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Food insecurity and dietary intake among US youth, 2007–2010

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Summary

Background: There is limited research describing associations between food insecurity and dietary intake.

Objective: To examine differences in dietary intake by food security status among a nationally representative sample of children and adolescents in the USA.

Methods: The sample included 5136 children, ages 2–15 years, from the National Nutrition and Health Examination Survey, 2007–2010. Propensity score weighting was used to improve covariate balance between food-secure and food-insecure (marginal, low or very low food security) participants. Multivariate measurement error models were used to model usual intake of various dietary components and assess differences by food security status.

Results: Initial analyses using multivariate measurement error models determined there were no differences between food-insecure and food-secure children across several dietary components. In sensitivity analyses, children experiencing very low food security consumed fewer whole grains and more solid fats and added sugars compared with their food-secure counterparts. Some of these differences were attenuated after propensity score weighting, although intake of whole grains and added sugars remained significantly different.

Conclusions: Food insecurity was largely not associated with dietary intake among 2–15-year-old US children, although some differences were observed comparing food-secure children to those experiencing very low food security.

Keywords: Adolescents, children, nutrition, propensity score methods, survey.

Introduction

In 2012, approximately 8.3 million children (11.3% of children in the USA) lived in households in which at least one child experienced food insecurity, a condition characterized by a lack of consistent, dependable access to enough food for active and healthy living (1). Many studies have evaluated associations between food insecurity and weight outcomes among children and adults in the USA, often producing conflicting findings (2–4). Different associations have been reported by sex, race or ethnicity, or by participation in food assistance programmes (2–5). A major limitation of these studies and a potential explanation for inconsistencies is the lack of evidence describing the pathways by which food insecurity may influence weight outcomes: namely, dietary intake.

Of the few studies that have been published to date, some have reported minimal differences between food-secure and food-insecure children's dietary patterns (6), while others have reported that food insecurity is linked with lower fruit and vegetable intake (7,8), and higher fat and juice intake (9). One previous study using the National Health and Nutrition Examination Survey (NHANES) reported that food insecurity was associated with reduced dairy and calcium intake and bone mineral content among adolescent boys, but not girls (10). Existing studies of food insecurity and dietary intake have been limited by small and/or convenience samples, and narrow assessments of dietary intake.

While prior studies have examined poverty and/or participation in food assistance in relation to dietary outcomes, these concepts are somewhat distinct from food insecurity (11); less than 60% of food-insecure households participate in food assistance programmes (1). A recent study found that children who receive Supplemental Nutrition Assistance (SNAP) consumed a greater amount of sugar-sweetened beverages, high-fat dairy and processed meats than comparably low-income non-participants (12). Although this study controlled for food insecurity, differences across food security categories were not explicitly examined.

Food insecurity is associated with income and participation in food assistance programmes, but other factors, such as neighbourhood context (socioeconomic factors [SES], urbanization) may influence food security, as they are associated with access to food and other resources (1,3,4,13,14). These contextual factors have been found to be associated with dietary intake, particularly among low-income populations (4,13,15), and have generally not been accounted for in studies of food security and dietary intake or related health outcomes (14).

The objective of this study was to examine differences in dietary intake by food security status, controlling for various individual-level and contextual confounders such as neighbourhood SES and urban/rural status.

Methods

Study population

Data were from the 2007–2010 NHANES. The study population consisted of children and adolescents (2–15 years) who completed at least one 24-h dietary recall in the mobile examination centre. Pregnant adolescents and breastfeeding children were excluded leaving a sample of 5183 children and adolescents, 5136 of whom had data on food security (99%). As this analysis used secondary data, it was not subject to review by the National Center for Health Statistics Ethics Review Board. The overall response rates for the NHANES MEC ranged from 82% to 87% for youth 2–15 years in 2007–2010.

Dietary intake

Dietary intake was assessed via 24-h recall completed by a trained interviewer with a second recall conducted for most participants via telephone 3–10 days later. Proxy respondents (e.g. primary caregiver) complete recalls for children younger than 6 years. Children 6–11 years complete the recalls with assistance from a proxy, and children 12 years and older complete the recalls for themselves. Because of these differences in reporting method, children were grouped by age into the following categories: 2–5 years, 6–11 years and 12–15 years. Data on dietary intake were obtained from the individual foods files and the total nutrients files, which include nutrient information based on the USDA's Food and Nutrient Database for Dietary Studies (FNDDS; Version 4.1. US Department of Agriculture, Food Surveys Research Group, Beltsville, MD, USA).

Unlike the FNDDS, the Food Patterns Equivalent Database (FPED) disaggregates food into its component parts to produce estimates of several dietary outcomes including: intact/whole fruit, fruit juice, total vegetables (which can be calculated to exclude white potatoes), whole grains, refined grains, solid fats (g) and added sugars (tsp; Version 2007–2008 and 2009–2010; US Department of Agriculture, Food Surveys Research Group) For example, using the FNDDS, the apples in apple pie would be coded as a grain (e.g. pie with apples), whereas the FPED differentiates between the ingredients, coding apples as a fruit. Grams of solid fats and teaspoons of added sugars were converted to their caloric equivalents and summed to create a category referred to as solid fats and added sugars (SoFAS); this category typically also contains alcohol, but as this study was limited to children, that item was not examined. The total nutrient file provides estimates of total kilocalories (kcal), protein (g), carbohydrates (g), number of foods and sodium (mg). Energy density (kcal/food item) was also calculated as a study of homeless youth suggested that food-insecure individuals may rely on more calorically dense foods as a consequence of food scarcity (16). Finally, the number of foods was included as a measure of dietary variety because food-insecure households might ration food, and children might be subject to lower dietary variety (11).

Food security and other covariates

During the household interview, an adult respondent completed the US Food Security Survey Scale, which consists of 18 items and is consistent with the USDA method of assessing food insecurity (17). Children in the household are assigned a score based on the eight items specific to households with children and characterized as 'food secure' (score of 0), 'marginal food security' (1), 'low food security' (2–4) or 'very low food security' (5–8). For the main analysis, the marginal, low or very low food security categories (unweighted *n*'s were 473, 633 and 92, respectively) were combined into one 'food insecure' group because of the relatively small numbers of children falling into each of the three categories. Sensitivity analyses examined alternative categorizations of food insecurity, including looking at household food insecurity, which was categorized in the same way as the main analysis (grouping marginal, low and very low household food security). Because children over the age of 15 completed the questionnaire themselves, the analysis was restricted to children 2–15 to avoid reporting bias.

Respondents also provided information about participation in a variety of food assistance programmes including SNAP, receipt of free or reduced price school lunch and/or breakfast, and participation in the Women, Infant and Children's Nutrition (WIC) programme (for children 0–5 years). Additional individual or household-level covariates included whether the child had public or private health insurance, whether the child was foreign born, caregiver marital status (i.e. single, married/cohabitating, divorced/separated/widowed), caregiver education level (i.e. less than high school, high school/GED, some college, college or higher) and age, household size, race/ethnicity, income-to-poverty ratio and household smoking.

Restricted data files with geographic identifiers were used to link participating children to auxiliary data based on their census tract and county of residence. These data sources and covariates included tract- and county-level socio-demographic and economic characteristics (e.g. racial and ethnic population distribution, population size, % poverty, median household income, % of residents with less than high school education) (18); residential racial segregation (19); the number of arrests per 100 000 county residents (20); the urban–rural designation of each county (21); county-level food store density (e.g. the number of grocery stores, convenience stores, fast food restaurants), food price (e.g. the price of milk, soda, fruit) and food assistance participation rates (22).

Statistical analyses

Propensity score models

If food-secure and food-insecure children are not 'exchangeable' or comparable with respect to all characteristics except for food security status, then estimation of the effect of food insecurity will be biased. For example, if food-insecure children are more likely to reside in disadvantaged neighbourhoods than food-secure children, and residing in these neighbourhoods is related to dietary intake, then differences in dietary intake by food security status will be confounded by neighbourhood SES. Propensity score methods can be used to ensure samples are balanced on potential confounders (23); in this case, propensity score weighting was used to ensure food-secure and food-insecure children are otherwise comparable (24). All relevant individual-level and contextual confounders were included in the propensity score estimation model (23), which was estimated in Stata 12.1 SE.(Release 12.1, StataCorp. College Station, TX, USA) Methods are described in Supporting Information Appendix S2. Consistent with recent guidelines on using propensity score methods with complex surveys, inverse probability of treatment weights (IPTW) were created from the propensity scores, and combined with the day one dietary survey weights in order to provide unbiased estimates of the average treatment effect (ATE) that are generalizable to the survey's target population (24). In this case, the ATE represents the effect of food insecurity and the target population is U.S. children aged 2–15 years.

Outcome models

Usual intake of various dietary components was modelled using methods developed by the National Cancer Institute (25,26). These methods use multivariate Markov Chain Monte Carlo models to estimate usual intake of several, possibly correlated, dietary components (25,26). Multipart non-linear mixed models with correlated random effects account for skewed data, sequence and weekend effects; and can be used to estimate the usual intake of episodically (e.g. whole fruit) or ubiquitously (e.g. kcal) consumed foods. Post-stratified balanced repeated replicate (BRR) weights were used to account for the complex survey design.

Two sets of multivariate measurement error models were run. The first set incorporated just the survey weights, and adjusting only for age group, race/ethnicity and sex (i.e. the 'regular' model). The second set of models incorporated both the propensity and survey weights, thereby controlling for potential confounders included in the propensity score estimation models (i.e. the 'IPTW' model). For both the regular and IPTW models, mean intake of various dietary components produced by the models were compared by food security status and differences were assessed based on *t*-tests (25,26). Outcome model analyses were conducted in SAS 9.3 (Version 9.3, SAS Institute Inc., Cary, NC, USA).

Sensitivity analyses examined two different categorizations of child food insecurity. First, children with either low or very low food security (9.8% of children, unweighted $n = 725$) were compared with food-secure children (84.3% of children, unweighted $n = 4447$). Second, children experiencing very low food security (1.1% of children, unweighted $n = 92$) were compared with food-secure children. The first sensitivity analysis produced results similar to the main analyses, thus only the findings for the main analysis and second sensitivity analysis are shown. A final sensitivity analysis examined household food insecurity, which is also reported for comparison. Household food insecurity was categorized in a similar way to the main results, children in food-secure households (unweighted $n = 3033$) were compared with those with either moderate, low, or very low household food security (unweighted $n = 2103$). These results are described as applying to 'children in food-insecure households' where all other results apply to child-level food security status.

Results

Approximately 16% of children 2–15 years old experienced food insecurity (i.e. marginal, low or very low food security) in the prior 12 months. There were substantial differences between food-secure and food-insecure children across several demographic and socioeconomic characteristics (see Supporting Information Appendix S2). Food-insecure children were more likely to be non-Hispanic black or Mexican-American, fall below the federal poverty threshold, and have caregivers with less than a high school education who were not married or cohabiting. Food-insecure children also lived in larger households than children who were food secure. Household smoking was reported for a greater proportion of food-insecure children, and nearly all food-insecure children participated in at least one food assistance programme (e.g. SNAP, WIC, free or reduced price school lunch or breakfast) in the prior year (94%) compared with only 67% of food-secure children. A greater proportion of food-insecure children were uninsured or on public insurance. There were several significant differences with respect to neighbourhood or contextual covariates. Food-insecure children were more likely to live in census tracts with high deprivation, as well as experience both individual-level poverty and neighbourhood deprivation. Food-insecure children also resided in smaller, more urban counties with higher levels of crime compared with food-secure children.

After propensity score weighting, food-secure and -insecure children were balanced with respect to included covariates. Supporting Information Appendix S1 illustrates the standardized percent bias (i.e. the mean difference between groups expressed as a percentage of the average standard deviation) between food-insecure and food-secure children pre- and post-propensity score weighting.

Dietary intake

No differences in dietary intake patterns were observed between food-secure and food-insecure children in either the regular or IPTW models. Mean intake of various dietary components can be seen in Table 1. Table 2 illustrates results of sensitivity analyses. In regular models, children experiencing very low food security consumed fewer whole grains (0.20 fewer servings, SE 0.09, $P < 0.05$), and a greater amount of SoFAS (137.47 kcal more, SE 51.23, $P < 0.05$) as compared with food-secure children. In IPTW models, differences between children experiencing very low food security and their food-secure counterparts were evident only for whole grain consumption (0.24 fewer servings, SE 0.09, $P < 0.05$), and teaspoons of added sugars (6.90 more teaspoons, SE 3.36, $P < 0.05$). Table 3 highlights differences by household food security status before and after propensity score weighting. In regular models, children in households that were food secure consumed 0.10 fewer cups of juice (SE 0.04, $P < 0.05$), 0.12 more servings of whole grains (SE 0.04, $P < 0.05$), 1.82 fewer teaspoons of added sugar (SE 0.61, $P < 0.05$), 42.19 fewer kcal from SoFAS (SE 18.89, $P < 0.05$), and a greater variety of food items (0.85 more foods, SE 0.21, $P < 0.05$) with lower average caloric density (by 12.34 kcal, SE 3.02, $P < 0.05$) compared with children in food-insecure households (consisting of households reporting moderate, low or very low food security). In IPTW models, all of these differences were completely attenuated. Supporting Information Appendix S3 presents differences in dietary intake by child food security status stratified by age group; these results were consistent with the main findings presented here.

Discussion

In 2007–2010, no differences in dietary intake were observed by child food security status among children aged 2 to 15 years old. These findings are consistent with at least one study that reported few differences between food-secure and food-insecure children (6). However, other studies have reported that food insecurity is linked with lower fruit and vegetable intake (7), and higher fat and juice intake (9). Inconsistencies could be due to different categorizations of food insecurity (e.g. grouping marginal, low and very low or breaking out these categories), the use of convenience samples in prior studies, or residual confounding. Results of the sensitivity analyses suggest that residual confounding may play a large role. When children were grouped by household food security status, several differences in intake observed in the regular models (i.e. for fruit juice, whole grains, added sugars, SoFAS, caloric density and dietary variety) were completely attenuated after adjusting for potential confounders in the IPTW models.

In support of the notion that categorization of food security status may affect findings, sensitivity analyses suggested that children experiencing very low food security consumed fewer whole grains and more calories from solid fats and added sugars than food-secure children. In the

Table 1 Dietary intake by food security status among children ages 2–15 years ($n = 5136$) in NHANES, 2007–2010

	Regular survey weights		IPTW + survey weights	
	Food secure Mean (SE)	Insecure Mean (SE)	Food secure Mean (SE)	Insecure Mean (SE)
Fruit juice (cups)	0.51 (0.11)	0.42 (0.15)	0.48 (0.08)	0.51 (0.11)
Whole fruit*	0.63 (0.17)	0.76 (0.22)	0.66 (0.08)	0.61 (0.10)
Vegetables excl white potatoes*	0.58 (0.04)	0.56 (0.06)	0.56 (0.03)	0.60 (0.05)
Starchy vegetables*	0.30 (0.07)	0.25 (0.07)	0.26 (0.02)	0.28 (0.07)
Whole grains	0.55 (0.07)	0.60 (0.08)	0.59 (0.05)	0.54 (0.15)
Refined grains	5.64 (0.10)	5.64 (0.31)	5.40 (0.09)	5.56 (0.34)
Solid fats (g)	34.66 (0.87)	34.38 (1.38)	34.23 (0.51)	34.70 (1.78)
Added sugars (tsp)	17.56 (0.92)	16.89 (1.67)	15.84 (0.23)	16.57 (1.90)
SoFAS (kcal)	592.91 (20.11)	579.68 (27.78)	561.46 (6.61)	577.40 (36.53)
Kcal	1826.36 (29.15)	1809.70 (51.95)	1760.91 (30.45)	1804.98 (66.73)
Protein (g)	65.05 (2.06)	66.52 (2.57)	65.32 (1.83)	65.76 (2.65)
Carbohydrate (g)	246.98 (6.71)	242.14 (7.80)	233.92 (3.73)	241.57 (9.73)
Fiber (g)	12.80 (0.24)	12.87 (0.56)	12.70 (0.35)	12.91 (0.63)
Caloric density (kcal/food item)	136.42 (5.47)	132.25 (5.56)	129.75 (3.82)	130.51 (6.93)
Sodium (mg)	2905.15 (45.95)	2882.04 (126.88)	2784.09 (83.74)	2886.72 (168.86)
Dietary variety (no. of foods)	14.30 (0.40)	14.61 (0.31)	14.38 (0.75)	14.70 (0.34)

Regular models used only the first day dietary recall survey weights, while IPTW models used propensity score weights. There were no significant differences between the groups in either the regular or IPTW models.
*Cup equivalent.

Table 2 Dietary intake among children ages 2–15 years ($n = 5136$) in NHANES 2007–2010, comparing food-secure children (unweighted $n = 4449$) to those with very low food security (unweighted $n = 92$)

	Regular survey weights		IPTW + survey weights	
	Food secure Mean (SE)	Very low food security Mean (SE)	Food secure Mean (SE)	Very low food security Mean (SE)
Fruit juice (cups)	0.51 (0.11)	0.37 (0.06)	0.48 (0.08)	0.37 (0.07)
Whole fruit*	0.63 (0.17)	0.59 (0.11)	0.66 (0.08)	0.53 (0.26)
Vegetables excl. white potatoes*	0.58 (0.04)	0.67 (0.09)	0.56 (0.03)	0.60 (0.21)
Starchy vegetables*	0.30 (0.07)	0.26 (0.05)	0.26 (0.02)	0.26 (0.05)
Whole grains	**0.55 (0.07)[a]**	**0.35 (0.06)[b]**	**0.59 (0.05)[a]**	**0.35 (0.09)[b]**
Refined grains	5.64 (0.10)	6.17 (0.35)	5.40 (0.09)	6.34 (1.01)
Solid fats (g)	**34.66 (0.87)[a]**	**41.72 (3.21)[b]**	34.23 (0.51)	42.52 (5.99)
Added sugars (tsp)	**17.56 (0.92)[a]**	**22.18 (2.08)[b]**	**15.84 (0.23)[a]**	**22.74 (3.42)[b]**
SoFAS (kcal)	**592.91 (20.11)[a]**	**730.39 (56.42)[b]**	561.46 (6.61)	746.43 (101.57)
Kcal	1826.36 (29.15)	1920.12 (90.50)	1760.91 (30.45)	1940.47 (175.72)
Protein (g)	65.05 (2.06)	68.49 (3.89)	65.32 (1.83)	68.16 (5.35)
Carbohydrate (g)	246.98 (6.71)	254.01 (12.11)	233.92 (3.73)	259.18 (21.39)
Fiber (g)	12.80 (0.24)	12.91 (0.98)	12.70 (0.35)	12.83 (1.02)
Caloric density (kcal/food item)	136.42 (5.47)	133.74 (7.59)	129.75 (3.82)	134.25 (11.6)
Sodium (mg)	2905.15 (45.95)	3024.12 (175.02)	2784.09 (83.74)	3065.27 (287.88)
Dietary variety (no. of foods)	14.30 (0.40)	15.25 (0.70)	14.38 (0.75)	15.26 (0.92)

Regular models used only the first day dietary recall survey weights, while IPTW models used propensity score weights.
*Cup equivalent.
[a,b]In bold type indicate significantly different, $P < 0.05$.

Table 3 Dietary intake among children ages 2–15 years ($n = 5136$) in NHANES 2007–2010, comparing children in food-secure households (unweighted $n = 3033$) to those in food-insecure households (unweighted $n = 2103$)

	Regular survey weights		IPTW + survey weights	
	Food secure Mean (SE)	Food-insecure Mean (SE)	Food secure Mean (SE)	Food-insecure Mean (SE)
Fruit juice (cups)	**0.41 (0.03)[a]**	**0.49 (0.03)[b]**	0.47 (0.07)	0.52 (0.19)
Whole fruit*	0.74 (0.05)	0.62 (0.04)	0.66 (0.09)	0.63 (0.15)
Vegetables excl. white potatoes*	0.58 (0.02)	0.57 (0.02)	0.56 (0.03)	0.56 (0.04)
Starchy vegetables*	0.24 (0.02)	0.27 (0.02)	0.25 (0.02)	0.26 (0.03)
Whole grains	**0.64 (0.03)[a]**	**0.52 (0.03)[b]**	0.60 (0.06)	0.50 (0.08)
Refined grains	5.34 (0.11)	5.70 (0.14)	5.16 (0.22)	5.69 (0.66)
Solid fats (g)	33.82 (0.72)	35.28 (0.73)	33.65 (0.67)	34.70 (4.01)
Added sugars (tsp)	**15.60 (0.26)[a]**	**17.42 (0.58)[b]**	15.41 (0.29)	16.91 (3.21)
SoFAS (kcal)	**553.97 (9.26)[a]**	**596.17 (15.00)[b]**	549.32 (9.38)	582.90 (86.27)
Kcal	1766.69 (22.91)	1837.27 (28.21)	1727.70 (41.56)	1810.13 (199.55)
Protein (g)	66.17 (0.74)	66.68 (1.05)	64.14 (2.02)	65.46 (6.74)
Carbohydrate (g)	234.20 (3.37)	246.21 (4.40)	229.56 (5.52)	243.17 (29.38)
Fiber (g)	12.79 (0.32)	12.91 (0.21)	12.40 (0.59)	12.84 (1.35)
Caloric density (kcal/food item)	**124.47 (1.15)[a]**	**136.81 (2.60)[b]**	126.28 (1.90)	135.29 (13.55)
Sodium (mg)	2819.39 (50.00)	2916.69 (44.77)	2728.64 (97.28)	2876.76 (249.33)
Dietary variety (no. of foods)	**15.15 (0.15)[a]**	**14.30 (0.17)[b]**	14.55 (0.54)	14.16 (0.66)

Regular models used only the first day dietary recall survey weights, while IPTW models used propensity score weights.
*Cup equivalent.
[a,b]In bold type indicate significantly different, $P < 0.05$.

IPTW models, which better accounted for various potential confounders, only reported consumption of whole grains and added sugars remained significantly different. Given the very small sample size of children in the very low food security group, conclusions are limited. However, more research is needed to further elucidate these potential relationships with larger samples of children reporting very low food security, particularly as whole grains and SoFAS each have been noted by the Dietary Guidelines for Americans as food items to encourage (whole grains) or reduce (SoFAS) because of their respective associations with chronic disease and cardiometabolic risk factors (27).

While not the focus of this study, we observed no overall differences in weight status by child food security (data not shown) in regular or IPTW models. Kohn *et al*. (5) used propensity score methods and found that food assistance programme participation was associated with higher weight among food-secure children in NHANES, but not among food-insecure children. As that study did not include various contextual confounders in the estimation of the propensity scores, residual confounding may have played a role.

There are a few limitations of this study worth noting. The measurement of food insecurity is challenging. Children may report the experience of food insecurity differently than adults in a household (28). Food insecurity is not a static condition over time and may affect household members differentially by age, as children may be protected while adult or adolescent members experience the effects of food insecurity (1,11). Moreover, the relationship between food insecurity and participation in food assistance programmes is complex and bidirectional (1). Controlling for participation in food assistance programmes may be controlling for a mediator, although some research has indicated that the effect of SNAP participation on food security and dietary intake may not be large (29,30). More research is needed to understand these complex relationships. Propensity score methods only control for observed confounders, and residual confounding may still be present. Finally, we did not look at energy-adjusted macronutrients, but given the lack of differences in energy intake and macronutrient amounts, it is unlikely that differences would have been observed if energy-adjusted macronutrient intake had been included as an outcome. As with all other studies that rely on dietary recall data, findings are subject to biases and misreporting of dietary intake.

The strengths of this study are the use of a nationally representative sample of children, the utilization of sophisticated methods developed by the National Cancer Institute to assess usual dietary intake and the employment of propensity score methods to more rigorously control for potential confounders vis-à-vis prior studies.

Conclusions

This analysis provides a description of dietary intake patterns among US children by food security status. Food insecurity was not associated with intake of several dietary components. Propensity score methods could be readily applied to examine associations between participation in food assistance programmes, dietary intake and other health outcomes such as obesity. Further research could help clarify some of these associations given the conflicting findings with respect to food insecurity, food assistance programme participation and obesity.

Conflict of Interest Statement

No conflict of interest was declared.

Author contributions

Lauren M. Rossen: Dr. Rossen conceptualized and designed the study, carried out and interpreted the analyses, drafted the initial manuscript and approved the final manuscript as submitted. Emily K. Kobernik: Ms. Kobernik carried out and interpreted the analyses, reviewed and revised the manuscript and approved the final manuscript as submitted.

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Supporting Information

Additional Supporting Information may be found in the online version of this article at the publisher's web-site:

Appendix S1. Propensity score methods.

Appendix S2. Socio-demographic characteristics.

Appendix S3. Differences in dietary intake by child food security status and age group.