_A,\,F_{C_1},\,\ldots,\,F_{Cn},\,O_A,\,O_{C_1},\,\ldots,\,O_{Cn},\,H}{Max} U(S_{\mathrm{A}}, S_{\mathrm{C}1}, S_{\mathrm{C}2}, \ldots S_{\mathrm{C}n}, N_{\mathrm{A}}, N_{\mathrm{C}1}, N_{\mathrm{C}2}, \ldots N_{\mathrm{C}n}, H, Y_{\mathrm{C}1}, Y_{\mathrm{C}2}, \ldots, Y_{\mathrm{C}n}) \tag{8}$$

subject to the constraints

$$S_i = f(F_i; X_i),\ \ i = \mathrm{A}, \mathrm{C}_1, \mathrm{C}_2, \ldots, \mathrm{C}_n \tag{9}$$

$$N_i = g(O_i; X_i),\ \ i = \mathrm{A}, \mathrm{C}_1, \mathrm{C}_2, \ldots, \mathrm{C}_n \tag{10}$$

$$Y_i = h(S_i, N_i; X_i),\ \ i = \mathrm{C}_1, \mathrm{C}_2, \ldots, \mathrm{C}_n \tag{11}$$

$$M = H + p \cdot (F_{\mathrm{A}} + \Sigma F_i) + q \cdot (O_{\mathrm{A}} + \Sigma O_i) \tag{12}$$

for $i = 1,\ldots,n$ children each with characteristics X_i. The marginal condition for relative food allocation between child i and child j is

$$U_{\mathrm{C}_i} f'\left(F_{\mathrm{C}_i}; X_i\right) + U_{Y_i} h_1\left(S_{\mathrm{C}_i}, N_{\mathrm{C}_i}; X_i\right) f'\left(F_{\mathrm{C}_i}; X_i\right) = U_{\mathrm{C}_j} f'\left(F_{\mathrm{C}_j}; X_j\right) + U_{Y_j} h_1\left(S_{\mathrm{C}_j}, N_{\mathrm{C}_j}; X_j\right) f'\left(F_{\mathrm{C}_j}; X_j\right) \tag{13}$$

Once again, greater allocations of food will tend to be made to those children with higher marginal products in either the production of food security or in future payoffs from increased food security, ignoring differences in marginal utilities. Both of these are likely to be greater for younger than older children, and the presence of dynamic complementarities (Cunha and Heckman, 2007) could generate an additional incentive to allocate more resources to younger children. Gender differences are not so clear. One possibility is that the rate of return to future earnings in investing in children is greater for girls because they have a higher likelihood of going to college relative to food investments in boys for building strength in non-college jobs. There could also be gender differences in activity levels, and more active children may have greater nutritional needs, although this would suggest a higher allocation to older children and to boys. Note that, similarly to the case of adults versus children discussed above, there is no necessity for levels of food security to be equalized across children, for only the marginal gains in utility from incremental food allocations are equalized.

A question to be examined below is whether any differences in food allocations and resulting food security tend to diminish as income rises. In the model as stated, there is no reason for those differences to decline because the continuous variable for food security could increase without bound. However, the empirical work here is based instead on discrete indicators of low food security. As income rises, it should be expected that food allocations rise and that means that food security does as well and, after a point, all individuals in the family are likely to have passed whatever threshold is determining the discrete indicators. Therefore it should be expected that these between-child differences in the food security indicators will decline and will decline for all household members as income rises. However, there is still an important empirical question of exactly how high income has to rise before the differences in the indicators start to narrow.

The model implies that the optimal food and non-food allocations to different children should be a function of income, the relative prices of food and non-food individualized consumption goods, and the parameters of the production and utility functions. The data set available here has no information on most of these variables, including the core choice variables which are the food and non-food allocations. Consequently, only reduced form equations for the main outcome variables

[24] Adult outcomes such as health and hence wage rates could also be affected by lack of sufficient food intake. These are examples of investments in health capital, as originally emphasized by Grossman (1972).

in the data – the food security levels of the focal child and of the adults – can be estimated. These equations have to be interpreted as reduced forms of the production functions for S, obtained by solving for the optimal allocations of F and O and substituting those into the equation.

However, several important aspects of possible correlates of age and gender gaps between children will be examined below. First, data are available on the nutritional needs of children of different ages and genders, and these can be used to explore the degree to which they can explain the gaps (these variables should be thought of as being included in the X vector). Second, data are available on household structure, which can be used to explore whether the gaps are related to the marital status of the mother. The data set here also has a measure of whether the household is well organized in a sense to be defined below. Third, data are available on household income, of course, but also on other aspects of resource availability, including resources from the household's network. These can be used to explore whether the age and gender gaps shrink as resources rise, as predicted by the model. Also available in the data is a variable for whether the household has difficulty meeting its desired expenditure ("financial strain"), which is both a measure of financial management skills of the parents as well as hardships that result from short-term shocks to resources (e.g., Bray, 2001 detected these separate dimensions in an analysis of responses to financial stress questions in Australia). With respect to financial management, a qualitative study by Edin et al. (2013) found that low-income parents invest enormous amounts of time in deciding where to shop for food, finding where the best prices are, looking for sales, planning meals around inexpensive foods, and managing their budget in general, and that some parents are more skilled at that activity than others. Mullainathan and Shafir (2013) have emphasized the cognitive challenges that low-income individuals face in making rational decisions. A quantitative analysis by Gundersen and Garasky (2012) had a measure of financial management skills and found that such skills reduce the incidence of food insecurity. With respect to the hardship element, Joyce et al. (2012) documented that children's food problems and hunger rarely happen in isolation but rather often co-occur with a constellation of other financial and non-financial hardships. The financial strain variable used below may capture both the management and hardship dimensions.

4. Investigation of correlates

4.1. Nutritional needs

Two measures of nutritional needs by the age and gender of children are available, one developed by the USDA used to set SNAP benefit levels and one from the Institute of Medicine. Regarding the first of these, the USDA has for many years estimated the cost of purchasing a minimally adequate diet for individuals of different ages and genders. The methodology uses dietary guidelines established for different ages and genders and determines the market basket of different food groups needed to meet the Recommended Daily Allowances (RDAs) for 15 essential nutrients (U.S. Department of Agriculture, 1999). Specific low-cost options for weekly meals which attain these RDAs are then calculated by obtaining prices for different foods which together will yield this outcome. The minimal cost of that bundle of meals is called the Thrifty Food Plan (TFP) and is widely used to assess the adequacy of family incomes to achieve minimally nutritious diets as well as being used by USDA to set SNAP allotments.[25]

Supplemental Appendix Table C-6 shows the 1999 USDA TFP weekly food costs for individuals of different ages and genders in a family of four. Food costs for children less than 12 do not differ by gender but rise significantly with age. Gender differences in food costs appear for older children and adults but those are also modest in size, but some of the age differences (e.g., between adolescents and those under 12) are larger. Given these differences, a family with limited financial resources may choose to forgo expenditures for adolescents with their high food costs in favor of protecting younger children and maintaining their food input at nutritionally adequate levels. Or, in the language of the model, the marginal product of a given amount of food expenditure may be greater for those with lower nutritional needs.

We follow a three-step method to determine how much of the age–gender gaps can be explained by nutritional needs. The first step is to use Supplemental Appendix Table C-6 to assign a TFP value to each focal child in the sample, using that focal child's age and gender.[26] Second, we reestimate the food insecurity equations in Table 2 but substitute the TFP variable for the focal child for the five age–gender indicators in that equation. The third step is to use these estimated equations to predict what the age–gender food security gaps would be, based solely on TFP differences. By comparing the predicted gaps to the actual ones, we can assess how much of the observed, actual gap can be explained by differential nutritional needs.

The estimates of the coefficients on the focal child TFP variable are positive and strongly significant for all six measures of food insecurity, with t-statistics ranging from 3 to 5 (not shown). But the main question is how much they explain the differences in marginal effects shown in the lower panel of Table 2. The predicted differences from the TFP estimates are given in Table 4, which should be compared to those in Table 2. For boys, differences in TFP explain a major part of the age gaps, ranging from a low of about one-fourth of the actual gap to all of it (or, in a couple of cases, more than all of it). Most of the values are in the one-half to two-thirds range for both the binary and SUM measures, and usually a larger fraction is explained for girls than for boys. But TFP nutritional needs explain almost none of the gender gaps that were significant

[25] Caswell and Yaktine (2013) and Ziliak (2016) critique the TFP measure by noting that it assumes that families purchase the lowest-cost foods and devote large amounts of time in food preparation. This implies that the TFP may underrepresent the cost for the average family which cannot devote that degree of time and must purchase higher-price food items.

[26] As noted in the footnote to Appendix Table C-6, those figures differ by family size, so this must be taken into account in the assignment.

Table 4
Age–gender differences in marginal effects arising from differences in TFP nutritional needs alone.

Variable	VLFS	SUM	VLFSA	SUMA	VLFSC	SUMC
Age differences (Relative to 12–18)						
Male						
0–5	−0.036*	−0.042*	−0.060*	−0.051*	−0.042*	−0.047*
	(0.011)	(0.010)	(0.014)	(0.015)	(0.007)	(0.008)
6–11	−0.013*	−0.015*	−0.021*	−0.018*	−0.021*	−0.023*
	(0.004)	(0.004)	(0.006)	(0.006)	(0.005)	(0.005)
Female						
0–5	−0.035*	−0.042*	−0.059*	−0.050*	−0.041*	−0.046*
	(0.011)	(0.010)	(0.014)	(0.014)	(0.007)	(0.008)
6–11	−0.012*	−0.014*	−0.019*	−0.016*	−0.019*	−0.021*
	(0.004)	(0.004)	(0.005)	(0.005)	(0.004)	(0.005)
Gender differences (Male minus female)						
0–5	.000	.000	.000*	.000*	.000*	.000*
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
6–11	−0.001*	−0.001*	−0.001*	−0.001*	−0.001*	−0.001*
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
12–18	.001*	.001*	.001*	.001 *	.001*	.002*
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)

See Table 2 notes.

in Table 2, which is not surprising given that the TFP does not have a gender component below age 15 and only a modest component at ages 15–18.

A second measure of nutritional needs is produced by the Institute of Medicine as part of its series of Dietary Reference Intakes (DRIs), which have replaced the old RDAs, and are calculated as estimated average requirements for over 20 nutrients by age and gender.[27] While most DRIs vary with age in the expected way, no gender differences for children 8 and below are estimated, and those for children over 8 are usually small. For the purpose of this exercise, the three nutrients with the strongest gender differences above age 8—Vitamin A, Zinc, and Magnesium—were purposely selected to obtain an upper bound on how much these nutrient indices can explain the gender gap. For all three, boys were estimated to have higher requirements than girls. The three-step procedure used to estimate the influence of TFP values was then duplicated—first determining the value of each nutrient for each focal child, then reestimating the food insecurity equation by replacing the age–gender dummies with the three nutrient values for the focal child, then predicting the age–gender gaps implied by those nutrient values alone. Supplemental Appendix Table C-7 shows the predicted age and gender gaps from these nutrient values alone, which should again be compared to the bottom panel of Table 2. For the age gaps, these nutrient values generally explain even more of the gaps for boys than the TFP values did, but the opposite is generally true for girls, where these nutrients, more often than not, explain less than the TFP values (with some exceptions). For gender gaps, while these nutrients explain little of the gaps for younger girls, they explain much more of the gaps for teenage boys and girls and, again, in some cases, explaining all or more than all of it. While the nutrients selected were intentionally those which had large gender gaps for teenagers, this does suggest that nutrient requirements have the potential to explain much of the gap for that age group.

These results imply that differences in nutritional needs “explain” a large fraction of the age differences in food insecurity across children. As noted previously, the needs differences explain the food insecurity differences only in the sense that they imply that parents do not allocate food expenditures across children to equalize levels of food insecurity, which does not imply that they do not allocate more expenditure per se to children with higher needs—just not enough to reduce their food insecurity levels to those of children with lower needs. These findings are consistent with the production function model outlined in the previous section.

4.2. Family structure and organization

The influence of family structure on child outcomes has been discussed in the literature.[28] While all households in this sample are poor and have children, both married and unmarried mothers are included, and unmarried mothers in this case are equivalent to single mothers.[29] While the marital status variable was a statistically insignificant determinant of the level

[27] http://www.nationalacademies.org/hmd/Activities/Nutrition/SummaryDRIs/DRI-Tables.aspx

[28] For example, Bertrand and Pan (2013) found that gender differences in outcomes (not inputs per se) among adolescents were affected by family structure, consistent with Table 5 below. The relationship between family structure and age gaps among children has been much less examined in the literature than the relationship with gender gaps. In the latter category, in addition to Bertrand and Pan, see Lundberg and Rose (2003), Dahl and Moretti (2008), Blau et al. (2017), and Kabátek and Ribar (2017). Bertrand and Pan (2013), the most relevant to our study, found that single mothers are less favorable toward boys than married mothers, which is a direction of effect similar to ours.

[29] The data have a measure of cohabitation as well, but it was tested and found to have the same effect as being unmarried.

Table 5
Age–gender differences in marginal effects for families with unmarried and married Mothers.

	VLFS		VLFSA		VLFSC
	Unmarried	Married	Unmarried	Married	Unmarried
Age differences (Relative to 12–18)					
Male					
0–5	−0.084*	−0.006	−0.098*	−0.012	−0.058*
	(0.020)	(0.008)	(0.022)	(0.020)	(0.016)
6–11	−0.060*	−0.004	−0.012	−0.011	−0.051*
	(0.022)	(0.011)	(0.025)	(0.018)	(0.016)
Female					
0–5	−0.049*	.026	−0.067*	−0.004	−0.047*
	(0.017)	(0.016)	(0.020)	(0.030)	(0.013)
6–11	−0.035*	.004	−0.035	−0.039	−0.034*
	(0.017)	(0.021)	(0.021)	(0.031)	(0.013)
Gender differences (Male minus female)					
0–5	.005	−0.030*	−0.006	−0.039*	.002
	(0.013)	(0.017)	(0.018)	(0.022)	(0.006)
6–11	.014	−0.006	.048*	−0.004	−0.004
	(0.018)	(0.022)	(0.022)	(0.025)	(0.009)
12–18	.040*	.001	.025	−0.032	.013
	(0.021)	(0.010)	(0.025)	(0.028)	(0.018)

All families with married mothers have VLFSC = 0.
See Table 2 notes.

of food insecurity in Supplemental Appendix Table C-4, this is an average effect over married and unmarried mother families and does not imply that the effects of age–gender composition might not vary by marital status.

Single parenthood could have many different channels of effects on food allocations to different children (holding mother's employment and household income fixed). Low-income male spouses may, on average, have different preferences over food allocations than wives, for example, either by gender or by age of the child (e.g., men may have stronger preferences for supporting teenage boys). Having a male spouse to help with household production in other aspects may free up time for the mother to devote to food preparation and to ensure that all children are obtaining needed food consumption. Indeed, having a husband present may allow the mother to spend more time simply monitoring the food consumption of their children. Wives may have superior knowledge of the food security production functions than husbands, and possibly better knowledge of the future payoffs to children of different ages from increased food allocations. The net effect of these and related considerations on age and gender differences in food security are not clear and should be an empirical matter to resolve.

Table 5 shows the results of estimating random effects probit equations for the overall binary indicator of food insecurity, VLFS, and that for adults and children, VLFSA and VLFSC, respectively, separately for households with married and unmarried mothers. Only binary indicators are examined here, for brevity (results using the SUM measures add very little). Estimates for VLFSC for children with married mothers are not possible because no observations have positive VLFSC, which is partly a result of small sample size but also an indicator, in and of itself, of a difference between the two types of mothers. As the table shows, there is a marked difference in the age and gender patterns of food insecurity for children in households with unmarried and married mothers, especially for the age patterns. For both boys and girls, large and statistically significant differences between younger children and older children in families where the mother is unmarried essentially disappear completely in significance for children in families where the mother is married.[30] For gender, there is an anomalous result for younger children, where a significant gender gap appears only for married mothers, but for older children, the occasional significant gender difference for unmarried mothers is not present for married mothers. Overall, these results suggest that household structure does have an impact.

The data also have a measure of household organization which is rarely available in other data sets, with questions aimed at ascertaining whether the family had established routines – whether they had a time when everyone talks or plays quietly, whether the children go to bed at the same time every night, whether they all eat dinner together every evening, and whether at least some of them eat breakfast together (see Supplemental Appendix Table C-3). Developmental psychologists have found that having such family routines is correlated with positive developmental outcomes for children. In our case, the last two questions are also directly related to whether the children are eating with the rest of the household, which could be related to monitoring of food intake by the adults.

We construct a variable defined as whether the sum of the responses to the four questions is below or above the median sum in the full sample, and define this as having Low or High Family Routines. Entering this variable linearly into the food

[30] The VLFSC estimates for children with unmarried mothers are almost identical to those in Table 3 but this is simply because children with married mothers are not contributing to the coefficients.

Table 6
Age–gender differences in marginal effects for households with low and high household routines.

	VLFS		VLFSA		VLFSC	
	Low	High	Low	High	Low	High
Age differences (Relative to 12–18)						
Male						
0–5	−0.099*	−0.041*	−0.106**	−0.061*	−0.070*	−0.024*
	(0.021)	(0.019)	(0.024)	(0.025)	(0.018)	(0.011)
6–11	−0.053*	−0.035*	−0.006	−0.017	−0.053*	−0.023*
	(0.022)	(0.018)	(0.029)	(0.025)	(0.017)	(0.010)
Female						
0–5	−0.019	−0.007	−0.033	−0.064*	−0.059*	−0.012
	(0.024)	(0.012)	(0.025)	(0.024)	(0.014)	(0.010)
6–11	−0.027	.004	−0.040	−0.041	−0.051*	−0.003
	(0.022)	(0.015)	(0.025)	(0.026)	(0.014)	(0.009)
Gender differences (Male minus female)						
0–5	−0.046*	.004	−0.066*	.011	−0.004	.002
	(0.017)	(0.012)	(0.021)	(0.015)	(0.006)	(0.009)
6–11	.007	.000	.041	.032	−0.005	−0.006
	(0.026)	(0.014)	(0.033)	(0.023)	(0.013)	(0.006)
12–18	.033	.038*	.007	.008	.007	.014
	(0.023)	(0.019)	(0.026)	(0.030)	(0.017)	(0.011)

See Table 2 notes.

insecurity questions reported previously shows that having household routines above the median has a strongly significant negative effect on food insecurity. Table 6 shows the results when the binary indicator probits for food insecurity are estimated separately for those with Low and High values of the routine index. The results show that there are many cases where age or gender differences are significant and large for those with low values of household routines which are much reduced in magnitude and sometimes in significance for those with high household routine values. This is especially the case for boys, where the age differences for children in families with high routine values are a half or less as large as those in families with low values. For girls, effects are insignificant for overall food insecurity (VLFS) (although larger in magnitude for families with low family routine values), and there is one unexpected result for young girls for adult food insecurity, but for child food insecurity the significant effects for low-routine-value households are rendered insignificant for households with high values. Gender differences are not significant much of the time in general, but in two cases a significant gender difference among young girls and boys which is significant in households with low routines values disappears for households with high values. In one case, for older boys and girls, an effect (VLFS) is moved slightly over the borderline of 10% significance for high routine value households, but the magnitude is essentially the same.

Thus, while there are occasional exceptions for some gender and age groups, the general tendency of the results suggests strongly that household structure and household organization and joint eating patterns affect the magnitude and presence of age and gender differences in food security between different children in the household. The effects are strongest in unmarried households and in those with low levels of household organization and who tend not to eat together.

4.3. Income, financial strain, and networks

As noted in the theoretical discussion and as is intuitively obvious, the fraction of household members experiencing food intake deficiencies below a fixed threshold should decline as income rises. In addition, while there is no necessary relationship between age–gender differences and income as income rises but food deficiencies are still below the threshold, it should not be surprising if all differences narrow as they all approach zero. But what the rate of decline is as income rises, and at exactly what point the differences begin to narrow or disappear, is an empirical question. The data being employed here were drawn from a sample of households with income less than or equal to 200% of the poverty line, which means that it is still, by any definition, a low-income sample. Whether within-household food security differences narrow as income rises up to the 200% of poverty level is not obvious.

A measure of total household cash income has been included in all estimated equations thus far, as is traditional in the literature on food insecurity, in addition to a dichotomous measure of whether that income is below the poverty line. The coefficients on income are usually statistically insignificant but those on the poverty status variable are always strongly significantly positive for all food security outcomes—overall, adult, and child (see Supplemental Appendix Table C-4 for the first of these)–indicating a positive association between food insecurity of the household and having income below the poverty line. Here, the approach to examining whether the age–gender differences fall as income rises is simply to estimate the equations separately for households with income below the poverty line (about $20,000 for a family of three in 2017) and those above it, to determine if those differences change with income category.

Two other measures of household income resources are also available in these data. One is a measure of what is termed "financial strain," which is constructed from a set of six questions asking the caregiver how often her household had to

Table 7A
Age–gender differences in marginal effects for household with income below and above the poverty line.

	VLFS		VLFSA		VLFSC	
	Below	Above	Below	Above	Below	Above
Age differences (Relative to 12–18)						
Male						
0–5	−0.114*	−0.019	−0.111*	−0.044*	−0.091*	−0.008
	(0.025)	(0.013)	(0.027)	(0.022)	(0.018)	(0.008)
6–11	−0.097*	−0.008	−0.064*	.015	−0.078*	−0.010
	(0.022)	(0.013)	(0.027)	(0.026)	(0.019)	(0.008)
Female						
0–5	.001	−0.019*	−0.033	−0.069*	−0.049*	−0.004
	(0.018)	(0.011)	(0.022)	(0.022)	(0.011)	(0.010)
6–11	−0.020	−0.012	−0.040*	−0.045*	−0.027*	−0.009
	(0.014)	(0.010)	(0.022)	(0.026)	(0.011)	(0.009)
Gender differences (Male minus female)						
0–5	−0.039*	−0.002	−0.033*	−0.006	−0.004	−0.005
	(0.015)	(0.007)	(0.018)	(0.011)	(0.005)	(0.009)
6–11	−0.001	.003	.020	.028	−0.013	−0.002
	(0.017)	(0.011)	(0.024)	(0.024)	(0.012)	(0.007)
12–18	.076*	−0.001	.044*	−0.031	.037*	−0.002
	(0.023)	(0.013)	(0.024)	(0.025)	(0.019)	(0.008)

See Table 2 notes.

borrow to pay bills, had to put off buying something it needed, could not afford to do things "for fun", had difficulty paying bills, could not afford the housing, food, and clothing they needed, or generally ended up with not enough money (see footnotes to Supplemental Appendix Table C-3).[31] These questions were aimed at determining more accurately the household's financial situation than just their income, but could be interpreted as reflecting either financial management or hardships resulting from negative shocks (see above for evidence on such shocks). A household that is an ideal rational economic agent which is experiencing a fixed level of income at all times should not be expected to have to borrow, to put off buying items, to pay bills unless it has unusual intertemporal preferences, for all these activities just push off consumption challenges to the future. Of course, low-income households may not fit that ideal type and may exhibit behavioral responses, cognitive challenges, or simply poor financial management skills that prevent them from fixing consumption at a permanent level to match their income (see literature references above). But the situation is likely to be worse for a household experiencing transitory shocks, either to income or to consumption needs (sick child, need to buy school supplies in September, and a host of others), and this may cause short-term problems of the type described by these financial strain questions. The approach taken here will be similar to that for poverty status, by simply estimating separating equations for those who are experiencing high levels of financial strain and those who are not, to determine if within-household food allocations differ by the two types of households; no attempt will be made to distinguish between these two explanations for any differentials.

Finally, the data also have responses to a set of four questions asked about the household's access to a supportive social network, regarding whether the household caregiver had access to people who will listen, help with child care, help with small favors, or loan money (again see footnotes to Supplemental Appendix Table C-3). Having a strong network implies that monetary or in-kind resources are available in case of negative shocks and hence has an insurance value to a household.[32] While 70% of the sample reported positively to at least one of the four questions, 30% responded negatively to all four. Not answering any of the four positive implies a very limited social network and a high degree of financial vulnerability to income or consumption shocks. As with the poverty status and financial strain variables, the approach here is simply to estimate the equations separately for households with lower and higher levels of network support to determine if age and gender differences in food insecurity differ for the two types of households.

Tables 7A–7C show the results of the estimation for the three different measures of resources, again only for the binary indicators of food insecurity for brevity. Table 7A shows major differences in age–gender differentials in almost all measures of food insecurity between households with income below and above the poverty line. For example, while age differences for boys are strong and significant in households with below-poverty level income, they disappear in significance or are greatly weakened in households with higher incomes. Several gender differences in households with below-poverty incomes are statistically and economically significant, and all of those disappear completely for households with incomes above

[31] The one question that asked about not having enough food could reflect food insecurity rather than the other way around. However, it does not have any necessarily relationship to the relative values of food insecurity across children of different ages and genders, which is the focus here.

[32] Martin et al. (2004), in a small sample of families in Connecticut, found that an index of social capital–which includes trust, reciprocity, and social networks–was positively associated with household food security, and that neighbor reciprocity was particularly strongly so associated. Edin et al. (2013) found that the availability of kin networks was extremely important in combating food crises by invitations from those kin to eat at their house, but that many families have no networks at all and have a much more difficult time in coping.

Table 7B
Age–gender differences in marginal effects for households with high and low levels of financial strain.

	VLFS		VLFSA		VLFSC
	High	Low	High	Low	High
Age differences (Relative to 12–18)					
Male					
0–5	−0.094*	−0.018	−0.053	−0.044*	−0.086*
	(0.032)	(0.016)	(0.035)	(0.021)	(0.020)
6–11	−0.087*	−0.016	−0.015	.017	−0.072*
	(0.028)	(0.011)	(0.034)	(0.017)	(0.021)
Female					
0–5	.003	−0.002	−0.013	−0.005	−0.074*
	(0.030)	(0.003)	(0.033)	(0.004)	(0.019)
6–11	−0.030	.014	−0.057*	−0.001	−0.046*
	(0.025)	(0.016)	(0.032)	(0.009)	(0.021)
Gender differences (Male minus female)					
0–5	−0.049*	.005	−0.065*	.001	−0.003
	(0.027)	(0.014)	(0.034)	(0.008)	(0.015)
6–11	−0.010	.009	.018	.023*	−0.016
	(0.027)	(0.014)	(0.037)	(0.013)	(0.016)
12–18	.047	.022*	−0.024	.040*	.009
	(0.031)	(0.013)	(0.031)	(0.018)	(0.022)

See Table 2 notes.
All families with low levels of Financial Strain have VLFSC = 0.

Table 7C
Age–gender differences in marginal effects for households with weak and strong networks.

	VLFS		VLFSA		VLFSC	
	Weak	Strong	Weak	Strong	Weak	Strong
Age differences (Relative to 12–18)						
Male						
0–5	−0.074*	−0.071*	−0.091*	−0.079*	−0.032*	−0.044*
	(0.030)	(0.014)	(0.034)	(0.017)	(0.019)	(0.020)
6–11	−0.054*	−0.058*	.043	−0.041*	−0.011	−0.046*
	(0.034)	(0.015)	(0.039)	(0.023)	(0.021)	(0.015)
Female						
0–5	−0.042*	−0.005	−0.034	−0.058*	−0.072*	−0.024*
	(0.027)	(0.013)	(0.031)	(0.017)	(0.020)	(0.011)
6–11	−0.025	−0.024*	.004	−0.062*	−0.060*	−0.015*
	(0.026)	(0.013)	(0.035)	(0.021)	(0.019)	(0.008)
Gender differences (Male minus female)						
0–5	.015	−0.030*	−0.017	−0.025*	.008	.004
	(0.025)	(0.009)	(0.030)	(0.013)	(0.014)	(0.018)
6–11	.018	.002	.079*	.018	.016	−0.007
	(0.032)	(0.010)	(0.046)	(0.021)	(0.017)	(0.012)
12–18	.047	.036*	.041	−0.004	−0.032	.024*
	(0.036)	(0.017)	(0.034)	(0.022)	(0.025)	(0.012)

See Table 2 notes.

the poverty line. Only the age differences for girls do not follow this pattern, where differentials are sometimes stronger in households with higher incomes for food insecurity measured in the household overall or among adults, although the pattern for child food insecurity again shows significant effects for lower income households and insignificant ones for higher income households. The general tendency, even if not present for every age–gender comparison, is for differentials to fall if income simply rises above the poverty line, usually to statistical insignificance.

The results for the impact of financial strain shown in Table 7B are similar but not quite as systematic across all comparisons. Again the most marked changes are for boys, where age differences fall in magnitude and/or significance when financial strain falls.[33] However, for girls the age differences move more uniformly to smaller magnitudes and insignificance, unlike the pattern of poverty status just discussed. A more mixed pattern appears for gender differences, where magnitudes and significance levels are sometimes higher and sometimes lower in households with lower levels of financial strain. To the extent that this variable is measuring the response to transitory shocks in income or consumption, it could be that

[33] For the differential between boys 0–5 and 12–18 in VLFSA, the differential falls in magnitude when strain falls but so does the standard error, moving the p-value just under 10%.

they result in changes in food allocations that are different than changes in response to changes in permanent income or resources.

Finally, the effects are considerably weaker for the impact of networks, as shown in Table 7C. While age differences in VLFSA for boys, age differences in VLFS and VLFSC for girls, and some gender differences are lower in households with stronger networks, there is no difference in differentials for boys in VLFS, and gender differences are sometimes greater and sometimes smaller in households with networks of different strength. It may be that the network questions underlying the index mix different kinds of effects, with some of them (e.g., having someone else take care of a child) possibly increasing differentials rather than decreasing them. It may also be that strong social networks create sets of reciprocal obligations on households that impose demands, while also providing resources.

The three measures of household resources examined in this section do not uniformly and consistently support the hypothesis that food insecurity differentials fall as resources rise for all age–gender categories, but the strong effects for cash income—which arguably is the most likely to have the expected effect –as well as the somewhat weaker effects for financial strain and network strength, show a clear general tendency in that direction.

5. Summary and conclusions

In summary, using a unique data set measuring food deprivation for children of different ages and gender in the U.S. from 1999 to 2005, significant differences in levels of food insecurity across children of different ages and genders are detected. Food insecurity levels are much higher among older children than among younger ones and are sometimes higher among older boys than among older girls. Allocations are strongly correlated with the dietary needs of the child as well as with household structure and the level of family organization. Further, the cross-child differences appear only in the poorest households with the lowest levels of money income and household resources in general, and most differences disappear in significance or are greatly reduced in magnitude when resources rise to only modest levels.

The results here should by far not be the last word on the subject, but should instead lead to further work to examine these issues with more data sets and samples in the U.S. and in Europe. More direct data on food consumption from consumption data sets would be quite valuable. Another missing element in this article is the relationship between the quantity and quality of food consumed, and whether low-income families save money by choosing unnutritious, unhealthy food (Bhattacharya and Currie, 2001; Bhattacharya et al., 2004). Studies examining these issues in Europe would be valuable given its generally much lower levels of income inequality and stronger safety net programs, and consequent lower levels of food hardship. Updating the results to more recent years of the U.S. would also be of interest since the relative size of the population with extremely low incomes has grown both because of further deterioration in the labor market of unskilled workers, and because of a long-run decline in the degree of welfare program support going to the lower income households (Moffitt, 2015). These and other issues should provide a fruitful agenda for research going forward.

Supplementary materials

Supplementary material associated with this article can be found, in the online version, at doi:10.1016/j.euroecorev.2018.04.005.

Appendix A. Food hardship questions in the three-city study

Adult caregiver

ST8 – At any time in the past 12 months, did you or other adults in your household cut the size of your meals or skip meals because there was not enough money for food?

ST9 – At any time in the past 12 months, did you or any other adults in your household not eat for a whole day because there was not enough money for food?

ST10 – In the past 12 months, were you ever hungry but did not eat because you could not afford enough food?

ST11 – Sometimes people lose weight because they do not have enough to eat. In the past 12 months, did you lose weight because there was not enough food?

Focal child

ST12 – At any time in the past 12 months, did you cut the size of any of [CHILD]'s meals because there was not enough money for food?

ST13 – At any time in the past 12 months, did [CHILD] skip a meal because there was not enough money for food?

ST14 – Did this happen...(frequency)?

ST15 – At any time in the past 12 months, was [CHILD] hungry but you just could not afford more food?

Appendix B. Analysis of the 1999 current population survey food security supplement

Because the TCS data only have 8 of the 18 USDA questions, we construct a VLFS variable which is correlated with the USDA definition of VLFS to the maximum extent. To make this determination, we obtained the data from the April 1999 CPS – which is closest in calendar time to the first wave of the TCS survey – and selected those households with children, living in a metropolitan area, and with household income below 185% of the poverty line (a variable that was available in the CPS) to approximate the TCS sample. For each of the resulting 1113 households in the CPS data, we constructed both a USDA VLFS indicator variable equal to 1 if 8 or more of the 18 questions were answered affirmatively, but also a set of VLFS indicator variables using only the 8 CPS questions that were used in the TCS survey. Specifically, using only those 8 in the CPS data, we constructed VLFS indicators for whether 1 or more, 2 or more, or 3 or more of the 8 TCS questions were answered affirmatively, and we then determined which of these indicators classified families most closely into the same VLFS categories as they were placed into using the full 18 questions.[34]

Our results showed that the "error rate" was smallest for a definition using the subset of TCS questions which classified a household as having VLFS if 2 or more of the 8 questions were answered affirmatively. For that definition, 81% of those classified as having VLFS also had VLFS by the 8-or-more-out-of-18-question USDA definition. Further, using this same 2-or-more-out-of-8 VLFS definition, 97% of those classified as not having VLFS were also not VLFS by the full USDA criterion. The overall misclassification rate, or error rate, was only 4%. In contrast, defining VLFS as having answered 1 or more of the 8 questions affirmatively resulted in a 7% misclassification rate (and only 57% of those classified as having VLFS from this definition were also classified as having VLFS by the USDA definition) and, going higher by requiring a household to answer 3 or more of the 8 questions affirmatively to be classified as VLFS resulted in a 6% misclassification rate. Other definitions resulted in even larger misclassification percents.

Applying this definition – namely, VLFS = 1 if 2 or more of the 8 questions are answered affirmatively – to the TCS data themselves yields a VLFS rate of 8.8%. The CPS sample we used for the analysis above has a VLFS rate of 9.4%, quite close.[35]

In a separate analysis, Moffitt and Ribar (2016) validated these count and binary measures from the TCS using the same formal (item-response theory, IRT) methods as Bickel et al. (2000). The formal analyses showed that the TCS responses follow a single-parameter "Rasch" IRT model and that a count of the affirmed responses is a sufficient statistic for food security.

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[34] Of course, the CPS questions for children ask about all children whereas the TCS questions only ask about the focal child, so there is a necessary noncomparability in that sense.

[35] In a separate analysis, we estimated logit models on the CPS data first using the USDA definition of VLFS as the dependent variable and then using the 2-or-more-out-of-8 definition. The signs and magnitudes of the coefficients on covariates for family structure, race, income, regional location, education, ages of children, and other socioeconomic characteristics were not very different.

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