Special Article

Relationship of food insecurity to women's dietary outcomes: a systematic review

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Context: *Food insecurity matters for women's nutrition and health.* ***Objective:*** *This review sought to comprehensively evaluate how food insecurity relates to a full range of dietary outcomes (food groups, total energy, macronutrients, micronutrients, and overall dietary quality) among adult women living in Canada and the United States.* ***Data sources:*** *Peer-reviewed databases (PubMed/MEDLINE, CINAHL, Scopus, Web of Science) and gray literature sources from 1995 to 2016 were searched.* ***Data extraction:*** *Observational studies were used to calculate a percentage difference in dietary intake for food-insecure and food-secure groups.* ***Results:*** *Of the 24 included studies, the majority found food-insecure women had lower food group frequencies (dairy, total fruits and vegetables, total grains, and meats/meat alternatives) and intakes of macro- and micronutrients relative to food-secure women. Methodological quality varied. Among high-quality studies, food insecurity was negatively associated with dairy, fruits and vegetables, grains, meats/meats alternatives, protein, total fat, calcium, iron, magnesium, vitamins A and C, and folate.* ***Conclusions:*** *Results hold practical relevance for selecting nutritional targets in programs, particularly for nutrient-rich foods with iron and folate, which are more important for women's health.*

INTRODUCTION

Food insecurity exists whenever there is limited or uncertain access to enough food.[1] Within households, experiences of food insecurity may not be evenly distributed, with studies finding that women are more affected by food insecurity than men.[2–5] One reason that women may experience greater levels of food insecurity compared with men is that women are primarily responsible for caregiving and food provisioning in

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their households.[6,7] Qualitative studies have demonstrated that as household food managers, women often allocate food to others before themselves.[5,8–10] Even in married and cohabitating households (with and without children), researchers have shown that women reported higher food insecurity than men.[11] Socioeconomic characteristics did not explain the higher odds of the household being classified as food insecure for female versus male respondents.[11] Thus, there is evidence that women's experiences of food insecurity should be considered separately from men's experiences of food insecurity.

Women's experiences of food insecurity negatively affect dietary outcomes. A handful of studies conducted in Canada and the United States have shown that food-insecure women have lower intakes of some food groups (eg, fruits and vegetables) and nutrients (eg, protein) compared with food-secure women.[12–17] However, there is less evidence for how food insecurity relates to a wider range of dietary outcomes in women. The most recent review to date was published by Hanson and Connor.[18] They completed a systematic literature review focused on food insecurity and dietary quality in US adults and children.[18] Although the review had strengths, such as comparing associations between US adults and children, there were also limitations.[18] Hanson and Connor's[18] review was not comprehensive in terms of its search methodology, did not complete a risk-of-bias assessment (eg, to assess quality), and did not separate results for men and women for the 13 studies that included US adults. Another limitation was that their review only included US studies. Canada and the United States both measure food insecurity with the Food Security Survey Module (FSSM), and there is precedent for compiling food insecurity research from Canada and the United States together.[19,20] However, Hanson and Connor's review did not include studies from Canada.[18]

Food insecurity remains an important issue because of its implications for health, including increased chronic disease, poor perceived health, more depressive symptoms, and lower subjective well-being.[21–24] The associations of food insecurity and adverse health outcomes (eg, diabetes) are more pronounced in women than in men[24] and may depend on dietary quality.[22,25,26] However, there is a limited number of studies relating food insecurity to a full range of dietary outcomes, including overall dietary quality, in women.[12–17] This study's objective was to systematically identify and comprehensively evaluate more of the available evidence relating food insecurity to a full range of dietary outcomes among women. The following research question was answered: do food-insecure women (aged 18–60 years) living in Canada and the United States have lower dietary intakes of food groups (dairy, fruits, vegetables, total fruits and vegetables, total grains, meats/meat alternatives), total energy, macronutrients (carbohydrate, protein, total fat, saturated fat, fiber), micronutrients (calcium, iron, magnesium, sodium, folate, vitamins A and C), and overall dietary quality (measure of total diet, such as the Healthy Eating Index) compared with food-secure women?

METHODS

The Preferred Reporting Items for Systematic reviews and Meta-Analyses (PRISMA) guidelines directed the manuscript preparation,[27] and the Institute of Medicine's standards for systematic literature reviews guided the process.[28] A team, including the lead author, a public health librarian, and an expert on food insecurity, decided on the information sources, developed and pretested the search strategy, and determined eligibility criteria. A PRISMA flowchart (Figure 1[27]) and checklist (Appendix S1 in the Supporting Information online) are included.[27]

Eligibility criteria

This review was intended to be generalizable to young and middle-aged women (aged 18–60 y) living in Canada and the United States, who are primarily responsible for caregiving and food provisioning in their households and more likely to be food insecure. Table 1[27] presents a summary of Population, Intervention or exposure, Comparison, Outcomes, and Study design (PICOS) parameters used to describe inclusion and exclusion criteria.

Inclusion criteria

Studies completed in 1995 or after with nonelderly women living in either Canada or the United States were included. The year 1995 was chosen as the start date because the United States starting measuring food insecurity with the FSSM in 1995. Studies from both Canada and the United States were included for 2 main reasons: 1) as previously mentioned, Canada and the United States use the same measure of food insecurity, the FSSM, which permits studies from both countries to be considered together[9]; and 2) there is a precedent in compiling food insecurity research between Canada and the United States, as seen in previous research studies.[19,20] There were no inclusion criteria related to sampling strategy. Only observational studies were included because food insecurity cannot be studied in experimental study designs.

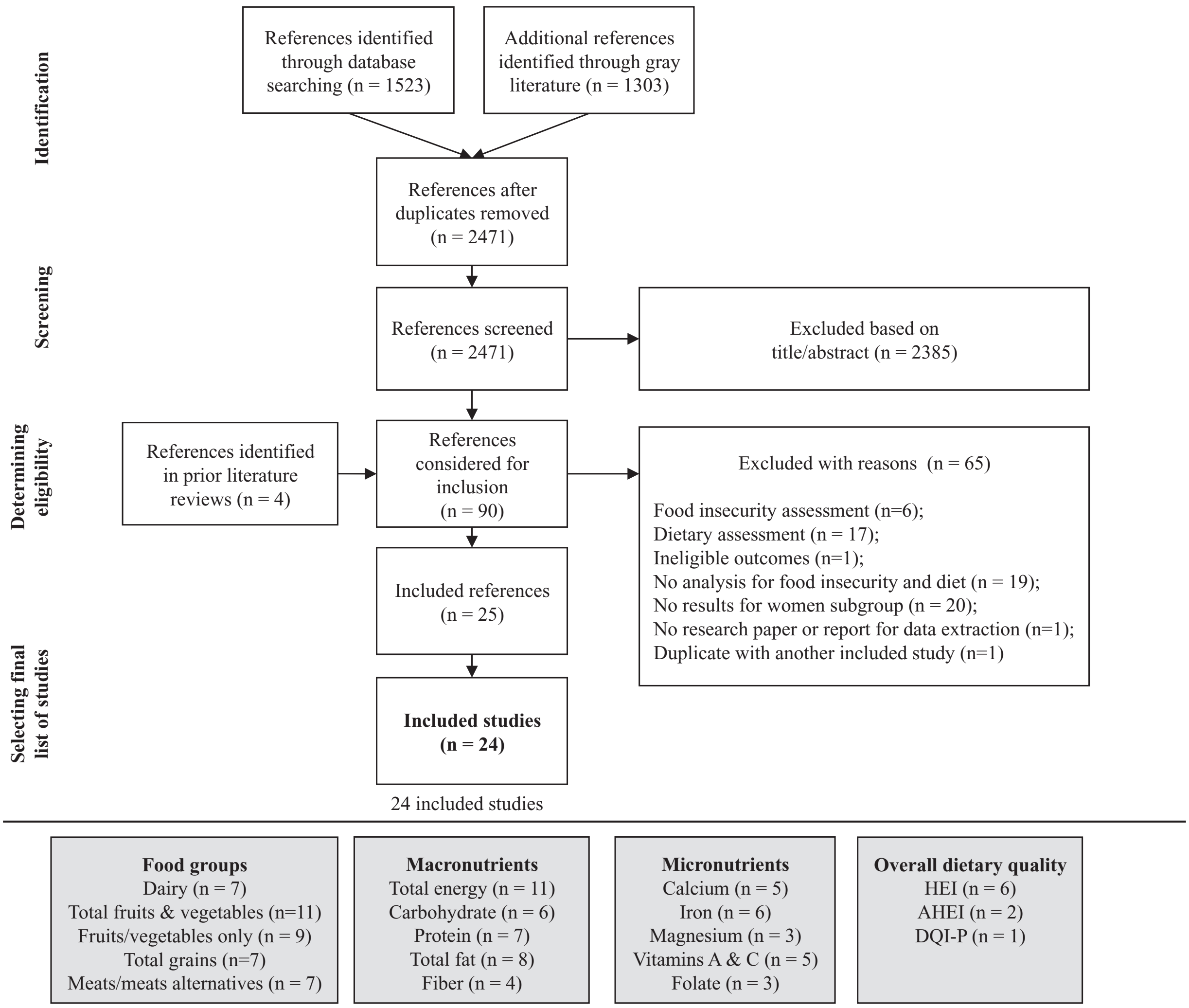

Figure 1 **Flow diagram of the literature search process.** This figure was based on PRISMA example.[27] Database searching included PubMed/MEDLINE, CINAHL, Scopus and ISI Web of Science, and we located additional references in the gray literature. The exact PubMed/MEDLINE search strategy was: "(women[mh] OR women[tiab] OR woman[tiab]) AND (diet[mh] OR dietary intake[tw] OR dietary intake[tiab] OR diet quality[tiab]) AND (hunger[mh] OR hunger[tiab] OR food supply[mh] OR food access[tiab] OR household food availability[tiab] OR food insecurity[tiab] OR food security[tiab] OR food insecure[tiab] OR food secure[tiab])." All studies (n=2471) were screened using the title and abstract. During screening, we excluded studies that were not related to the topic, the population, or not written in English. Ninety references were potentially related and reviewed more carefully using the full-text of the research paper or report. Twenty-four research studies were eligible for this review and included in the final set of studies. Each included study reported a different number of associations with dietary outcomes. For example, there were seven studies reporting the association with dairy. Abbreviations: AHEI, Alternative Healthy Eating Index; HEI, Healthy Eating Index; DQI-P, Diet Quality Index for Pregnancy; PRISMA, Preferred Reporting Items for Systematic reviews and Meta-Analyses

Eligible studies used previously validated measures of food insufficiency or food insecurity.[18] Research studies that measured food insufficiency were eligible because the measurement of food insecurity historically began with food insufficiency. The 2 terms—food insufficiency and food insecurity—are defined differently. According to the US Department of Agriculture, food insufficiency means there is not enough food for the household.[30] Food insecurity means not having consistent, dependable access at all times to enough food for an active, healthy life for all household members.[1] Included studies used validated food insecurity measures, such as the US FSSM[31–33] and Radimer/Cornell questionnaire.[12] In addition, single-item assessments used in national surveys[34,35] and brief assessments used in intervention studies were allowed.[36] This current review includes 1 early and influential research report on food insufficiency,[37] which used a validated measure.[34] Eligible studies also used previously validated dietary assessments, such as food records, 24-hour dietary recalls, food-frequency questionnaires, or brief dietary assessments, such as the National Cancer Institute's 2-item fruit and vegetable screener.[38]

Table 1 **PICOS criteria for inclusion and exclusion of studies**

Parameter	Inclusion criteria	Exclusion criteria
Population	Adult women (aged 18–60 y) living in Canada and the United States	Older and elderly adults (mean age of sample >60 y); refugees, drug users, and people with human immunodeficiency virus/AIDS
Intervention or exposure	Food insufficiency or food insecurity as assessed by valid, reliable measure (eg, Food Security Survey Module)	Nonvalid measure (eg, food insecurity determined in qualitative study)
Comparison	None	None
Outcomes	Frequencies of food groups (dairy, fruits, vegetables, fruits and vegetables, grains, meats/meats alternatives); intake of total energy, macronutrients (carbohydrate, protein, total fat, saturated fat, fiber), micronutrients (calcium, iron, magnesium, potassium, sodium, folate, vitamins A, C, and D); overall dietary quality (index, eg, Healthy Eating Index total score)	Nonvalid measure Adequacy-based dietary outcomes (eg, percentage meeting dietary targets, or recommended daily allowance)
Study design	Observational studies	Experimental studies

Exclusion criteria

Studies focused on older and elderly adults (mean age > 60 y) were excluded.[39] Older adults may have shifted caregiving responsibilities to others or have different age-related circumstances affecting food insecurity and diet.[39] Studies with refugees, drug users, and people with human immunodeficiency virus/AIDS were also excluded because these circumstances make them less generalizable. Studies were also excluded when it was not clear how they measured food insecurity or diet; when diet was measured indirectly, such as perceived diet quality; and when they used an adequacy-based measure of diet (or the extent that dietary intake met recommended targets).

Information sources

The search covered from January 1995 through October 2016. Following Institute of Medicine (IOM) recommendations, the databases PubMed/MEDLINE, CINAHL, Scopus, and Web of Science and sources of gray literature were searched.[28] These 4 databases covered peer-reviewed literature in health (including medicine, public health, nursing, and allied health) and social sciences. Search strategies for all databases included words and phrases related to the target population (women), exposure (food insecurity), and outcome (dietary intake and quality). The exact PubMed/MEDLINE search strategy is shown in Figure 1 (PRISMA flowchart). For the gray literature, gray literature databases, governmental and nongovernmental reports, dissertations, library catalogs, conference proceedings, relevant journal archives, subject matter experts (searching PubMed/MEDLINE for publications by experts and researchers in the field), and Google Scholar (see Appendix S2 in the Supporting Information online for more detail) were searched. The lead author initiated personal communication with researchers and experts to identify additional studies that had not been published. Eligible studies provided all data needed for the review through a journal article, research report, or personal communication.

Study identification, screening, and selection

Figure 1 presents the PRISMA flowchart and shows the identification, screening, and selection process. There were 2 phases to study selection. First, the lead author completed preliminary screening using the title and abstract to identify potentially relevant studies. Studies that were unrelated to the topic (food insecurity/food insufficiency and diet) or population (nonelderly women living in Canada and the United States) and those not written in English were excluded. When there was any doubt, the study was retained for the next level of review. Second, all potentially relevant studies were evaluated to determine eligibility. During this full-text review, information from the entire paper or report was used. The lead author completed the full-text review, and a co-author reviewed decisions. When there was any doubt, a decision was made in consultation with a third co-author. Corresponding authors were contacted and asked to provide additional information needed to determine eligibility.

Data collection process

The lead author extracted the following data from the included studies: author(s), year, setting, data source, sampling strategy, and sample characteristics (racial/ethnic/cultural groups, age), food insecurity measure, dietary assessment, and dietary outcomes. Dietary outcomes included frequencies of food groups (servings/day or cups/day); intake of total energy (kilocalories/day), macronutrients (grams/day or percentage of total energy), and micronutrients (varied units); and overall dietary quality (eg, Healthy Eating Index [HEI] total score).

For each dietary outcome, the lead author extracted the mean and the standard deviation of the food-insecure and food-secure groups and the unadjusted and adjusted *P* value for the association. The percentage (%) difference was used as the summary measure, which was calculated using the following formula and using the means of the food-insecure group and food-secure group (referent): $(\text{Intake}_{\text{Food insecure}} - \text{Intake}_{\text{Food secure}})/\text{Intake}_{\text{Food secure}} \times 100 = \%$ difference. The measurement and categorization of food insecurity has changed over time.[40] Food secure was operationalized as food sufficient, no hunger, or high and marginal food security; and food insecure was operationalized as food insufficient, hunger, or low food and very low food security, depending on the measure and the study (see Appendix S3 in the Supporting Information online for more detail).

Risk-of-bias assessment

The IOM recommends evaluating the risk of bias at the study or outcome level.[28] At the study level, risk of bias was evaluated based on the Effective Public Health Practice Project Quality Assessment Tool for Quantitative Studies[41] and the Agency for Healthcare Research and Quality approach.[42] At the outcome level, the risk of bias was evaluated to determine the quality of evidence for each dietary outcome using the Grades of Recommendation, Assessment, Development, and Evaluation (GRADE).[43] Specifically, information from each study's methods section was used to determine the risk of bias (no risk, low, moderate, and high risk). When the risk was not clear, the level was uncertain. Each study was assigned an overall assessment of quality (based on methodological deficiencies) and applicability (to target population of women at risk for food insecurity).[42] Traditionally, quality assessments penalize observational studies for having nonrandom samples, but for food insecurity, the target population is people at risk of food insecurity, such as lower- and low-income households, households with children headed by single women, and black- and Hispanic-headed households.[1] Thus, studies that prioritized the target population were rated as less biased than nationally representative samples. Studies with low-/lower-income samples and with fewer methodological deficiencies were rated as having no or low risk of bias. Given that food insecurity cannot be studied in experimental study designs, all studies were observational; this was not included in the bias assessment. Per GRADE, evidence from observational studies starts as low-quality evidence and can be downgraded based on limitations, inconsistency, indirectness, imprecision, and publication bias.[43] Table 2[12,13,15–17,29,31–37,39,44–62] presents the evaluation of the risk of bias at the study level. Appendix S4 in the Supporting Information online presents the risk of bias at the outcome level.

RESULTS

This search generated 2471 references (Figure 1). After preliminary screening, there were 90 potentially relevant references. Of those 90 references, 25 references, representing 24 unique research studies, were eligible for this review and included.[13,15–17,37,39,44–62] For 1 study, dietary outcomes were reported separately for women aged 19–30 years and women aged 31–50 years,[53] and tables present associations separately for the 2 age groups. Sixteen studies had women-only samples, [13,15–17,37,45–52,58,60–62] and 8 studies had mixed samples (women and men).[39,44,53–57,59] Results for women subgroups were provided for 2 studies.[39,53] For 6 studies (with mixed samples), data were not reported for women only, and corresponding authors provided subanalyses for women aged <60 years.[44,54–57,59] Subanalyses were provided for 3 other studies.[45,52,61]

Based on the risk-of-bias assessment at the study level, 13 studies had a high risk of bias and were considered low quality (Table 2).[13,37,45,47,52,54,56,58–62] The lower quality ratings were primarily due to incongruence in the timing of food insecurity and dietary assessment or not controlling for confounding.[13,37,45,47,52,54,56,58–62] Some studies had bias attributed to the measures.[37,45,47,54,56–59,61,62] Seven studies were rated as having some bias[39,46,48,50,51,53,55] and considered fair quality. Four studies had the least bias[15–17,44,49] and were considered high quality. For many studies (n = 20 of 24), results were applicable to women at risk of food insecurity (eg, low-income women) or a relevant subgroup (eg, lower-income women).[13,15–17,37,44–52,54–57,59–62] All included studies were observational studies because food insecurity cannot be studied in experimental studies, which meant that the quality of evidence was low for all dietary outcomes (Appendix S4 in the Supporting Information online).

Studies varied according to purpose, setting, and participants (Table 3[13,15–17,37,39,44–62]). Data came from a validation study,[13] cohort study,[44] intervention studies,[45,47,50,51,55,57,60] observational studies,[15–17,46,49,52,54,59,62] and analyses of national health survey data.[37,39,48,53,58] This review included 6 Canadian studies[15–17,49,53,56,59] and 18 US studies.[13,37,39,44–48,50–52,54,55,57–62] Most studies were completed in urban settings (only 4 studies focused on rural areas[13,52,61,62]). Across the studies, women were from diverse racial, ethnic, and cultural

Table 2 **Risk of bias assessment for studies relating food insecurity to dietary outcomes in Canadian and US women**

References	Selection bias	Data collection method			Analysis	Overall	
	Recruitment or inclusion criteria	Food insecurity assessment (reference period)	Dietary assessment (reference period)	Congruence in reference periods	Control of confounding	Quality	Applicability
Kendall et al. (1996)[13]	Moderate risk: women recruited from varied SES, oversampled from lower SES	No risk: radimer/ Cornell questionnaire[12] (NR, typically, reference frame is last 12 mo)	Low risk: 2 dietary recalls (last 24 h, done within a month, second recall, done 3 wk later), minimizes recall bias	Uncertain risk: unknown	High risk: no	C	II
McIntyre et al. (2007)[15]	No risk: women recruited from food pantries and community sites (all low-income)	No risk: common scale developed for the study[29] (last 30 d)	Low risk: 3–4 dietary recalls (last 24 h, recalls done weekly for 1 mo), minimizes recall bias	Low risk: yes	Low risk: yes	A	I
Tarasuk (2001)[16]; Tarasuk and Beaton (1999)[17]	No risk: women recruited from food pantries (all low-income)	No risk: US FSSM 18-item[31] (last 30 d)	Low risk: 3 dietary recalls (last 24 h, done within a month), minimizes recall bias	Low risk: yes	Low risk: yes	A	I
Basiotis and Lino (2002)[37]	High risk: NHANES sample (national survey)	High risk: 1-item food sufficiency (NHANES)[34] (NR)	Moderate risk: 1 dietary recall (last 24 h), subject to measurement error	Uncertain risk: unknown	High risk: no	C	III
Zizza et al. (2008)[39]	High risk: NHANES sample (national survey)	No risk: US FSSM 10-item[32] (last 12 mo)	Moderate risk: 1 dietary recall (last 24 h), subject to measurement error	High risk: no	Low risk: yes	B	III
Berkowitz et al. (2014)[44]	Low risk: women recruited from Puerto Rican community	No risk: US FSSM 10-item[32] (last 12 mo)	Low risk: FFQ (last 12 mo), developed and validated for the study population	Low risk: yes	Low risk: yes	A	II
Di Noia et al. (2016)[45]	No risk: women recruited from WIC (all low income)	Moerate risk: 2-item screener (Hager et al)[36] (last 12 mo)	High risk: 2-item dietary screener (NR), subject to recall bias and measurement error in estimating quantities	Uncertain risk: unknown	Low risk: yes	C	I
Duffy et al. (2009)[46]	No risk: women recruited from food pantry (all low-income)	No risk: US FSSM 10-item[32] (last 12 mo)	Moderate risk: 1 dietary recall (last 24 h), subject to measurement error	High risk: no	NA[a]	B	I
Feder (2001)[47]	No risk: women recruited from WIC (all low-income)	No risk: Radimer/ Cornell questionnaire[12] (last 3 mo)	High risk: FFQ (last month), subject to recall bias and measurement error in estimating quantities	High risk: no	High risk: no	C	I
Gamba et al. (2016)[48]	Low risk: NHANES sample restricted to pregnant women from households with income < 300% FPL	No risk: US FSSM 18-item[31] (last 12 mo)	Moderate risk: 1-2 dietary recalls (last 24 h), subject to measurement error	High risk: no	Low risk: yes	B	II

(continued)

Table 2 **Continued**

References	Selection bias	Data collection method			Analysis	Overall	
	Recruitment or inclusion criteria	Food insecurity assessment (reference period)	Dietary assessment (reference period)	Congruence in reference periods	Control of confounding	Quality	Applicability
Glanville and McIntyre (2006)[49]	No risk: women recruited from community programs and sites (all low-income)	No risk: Radimer/ Cornell questionnaire[12] (last week, assessed weekly for 1 mo)	Low risk: 4 dietary recalls (last 24 h, recalls done weekly for 1 mo), minimizes recall bias	Low risk: yes	NA[a]	A	I
Herman (2002)[50]	No risk: women recruited from WIC (all low-income)	No risk: US FSSM 18-item[31] (last 12 mo at first trimester, and last 3 mo at third trimester and postpartum)	Low risk: 3 dietary recalls (last 24 h, done during first trimester, third trimester, and 3–6 mo postpartum), minimizes recall bias	Moderate risk: some congruence in timing	High risk: no	B	I
Hilmers et al. (2014)[51]	No risk: women recruited from EFNEP (all low-income)	Low risk: US FSSM 6-item[33] (last 12 mo)	Moderate risk: 1 food record (last 24 h), subject to recall bias and underreporting	High risk: no	Low risk: yes	B	I
Johnson et al. (2014)[52]	No risk: women recruited from community programs and sites (all low-income)	Low risk: US FSSM 6 item[33] (last 12 mo)	Low risk: 3 dietary recalls (last 24 h), minimizes recall bias	High risk: no	High risk: no	C	I
Kirkpatrick and Tarasuk (2008)[53]	High risk: Canadian Community Health Survey sample (national survey)	No risk: US FSSM 18-item[31] (last 12 mo)	Moderate risk: 1 dietary recall (last 24 h), subject to measurement error	High risk: no	Low risk: yes	B	III
Mayer et al. (2015)[54]	No risk: women recruited from clinical population (all low income)	No risk: US FSSM 18-item[31] (last 12 mo)	High risk: FFQ (last 30 days), subject to recall bias and measurement error in estimating quantities	High risk: no	High risk: no	C	I
Mello et al. (2010)[55]	No risk: women recruited from community sites (all low-income)	High risk: 1-item (BRFSS)[35] (last 30 d)	High risk: FFQ (last month), subject to recall bias and measurement error in estimating quantities	Low risk: yes	Low risk: yes	B	I
Miewald et al. (2012)[56]	Low risk: women recruited from food box program depots serving more low-income residents	No risk: US FSSM 18-item[31] (last 12 mo)	High risk: FFQ (last month), subject to recall bias and measurement error in estimating quantities	High risk: no	High risk: no	C	II
Mook et al. (2016)[57]	Low risk: women recruited from economically disadvantaged neighborhoods	Low risk: US FSSM 6-item[33] (last 12 mo)	High risk: FFQ (last month), subject to recall bias and measurement error in estimating quantities	High risk: no	Low risk: yes	C	II

(continued)

Table 2 **Continued**

References	Selection bias	Data collection method			Analysis	Overall	
	Recruitment or inclusion criteria	Food insecurity assessment (reference period)	Dietary assessment (reference period)	Congruence in reference periods	Control of confounding	Quality	Applicability
Park et al. (2014)[58]	High risk: NHANES sample (US national survey)	No risk: US FSSM 18-item[31] (last 12 mo)	Moderate risk: 1 dietary recall (last 24 h), subject to measurement error	High risk: no	High risk: no	C	III
Rush et al. (2007)[59]	No risk: women recruited from food pantry (all low-income)	No risk: Radimer/ Cornell questionnaire[12] (last 30 d)	Moderate risk: 1 dietary recall (last 24 h), subject to measurement error	High risk: no	High risk: no	C	I
Sharpe et al. (2016)[60]	Low risk: women recruited from high-poverty census tracks.	Low risk: USDA FSSM 6-item[33] (last 12 mo)	Low risk: 3 dietary recalls (last 24 h, and 3 recalls done within 15-d period), minimizes recall bias	High risk: no	High risk: no	C	II
Swindle et al. (2018)[61]	Low risk: women were early childhood educators (primarily low-wage workers)	High risk: 2-item screener (Hager et al)[36] (last 12 mo)	High risk: FFQ (NR), subject to recall bias and measurement error in estimating quantities	Uncertain risk: unknown	Low risk: yes	C	I
Ward et al. (2011)[62]	Low risk: women recruited from health department serving more low-income residents	No risk: US FSSM 18-item[29] (last 30 d)	High risk: FFQ (last 12 mo), subject to recall bias and measurement error in estimating quantities	High risk: no	Low risk: yes	C	II

This table presents risk of bias assessment at the study level. The Effective Public Health Practice Project Quality Assessment Tool for Quantitative Studies was used to rate components,[41] and the Agency for Healthcare Research and Quality's approach to evaluate overall study quality (A = Least bias; B = Susceptible to some bias, but not sufficient to invalidate results; and C = Significant bias, may invalidate the results) and applicability (I = Representative of the target population; II = Representative of a relevant subgroup of the target population; and III = Representative of a narrow subgroup).[42] Studies with the lowest risk across components were rated as relatively high study quality (rated A), those with the highest risk were rated as relatively low study quality (rated C).

Abbreviations: BRFSS, Behavioral Risk Factor Surveillance System; ENFEP, Expanded Food and Nutrition Education Program; FFQ, Food Frequency Questionnaire; FPL, federal poverty level; FSSM, Food Security Survey Module; NA, not applicable; NHANES, National Health and Nutrition Examination Survey; NR, not reported; SES, socioeconomic status; WIC, Special Supplemental Nutrition Program for Women, Infants, and Children.

[a]Study did perform additional analyses after nonsignificant bivariate association of food insecurity with diet.

Table 3 **Characteristics of included research studies relating food insecurity to dietary outcomes in Canadian and US women (n = 24)**

References	Setting	Geography	Racial, ethnic, or cultural group	No.	Age, y Mean (range)	Food insecure (%)
Kendall et al. (1996)[13]	New York, USA	Rural	White	193	33.6 (20–39)	53
McIntyre et al. (2007)[15]	Atlantic Provinces and Ontario, Canada	Urban	White,[a] African Canadian, racially visible immigrant, aboriginal, other/not stated	226	NR (19–46)	41
Tarasuk (2001)[16]; Tarasuk and Beaton (1999)[17]	Ontario, Canada	Urban	White,[a] black, Latin American, Asian, aboriginal Canadians, and undefined	153	33 (19–49)	57
Basiotis and Lino (2002)[37]	National, USA	Varied	NR	5241	NR (19–55)	8
Zizza et al. (2008)[39]	National, USA	Varied	Non-Hispanic black, non-Hispanic white, Hispanic	2707	NR (18–60)	14
Berkowitz et al. (2014)[44]	Massachusetts, USA	Urban	Latina (Puerto Rican)	604[b]	52.5[b] (<60)	30[b]
Di Noia et al. (2016)[45]	New Jersey, USA	Urban	African American, Hispanic or Latina,[a] white or other, >2 races	744	29.0 (No age restriction)	55
Duffy et al. (2009)[46]	Alabama, USA	Urban[d]	Black,[a] white, other	55	34.4 (19–50)	65
Feder (2001)[47]	Pennsylvania, USA	Urban	African American,[a] white, Hispanic, Southeast Asian, other	180	23.9 (18–43)	65
Gamba et al. (2016)[48]	National, USA	Varied	Non-Hispanic Black, Hispanic, non-Hispanic, White and Other[a]	688	25.6 (No age restriction)	32
Glanville and McIntyre (2006)[49]	Atlantic Provinces, Canada	Urban	English-speaking Canadian,[a] African Canadian, First Nation, Acadian, or French Canadian, other	141	29.3 (19–46)	78
Herman (2002)[50]	California, USA	Urban	African American, Hispanic[a]	313	25.1 (18–45)	43
Hilmers et al. (2014)[51]	Texas, USA	Urban	Latina (Mexican American)	707	35.2 (14–45)	46
Johnson et al. (2014)[52]	North Carolina, USA	Rural and urban	Black,[a] Latina, white	101[b]	32.3[b] (<50)	49[b]
Kirkpatrick and Tarasuk (2008)[53]	National, Canada	Varied	NR	7506	NR (19–50)	11
Mayer et al. (2015)[54]	Pennsylvania, USA	Urban	Non-Hispanic black,[a] non-Hispanic white, all other	187[b]	49.7[b] (<60)	54[b]
Mello et al. (2010)[55]	Rhode Island, USA	Urban	Black, White, Hispanic,[a] Other	1435[b]	37.6[b] (<60)	50[b]
Miewald et al. (2012)[56]	British Columbia, Canada	Urban	NR	74[b]	36.7[b] (<60)	39[b]
Mook et al. (2016)[57]	California, USA	Urban	Black,[a] Latina, white, Asian, Native American, Alaska Native, Pacific Islander, other	377[b]	43.6[b] (<60)	43[b]
Park et al. (2014)[58]	National, USA	Varied	Black, Latina, white[a]	1045	NR (13–54)	16
Rush et al. (2007)[59]	Ontario, Canada	Urban	Latina (Columbian immigrants)	38[b]	37.5[b] (<60)	100[b]
Sharpe et al. (2016)[60]	South Carolina, USA	Urban	Black,[a] white	202	38.2 (25–50)	39
Swindle et al. (2018)[61]	Arkansas, USA	Rural and urban	NR	210[b]	NR (<45)	34[b]
Ward et al. (2011)[62]	North Carolina, USA	Rural	Latina (all immigrants)	74	28.8 (18–44)	NR[c]

Abbreviaton: NR, not reported.
[a]Largest racial/ethnic subgroup in the sample or women-only subgroup.
[b]Unpublished data provided via personal communication with corresponding author.
[c]Mean score of 5.6 was reported. Responding affirmatively to more than 3 items on the 18-item US Food Security Survey Module scale indicates food insecurity.

groups. Of studies for which there was information on racial/ethnic/cultural groups, all but 1 study[13] included women of African and Latin descent. Seven studies focused exclusively on female caregivers,[13,15–17,45,49,51,52] and 4 studies focused on pregnant women.[47,48,50,58] Average age ranged from 23.9 years to 52.5 years. The prevalence of food insecurity and sample sizes varied widely.

Associations of food insecurity with dietary outcomes for women

Each study included associations for a different number of dietary outcomes. Figure 1 shows the number of studies for which associations of food insecurity with specific dietary outcomes were reported. For example, associations with total fruits and vegetables were reported for 11[15,16,47,50,52,53,55–57,59,60] of the 24 included studies.[13,15–17,37,39,44–62]

Food groups. Four[13,15,16,53] of 7 studies[13,15,16,52,53,59,60] found that food-insecure women consumed fewer servings of dairy than food-secure women (range, −7% to −31%) (Table 4[13,15,16,45,47,50–57,59,60]). Two of these studies found significant differences ($P < 0.05$).[15,53] Nine[15,16,47,52,53,56,57,59,60] of 11 studies[15,16,47,50,52,53,55–57,59,60] found that food-insecure women consumed fewer daily servings of combined fruits and vegetables than food-secure women (range, −6% to −32%). Five of these studies found statistically significant differences ($P < 0.05$)[15,16,53,56,57]; food-insecure women consumed significantly ($P < 0.05$) fewer servings of fruits and vegetables than food-secure women.[15,16,53,56,57] Four[15,16,53,59] of 7 studies[13,15,16,52,53,59,60] found that food-insecure women consumed fewer servings of total grains than food-secure women (range, −6% to −22%). Two of these studies found significant differences ($P < 0.05$).[15,53] Five[15,16,52,53,59] of 7 studies[13,15,16,52,53,59,60] found that food-insecure women consumed fewer servings of meats/meats alternatives relative to food-secure women (range, −3% to −36%). Two of these studies found significant differences ($P < 0.05$).[15,16]

Total energy and macronutrients. Seven[13,15,17,51–53,59] of 11 studies[13,15,17,37,39,44,51–53,59,60] found that food-insecure women had lower total energy compared with food-secure women, with percentage differences ranging from −2% to −18% (Table 5[13,15,17,37,39,44,51–53,59,60]). Two of these studies found statistically significant differences ($P < 0.05$).[15,17] Four[17,52,59,60] of 6 studies[17,39,52,53,59,60] found that food-insecure women had higher carbohydrate intake relative to food-secure women (range, +1% to +13%) (Table 6[13,15,17,39,51–53,59,60]). Three of these studies found significant differences ($P < 0.05$),[17,53,60] and another 1 of these found borderline significance ($P = 0.05$).[52] Five[15,17,53,59,60] of 7 studies[15,17,39,52,53,59,60] found that food-insecure women had lower protein intake than food-secure women (range, −2% to −7%). Two of these found significant differences ($P < 0.05$),[15,17] and 1 of 7 found borderline significance ($P = 0.05$).[60] Five[17,51,52,59,60] of 8 studies[13,17,39,51–53,59,60] fond that food-insecure women had lower total fat intake relative to food-secure women (range, −1% to −19%). Two of these found statistically significant differences ($P < 0.05$).[17,52] Three[13,53,60] of 4 studies[13,51,53,60] found that food-insecure women consumed less fiber relative to food-secure women (range, −4% to −19%). Two of these studies found significant differences ($P < 0.05$).[13,53]

Micronutrients. Five[13,15,17,51,53] of 5 studies[13,15,17,51,53] found that food-insecure women consumed less calcium than food-secure women (range, −2% to −21%) (Table 7[13,15,17,51,53,58,60]). Two of these studies found statistically significant differences ($P < 0.05$),[15,53] and another study found borderline significance ($P = 0.05$).[17] Six[13,15,17,51,53,58] of 6 studies[13,15,17,51,53,58] found that food-insecure women had lower iron intake than food-secure women (range, −2% to −23%). Three of these studies found significant differences ($P < 0.05$).[15,17,53] Three[15,17,53] of 3 studies[15,17,53] found that food-insecure women consumed lower intakes of magnesium than food-secure women (range, −13% to −19%), and all were significant differences ($P < 0.05$).[15,17,53] Four[15,17,51,53] of 5 studies[13,15,17,51,53] found that food-insecure women consumed less vitamin A than food-secure women (range, −2% to −52%), and 3 of these studies found significant differences ($P < 0.05$).[15,17,53] Three[17,51,53] of 3 studies[17,51,53] found that food-insecure women consumed less folate than food-secure women (range, −8% to −22%), and all found statistically significant differences ($P < 0.05$).[17,51,53]

Overall dietary quality. Nine studies[37,44,46,48–50,52,60,62] used the following indices for overall dietary quality: HEI (versions 1999/2000, 2005, 2010),[63–65] the Alternative Healthy Eating Index (AHEI),[66] the AHEI for Pregnancy,[67] and the Diet Quality Index for Pregnancy[68] (Table 8[37,44,46,48–50,52,60,62–68]). Three[44,48,62] of 9 studies[37,44,46,48–50,52,60,62] used adjusted models to determine the association of food insecurity with overall dietary quality, controlling for sociodemographic factors.[44,48,62] Six[37,44,46,49,50,52] of 9 studies[37,44,46,48–50,52,60,62] used the HEI total score to evaluate overall dietary quality. Two[37,44] of 9 studies[37,44,46,48–50,52,60,62] found that food-insecure women had lower overall dietary quality compared with food-secure women; both found significant differences ($P < 0.05$) for the HEI total score (range, −3% to −6%).[37,44] Three[37,44,50] of 9 studies[37,44,46,48–50,52,60,62] also found significant differences ($P < 0.05$) for HEI component scores (Appendix S5 in the Supporting Information online).[37,44,50]

Strengths and weaknesses in the body of evidence

In summary, 15 studies found significant associations of food insecurity with at least 1 dietary outcome.[13,15–17,37,39,44,45,50–53,56,57,60,61] However, most evidence came from studies of fair to low quality (Table 2). Given that all studies were observational and had methodological limitations, the quality of evidence was low for all dietary outcomes (Table S3 in the Supporting Information online). Thus results were examined when considering

Table 4 **Percentage differences in daily frequency of food groups between food-insecure and food-secure women**

Reference	Food secure, mean (SD)	Food insecure, mean (SD)	Percentage difference	Unadjusted *P*-value	Adjusted *P* value	Quality rating
Dairy (servings/d)						
Kendall et al. (1996)[13]	1.5 (NR)	1.4 (NR)	−7	0.58	–	C
McIntyre et al. (2007)[15]	1.2 (1.2)	0.8 (0.7)	−31	0.0056	0.0762[a]	A
Tarasuk (2001)[16]	1.0 (1.0)	0.7 (0.6)	−24[b]	NR	–	A
Johnson et al. (2014)[52,c]	1.1 (1.0)	1.2 (1.1)	+1	0.96	–	C
Kirkpatrick and Tarasuk (2008),[53] 19–30 y	1.6 (4.6)	1.2 (1.8)	−25	0.02	0.53[d]	B
Kirkpatrick and Tarasuk (2008),[53] 31–50 y	1.5 (6.8)	1.3 (4.4)	−13	0.03	0.2[d]	B
Rush et al. (2007)[59,c]	1.4 (0.5)	1.5 (1.3)	+7[b]	0.9	–	C
Sharpe et al. (2016)[60]	1.1 (1.0)	1.2 (0.9)	+9	0.7	–	C
Fruits (servings/d)						
Kendall et al. (1996)[13]	1.2 (NR)	0.7 (NR)	−42	<0.001	–	C
Di Noia et al. (2016)[45,c]	2.7[e](1.6)[e]	2.8[e] (1.8)[e]	+4	0.3	0.2[f]	C
Hilmers et al. (2014)[51]	0.8[g] (1.4)[g]	0.8[g] (1.4)[g]	+6	–	NR[g,h]	B
Johnson et al 2014)[52,c]	1.1 (1.3)	0.9 (1.3)	−22	0.34	–	C
Mayer et al. (2015)[54,c]	0.7[i] (0.70[i]	0.7[i] (1.1)[i]	+4	0.77	–	C
Mello et al. (2010)[55,c]	4.9 (2.7)	5.3 (2.7)	+8	0.06	0.26[j]	B
Miewald et al. (2012)[56,c]	2.4 (1.3)	2.1 (1.6)	−13	0.371	–	C
Sharpe et al. (2016)[60]	1.0 (1.0)	0.9 (1.0)	−10	0.76	–	C
Swindle et al. (2018)[61,c]	2.3 (1.0)	2.1 (0.9)	−9	0.137	0.078[k]	C
Vegetables (servings/d)						
Kendall et al. (1996)[13]	1.2 (NR)	1.1 (NR)	−8	0.89	–	C
Di Noia et al. (2016)[45,c]	1.3[e] (1.1)[e]	1.5[e] (1.2)[e]	+15	0.01	0.02[f]	C
Hilmers et al. (2014)[51]	1.8[g] (2.0)[g]	1.7[g] (2.0)[g]	−5	–	NR[h],[g]	B
Johnson et al. (2014)[52,c]	2.0 (1.2)	1.9 (1.2)	−4	0.78	–	C
Mayer et al. (2015)[54,c]	0.5[i] (0.4)[i]	0.4[i] (0.4)[i]	−14	0.17	–	C
Mello et al. (2010)[55,c]	2.7 (2.7)	2.7 (2.7)	+2	0.53	0.48[j]	B
Miewald et al. (2012)[56,c]	3.2 (2.0)	2.0 (1.0)	−38	0.002		C
Sharpe et al. (2016)[60]	2.5 (1.4)	2.3 (1.4)	−8	0.35	–	C
Swindle et al. (2018)[61,c]	2.5 (1.0)	2.2 (1.0)	−12	0.043	0.078[k]	C
Total fruits and vegetables						
McIntyre et al. (2007)[15]	3.8 (2.6)	2.9 (2.1)	−24	0.0049	0.0073[a]	A
Tarasuk (2001)[16]	5.0 (3.3)	3.7 (2.3)	−26[b]	NR[h]	–	A
Feder (2001)[47]	4.9 (4.4)	3.7 (3.3)	−24	0.068	–	C
Herman (2002)[50]	8.9 (5.6)	9.1 (6.1)	+2	NR	–	B
Johnson et al. (2014)[52,c]	3.1 (1.8)	2.8 (1.8)	−10	0.39	–	C
Kirkpatrick and Tarasuk (2008),[53] 19–30 y	4.8 (9.2)	3.5 (5.5)	−27	<0.01	0.02[d]	B
Kirkpatrick and Tarasuk (2008),[53] 31–50 y	4.9 (6.8)	3.8 (4.4)	−22	<0.01	<0.0[d]	B
Mello et al. (2010)[55,c]	7.6 (5.4)	8.0 (5.4)	+6	0.09	0.26[j]	B
Miewald et al. (2012)[56,c]	5.6 (2.6)	3.8 (2.1)	−32	0.006	–	C
Mook et al. (2016)[57,c]	2.9 (1.5)	2.0 (1.5)	−31	<0.0001	<0.0001[l]	C
Rush et al. (2007)[59,c]	4.0 (1.9)	3.3 (0.9)	−18[b]	0.7	–	C
Sharpe et al. (2016)[60]	3.4 (1.7)	3.2 (1.8)	−6	0.36	–	C
Total grains (servings/d)						
Kendall et al. (1996)[13]	4.2 (NR)	4.2 (NR)	0	0.83	–	C
McIntyre et al. (2007)[15]	4.6 (2.4)	3.9 (2.1)	−15	0.0328	0.0578[a]	A
Tarasuk (2001)[16]	4.7 (2.7)	3.6 (2.1)	−22[b]	NR	–	A
Johnson et al. (2014)[52,c]	5.7 (2.9)	5.7 (2.9)	+1	0.9	–	C
Kirkpatrick and Tarasuk (2008),[53] 19–30 y	5.5 (9.2)	4.4 (3.7)	−20	<0.01	0.09[d]	B
Kirkpatrick and Tarasuk (2008),[53] 31–50 y	5.0 (6.8)	4.7 (6.6)	−6	0.28	0.42[d]	B
Rush et al. (2007)[59,c]	6.6 (1.1)	5.4 (1.6)	−18[b]	0.2	–	C
Sharpe et al. (2016)[60]	5.8 (3.0)	5.8 (2.5)	0	0.98	–	C
Meats/meat alternatives (servings/d)						
Kendall et al. (1996)[13]	1.6 (NR)	1.6[m] (NR)	0	0.88	–	C
McIntyre et al. (2007)[15]	2.1 (1.1)	1.9 (1.1)	−10	0.1189	0.0398[a]	A
Tarasuk (2001)[16]	2.5 (1.3)	1.6 (1.1)	−36[b]	NR[h]	–	A
Johnson et al. (2014)[52,c]	5.3 (2.5)	4.8 (2.5)	−9	0.35	–	C
Kirkpatrick and Tarasuk (2008),[53] 19–30 y	2.9 (4.6)	2.8 (3.7)	−3	0.52	0.72[d]	B

(continued)

Table 4 **Continued**

Reference	Food secure, mean (SD)	Food insecure, mean (SD)	Percentage difference	Unadjusted *P*-value	Adjusted *P* value	Quality rating
Kirkpatrick and Tarasuk (2008),[53] 31–50 y	3.4 (13.5)	3.1 (4.4)	−9	0.24	0.59[d]	B
Rush et al. (2007)[59,c]	2.0 (0.5)	1.8 (0.3)	−10[b]	0.6	–	C
Sharpe et al. (2016)[60]	5.2[m] (2.7)	5.3[m] (2.9)	+2	0.86	–	C

Unadjusted means except where noted otherwise. When standard error (SE) was reported, standard deviation (SD) was calculated using the SE and sample size. A negative value indicates that food-insecure women had lower intakes compared with food-secure women. *P* values and adjustment variables noted as reported. Information from the risk-of-bias assessment at the study level was used to determine quality rating (Table 2).

Abbreviaton: NR, not reported.

[a]Adjusted *P* values (study site [Atlantic vs Toronto], education [postsecondary or degree], age of oldest child <4 y, daily smoker, presence of employment income, and number of children [>3]).

[b]Difference calculated between the most food insecure and least food insecure group.

[c]Unpublished data provided via personal communication with corresponding author.

[d]Adjusted *P* values (income adequacy, respondent education, immigrant status, current daily smoking status, and household size).

[e]Intake in cups/day.

[f]Adjusted *P* values (age, race/ethnicity, education).

[g]Adjusted means and *P* values (sociodemographic variables, body mass index score, Supplemental Nutrition Assistance Program participation, and energy intake).

[h]$P < 0.05$.

[i]Intake in cup equivalents/day.

[j]Adjusted *P* values (age, race/ethnicity, and education).

[k]Adjusted *P* values (age, teacher's role, and agency type).

[l]Adjusted *P* values (age, black race, and education).

[m]Meat alternative intake was 0.

Table 5 **Percentage differences in daily intake of total energy (kilocalories/day) between food-insecure and-food secure women**

Reference	Food secure, mean (SD)	Food insecure, mean (SD)	Percentage difference	Unadjusted *P* value	Adjusted *P* value	Quality rating
Kendall et al. (1996)[13]	1678 (NR)	1598 (NR)	−5	0.31	–	C
McIntyre et al. (2007)[15]	1787 (776)	1515 (610)	−15	0.0082	0.0374[a]	A
Tarasuk and Beaton (1999)[17]	1717 (767)	1432[b] (NR)	−17	0.0110	0.0307[c]	A
Basiotis and Lino (2002)[37]	1868 (NR)	1959 (NR)	+5	NR	–	C
Zizza et al. (2008)[39]	1897[d] (1381)	1995[d] (724)	+5[e]	–	NR[d]	B
Berkowitz et al. (2014)[44,e]	2180 (1037)	2323 (1224)	+7	0.1420	0.1842[f]	A
Hilmers et al. (2014)[51]	1543[g](700)	1509[g](739)	−2	–	NR[g]	B
Johnson et al. (2014)[52,e]	1899 (715)	1736 (715)	−9	0.3	–	C
Kirkpatrick and Tarasuk (2008),[53] 19–30 y	1919 (1746)	1764 (1231)	−8	0.08	0.37[h]	B
Kirkpatrick and Tarasuk (2008),[53] 31–50 y	1850 (2100)	1707 (1447)	−8	0.06	0.12[h]	B
Rush et al. (2007)[59,e]	1644 (481)	1352 (549)	−18[i]	0.6	–	C
Sharpe et al. (2016)[60]	1906 (825)	1955 (656)	+3	0.65	–	C

Unadjusted means except where noted otherwise. When intake was reported in kilojoules, it was converted into kilocalories (1 kJ = 0.239 kilocalorie). When standard error (SE) was reported, standard deviation (SD) was calculated using the SE and sample size. A negative value indicates that food-insecure women had lower intakes compared with food-secure women. *P* values and adjustment variables noted as reported. Information from the risk-of-bias assessment at the study level was used to determine quality rating (Table 2).

Abbreviaton: NR, not reported.

[a]Adjusted *P* values (study site [Atlantic vs Toronto], education [postsecondary or degree], age of oldest child <4 y, daily smoker, presence of employment income, and number of children [>3]).

[b]The mean of the hunger (food-insecure) group was calculated using the mean of the no hunger (food-secure) group and the unadjusted intake difference.

[c]Adjusted *P* values (disposable income [adjusted for family size and composition], presence of employment income in the household, presence of a partner in the household, and woman's level of education, smoking status, and ethnoracial identity).

[d]Adjusted means (age, ethnicity/race, education, and income).

[e]Unpublished data provided via personal communication.

[f]Adjusted *P* values (age, and income-to-poverty ratio).

[g]Adjusted means (sociodemographic variables, body mass index score, Supplemental Nutrition Assistance Program participation).

[h]Adjusted *P* values (income adequacy, respondent education, immigrant status, current daily smoking status, and household size variables).

[i]Total energy was reported for more than 2 food insecurity groups. Difference based on the most and least food insecure groups.

only high-quality studies (those considered to have the least bias). For dairy, total grains, and meats/meat alternatives, there were 2 quality studies; both found a negative association with at least 1 outcome, and significance varied by study.[15,16] For total fruits and vegetables, there were 2 high-quality studies; both found a

Table 6 **Percentage differences in daily intake of macronutrients between food-insecure and food-secure women**

Reference	Food secure, mean (SD)	Food insecure, mean (SD)	Percentage difference	Unadjusted *P* value	Adjusted *P* value	Quality rating
Carbohydrate (% total energy)						
Tarasuk and Beaton (1999)[17]	56.5 (NR)	56.9[a] (NR)	+1	0.0181	0.0431[b]	A
Zizza et al. (2008)[39]	53.2[c] (NR)	50.8[c] (NR)	−5[d]	–	NR[c]	B
Johnson et al. (2014)[52,e]	46.5 (8.2)	49.7 (8.3)	+7	0.05	–	C
Kirkpatrick and Tarasuk (2008),[53] 19–30 y	51.9 (23.0)	51.8 (16.5)	0	0.85	0.75[f]	B
Kirkpatrick and Tarasuk (2008),[53] 31–50 y	48.2 (33.8)	52.3 (30.9)	+9	<0.01	0.08[f]	B
Rush et al. (2007)[59,e]	53.3 (9.5)	60.3 (8.5)	+13[d]	0.4	–	C
Sharpe et al. (2016)[60]	47.7 (8.0)	50.1 (7.8)	+5	0.04	–	C
Protein (% total energy)						
McIntyre et al. (2007)[15]	15.0 (NR)	14.8 (NR)	−2	0.0039	0.0386[g]	A
Tarasuk and Beaton (1999)[17]	15.8 (NR)	14.7[a] (NR)	−7	0.0009	0.0041[b]	A
Zizza et al. (2008)[39]	13.7[c] (NR)	14.0[c] (NR)	+2[d]	–	NR[c]	B
Johnson et al. (2014)[52,e]	15.7 (4.0)	16.4 (4.0)	+4	0.4	–	C
Kirkpatrick and Tarasuk (2008),[53] 19–30 y	15.7 (13.8)	14.7 (11.0)	−6	0.10	0.44[f]	B
Kirkpatrick and Tarasuk (2008),[53] 31–50 y	16.6 (20.3)	16.0 (13.3)	−4	0.38	0.99[f]	B
Rush et al. (2007)[59,e]	14.8 (1.9)	13.7 (3.2)	−7[d]	0.4	–	C
Sharpe et al. (2016)[60]	16.2 (4.3)	15.1 (3.2)	−7	0.05	–	C
Total fat (% total energy)						
Kendall et al. (1996)[13]	35.9 (NR)	36.6 (NR)	+2	0.56	–	C
Tarasuk and Beaton (1999)[17]	28.5 (NR)	28.1[a] (NR)	−1	0.0423	0.0876[b]	A
Zizza et al. (2008)[39]	33.3[c] (NR)	35.6[c] (NR)	+7[d]	–	NR[c,h]	B
Hilmers et al. (2014)[51]	32.2[i] (11.5)	31.0[i] (12.1)	−4	–	NR[i]	B
Johnson et al. (2014)[52,e]	37.3 (6.4)	33.5 (6.4)	−10	0.004	–	C
Kirkpatrick and Tarasuk (2008),[53] 19–30 y	30.4 (18.4)	31.1 (14.7)	+2	0.40	0.74[f]	B
Kirkpatrick and Tarasuk (2008),[53] 31–50 y	32.2 (27.0)	30.1 (26.5)	−7	0.09	0.13[f]	B
Rush et al. (2007)[59,e]	31.9 (10.6)	25.9 (7.0)	−19[d]	0.4	–	C
Sharpe et al. (2016)[60]	35.4 (5.9)	34.5 (6.4)	−3	0.27	–	C
Saturated fat (% total energy)						
Kendall et al. (1996)[13]	12.7 (NR)	12.7 (NR)	0	0.97	–	C
Zizza et al. (2008)[39]	11.0[c] (NR)	12.0[c] (NR)	+10[d]	–	NR[c,h]	B
Hilmers et al. (2014)[51]	11.0[i] (4.7)	10.7[i] (4.9)	−3	–	NR[i]	B
Johnson et al. (2014)[52,e]	12.6 (3.5)	11.7 (3.4)	−7	0.22	–	C
Sharpe et al. (2016)[60]	11.2 (2.5)	11.2 (2.8)	0	0.91	–	C
Fiber (g)						
Kendall et al. (1996)[13]	9.8 (NR)	8.1 (NR)	−17	0.03	–	C
Hilmers et al. (2014)[51]	15.1[i] (8.8)	15.1[i] (9.2)	0	–	NR[i]	B
Kirkpatrick and Tarasuk (2008),[53] 19–30 y	14.9 (18.4)	12.0 (9.2)	−19	<0.01	0.03[f]	B
Kirkpatrick and Tarasuk (2008),[53] 31–50 y	15.8 (27.0)	13.0 (15.5)	−18	<0.01	0.01[f]	B
Sharpe et al. (2016)[60]	13.4 (6.4)	12.8 (6.4)	−4	0.54	–	C

Unadjusted means except where noted otherwise. When intake was reported in only grams per day, the percentage contribution was estimated using the group mean (g/d), total energy (kcal/d), and the following conversions: 1 g carbohydrate = 4 kcal/g, 1 g protein = 4 kcal/g, 1 g total fat = 9 kcal/g, and 1 g saturated fat = 9 kcal/g. When total energy was reported in kilojoules, it was converted into kilocalories (1 kJ = 0.239 kcal). When standard error (SE) was reported, standard deviation (SD) was calculated using the SE and sample size. A negative value indicates that food-insecure women had lower intakes compared with food-secure women. *P* values and adjustment variables noted as reported. Information from the risk-of-bias assessment at the study level was used to determine quality rating (Table 2).

Abbreviaton: NR, not reported.

[a]The mean of the hunger (food-insecure) group was calculated using the mean of the no hunger (food-secure) group and the unadjusted intake difference.

[b]Adjusted *P* values (disposable income [adjusted for family size and composition], presence of employment income in the household, presence of a partner in the household, and woman's level of education, smoking status, and ethnoracial identity).

[c]Adjusted means and *P* values (age, ethnicity/race, education, and income).

[d]Difference calculated between the most food insecure and least food insecure group.

[e]Unpublished data provided via personal communication with corresponding author.

[f]Adjusted *P* values (income adequacy, respondent education, immigrant status, current daily smoking status, and household size).

[g]Adjusted *P* values (study site [Atlantic vs Toronto], education [postsecondary or degree], age of oldest child <4 y, daily smoker, presence of employment income, and number of children [>3]).

[h]$P < 0.05$.

[i]Adjusted means and *P* values (sociodemographic variables, body mass index score, and Supplemental Nutrition Assistance Program participation).

Table 7 **Percentage differences in daily intake of micronutrients (minerals and vitamins) between food-insecure and food-secure women**

Reference	Food secure, mean (SD)	Food insecure, mean (SD)	Percentage difference	Unadjusted *P* value	Adjusted *P* value	Quality rating
Calcium (mg)						
Kendall et al. (1996)[13]	731 (NR)	663 (NR)	−9	0.23	–	C
McIntyre et al. (2007)[15]	625 (404)	495 (287)	−21	0.0089	0.0497[a]	A
Tarasuk and Beaton (1999)[17]	560 (355)	459[b] (NR)	−18	0.0505	0.1071[c]	A
Hilmers et al. (2014)[51]	631[d] (365)	617[d] (385)	−2	NR	NR[d]	B
Kirkpatrick and Tarasuk (2008),[53] 19–30 y	881 (1319)	752 (891)	−15	0.02	0.33[e]	B
Kirkpatrick and Tarasuk (2008),[53] 31–50 y	832 (1305)	750 (1155)	−10	0.05	0.21[e]	B
Iron (mg)						
Kendall et al. (1996)[13]	10 (NR)	10 (NR)	−2	0.83	–	C
McIntyre et al. (2007)[15]	11 (6)	9 (4)	−15	0.0277	0.2082[a]	A
Tarasuk and Beaton (1999)[17]	12 (7)	9[b] (NR)	−23	0.0030	0.0122[c]	A
Hilmers et al. (2014)[51]	13[d] (6)	12[d] (6)	−3	–	NR[d]	B
Kirkpatrick and Tarasuk (2008),[53] 19–30 y	13 (14)	11 (7)	−16	<0.01	0.2[e]	B
Kirkpatrick and Tarasuk (2008),[53] 31–50 y	12 (14)	11 (11)	−10	0.03	0.11[e]	B
Park and Eicher-Miller (2014)[58]	15 (1)	15 (1)	−4	0.59	–	C
Magnesium (mg)						
McIntyre et al. (2007)[15]	228 (103)	196 (84)	−14	0.0178	0.0261[a]	A
Tarasuk and Beaton (1999)[17]	237 (100)	192[b] (NR)	−19	0.0033	0.0082[c]	A
Kirkpatrick and Tarasuk (2008),[53] 19–30 y	289 (290)	252 (185)	−13	<0.01	0.29[e]	B
Kirkpatrick and Tarasuk (2008),[53] 31–50 y	307 (311)	265 (243)	−14	<0.01	0.02[e]	B
Sodium (mg)						
Sharpe et al. (2016)[60]	3251 (1343)	3105 (1084)	−4	0.42	–	C
Hilmers et al. (2014)[51]	2555[d] (895)	2642[d] (945)	+3	–	NR[d]	B
Kirkpatrick and Tarasuk (2008),[53] 19–30 y	2769 (3589)	2568 (2220)	−7	0.29	0.39[e]	B
Kirkpatrick and Tarasuk (2008),[53] 31–50 y	2792 (3623)	2410 (2671)	−14	<0.01	0.02[e]	B
Folate (mg)						
Tarasuk and Beaton (1999)[17]	198 (116)	155[b] (NR)	−22	0.0085	0.0247[c]	A
Hilmers et al. (2014)[51]	356[d] (183)	328[d] (194)	−8	–	NR[d,f]	B
Kirkpatrick and Tarasuk (2008),[53] 19–30y	422 (510)	370 (370)	−12	0.04	0.35[e]	B
Kirkpatrick and Tarasuk (2008),[53] 31–50 y	424 (669)	378 (424)	−11	0.03	0.06[e]	B
Vitamin A (retinol activity equivalents)						
Kendall et al. (1996)[13]	5550[g] (NR)	6622[g] (NR)	+19	0.28	NR	C
McIntyre et al. (2007)[15]	743 (946)	432 (390)	−42	0.0001	0.0003[a]	A
Tarasuk and Beaton (1999)[17]	1339[h] (1684)	646[b,h] (NR)	−52	0.0006	0.0015[c]	A
Hilmers et al. (2014)[51]	563[d] (1223)	549[d] (1291)	−2	–	NR[d]	B
Kirkpatrick and Tarasuk (2008),[53] 19–30 y	603 (1195)	478 (874)	−21	<0.01	0.08[e]	B
Kirkpatrick and Tarasuk (2008),[53] 31–50 y	641 (1332)	575 (1272)	−10	0.10	0.44[e]	B
Vitamin C (mg)						
Kendall et al. (1996)[13]	96 (NR)	82 (NR)	−15	0.23	–	B
McIntyre et al. (2007)[15]	100 (82)	78 (64)	−22	0.0389	0.0405[a]	A
Tarasuk and Beaton (1999)[17]	108 (82)	81[b] (NR)	−25	0.028	0.1042[c]	A
Hilmers et al. (2014)[51]	70[d] (80)	69[d] (84)	−1	–	NR[d]	B
Kirkpatrick and Tarasuk (2008),[53] 19–30 y	136 (248)	109 (198)	−19	<0.01	0.08[e]	B
Kirkpatrick and Tarasuk (2008),[53] 31–50 y	117 (257)	109 (256)	−7	0.06	0.17[e]	B

Unadjusted means except where noted otherwise. When standard error (SE) was reported, standard deviation (SD) was calculated using the SE and sample size. A negative value indicates that food-insecure women had lower intakes compared with food-secure women. *P* values presented exactly as reported. Adjustment variables noted as reported. Information from the risk-of-bias assessment at the study level was used to determine quality rating (Table 2).

Abbreviaton: NR, not reported.

[a]Adjusted means and *P* values (study site [Atlantic vs Toronto], education (postsecondary or degree), age of oldest child <4 y, daily smoker, presence of employment income, and number of children [>3]).

[b]The mean of the hunger (food-insecure) group was calculated using the mean of the no hunger (food-secure) group and the unadjusted intake difference.

[c]Adjusted *P* values (disposable income [adjusted for family size and composition], presence of employment income in the household, presence of a partner in the household, and woman's level of education, smoking status, and ethnoracial identity).

[d]Adjusted means and *P* values (sociodemographic variables, body mass index score, Supplemental Nutrition Assistance Program participation, and energy intake).

[e]Adjusted *P* values (income adequacy, respondent education, immigrant status, current daily smoking status, and household size).

[f]$P < 0.05$.

[g]International units.

[h]Retinol equivalents.

Table 8 **Percentage differences in overall dietary quality for food insecure women compared to food secure women**

Reference	Food secure, mean (SD)		Food insecure, mean (SD)		Percentage difference	Unadjusted *P*-value	Adjusted *P*-value	If adjusted: β (SE)	Quality rating
HEI[63–65]									
Basiotis and Lino (2002)[37,a]	62.7	NR	58.8	NR	−6	NR[b]	–	–	C
Berkowitz et al. (2014)[44,c,d]	71.6	9.7	69.5	9.6	−3	0.0173	0.0462[e]	−1.7 (0.9)[e]	A
Duffy et al. (2009)[46,d]	NR	NR	NR	NR	NR	NR	–	–	B
Glanville and McIntyre (2006)[49,f]	NR	NR	NR	NR	NR	NR	–	–	A
Herman et al. (2002)[50,a]	64.6	14.1	65.5	14.6	+1	NR	–	–	B
Johnson et al. (2014)[52,d,g]	46.2	14.0	48.2	15.4	+4	0.5	–	–	C
AHEI[66–67]									
Gamba et al. (2016)[48,h]	40.9[i]	NR	42.6[i]	NR	+4	NR	NR[j]	0.3 (1.6)[j]	B
Sharpe et al. (2016)[60,k]	30.8	9.8	28.6	8.8	−7	0.65	–	–	C
DQI-P[68]									
Ward et al. (2011)[62,l]	NR	NR	NR	NR	NR	–	0.37[m]	−0.3 (0.3)[m]	C

Studies used different indices to measure overall dietary quality.[63–68] Parameter estimates (β) were from regression analyses modeling the association of food insecurity with overall dietary quality. Information from the risk-of-bias assessment at the study level was used to determine quality rating (Table 2).

Abbreviaton: AHEI, Alternate Healthy Eating Index; DQI-P, Diet Quality Index for Pregnancy; HEI, Healthy Eating Index; NR, not reported.

[a]HEI 1999–2000.

[b]Study indicated difference in HEI total score was statistically significant.

[c]HEI-2005.

[d]Unpublished data provided via personal communication with corresponding author.

[e]Adjusted *P* values (age, and income-to-poverty ratio).

[f]HEI for Canada accommodates Canadian dietary recommendations.

[g]HEI-2010.

[h]AHEI for pregnancy.

[i]Median scores.

[j]Adjusted *P* values (age, education, race/ethnicity, income, marital status, and nativity).

[k]Modified AHEI to exclude multivitamins.

[l]DQI-P.

[m]Adjusted *P* values (age and education).

negative, significant association ($P < 0.05$).[15,16] There were no high-quality studies for fruits only or vegetables only. For total energy, the association was inconsistent among the 3 high-quality studies.[15,17,44] One study found a positive, nonsignificant association ($p > 0.05$),[44] whereas 2 other studies found a negative, significant association ($p < 0.05$).[15,17] For carbohydrate, there was 1 high-quality study, which foujd a positive, significant association ($p < 0.05$).[17] For protein, there were 2 high-quality studies; both found a negative, significant association ($p < 0.05$).[15,17] For total fat, there was 1 high-quality study, which found a negative, significant association ($p < 0.05$) (unadjusted analyses only).[17] There were no high-quality studies for fiber. For calcium, iron, magnesium, vitamin A, and vitamin C, there were 2 high-quality studies. Both found negative associations, and significance varied by study.[15,17] There were no high-quality studies for potassium and vitamin D. For overall dietary quality, there were 2 high-quality studies: 1 study found no association,[49] and the other study found a negative, significant association ($P < 0.05$).[44]

Strengths in the body of evidence were related to the samples. Evidence came from racially/ethnically diverse, young- and middle-aged women living in Canada and the United States. Most studies (n = 20 of 24) were completed with low- and lower-income samples. Samples represented various women subgroups at increased risk of food insecurity. By compiling results for a more homogenous group (mostly low-income women), this review better summarized the association of food insecurity with dietary outcomes.[24] However, there were also weaknesses at the study and outcome level (Table 2; and Table S3 in the Supporting Information online, respectively). All studies analyzed cross-sectional data. Several studies used measures that compromised accuracy to minimize participant burden, and the measurement reduced the overall quality of the study. Nearly half of the studies did not provide control of confounding. Only 5 studies had congruent reference periods. There were weaknesses at the outcome level, such as having only 1 or 2 high-quality studies per outcome. Across all dietary outcomes, the quality of evidence was low.

DISCUSSION

Given that women's experiences of food insecurity are unique[2–4,11] and that diet may be an important mediator between food insecurity and adverse health outcomes,[22,25,26] this study fills a gap in the literature. The most important finding is that food-insecure women had lower intakes of 7 food groups and nutrients beyond those identified in a prior systematic literature review.[18] Hanson and Connor's[18] systematic literature review concluded that food-insecure adults in the United States had lower frequencies of dairy and total fruits and vegetables, and lower intakes of calcium, magnesium, and vitamin A. The present review, which is specific to women in Canada and the United States, finds support for those same associations (dairy, total fruits and vegetables, calcium, magnesium, and vitamin A) and extends the findings to these additional 7 food groups and nutrients: total grains, meats/meats alternatives, protein, total fat, iron, vitamin C, and folate. Results demonstrate that food insecurity negatively affects the entire diet—not only intake of fruits and vegetables or protein but also intake of all major food groups, macronutrients, and micronutrients. Overall, these findings are supported by previous research among Canadian and US adults.[19,53]

The second key finding is that food-insecure women on average had higher intakes of carbohydrates compared with food-secure women. For all other dietary outcomes, food-insecure women consistently reported lower food group frequencies and nutrient intakes. This result regarding carbohydrates is not surprising. Prior research supports that low-income and food-insecure women often opt for carbohydrate-rich foods, such as pasta and bread, to minimize food costs.[69] Econometric research also indicates that carbohydrate-rich foods, particularly refined grain products, are often the most affordable foods.[70]

Third, the associations of food insecurity with micronutrients were found to be extremely consistent. Although the association with micronutrients ($n = 3–6$ studies per dietary outcome) was reported for fewer studies, all of the studies found that food-insecure women on average had lower intakes of calcium, iron, magnesium, and folate. This finding is noteworthy given women's unique dietary needs for iron and folate.[71] For women, iron and folate are critical nutrients during conception, pregnancy, and breastfeeding.[71] Dietary guidelines in the United States describe iron as a nutrient of public health concern for pregnant women and those who may become pregnant for preventing iron-deficiency anemia and stress the importance of folate for preventing neural tube defects in pregnant women.[71]

A few items warrant additional discussion. First, the included studies were heterogeneous in terms of study designs, samples, methods (measures and analytic techniques), and timing. The heterogeneity offers an explanation for why some studies found larger or statistically significant differences between food-insecure and food-secure women and other studies did not. Second, despite a comprehensive search of peer-reviewed and gray literature, relatively few high-quality studies were identified. Three Canadian studies were exceptional.[15–17,53] These studies had higher methodological quality relative to others (Table 2).[15–17,53] Additionally, more consistent and statistically significant associations were reported.[15–17,53] Although food insecurity may have a more pronounced influence on dietary outcomes among Canadian versus US adults,[20] it is also possible that the higher quality studies—with better measures, agreement in reference periods for food insecurity and dietary assessment, and control of confounding—captured true differences between food-insecure and food-secure women. Second, 1 US study consistently found associations in the opposite direction[39]; specifically, the authors found that food-insecure women had greater intakes of total energy, protein, and total fat and lower intakes of carbohydrate relative to food-secure women.[39] This may be due to their sample (of National Health and Nutrition Examination Survey [NHANES] respondents) not representing the target population.

This review has limitations, such as restricting studies to the English language, and only having 1 reviewer, which increased the risk of bias. At the same time, limitations of the included studies themselves (eg, quality of the measures, incongruence in reference periods, and not controlling for confounding) and in the quality of evidence for individual dietary outcomes are acknowledged. Generally, there were only 1 or 2 high-quality studies per dietary outcome. Although the included studies represented women of different ages, racial/ethnic backgrounds, and geographic areas, only 4 studies focused on rural women.[13,52,61,62] Lastly, there was not one common dietary outcome across all studies. This was addressed by calculating a percentage difference to summarize and compare associations across studies.

Strengths of the review relate to the comprehensive search methodology and risk-of-bias assessment. This review applied IOM recommendations to search 4 transdisciplinary databases and the gray literature, which minimizes publication bias. As part of the gray literature search, the authors of this review collaborated with other researchers to identify unpublished analyses. This review benefits from the inclusion of subanalyses from 9 previously unpublished studies.[44,45,52,54–57,59,61] Together, these efforts resulted in more complete retrieval of identified research and summary of the available evidence from 24 studies in Canada and the United States. In comparison, Hanson and Connor's[18] systematic literature review was limited to PubMed/MEDLINE, ProQuest, and JSTOR databases and typical gray literature sources (Google Scholar and the library catalog); they identified 13 studies with US adults. Their review did not include a risk-of-bias assessment. A detailed risk-of-bias assessment documents the methodological quality of the included studies and the quality of evidence for outcomes. This step is essential for characterizing the evidence base and identifying future research opportunities.

A need for high-quality, prospective studies on food insecurity and diet, particularly in rural areas, remains. Future studies can benefit from congruent, carefully timed assessments of food insecurity and diet, as well as contextual data to understand whether food insecurity was episodic or persistent and the proximal causes. Especially for low-income households, noticeable changes occur within a monthly period as economic resources diminish.[9,10] Prior research has documented changes in household food inventory[72,73] and decreases in women's nutrient intakes within a monthly period.[74] Future studies might consider including a common dietary outcome, such as the HEI, to ease comparison across studies. In the current review, use of HEI was reported for only 6 studies, even though the HEI has existed since 2000.[63] Anecdotally, HEI was not widely adopted because of its complex scoring algorithm.[65,75] But, with updates to the Nutrition Data System for Research (NDSR; eg, added the solid fat variable in 2014) and step-by-step instructions,[76] more studies may use HEI in the future. A final opportunity is to focus on rural populations. The majority of included studies were completed in urban areas, and only 4 studies recruited participants from rural areas.[13,52,61,62] Where people live matters, and research shows important differences for rural, urban, and suburban areas.[77]

CONCLUSION

In conclusion, this review systematically evaluated evidence for food insecurity and diet among adult women taken from 24 published and unpublished studies in Canada and the United States. This review is the most comprehensive to date. Among studies of relatively high quality, food insecurity was negatively and significantly associated with lower frequencies of dairy, total fruits and vegetables, total grains, and meats/meats alternatives; lower intakes of protein and total fat; and lower intakes of calcium, iron, folate, magnesium, and vitamins A and C. Findings from this review can be used to select nutritional targets in public health programs and prioritize policies to improve access to a variety of nutrient-rich foods, especially for women at increased risk of food insecurity (eg, low-income women and those in female-headed households).[1] Across studies, results showed food insecurity was consistently and negatively associated with micronutrients, including folate and iron, which are especially important for women who are pregnant and breastfeeding.[71] These findings, related to micronutrients in particular, support food insecurity screening for pregnant women and those who may become pregnant. This review also offers general support for existing food assistance and nutrition programs, such as the Supplemental Nutrition Assistance Program (SNAP) and the Special Supplemental Nutrition Program for Women, Infants, and Children (WIC), that address food insecurity and improve dietary quality among low-income women.[78] SNAP and WIC are essential programs for mitigating food insecurity's effects among low-income women, but they are insufficient. Social and policy changes are needed to make it easier for everyone to access a variety of nutrient-rich foods.

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Supporting Information

The following Supporting Information is available through the online version of this article at the publisher's website.

Appendix S1 **PRISMA checklist**

Appendix S2 **Sources of gray literature**

Appendix S3 **Operationalization of food secure and food insecure categories**

Appendix S4 **GRADE evidence profile**

Appendix S5 **Percentage differences in Healthy Eating Index (HEI) components**

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