Food insecurity and dietary quality in US adults and children: a systematic review

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ABSTRACT
Background: Food insecurity is adversely associated with the physical and mental health of adults and children, and the mechanism that underlies this association has been assumed to be dietary intake of lower quality in food insecure than food secure individuals. A thorough understanding of observed associations between food insecurity and dietary quality is needed to test this assumption and may highlight pathways through which to improve the health of food-insecure adults and children.

Objective: We systematically reviewed all evidence of associations between food insecurity and dietary quality and contrasted associations observed in adults and those for children.

Design: Evidence came from studies that appeared in indexed, peer-reviewed journals and 1) sampled US residents, 2) separately sampled children and adults, 3) contained a measure of food insecurity or food insufficiency, and 4) included at least one measure of dietary quality.

Results: In adults, 170 associations between food insecurity and dietary quality were tested, and 50 associations (29%) suggested an adverse association. Food-insecure adults consumed fewer vegetables, fruit, and dairy products than did food secure adults and had lower intake of vitamins A and B-6, calcium, magnesium, and zinc. In children, 130 associations were tested, and 21 associations (16%) showed an adverse association. There was substantial evidence of only lower fruit consumption in food-insecure compared with food-secure children. Reporting and publication biases may have contributed to an overestimation of the association between food insecurity and dietary quality.

Conclusions: Food insecurity is adversely associated with dietary quality in adults, particularly intakes of nutrient-rich vegetables, fruit, and dairy that promote good health. However, food insecurity was less-consistently associated with lower dietary quality in children. The idea that parents effectively shield their children from food insecurity is supported by the evidence. Am J Clin Nutr 2014;100:684–92.

INTRODUCTION
In 2012, 20% of American households with children were considered food insecure at some point during the previous year, and in 10% of households, children experienced food insecurity as well as did adults (1). Extensive research has documented negative effects of food insecurity on the physical and mental health of adults (2–5) and, particularly, children (5–11). The measurement of food insecurity was originally conceptualized to consider the following 4 components: quantity, quality, feelings of deprivation, and disrupted eating (12). Dietary Guidelines for Americans (DGAs) emphasize the growing evidence that dietary quality is related to body weight, risk of chronic disease, and overall health (13). As such, a thorough understanding of the association between food insecurity and dietary quality may be a particularly important public health question. To our knowledge, there has been no comprehensive review of studies that examined the association between food insecurity and dietary quality for adults or children.

We had 3 objectives in conducting this review. First, we aimed to assess the overall association between food insecurity and dietary quality. Second, we separately examined associations between food insecurity and dietary quality in adults and children to evaluate differences. In households with children, adults reported taking steps to shield children from household food shortages including limiting or altering their own eating (12, 14). To the extent that parents successfully protect children from compromised dietary quality because of household food shortages, evidence of adverse associations between food insecurity and adults’ dietary intakes may be more pronounced than in children. However, adults and children may not report food insecurity equivalently. Recent evidence has suggested that adolescent self-reports of their own food insecurity are more common than parents’ reports of food insecurity for those same adolescents (15). In addition, a qualitative study has suggested that children are not shielded from food insecurity as effectively as parents report, and children also experience and manage household food shortages and do it differently than adults (16). If children are not actually protected from household food shortages, adverse associations between food insecurity and dietary quality may not differ for adults and children. Our third objective in conducting this review was to assess whether the evidence suggests that parents in food-insecure households protect children from experiencing poor dietary quality.

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4 Abbreviations used: DGAs, Dietary Guidelines for Americans; LFS, low food security; MFS, marginal food security; RDA, Recommended Daily Allowance; VLFS, very low food security.

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METHODS

This systematic review proceeded in accordance with the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) statement (17) and includes all relevant PRISMA checklist items.

Search process

Studies that examined the association between food insecurity and dietary quality were identified in peer-reviewed journals indexed by PubMed (www.ncbi.nlm.nih.gov/pubmed), ProQuest (www.proquest.com), JSTOR (www.jstor.org), Google Scholar (scholar.google.com), and the Cornell University Library (www.library.cornell.edu) up to August 2013. The identification of articles used combinations of the search terms food insecurity or food insufficiency, dietary intake, dietary quality, or nutrient intake. Searches were limited to human studies published in the English language in peer-reviewed journals. First, the title and abstract were assessed by one reviewer (LMC) for general relevance. Second, the full text of remaining articles was examined for accordance with eligibility criteria by each reviewer. Reference lists of selected articles also were examined on the basis of search criteria for possible inclusion, and all selected articles were entered into the Social Science Citation Index (apps.webofknowledge.com) to identify additional and possibly more-recent articles. These subsequently identified articles were reviewed for accordance with selection criteria by both reviewers. Final decisions on inclusion were determined by consensus.

Eligibility criteria

Relevant articles were obtained and included in this review if they 1) used a sample of US residents, 2) sampled children or adults but, if both adults and children were sampled, did not mix the 2 age groups together for analysis, 3) contained a measure of food insecurity or food insufficiency as an independent variable, and 4) included data from a 24-h dietary recall or food-frequency questionnaire and reported at least one of our key measures of dietary quality as a dependent variable (Table 1).

Quality assessment

All articles were primary studies with cross-sectional design that statistically tested relations between food insecurity and dietary quality. Sampling methodologies varied in strength, but all studies were retained, and these sampling differences were prominently denoted on summary figures and considered in making conclusions. All eligible articles either used or adapted validated instruments to collect dietary intake data. No additional quality assessment was conducted, and all eligible articles were retained for data extraction.

Data extraction

Data were independently extracted from articles by one reviewer and verified by the other. Discrepancies in data extraction were discussed and resolved by consensus. Extracted data included the authors, year, sampling approach, sex, age, and income level of respondents and sample size. Particular emphasis was placed on identifying studies that used nonprobability sampling methods because they limited the generalizability of results from those studies. We also extracted aspects of the measures of food insecurity or food insufficiency including the number of questions asked, reference time frame of the food-insecurity questions, and number and severity of categories compared.

Finally, we extracted dietary quality measures that included the method of collection for dietary intake (eg, 24-h recall or food-frequency questionnaire), number of days of dietary recall (if applicable), and key measures of dietary quality. Measures of dietary quality were considered whether measured in units (eg, g, mg, or servings) with frequency (eg, times/d or d/wk), or as intake relative to recommendations [eg, percentage of the Recommended Daily Allowance (RDA) or indicators of meeting recommendations]. Measures of dietary intake relative to recommendations were considered more robust than measures in units or reflecting frequency. If a single study presented both intake measured in units and intake relative to recommendations, we extracted only measures of intake relative to recommendations.

The direction, magnitude, and significance level of associations between food insecurity and dietary quality from each of the included studies were extracted for a qualitative synthesis. Only associations that were significant at the ≥95% confidence level were considered significant, and associations reported at lower levels of confidence were considered nonsignificant. Findings adjusted for at least one measure of socioeconomic status were extracted unless only unadjusted results were available in the article. When the article compared groups defined by both food insecurity status and income, we contrasted results for levels of food security in low-income individuals (with the omission of results for higher-income individuals). In this case, we noted findings as coming from a low-income sample. Results from stratified analyses by age or sex, or both, also were extracted. When stratified analyses were conducted, results for each stratum were independently extracted and presented on summary figures. Therefore, the number of results presented for each dietary measure may have exceeded the number of studies that included that measure. Only published results were examined, and no additional information was obtained from authors of selected articles.

All significant associations were presented as the effect of food insecurity relative to food security. For example, if food-insecure adults reported one serving of fruit, and food-secure adults reported 2 servings of fruit, this result was extracted and presented as minus one serving. For studies that used measures of food insecurity with more than 2 levels, we considered evidence

<p>| TABLE 1 |</p>
<table>
<thead>
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<th>Key measures of dietary quality</th>
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<tr>
<td><strong>Foods</strong></td>
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<tr>
<td>Vegetables and fruit</td>
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<tr>
<td>Vegetables</td>
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<td>Fruit</td>
</tr>
<tr>
<td>Grains</td>
</tr>
<tr>
<td>Dairy</td>
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<tr>
<td>Added sugar&lt;sup&gt;2&lt;/sup&gt;</td>
</tr>
<tr>
<td>Sweets and snacks&lt;sup&gt;2&lt;/sup&gt;</td>
</tr>
<tr>
<td>Sugar-sweetened beverages&lt;sup&gt;2&lt;/sup&gt;</td>
</tr>
</tbody>
</table>

<sup>1</sup> Measure of dietary quality identified only in studies with adults.

<sup>2</sup> Measure of dietary quality identified only in studies with children.
of a significant association to include a significant regression coefficient or post hoc test between dietary quality and low food security (LFS) or very low food security (VLFS). If both LFS and VLFS were significantly associated with dietary quality, this was considered as just one significant result for the sample or strata. If only marginal food security (MFS) or only food sufficiency with limitations was associated with dietary quality, we did not consider this sufficient evidence to report an association. If only an overall association between multiple levels of food security and dietary quality was presented, we considered a significant $F$ test or chi-square test to indicate an association.

**Synthesis of results**

DGAs (13) and Dietary Reference Intakes (18, 19) guided our interpretation of results. We considered a better dietary quality to include 1) higher Healthy Eating Index scores; 2) eating more vegetables and fruit and more often eating vegetables and fruit; 3) meeting recommendations for the consumption of vegetables and fruit, total grains, and dairy; 4) consuming less added sugar, eating fewer sweets and snacks, and drinking fewer sugar-sweetened beverages; 5) meeting recommendations for the consumption of carbohydrates, protein, total fat, saturated fat, and fiber; 6) meeting recommendations for intakes of folate, niacin, riboflavin, thiamin, and vitamins A, B-6, B-12, C, and E; and meeting recommendations for intakes of calcium, iron, magnesium, phosphorus, potassium, sodium, and zinc.

Results were summarized for foods, macronutrients, vitamins, and minerals for which $\geq 3$ studies for adults or $\geq 3$ studies for children included the measure. The consumption of meat and other protein-rich foods was not assessed because current recommendations include all protein-rich foods together, and all studies measured these foods separately (eg, meat, eggs or legumes). Associations between food insecurity and dietary quality were categorized into the following 5 groups:

1) **Adverse (−)**: food insecurity was significantly associated with poorer dietary quality.
2) **Beneficial (+)**: food insecurity was significantly associated with better dietary quality.
3) **Inconsequential (≈)**: the association between food insecurity and dietary quality was inconsequential because, although there was a significant association between food insecurity and nutrient units (eg: g, mg, or servings), mean intake for both food-secure and food-insecure individuals exceeded the DGAs recommendation or the RDA.
4) **Ambiguous (?)**: the association between food insecurity and dietary quality was ambiguous because, although there was a significant association between food insecurity and vitamin or mineral intake measures in units (eg, g or mg), mean intake for food-insecure individuals exceeded the Estimated Average Requirement but did not meet the RDA. Therefore, the association could neither be considered adverse (as when mean intake for food-insecure individuals was below the Estimated Average Requirement) nor inconsequential (as when mean intake for food-insecure individuals was above the RDA).
5) **Nonsignificant**: there was no significant association between food insecurity and the measure of dietary quality.

Throughout this review, inconsequential, ambiguous, and non-significant results are presented together.

Overall summary statistics on adverse associations across all food and nutrient measures were calculated 2 ways. First, the total count of samples and strata that showed a significant adverse association for each food or nutrient was divided by the total number of associations considered to yield the overall percentage that indicated an adverse association between food insecurity and dietary quality. The second summary measure counted adverse effects at the study level, which gave equal weight to each study irrespective of the number of strata or samples used or number of tests across levels of food security. For example, in this calculation, significant adverse results for 1 of 4 strata were counted as 0.25, and 1 of 2 post hoc tests were counted as 0.50. This count was divided by the total number of studies to yield the overall percentage of studies that indicated an adverse association between food insecurity and dietary quality. Both of these summary statistics were contrasted to the 5% of results expected to be significant by chance alone.

**RESULTS**

The initial database searches yielded 2623 articles that matched search criteria (Figure 1). After an examination of the title and abstract, 2577 articles were excluded from additional consideration. Full texts of the remaining 46 articles were assessed in accordance with study-selection criteria, and 21 articles were retained for inclusion. Five additional eligible articles were identified through the use of article references and the Social Science Citation Index. In total, 26 articles met all criteria and were selected for analysis, with 13 articles that included data for adults, and 16 articles that contributed data for children (Figure 2).

Across all studies, food security or food sufficiency was generally measured for the household and indicated by $\leq 4$ categories including 1) food secure or food sufficient, 2) MFS, 3) food sufficient with limitations (ie, “enough but not always what we wanted to eat,”) 4) LFS, 5) VLFS, and 6) food insecure or food insufficient, which was equivalent to LFS and VLFS combined.

Two adult studies measured food insecurity according to whom it affected as follows: the household (household food insecurity), individual (individual food insecurity), or child (child food insecurity) (20, 21). One adult study contrasted food security without Supplemental Nutrition Assistance Program benefits, food insecurity with Supplemental Nutrition Assistance Program benefits, and food insecurity without the Supplemental Nutrition Assistance Program (22). Three child studies measured food insecurity for children in the household (child food insecurity) (23–25), and one study used information reported by the children themselves to determine level of food security: food secure or food sufficient, MFS, LFS, and VLFS (26). One child study distinguished between food insufficiency that happened sometimes with food insufficiency that happened often (27). See Supplemental Tables 1 and 2 under “Supplemental data” in the online issue for scales used to assess food insecurity for each study.

**Adults**

Thirteen articles included data on the association between food insecurity and dietary quality in adult Americans (see Supplemental Table 1 under “Supplemental data” in the online issue for
complete data items for all studies) (3, 14, 20–22, 28–35). Studies with the strongest sampling strategies were the 8 studies that used data from nationally representative samples of >1000 adults each (3, 14, 22, 28, 29, 32, 33, 35). Three of these national samples included adults of most ages and stratified analyses by age group or sex and age, which further strengthened their approach (14, 29, 33). Of the remaining 5 studies with national samples, 2 studies focused exclusively on older adults (3, 22), 2 studies examined working-age women (28, 32), and one study included working-age adults stratified by sex (35). Four studies used locally representative samples (20, 21, 30, 31), 3 studies of which focused exclusively on parents (20, 21, 30), and only one study used a convenience sample of adults (34).

In total, 170 associations between food insecurity and dietary quality were tested in adult samples or strata (see Figure 3, in which one shape corresponds to one association for a sample or strata). Fifty of these samples or strata (29%) suggested an adverse association, 3 results (2%) suggested a beneficial relation, 20 results (12%) were ambiguous or inconsequential, and the remainder of results indicated no association. When studies were equally represented irrespective of the number of samples or strata used or the number of levels of food security contrasted, 26% of studies suggested an adverse association between food insecurity and dietary quality.

Four studies examined measures of overall dietary quality (22, 28, 29, 31) on 6 samples or strata. Three nationally representative samples showed an adverse association between food insecurity and overall dietary quality in adults aged 18–64 y (29), women aged 19–55 y (28), and one sample of adults aged ≥60 y (22). Two other samples of adults aged ≥60 y showed no association (22, 29), nor did one locally representative sample of adults aged ≥18 y (31).

Eight studies examined associations between food insecurity and at least one food measure (20, 21, 28, 30–34). All of these studies included at least one measure of vegetable or fruit consumption, and 7 studies reported at least one adverse finding related to vegetables or fruit (20, 21, 28, 30–33). Only in the convenience sample of low-income adults who volunteered for a dietary intervention was food insecurity unrelated to vegetable consumption and positively related to fruit consumption (34).

There was no evidence of an association between food insecurity and grain consumption (21, 28, 31, 32), whereas 3 nationally representative samples indicated adverse associations between food insecurity and dairy consumption for working-age adults (28, 32, 33) but not older adults (≥60 y of age) (33). Two locally representative samples showed no association between food insecurity and dairy consumption (21, 31).

Seven studies examined associations between food insecurity and at least one macronutrient measure. There was no evidence of any association between food insecurity and intake of carbohydrates or protein and very limited evidence of adverse associations with total fat (35) or fiber (21, 32). There was limited and mixed evidence concerning intake of saturated fat. One nationally representative sample of adults reported an adverse association (35), whereas 2 other nationally representative samples showed beneficial associations in low-income women (32) and older adults (60–96 y of age) (3).

Six studies examined associations between food insecurity and at least one measure of vitamin intake (3, 14, 21, 31–33). There was no evidence of associations between food insecurity and intake of thiamin or vitamin B-12. There was only very limited evidence to suggest adverse associations between food insecurity and intake of folate (14, 32), niacin (14), riboflavin (14), vitamin C (14, 21), or vitamin E (14). However, there was more evidence in women of adverse associations between food insecurity and intakes of vitamin A (14, 31) and vitamin B-6 (14, 32).

Seven studies examined associations between food insecurity and at least one measure of mineral intake. There was no evidence of associations between food insecurity and intake of iron or sodium and only very limited evidence to suggest an adverse association between food insecurity and intake of phosphorus (14). There was substantial evidence across samples of varying age and sex of adverse associations between food insecurity and intakes of calcium (14, 32, 33), magnesium (3, 14, 32, 33), and zinc (14, 33).
Sixteen articles examined associations between food insecurity and dietary quality in US children (see Supplemental Table 2 under “Supplemental data” in the online issue for complete data items from all articles) (14, 23–27, 29, 32, 36–43). Studies with the strongest sampling strategies were the 8

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<th>Authors</th>
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<th>Ages or strata</th>
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<td>•</td>
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<td>18-64y 65y+ 2-5y 6-11y 12-17y</td>
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<td></td>
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<td>f, 18-60y 18-60y</td>
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Key: • = age-diverse nationally representative
      • = age or sex-specific nationally representative
      ▲ = geographic cohort, population or locally representative
      ● = convenience

FIGURE 2. Articles selected for review with sample characteristics. SES adjust., adjusted for socioeconomic status.
studies that used data from nationally representative samples of >1000 children each (14, 23, 24, 29, 32, 37, 40, 41). Five of these national samples included children of most ages (23, 24, 29, 37, 41), and 3 of these studies stratified analyses by age group or sex and age, which further strengthened their approach (23, 24, 29). The remaining 3 national samples focused exclusively on preschool age children (14, 32, 40), as did 2 studies that used birth-cohort data (38, 43) and 2 studies that used convenience samples (25, 36). One study used population data for adolescents enrolled in a geographic cluster of schools (27).

Although there were more studies that examined associations between food insecurity and dietary quality in children than there were for adults, many studies used only a few measures of dietary quality. In total, 130 associations between food insecurity and dietary quality were tested in samples or strata of children (Figure 4).

Twenty-one results (16%) suggested an adverse association, 4 results (3%) suggested a beneficial relation, 4 results were ambiguous or inconsequential, and the remainder of results indicated no association. When studies were equally represented irrespective of the number of samples or strata used or number of levels of food security contrasted, 14% of studies suggested an adverse association between food insecurity and dietary quality.

Only 3 studies examined associations between food insecurity and overall dietary quality or variety (25, 29, 40). One nationally representative sample showed an adverse association only in the adolescent age strata (12–17 y) (29), and one convenience sample showed an adverse association in young children (aged 3–6 y) (25).

Thirteen studies examined the association between food insecurity and at least one measure of food consumption. There was no evidence of associations between food insecurity and the consumption of grains and very limited and mixed evidence of associations with vegetable consumption (27). However, there was evidence of an adverse association between food insecurity and fruit consumption in children (32, 38, 39) and adolescents (27). There was very limited evidence of an adverse association between food insecurity and dairy consumption identified only in boys (aged 8–11 y) (24) and young children aged 3–6 y (25). There was only limited evidence of an adverse association between food insecurity and the consumption of sweets (43) and sugar-sweetened beverages (38) and limited findings of mixed direction concerning added sugar (26, 37).

Seven studies examined associations between food insecurity and at least one macronutrient measure. No associations were observed between food insecurity and intake of carbohydrates or protein, and there was only very weak evidence of an adverse association between food insecurity and intakes of total fat and saturated fat (43) or fiber (32).

Only 4 studies assessed any association between food insecurity and intake of vitamin B-6 in young children (aged 1–5 y) (14). Eight studies examined associations between food insecurity and at least one measure of mineral intake (most commonly calcium and iron). Six studies explored associations between food insecurity and calcium intake (14, 24, 26, 27, 32, 43), with one nationally representative sample that showed an adverse association only in boys (aged 8–11 y) (24), one population study that showed an adverse association in adolescents (27), and one convenience sample that reported a beneficial association in...
children (aged 6–11 y) (26). Five studies measured the association between food insecurity and iron intake (14, 23, 25, 42, 43), with nationally representative samples that showed an adverse association only in adolescents (aged 16–19 y) (23) and young children (aged 1–5 y) (14).

**DISCUSSION**

There was substantial evidence that dietary quality was lower for food-insecure adults than food-secure adults. Because of our selection of a minimum 95% confidence level, we expected 5% of tested associations would be significant by chance alone. The frequency of significant adverse associations between food insecurity and specific measures of dietary quality (29%) was much greater than we would have expected by chance, even when the studies were equally represented irrespective of the number of samples or strata used or number of levels of food security contrasted (27%). There was considerable evidence that food-insecure adults ate less vegetables, fruit, and dairy products and had lower intake of vitamins A and B-6, calcium, magnesium, and zinc. High amounts of magnesium have been shown in green leafy vegetables (18), calcium is abundant in dairy products (19), and vitamin A is available in dairy, vegetables, and fruit (18). Together, the evidence suggests that vegetable, fruit, and dairy consumption and intakes of magnesium, vitamin A, and calcium reflect the same dietary limitations. Americans largely obtain zinc and vitamin B-6 from meat (18). Because recommendations include all protein-rich foods together, we were unable to assess the evidence of associations between food insecurity and meat and, therefore, cannot support associations between food insecurity and intake of zinc or vitamin B-6 with relevant food-consumption measures.

There was less evidence that the quality of dietary intake differed for children according to food-security status with adverse associations between food insecurity and fruit consumption in children most consistently observed. Overall, significant adverse associations between food insecurity and measures of dietary quality in children (14–16%) were less common than in adults but still greater than we would have expected by chance alone. However, measures of dietary quality differed somewhat for adults and children. Three different measures of sugar consumption were available for children, and none were available for adults, whereas studies of adults included more measures of vitamin and mineral intake than studies of children. All measures of sugar consumption showed no association with food insecurity, and these nonsignificant results contributed to the lower overall percentage of results that showed adverse associations in children than adults.

There is substantial publication bias away from analyses that report no association (44), and this bias is largest for observational studies (45) such as those included in this review. Because of this bias, the overall number of significant adverse associations between food insecurity and dietary quality may overestimate the true number of associations. However, there also were very few beneficial relations between food insecurity and dietary quality observed in adults or children. Only one component had more than one study that suggested a beneficial relation between food insecurity and dietary quality: Adults from food-insecure households reported saturated fat consumption that was closer to DGAs than did adults from food-secure households (3, 32). We considered significant beneficial associations between food insecurity and dietary quality to be quite publishable, although they may have been counter to the investigators’ initial hypotheses.
However, all studies included in our review used 2-tailed tests, which suggested that initial hypotheses encompassed the possibility of beneficial associations. The high number of adverse associations suggested a clear direction to the majority of the significant results.

Note that most data for children came from parental reports of both household food insecurity and children’s dietary intakes. A recent study suggested that adult and adolescent reports of the adolescent’s own food security did not agree well (15). Thirteen of the child studies (81%) used only adult reports of food insecurity. In addition, 8 studies (50%) relied exclusively on adult reports of children’s dietary intakes, and 4 studies (25%) used reports from parents and children. Parents are dependable reporters of their children’s eating at home but are less reliable when eating occurs outside the home (46). There was not enough evidence to allow for the contrast of findings from the perspectives of adult and child reporters or to contrast parent reports of dietary intake for younger and older children. However, because of the potential for this type of reporting bias in parent reports of children’s dietary intakes, the lesser evidence of adverse associations between food insecurity and dietary quality observed in children than adults should be viewed with caution.

Underreporting of dietary intake is known to occur and vary according to respondent characteristics. To the best of our knowledge, there is no evidence that an underreporting of dietary intake varies according to food security status. However, there has been some evidence that less-educated and lower-income adults may be more likely to underreport dietary intake (47). Lesser education (48, 49), a low income (48) and reductions in income (49–51) are all known risk factors for food insecurity, and therefore, underreporting according to socioeconomic status may exaggerate adverse associations between adult dietary intake and household food-security status. Even in child-reported dietary data, there has been some evidence that children from low-income families may be more likely to underreport intake than their counterparts from higher-income families (52). Our review included results from low-income samples or subsamples or results that controlled for income whenever available in an effort to minimize the effect of this bias on differences in dietary quality for the food secure and food insecure.

All of the studies reviewed included measures of food insecurity and dietary quality that reflected incongruent time frames. Food insecurity considered a timeline as long as 1 y, and measures of dietary quality showed eating behavior for as short as 1 d. These variables may have influenced results because the greater the incongruence between time frames, the more difficult it may be to observe a significant association. This measurement issue may have biased downward the number of associations observed in reviewed articles. One additional drawback of this review was the limited evidence available on associations between food insecurity and dietary quality in men. Six of 13 studies of adults (46%) sampled only women.

This comprehensive review of the evidence suggested that food insecurity is adversely associated with adult dietary quality, particularly intakes of vegetables, fruit, and dairy products. There was more supporting evidence for women than for men because of a limited number of samples that included men. Although substantial measurement issues, a recall bias, and a publication bias away from nonsignificant findings tempered this conclusion, the evidence suggests that public policies need to support access to adequate, healthful food to households experiencing food shortages. Food insecurity was not clearly associated with children’s dietary quality, with the exception of evidence of an adverse association with fruit intake. Results for adults and children, taken together, suggest that children may be successfully shielded by adults from household food shortages. However, this conclusion is moderated by the fact that dietary intake for children was often reported by parents in these studies. Parents may not be reliable reporters of their children’s consumption, and their desire to protect their children from food shortages may have further biased these reports.

In conclusion, there is consistent evidence that food insecurity is adversely related to children’s health and wellbeing. This review suggests that worse dietary quality may not be the only process through which this association manifests. Future research needs to focus on mechanisms underlying observed associations between food insecurity and child wellbeing. Longitudinal studies that could disentangle poor child health as the result of food insecurity and poor child health as a risk factor for food insecurity would be particularly beneficial.

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REFERENCES


