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Food Insecurity and Mental Health: A Meta-Analysis

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Abstract Cover Page

Food Security and Mental Health: A Meta-Analysis

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B.A. Anthropology
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2015

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An abstract of
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Abstract

Food Security and Mental Health: A Meta-Analysis
By Anna Grace Tribble

Background: A growing body of literature investigates whether food insecurity is related to common mental disorders (CMD). This paper aims to characterize the association between food insecurity and CMD across studies.

Methods: We performed a PubMed search for relevant articles published between January 2000 and December 2018. Only studies of adult participants (>=18 years) were eligible. Data extracted from each published study included the food insecurity and mental health variables, the relevant point estimates, confidence intervals, and standard errors. We completed five random-effects meta-analyses to quantify the associations between food insecurity and various CMD-related outcomes. The results of each meta-analysis were expressed as meta-odds ratios (meta-ORs) and corresponding 95% confidence intervals (CIs). Inter-study heterogeneity was assessed by calculating an I_2 statistic.

Findings: Of 2,014 candidate records, 110 were suitable for inclusion in a meta-analysis. Food insecurity was associated with greater odds of depressive symptoms (81 studies, 304,405 participants; meta-OR 2·35, 95% CI 2·14–2·59, I_2=95%), anxiety symptoms (16 studies, 93,997 participants; meta-OR 1·78, 95% CI 1·49–2·13, I_2=71·80%), post-traumatic stress (5 studies, 5,838 participants; meta-OR 1·81, 95% CI 1·54–2·13, I_2=0%), psychosocial stress (9 studies, 17,110 participants; meta-OR 2·39, 95% CI 1·90–3·00, I_2=45%), and self-reported poor mental health or unspecified CMD (36 studies, 396,848 participants; meta-OR 2·40 95% CI 2·02–2·86, I_2=98%).

Interpretation: Food insecurity is related to CMD. Future research should explore directionality, possible causal mechanisms, and opportunities for interventions.

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Introduction

Common mental disorders (CMD) comprise two globally prevalent diagnostic categories: depressive disorders (e.g., major depressive disorder and dysthymia) and anxiety disorders (e.g., generalized anxiety disorder [GAD] and post-traumatic stress disorder [PTSD]).[1] Current estimates place the number of people suffering from depression and anxiety at 322 million and 264 million, respectively.[1] As such, major depressive disorder is now the second leading cause of years lived with disability, while anxiety disorders rank ninth.[2] Moreover, the damage these disorders inflict extends beyond the individual as their projected global cost exceeds US $1 trillion annually.[3]

Although the causes of CMD are multifactorial and their consequences are numerous, several papers suggest a specific link between food insecurity and both anxiety and depression.[4–7] Notably, food insecurity is a far more expansive concept than hunger, which refers only to undernutrition or the physiological sensation associated with insufficient dietary intake. Individuals are considered food insecure when they have limited or inconsistent access to "sufficient, safe and nutritious food that meets their dietary needs and food preferences for an active and healthy life".[8] In this sense, then, certain aspects of the food insecurity experience are necessarily subjective. Although precise estimates are unavailable, it can generally be presumed that the number of people facing food insecurity exceeds the 821 million who are chronically undernourished.[8]

Some of the earliest studies on food insecurity and CMD come from the turn of the 21st century,[9–11] but interest in the relationship has expanded over the past decade. This is apparent in the observation that a systematic review in 2009 identified only 16 quantitative studies on the topic,[6] while the search conducted for this publication generated 110 relevant

studies. In addition, many of the studies included in the previous review were completed before the widespread adoption of so-called experience-based scales,[12] which align more closely with current understandings of food insecurity than earlier measures. In view of the expanded body of literature, this meta-analysis aims to characterize the relationship between food insecurity and mental health using the most current data.

Methods

Search Strategy and Selection Criteria

The PubMed database was searched for English-language articles published between January 2000 and December 2018. Each search specified a single food insecurity term and a single mental health term using the AND function. The search terms for food insecurity were "food security," "food insecurity," "food scarcity," "food sufficiency," "food insufficiency," and "hunger". The mental health search terms were "mental health," "common mental disorder," "CMD," "depression," "depress*," "anxiety," "mood disorder," "psychosocial," "post-traumatic stress disorder," "PTSD," "stress," "panic," and "distress." Each search also included three exclusion terms specified using the NOT function: "bulimia," "anorexia," and "eating disorder". Duplicate records identified from each search were eliminated using Mendeley Citation Manager. No unpublished studies were identified during the search process.

The publications were screened by reviewing titles and abstracts. Articles were excluded if their titles or abstracts focused on eating disorders, chronic disease management, obesity and weight loss, the neurological aspects of satiety, dementia, or suicide. Publications with full texts in a language other than English were also excluded. Two co-authors each completed a full text review of all retained articles. Disagreements were resolved by

consensus. Studies retained for the systematic review were then evaluated for inclusion in the quantitative meta-analyses based on the following exclusion criteria: only bivariate results, only continuous outcomes, lagged outcomes from a period far in the past (e.g., childhood), or only multilevel outcomes.

As used here, mental health refers not only to clinical diagnoses of CMD but also to scale-based appraisals of anxiety, depression, PTSD, psychological distress, and psychosocial stress collected in the field. Although psychological distress is not a diagnostic category, such scales are generally structured around self-reported symptoms and intended to identify probable cases of CMD (e.g., Kessler-10). Similarly, many of the social factors that leave individuals vulnerable to CMD also foment psychosocial stress, which may itself be antecedent to the development of depression or anxiety.[13] Food insecurity measures were taken to include experience-based scales as well as specific questions addressing specific aspects of insufficient food access (e.g., hunger, forgoing meals). Anthropometric measures (e.g., mid-upper arm circumference) were not included as stand-ins for food insecurity because this would conflate definition (food insecurity) and outcome (malnutrition).

Data Analysis

The main measure of interest in each study was an adjusted odds ratio and the corresponding 95% confidence interval from a multivariate logistic regression testing the association between food insecurity and mental health. Prevalence ratios and risk ratios were also included, if available. When more than one point estimate was reported for a given association, we selected the most adjusted measure. When point estimates were reported for multiple variable levels (e.g., mild and severe food insecurity), the data for the

most severe level were used. Where results were reported for more than one sample, the most inclusive group was chosen (e.g., parents rather than mothers and fathers). We extracted the information form each article that met eligibility criteria: publication year, authors, study type, sample size, study site, sampling strategy, target population, food insecurity measure(s), and mental health measure(s).

Meta-analyses were conducted in R Version 1.2.1335 using the *metafor* package. Separate meta-analyses were conducted for five different outcomes: depression, anxiety, PTSD, psychosocial stress, and self-reported poor mental health or unspecified CMD (e.g., psychological distress or a composite measure of multiple diagnosed disorders). When categorizing studies among these outcomes, we examined the content of the scales and questions used rather than deferring to the authors' own terminology (Appendix). All results were expressed as meta-odds ratios (meta-ORs) with corresponding 95% CIs. All meta-analyses were assessed for heterogeneity with the I_2 statistic. Except for PTSD, all meta-analysis results were obtained using random-effects models; low inter-study heterogeneity among PTSD papers allowed for the use of a fixed-effects model.[14–16] Because odds ratios, prevalence ratios, and risk ratios were pooled, we conducted a sensitivity analysis for the meta-regression of food insecurity and depression by removing all studies reporting prevalence ratios and risk ratios.

Trim-and-fill analyses were used to assess for publication bias. The trim-and-fill method estimates the number of missing studies (based on the asymmetry of the funnel plot) that might exist in a meta-analysis and provides an adjusted pooled estimate that accounts for the effect of those missing studies.[17] By examining both the estimated number of missing studies and the updated pooled estimate, we can gauge the effects of publication bias.

To assess each study's methodological strength, we adapted the Ottawa- Newcastle Scale for Study Quality.[18] We restated the 5 most relevant concerns about methodological quality in the affirmative and ranked each article based on how many favorable design characteristics it included.[18] The five characteristics were (1) a systematic sampling strategy not based on convenience or snowball sampling, (2) use of a validated food insecurity scale, (3) use of a validated mental health scale, (4) clear operationalizations of food insecurity and mental health (e.g., binary cut-off score specified), and (5) estimates from an adjusted multivariate regression. High quality studies were those that included all 5 favorable characteristics. Following administration of the Ottawa-Newcastle Scale, we conducted sub-analyses restricted to high-quality studies. Depression and CMD were the only outcomes with a sufficient number of high-quality papers to allow for sub-analyses.

Results

A total of 3,954 records were identified through electronic searches. After removing duplicates, 2,014 articles were screened based on their titles and abstracts (Figure 1). The full texts of the 511 remaining articles were reviewed for eligibility using the exclusion criteria outlined in the methods section. Following those exclusions, the final meta-analyses drew on 110 articles (Appendix). These articles examined the relationship between food insecurity and depression (n=81), anxiety (n=16), PTSD (n=5), psychosocial stress (n=9), and self-reported poor mental health or unspecified CMD (n=36). High-quality sub-analyses were conducted for depression (n=9) and CMD (n=9).

The meta-OR reflecting the association between food insecurity and depressive symptoms was 2·35 (95%: CI 2·14-2·59) for all studies and 2·52 (95% CI: 1·95-3·25) among high-quality studies (Figure 2), but the results were highly heterogeneous with both I_2 >80%

(Table 1). When using the trim-and-fill approach, the corresponding meta-ORs (95% CIs) attenuated to 1·93 (1·74-2·15) and 1·86 (1·30-2·67) for all studies and high-quality studies, respectively.

We conducted a sensitivity analysis for the association between food insecurity and depression by removing studies that reported prevalence ratios or risk ratios. The meta-OR was 2·45 (95% CI: 2·22-2·71). The I_2 estimates remained above 80% (Table 1). In the trim-and-fill analyses, the meta-OR was 2·00 (95% CI: 1·81-2·23).

The second meta-analysis tested the association between food insecurity and anxiety. The meta-OR for this association was lower than that for food insecurity and depression at 1·78 (95% CI: 1·49-2·13) for all studies (Figure 3), but the results were moderately heterogeneous (I_2=72%) (Table 1). When using the trim-and-fill approach, the corresponding meta-OR (95% CI) lessened to 1·66 (1·38-1·99).

The meta-OR representing the association between food insecurity and PTSD was 1·81 (95% CI: 1·54-2·13) when pooled across all studies (Figure 4), and the results were homogenous (I_2=0%) (Table 1). When using the trim-and-fill approach, the corresponding meta-OR (95% CI) attenuated to 1·71 (1·49-1·97).

The meta-OR testing the association between food insecurity and psychosocial stress equaled 2·39 (95% CI: 1·90-3·00) for all studies (Figure 5), but the results were moderately heterogenous (I_2=45%) (Table 1). When using the trim-and-fill approach, the corresponding meta-OR (95% CI) did not change.

The final meta-analysis tested the association between food insecurity and self-reported poor mental health or unspecified CMD. The meta-OR was 2·40 (95% CI: 2·02-2·86) for all studies and 3·01 (95% CI: 2·46-3·69) among high-quality studies (Figure 6). The results

were highly heterogeneous ($I_2 > 80\%$) and moderately heterogeneous ($I_2 > 60\%$), respectively (Table 1). When using the trim-and-fill approach, the corresponding meta-ORs (95% CIs) were reduced to 1·95 (1·60-2·36) and 2·94 (2·40-3·61) for all studies and high-quality studies, respectively.

Discussion

The meta-analyses presented in this article demonstrate significant, positive associations between food insecurity and depression, anxiety, PTSD, psychosocial stress, and self-reported poor mental health or unspecified CMD. These associations appear to be independent of confounding factors, such as household income, education, and employment status. There was substantial heterogeneity across results indicating that a single meta-estimate may not support robust inference. Moreover, there was evidence of publication bias, with several authors referring to unpublished results that were not statistically significant. Nevertheless, the effect size reductions suggested by trim-and-fill analyses were always small, and all results retained their statistical significance.

The studies included in the meta-analyses were primarily cross-sectional. When longitudinal studies were available, the variables of interest were frequently not the same as those time lagged. Many studies collected data on food insecurity and mental health during the same stage of data collection, effectively making them cross-sectional. In addition, several studies relied on fairly short follow-up periods (e.g., the length of a pregnancy). These issues limit conclusions about the directionality of the relationship between food insecurity and poor mental health. Additional longitudinal studies that clearly assess the effects of both previous and current food insecurity on multiple mental health variables are warranted.

There was a marked lack of consistency in measurement approach (Table 3, Appendix). Measurement tools for food insecurity ranged from a single question regarding concern over one's food resources to the USDA's 18-item Household Food Security Survey Module,[19] which parses response patterns into four different severity levels. As a result, differing degrees of food insecurity were necessarily lumped together during meta-analyses. The mental health measures were similarly diverse and their use often based on authors' personal analytic preferences rather than validated cut-points. These inconsistencies pose problems for the meta-analysis, and likely increased the inter-study heterogeneity. The adoption of international measurement guidelines would substantially improve interdisciplinary communication on the topic.

Although the meta-analyses were based on a geographically diverse group of papers, the studies were predominantly conducted in the United States (43·2%) or Canada (14·4%). Future research should explore geographic and sociocultural diversity to more fully understand causal mechanisms between food insecurity and mental health. The links between them may vary dependent on local food systems, gender norms, and the other resource pressures present.[20–23]

Future studies should also move away from simply documenting the relationship between food insecurity and poor mental health, and instead focus on understanding the mechanisms that connect these two phenomena.[24] For example, reduced access to food's sociocultural value may generate feelings of shame, subordination, powerlessness, and exclusion that contribute to the development of mood disorders.[24,25] There is also growing evidence that *relative* food insecurity influences the strength of the relationship between food insecurity and poor mental health.[26–28] In addition, it is possible that restricted access to food's

nutritional content leads to CMD because of its associations with micronutrient undernutrition; micronutrient levels,[29,30] micronutrient supplementation,[31] and diet quality[32] have been implicated in CMD risk and severity to varying degrees. Alternatively, mental illness may threaten individuals' socioeconomic capacity, thereby placing them at risk for food insecurity. In such instances, the relationship between food insecurity and mental health would be aligned more closely with social selection and drift hypotheses.[5] Healthcare providers should be made aware that food insecurity may be accompanied by poor mental health, especially in communities at high risk for either. For example, a recent study found that a minority of US hospitals (35·5%) and physician practices (27·8%) screen for food insecurity.[33] Policymakers should consider food insecurity's relationship to mental health when developing and providing support for nutrition assistance programs and other interventions intended to alleviate poverty, food insecurity, or common mental disorders.

Panel: Research in context

Evidence before this study

Research suggests that poverty and CMD are linked and that this association may be bi-directional.[6] The experiences accompanying poverty (e.g., social exclusion, malnutrition) increase CMD risk even as CMDs limit the capacity of the poor to cope with economic adversity.[4,5,34] However, less is known about the associations between CMD and specific dimensions of poverty. While some poverty-related variables appear to be consistent predictors of CMD (e.g., social class, financial stress, education), the evidence for an association between CMD and other seemingly more direct measures of poverty is mixed (e.g., income, consumption, employment).[4] Prior to this paper, no attempts had yet

been made to quantify the association between food insecurity and CMD outcomes across studies.

Added value of this study

This is the first meta-analysis of the social epidemiological literature systematically evaluating the relationship between food insecurity and poor mental health.

Implications of all the available evidence

This review encourages scholars to turn their attention away from cross-sectional studies that seek to establish the existence of a connection between food insecurity and poor mental health; future research should instead focus on understanding the social and biological mechanisms underpinning this bidirectional relationship.

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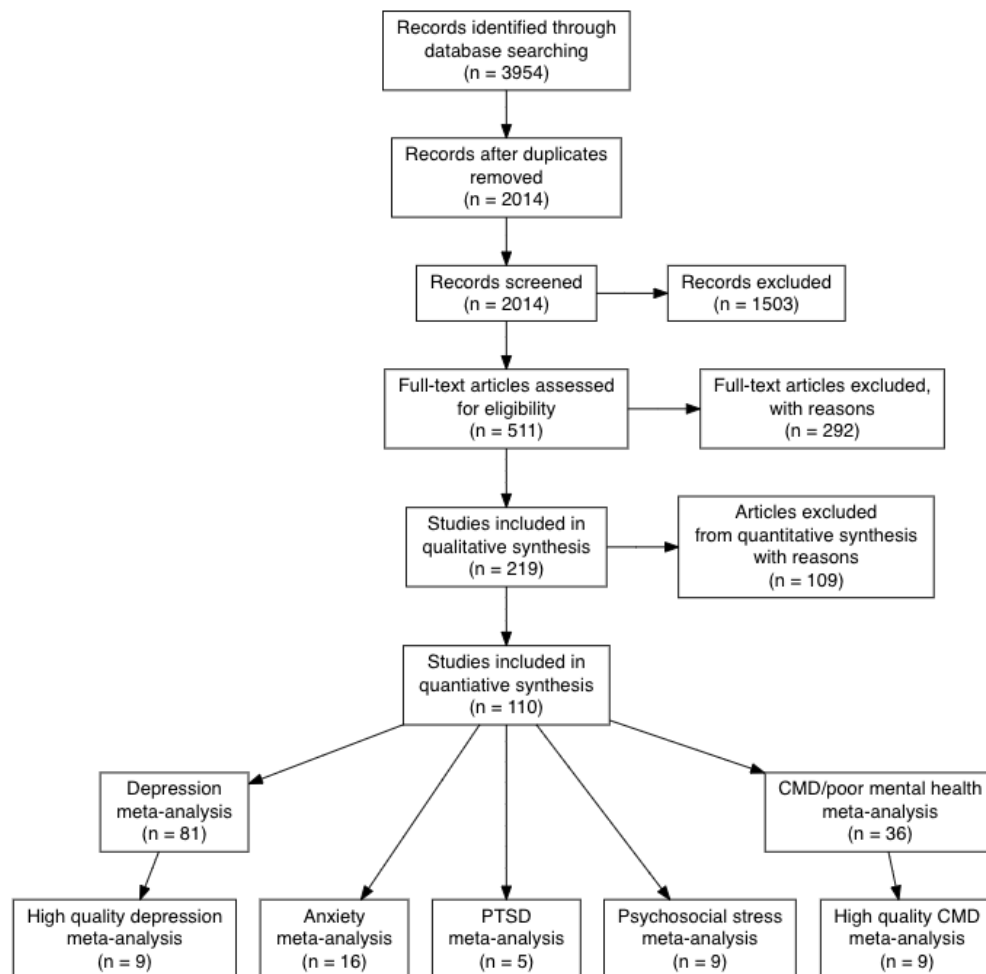
Figure 1. PRISMA flow diagram illustrating the study inclusion/exclusion process for the systematic review and meta-analysis. The full texts of the 511 remaining articles were reviewed for eligibility using the exclusion criteria outlined in the methods section. Exclusions (n=292) based on full-text assessment were distributed as follows: no clearly defined measure of food insecurity (n=47), no clearly defined measure of mental health (n=99), no reported test of the association between food insecurity and mental health (n=70), results reported for a combined sample of adults and adolescents/children (n=26), no quantitative data reported (n=24), no original data reported (i.e., review articles) (n=24), and main article not in English (n=2). Articles were then further excluded for the following reasons: reporting only bivariate or unadjusted results (n=26), using continuous variables for food insecurity or mental health (scale diversity prevents comparison of beta coefficients) (n=57), treating food insecurity or mental health as a multilevel outcome variable in multinomial ordinal regressions (n=22), or having a lagged predictor variable far in the past (e.g., childhood hunger) (n=4). Following those exclusions, the final meta-analyses drew on 110 articles.

AuthorYear	Sample Size		Odds Ratio [95%CI]
Garg2015	2917		1.50 [1.06, 2.12]
DeCastro2017.1	4239		1.58 [1.39, 1.79]
DeCastro2017.2	4239		1.75 [1.29, 2.38]
Montgomery2017.3	6731		2.00 [1.01, 3.95]
Hernandez2014	1690		2.03 [1.45, 2.84]
Whitaker2006	2870		2.20 [1.63, 2.96]
Tong2018	350		3.01 [1.69, 5.37]
Montgomery2017.1	1520		3.10 [1.42, 6.78]
Leung2015	3518		3.42 [2.61, 4.49]
Montgomery2017.2	1685		3.90 [1.70, 8.97]
Ezzeddin2018	325		6.69 [3.12, 14.35]
Gebreyesus2018	3091		12.50 [4.02, 38.88]
Overall			2.52 [1.95, 3.25]

0 5 10 15 20 25 30 35 40

Figure 2. Forest plot of meta-analysis results showing the relationship between food insecurity and depression in high-quality observational studies (N=12 outcomes, 9 studies). De Castro (2017) presents data for low socioeconomic status participants separately from middle and high socioeconomic status participants. Montgomery (2017) presents data separately for diabetics and prediabetics. Substantial inter-study heterogeneity was present with an I_2 of 81%.
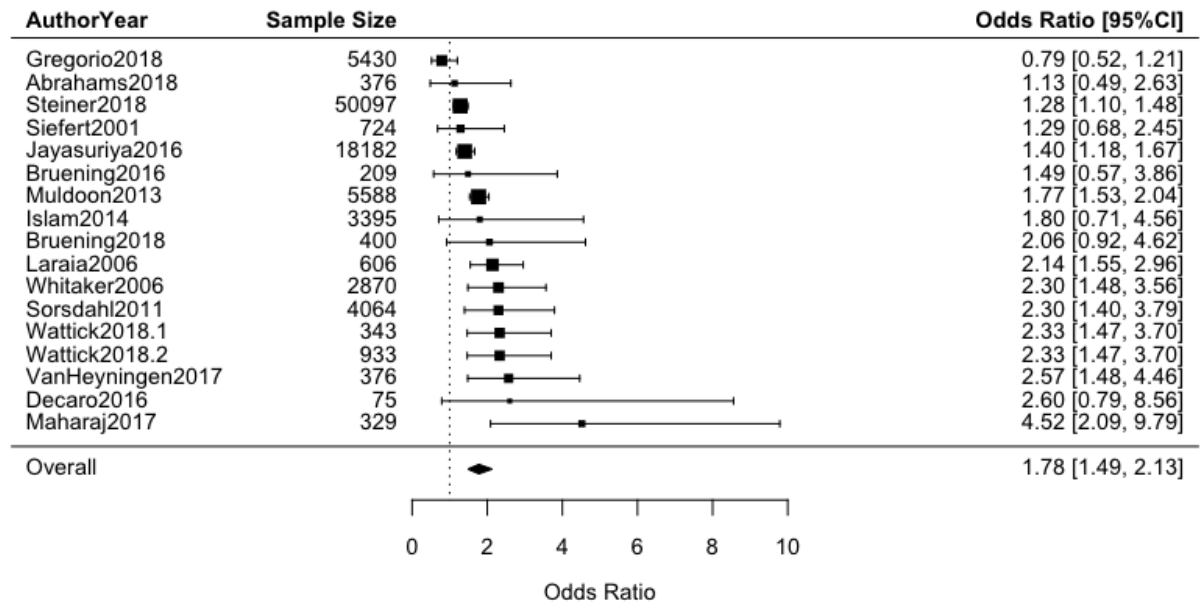
Figure 3. Forest plot of meta- analysis results showing the relationship between food insecurity and anxiety in observational studies (N=17 outcomes, 16 studies). Wattick (2018) separates male and female students. Moderate inter-study heterogeneity was present with an I_2 of 72%.

AuthorYear	Sample Size		Odds Ratio [95%CI]
Golin2016	1008		1.64 [1.16, 2.32]
Mugisha2015b	2361		1.74 [1.33, 2.28]
Clay2018a	737		1.80 [0.97, 3.35]
Seino2008.2	617		1.86 [1.07, 3.23]
Seino2008.1	555		2.04 [1.45, 2.88]
Pitpitan2013	560		2.10 [1.06, 4.16]
Overall			1.81 [1.54, 2.13]

Odds Ratio
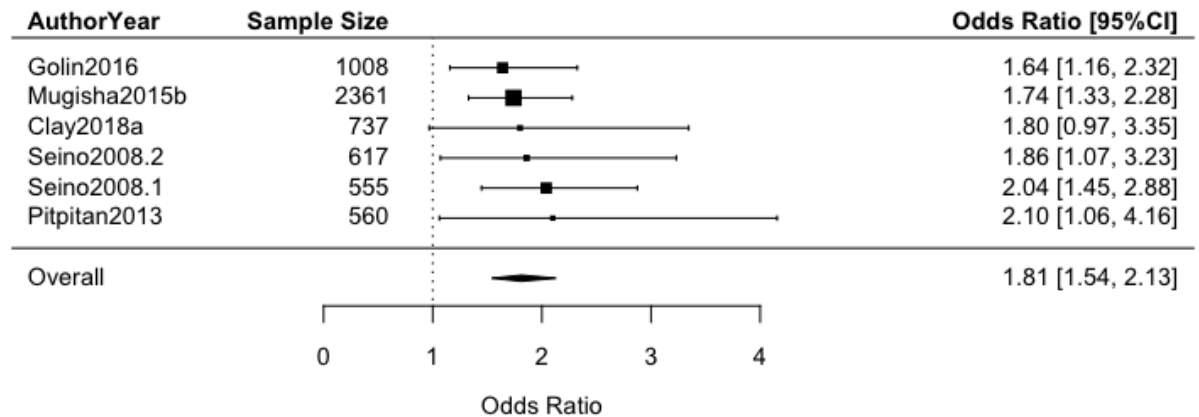
Figure 4. Forest plot of meta- analysis results showing the relationship between food insecurity and PTSD in observational studies (N=6 outcomes, 5 studies). Seino (2008) separates participants based on those who did and did not experience armed conflict. No inter-study heterogeneity was present with an I_2 of 0%.

AuthorYear	Sample Size	Odds Ratio [95%CI]
Bruening2016	209	1.42 [0.77, 2.61]
Bruening2018	1138	1.69 [1.16, 2.46]
Chung2016	5862	1.96 [1.08, 3.54]
Weigel2016	794	2.14 [1.00, 4.59]
Laraia2006	606	2.24 [1.63, 3.08]
Garcia2013	232	2.85 [0.89, 9.13]
Kaiser2007	4037	3.10 [2.49, 3.85]
Willows2011	837	3.13 [1.44, 6.79]
Islam2014	3395	5.80 [2.67, 12.58]
Overall		2.39 [1.90, 2.99]
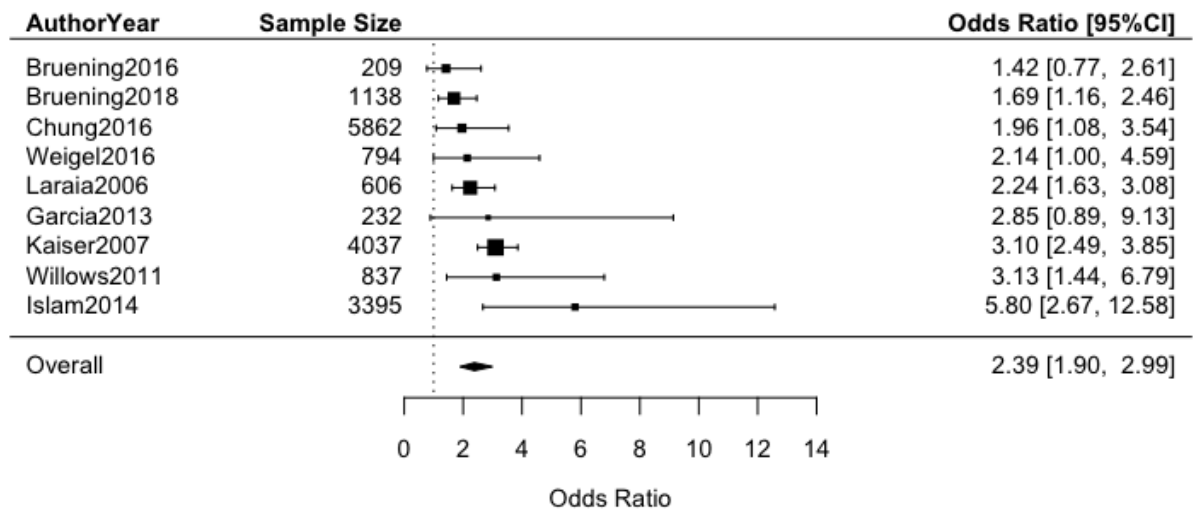
Figure 5. Forest plot of meta-analysis results showing the relationship between food insecurity and psychosocial stress in observational studies (N=9 outcomes, 9 studies). Moderate inter-study heterogeneity was present with an I_2 of 45%.
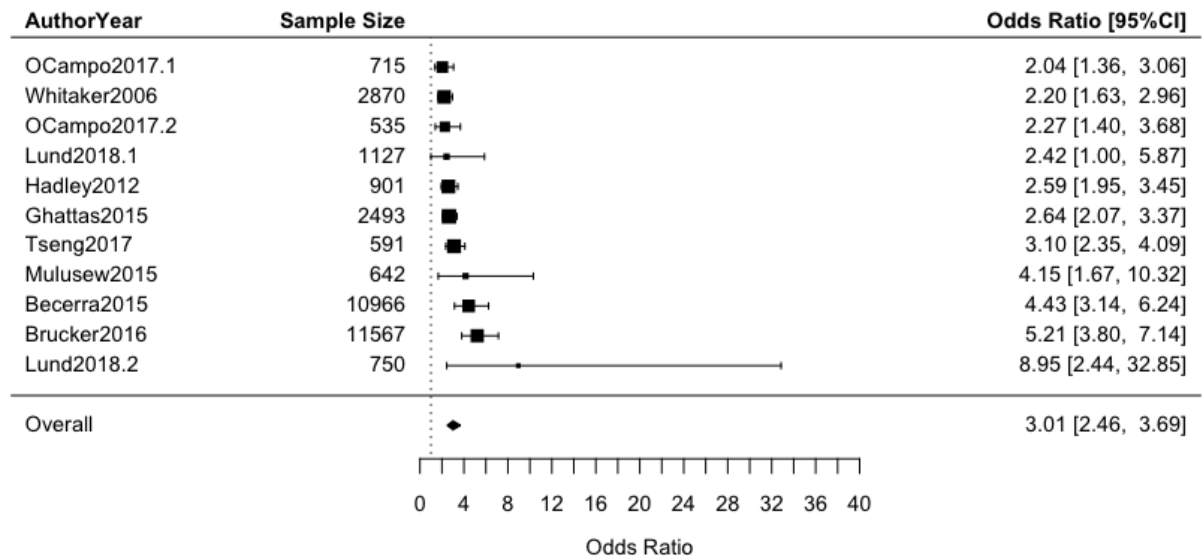
Figure 6. Forest plot of meta- analysis results showing the relationship between food insecurity and self-reported poor mental health or unspecified common mental disorder in high-quality observational studies (N=11 outcomes, 9 studies). O'Campo (2017) reports results separately for moderate and high needs homeless people. Moderate heterogeneity existed with an I_2 of 65%.

Outcome, Type of Analysis	Original Analysis			Trim-and-Fill Analysis	
	Studies	Meta-OR (95% CI)	I_2	Studies	Meta-OR (95%CI)
Depression, all studies	81	2·35 (2·14-2·59)	95%	109	1·93 (1·74-2·15)
Depression, high-quality studies	9	2·52 (1·95-3·25)	81%	14	1·86 (1·30-2·67)
Depression, sensitivity analysis*	74	2·45 (2·22-2·71)	92%	101	2·00 (1·81-2·23)
Anxiety, all studies	16	1·78 (1·49-2·13)	72%	19	1·66 (1·38-1·99)
PTSD, all studies	5	1·81 (1·54-2·13)	0%	8	1·71 (1·49-1·97)
Psychosocial stress, all studies	9	2·39 (1·90-3·00)	45%	9	2·39 (1·90-3·00)
Poor mental health**, all studies	36	2·40 (2·02-2·86)	99%	46	1·95 (1·60-2·36)
Poor mental health**, high-quality studies	9	3·01 (2·46-3·69)	65%	10	2·94 (2·40-3·61)

Table 1. Results of all meta-analyses.

* Excludes studies that reported risk ratios and prevalence ratios (sensitivity analysis),

** Self-reported poor mental health or unspecified common mental disorder.

Appendix

Authors	Study Type	Size	Study Site	Sampling	Population	Food Security Measure(s)	Mental Health Status Measure(s)	Quality Score (of 5)
Siefert et al. (2001)[9]	cross-sectional	724	USA	random	Eligible single mothers in an urban Michigan county	food insufficiency	depressive symptoms; anxiety	4
Patel et al. (2002)[11]	longitudinal	270	India	recruitment	Women in their last trimester of pregnancy	antenatal hunger	postnatal depression	2
Vozoris et al. (2003)[10]	cross-sectional	81,581	Canada	random	Canadians	food insufficiency	depressive symptoms; distress	3
Siefert et al. (2004)[35]	longitudinal	676	USA`	random	African American and white women who were welfare recipients in 1997	food insufficiency at time 2	depressive symptoms at time 2	4
Casey et al. (2004)[36]	cross-sectional	5,306	USA	convenience	Female primary caregivers of children ages 0 to 3 years who visited emergency dept	food insecurity	depressive symptoms	2
Whitaker et al. (2006)[37]	cross-sectional	2,870	USA	random	Mothers of children aged 3	food insecurity	depressive symptoms anxiety; depression or anxiety	5
Laraia et al. (2006)[38]	cross-sectional	606	USA	recruitment	Women before 20 weeks gestation at less than 400% federal poverty line	food insecurity	perceived stress; depressive symptoms; anxiety	4
Patel et al. (2006)[39]	cross-sectional	2,494	India	random	Women ages 18 to 45 years	hunger	common mental disorders	3
Siefert et al. (2007)[40]	cohort	824	USA	random	Low income African American mothers over 18	food insufficiency	depressive symptoms	4
Weigel et al. (2007)[41]	cross-sectional	100	USA	convenience	Farmworkers	food insecurity	depressive symptoms	3
Seino et al. (2008)[42]	cross-sectional	555 617	Afghanistan	random	Mothers of children less than 5 years	food insecurity among women who did or did not experience armed conflict	PTSD among women who did or did NOT experience armed conflict	4
Wu et al. (2008)[43]	cross-sectional	78	Peru	recruitment	Women living with HIV	food scarcity	depressive symptoms	3
Melchior et al. (2009)[44]	cohort	360	UK	random	Mothers	food insecurity	depressive symptoms	4

Rajkumar et al. (2009)[45]	cross-sectional	1,000	India	random	elderly people over 65 years	hunger	depressive symptoms	4
Anema et al. (2010)[46]	cross-sectional	1,053	Canada	convenience	People who injected illicit drugs in the last month	hunger	depressive symptoms	4
Anema et al. (2011)[47]	cross-sectional	457	Canada	convenience	Adults older than 18 years and antiretroviral naive prior to beginning HAART	food insecurity	depressive symptoms	4
Carter et al. (2011)[48]	cross-sectional	18,090	New Zealand	random	Adults	food insecurity	moderate to high psychological distress	4
Kollannoor et al. (2011)[49]	cross-sectional	185	USA	convenience	Latinos living in Hartford, CT with Type 2 diabetes	food insecurity	depressive symptoms	4
Sorsdahl et al. (2011)[50]	cross-sectional	4,185	South Africa	random	Residents in households or hostels (single-sex migrant laborer group quarters) and were at least 18 years old	often or sometimes food insufficient	Mood disorders in the past 12 months; anxiety disorders in the past 12 months	4
Willows et al. (2011)[51]	cross-sectional	837	Australia	random	Aboriginal community members	food insecurity	poor mental health; perceived stress	4
Hromi-Fiedler et al. (2011)[52]	cross-sectional	131	USA	recruitment	Latina women who were 4 to 8 months pregnant, lived in the Hartford area, were 18 years of age or older, participated in WIC or eligible for WIC, planned to deliver at one of the two city hospitals, and were not living in temporary housing	food insecurity	depressive symptoms	4
German et al. (2011)[53]	cross-sectional	112	Israel	convenience	Welfare recipients ages 60 to 92	food insufficiency	depressive symptoms	4
Sharkey et al. (2011)	cross-sectional	1,290	USA	random	Women living in Central Texas	food insecurity	mental distress	3
Vogenthaler et al. (2011)[54]	cross-sectional	286	USA	recruitment	HIV infected crack cocaine users	food insufficiency	depressive symptoms	3
Waitzkin et al. (2011)[55]	longitudinal	443	USA	random	Patients diagnosed with depression using the PHQ	food insecurity	depressive symptoms	3
Kinyanda et al. (2011)[56]	cross-sectional	618	Uganda	recruitment	People older than 18 years and registered at HIV clinic	food insecurity	depressive symptoms	2

Study	Design	N	Country	Sampling	Population	Food insecurity measure	Mental health outcome	Score
Hadley et al. (2012)[57]	cohort	901	Ethiopia	random	Parents with children less than 24 months old	food insecurity	mental distress	5
Chung et al. (2012)[58]	cross-sectional	1,650	USA	random	Older adults in eligible senior centers	food insecurity as concern about food; food insufficiency due to finances; food insufficiency due to mobility	depressive symptoms	4
Palar et al. (2012)[59]	cohort	573	Uganda	unclear	Treatment-naive patients initiating clinical care	severe food insecurity	depressive symptoms	4
Ramsey et al. (2012)[60]	cross-sectional	487	Australia	random	Individuals aged between 25 and 45 years who lived in the most disadvantaged 5 % of census collector districts in	food insecurity	depression	4
Cunningham et al. (2012)[61]	cross-sectional	2,535 7,685 2,882 7,747	Australia	random	Australians aged 18 to 64 who were indigenous or non-indigenous	food insecurity among indigenous males and females; non-indigenous males and females	psychological distress among indigenous males and females; non-indigenous males and females	4
Kuo et al. (2012)[62]	cross-sectional	1,599	South Africa	random	Adults who were caregivers for orphaned children in Umlazi Township, South Africa	food insecurity	depressive symptoms	3
Okechukwu et al. (2012)[63]	cross-sectional	416	USA	convenience	Adults working as low-wage nursing home employees in Massachusetts	food insufficiency	depressive symptoms	3
Muldoon et al. (2013)[64]	cross-sectional	5,588	Canada	random	Adults aged 18 to 64	food insecurity with hunger	depressive symptoms; anxiety; poor mental health	4
Dibaba et al. (2013)[65]	cross-sectional	622	Ethiopia	unclear	Women in their 2nd and 3rd trimesters	food insecurity	depressive symptoms	4
Garcia et al. (2013)[66]	longitudinal	232	Ghana	recruitment	Postpartum mothers recruited prenatally who accepted testing and answered the food security module at any time point postpartum	food insecurity	perceived stress	4

Peterman et al. (2013)[67]	cross-sectional	129	USA	random	Cambodian women ages 30 to 65 years who had been living in the US for 5 years or more	low and very low food security	depressive symptoms	5
Pitpitan et al. (2013)[68]	cross-sectional	560	South Africa	convenience	Women drank in one of twelve study sites, lived in the township, and were greater than 18 years old	food insecurity	depressive symptoms; PTSD	4
Siriwardhana et al. (2013)[69]	cross-sectional	449	Sri Lanka	random	Participants were Sri Lankans aged between 18 to 65 years who were previously resident in the Northern Province of Sri Lanka but displaced in 1990 and residing in welfare camps and other settlements in Kalpitiya division of Puttalam district since, or born to at least one displaced parent	food insufficiency	common mental disorders	4
Tarasuk et al. (2013)[70]	cross-sectional	58,187	USA, Canada	random	Adults aged 18 to 64	food insecurity	mood or anxiety disorder	4
Dewing et al. (2013)[71]	cross-sectional	249	South Africa	convenience	Women at various stages of pregnancy who agreed to take part in a home-based maternal-child health nutrition intervention	food insecurity	postpartum depressive symptoms	4
Cook et al. (2013)[72]	cross-sectional	41,515	USA	unclear	Caregivers of children aged less than 48 months neither of which was critically ill or injured	food insecurity	depressive symptoms	2
Hernandez et al. (2014)[73]	longitudinal	1,690	USA	random	Mothers and children in Fragile Families and Wellbeing study	food insecurity at time 1 or time 2	depressive symptoms at time 2	5
Davey-Rothwell et al. (2014)[74]	cross-sectional	225 218	USA	recruitment	Adult women aged 18 to 55 years old who had not injected drugs in the past 6 months, had self-reported sex with at least one male partner in the past 6 months, and had one of the following: current	food insecurity among drug users and non-drug users	depressive symptoms among drug users and non-drug users	4

					use of heroin or cocaine or sexual risk behavior in the past 6 months (i.e. two or more sex partners, recent STI diagnosis, or having a high-risk sex partner such as someone who injected drugs, smoked crack or was HIV positive)			
Islam et al. (2014)[75]	cross-sectional	3,395	Canada	random	Immigrants from South Asia to Canada	food insecurity	mood disorder; anxiety; poor to fair self-perceived mental health status	2
Leung et al. (2015)[76]	cross-sectional	3,518	USA	random	Adults living at or below 130% of the federal poverty line	Marginal, low, very low food security	depressive symptoms	5
Garg et al. (2015)[77]	longitudinal	2,917	USA	random	Low income mothers with children who were 9 month and 24 month at subsequent time points	depressive symptoms	food insecurity	5
Ghattas et al. (2015)[78]	cross-sectional	2,493	Palestine	random	Adults	severe food insecurity	poor mental health	5
Mulusew et al. (2015)[79]	cross-sectional	642	Ethiopia	random	Pregnant women	food insecurity	mental distress	5
Becerra et al. (2015)[80]	cross-sectional	10,966	USA	random	Hispanics 18 and older living below 200% of the federal poverty line	very low food security	high psychological distress	5
Palar et al. (2015)[81]	cohort	346	USA	recruitment	People living with HIV who were marginally housed	Severe food insecurity	depressive symptoms	4
Dipnall et al. (2015)[82]	cross-sectional	3,779	USA	random	Adults aged 20 to 75 years	severe food insecurity	depressive symptoms	4
Silverman et al. (2015)[83]	cross-sectional	287	USA	recruitment	Participants aged 30 to 70 years old who had poorly controlled type 2 diabetes (A1c ≥ 8.0 % on eligibility screen) and household income below 250 % of the federal poverty level	food insecurity	depressive symptoms	4
Wang et al. (2015)[84]	cross-sectional	6,665	USA	unclear	US Veterans	food insecurity	depressive symptoms	4

Mugisha et al. (2015a)[85]	cross-sectional	2,312	Uganda	random	Adults over the age of 18	food insecurity	depressive symptoms	3
Goldberg et al. (2015)[86]	cross-sectional	2,033	USA	random	Adults 60 and older	food insecurity	moderate/severe depressive symptoms	3
Kapulsky et al. (2015)[87]	cross-sectional	183	USA	convenience	HIV-infected Hispanic adults from the Greater Boston area	food insecurity	depressive symptoms	4
Mugisha et al. (2015b)[88]	cross-sectional	2,361	Uganda	random	Participants lived in one of three northern districts in Uganda and were greater than 18 years of age	food insecurity	PTSD	3
Davison et al. (2015)[89]	cross-sectional	97	Canada	random	Adults randomly selected from the membership list of the Mood Disorder Association of British Columbia	food insecurity	depressive symptoms	3
Mayston et al. (2015)[90]	cross-sectional	1,934	India	convenience	Individuals attending the clinic to undertake pre-test counselling and an HIV blood test who were fluent in Konkani, Hindi or English and were at least 18 years old	food insecurity	depression	2
Brucker (2016)[91]	cross-sectional	11,567	USA	random	Adults aged 18 to 25 years old	food insecurity	psychological distress	5
Heyningen et al. (2016)[92]	cross-sectional	376	South Africa	random	Pregnant women	food insecurity	depressive symptoms	4
Anema et al. (2016)[93]	cross-sectional	218	Canada	convenience	Participants were at least 19 years old and had self-reported HIV	food insecurity	depressive symptoms	4
Pryor et al. (2016)[94]	cohort	1,109	France	random	Adults aged 18 to 35 years old	food insecurity	depressive symptoms	4
Jayasuriya et al. (2016)[95]	cross-sectional	18,182	Sri Lanka	random	Sri Lankans historically exposed to conflict	food scarcity	depressive symptoms; anxiety	4
Pulgar et al. (2016)[96]	cross-sectional	248	USA	convenience	Farmworkers and seasonal workers who are mothers of small children	very low food security	depressive symptoms	4
Shiue (2016)[97]	cross-sectional	2,799	USA	random	Adults 20 and older	food insecurity	depressive symptoms	4
Weigel et al. (2016)[98]	longitudinal	794	Ecuador	convenience	Mother or another adult female head of household (e.g., grandmother, aunt, and stepmother) living in the same home with at least	very low food security	depressive symptoms; perceived stress; poor mental health	4

					one schoolchild (ages 6–12 years), a permanent resident of their present community			
Chung et al. (2016)[99]	cross-sectional	5,862	South Korea	random	Adults aged 20 to 64 years with no chronic diseases	food insecurity with or without hunger	perceived stress; depressive symptoms; anxiety and depression	3
Decaro et al. (2016)[100]	cross-sectional	75	Tanzania	convenience	Mother-infant (less than 12 months) dyads	severe food insecurity	high depression; high anxiety	4
Parpouchi et al. (2016)[101]	cross-sectional	421	Canada	unclear	Participants were at least 19 years of age, absolutely homeless or precariously housed and had a mental disorder	food insecurity	poor mental health	3
Schure et al. (2016)[102]	cross-sectional	81,405	USA	random	Non-institutionalized adults aged 18 years or older	food insecurity	poor mental health	3
Golin et al. (2016)[103]	longitudinal	1,008	USA	convenience	Individuals were 18 to 44 years of age, self-identified as women (transgender individuals were eligible), reported at least one episode of unprotected vaginal and/or anal sex with a man in the six months before enrollment, and had one or more self-reported personal or partner HIV risk characteristics (e.g., participant or partner in the last six months with a sexually transmitted infection, illicit drug use, binge alcohol drinking or dependence, sex exchange)	food insecurity	PTSD acquisition	3
Bruening et al. (2016)[104]	cross-sectional	209	USA	recruitment	First year students living in dorms	food insecurity	depressive symptoms; perceived stress; anxiety	2
Fahey et al. (2016)[105]	cross-sectional	632	India	random	Adults with the ability to comprehend and speak Gujarati who	food insecurity	common mental disorders	2

					had rural residence within the Anand district			
De Castro et al. (2017)[106]	cross-sectional	4,239	Mexico	random	Mothers and their children under five years old	food insecurity among low or middle to high socio-economic status participants	depressive symptoms among people of low or medium to high socio-economic status	5
Montgomery et al. (2017)[107]	cross-sectional	1,685 1,520 6,731	USA	random	Diabetics prediabetics, or normal glycemia from NHANES STUDY	severe food insecurity among adults with diabetes, pre-diabetes, or normal glycemia	depressive symptoms among adults with diabetes, pre-diabetes, or normal glycemia	5
Tseng et al. (2017)[108]	cross-sectional	591	USA	random	Parents who participated in the 2014-15 National Health Interview Survey	food insecurity	psychological distress	5
O'Campo et al. (2017)[109]	longitudinal	715 535	Canada	random	Adult aged 18 years or older experiencing absolute homelessness or being precariously housed with a severe mental illness with or without a concurrent substance use problem	high food insecurity among moderate or high need homeless people	common mental disorders among moderate or high need homeless people	5
Van Heyningen et al. (2017)[110]	cross-sectional	376	South Africa	recruitment	Pregnant women	food insecurity	anxiety	4
Brostow et al. (2017)[111]	cross-sectional	1,254	USA	random	US veterans	food insecurity	depressive symptoms	4
Davison et al. (2017)[112]	cross-sectional	15,546	Canada	unclear	Adults aged 19 to 70 years	food insecurity	poor mental health	4
Khan et al. (2017)[113]	cross-sectional	264	Bangladesh	convenience	Mothers having under-five children at Kamrangirchar area of Dhaka	severe food insecurity	common mental disorders	4
Maharaj et al. (2017)[114]	cross-sectional	329	South Africa	convenience	Adult refugees in Durban	food insecurity regarding not eating enough	Anxiety; depressive symptoms	4
Pellowski et al. (2017)[115]	cohort	761	South Africa	convenience	Pregnant women who were at least 18 years of age, had attended one of the two study clinics,	food insecurity	depressive symptoms; psychological distress	4

					and planned to stay in the study area for at least one year			
Ippolito et al. (2017)[116]	cross-sectional	1,237	USA	convenience	Adults aged 18 years or older with English or Spanish language fluency and point-of-care glycated Hb (HbA1c) percentage greater than or equal to 6·5 %, or self-reported diagnosis	Very low food security	depressive symptoms	4
Hessol et al. (2017)[117]	cross-sectional	223	USA	recruitment	Adults include age 50 or over living with HIV	very low food security	depressive symptoms	4
Cox et al. (2017)[118]	longitudinal	525	Canada	convenience	Participants were older than 16 years of age, had documented HIV infection, and evidence of HCV infection	food insecurity	depressive symptoms	3
Yeneabat et al. (2017)[119]	cross-sectional	390	Ethiopia	convenience	People living with HIV who were receiving ART in clinic	food insecurity	depressive symptoms	3
Brucker (2017)[120]	cross-sectional	12,933	USA	random	Adults over 18 years old	food insecurity	poor mental health	2
Farahbakhsh et al. (2017)[121]	cross-sectional	58	Canada	convenience	College students	severe food insecurity	poor mental health	2
Bekele et al. (2018)[122]	cross-sectional	649	Canada	recruitment	Adults aged 19 years or older and living with HIV	food insecurity	depressive symptoms	5
Gebreyesus et al. (2018)[123]	cross-sectional	3,091	Ethiopia	random	Women with children between 0 and 59 months	severe food insecurity	depressive symptoms	5
Wattick et al. (2018)[124]	cross-sectional	299;779 343;933	USA	convenience	Students at a large university in Appalachia	food insecurity in men or in women	depressive symptoms or anxiety in men or in women	4
Ezzeddin et al. (2018)[125]	cross-sectional	325	Iran	random	Women aged 18 to 45 years who had given birth in the past 3 to 8 months and who had no history of depression and chronic disease	food insecurity with moderate or severe hunger	post-partum depression	5
Lund et al. (2018)[126]	cross-sectional	1,127 750	Denmark	random	Adults in Denmark	very low food security among women or men	high psychological distress among women or men	5

Tong et al. (2018)[127]	cross-sectional	350	USA	random	Homeless adults aged 50 years or older	very low food security	depressive symptoms	5
Clay et al. (2018a)[128]	cross-sectional	683	USA	random	Households on the Gulf Coast	food insecurity	mental distress	4
Abrahams et al. (2018)[129]	cross-sectional	376	South Africa	random	Pregnant women aged 18 years and older	food insecurity	depressive symptoms; anxiety	4
Ayyub et al. (2018)[130]	cross-sectional	367	Pakistan	random	Pregnant women living in the slum districts of Lahore, Pakistan	food insecurity	antenatal depression	4
Bruening et al. (2018)[131]	longitudinal	1,138 400	USA	convenience	First year students in a dorm	previous or current food insecurity	perceived stress; depressive symptoms; anxiety	4
Clay et al. (2018b)[132]	longitudinal	737	USA	random	Households living in areas classified by the Federal Emergency Management Agency (FEMA) assessments as moderately to extensively damaged or living in FEMA subsidized housing	food insecurity	poor mental health; PTSD	4
Dong et al. (2018)[133]	cross-sectional	304	USA	convenience	English-speaking adults aged 18 years or older that were under active probation supervision at one particular probation office in Rhode Island between July and October 2016	food insecurity	depressive symptoms	4
Gregorio et al. (2018)[134]	cross-sectional	5,430	Portugal	random	Adults older than 18 years old who were non-institutionalized and living in private households in the mainland and the islands (Azores and Madeira) of Portugal	food insecurity	depressive symptoms; anxiety	4
Azale et al. (2018)[135]	cross-sectional	3,147	Ethiopia	recruitment	Women who had given birth in the past one to 12 months in Sodo district in southern Ethiopia	hunger	post-partum depression	3
Barreto et al. (2018)[136]	longitudinal	753	Canada	recruitment	Women (transgender and cisgender	food insecurity	mental disorders	3

					inclusive) aged 14 years and older, who had exchanged sex for money within the last 30 days at baseline			
Gibbs et al. (2018)[137]	cross-sectional	106 107	South Africa	convenience	Adults aged 18 to 30 years old	hunger among men or women	depressive symptoms among men or women	2
Scanlon et al. (2018)[138]	cross-sectional	189	USA	convenience	HIV-negative African American men who were at least 18 years of age and were incarcerated for three years or less on a non-rape/murder offense in the North Carolina Department of Public Safety and who were scheduled to be released within three months	food insecurity	depressive symptoms	3
Steiner et al. (2018)[139]	cross-sectional	50,097	USA	random	Kaiser Permanente Colorado members at any time between 2012 and 2015 who were younger than 65 years of age	food insecurity	depressive symptoms; anxiety; fair or poor mental health	2

Table 2. Characteristics of studies included in the meta-analysis.
Study site has been simplified to indicate the country of research for clarity but not all papers are nationally representative. Sampling has been simplified to illustrate strategies that introduced randomness, whether it was cluster or simple random sampling, compared to strategies of convenience. Sampling strategies not clearly described in the paper have been denoted as unclear, such as when recruitment processes are described but not clearly indicated whether randomness was introduced during recruitment.

DEPRESSION SCALES
Composite International Diagnostic Interview-Short Form (WHO-CIDI-SF, UM-CIDI-SF Depression Modules)
Center for Epidemiologic Studies Depression Scale (CES-D-7, CES-D-10, CES-D-11, CES-D-12, CES-D-20)
Patient Health Questionnaire (PHQ-2, PHQ-8, PHQ-9, PHQ-16)
Edinburgh Postnatal Depression Scale (EPDS-10)
Diagnostic Interview Schedule from DSM 4 (Depression Criteria)
Harvard Trauma Questionnaire (HTQ Depression Questions)
Beck Depression Inventory (BDI-21)
MINI Neuropsychiatric Interview (MINI Plus) (Depression Module)
Hopkins Symptom Checklist (HSCL-15, HSCL-25 Depression Subscale)
American College Health Association Survey (Depression Questions)

Geriatric Depression Scale (GDS-15)
Brief Symptom Inventory (BSI-18 Depression Subscale)
Burnam Depression Screen(8-item)
Kemper Maternal Depression Screener (3-item)
Hamilton Depression Scale (HAM-D-17)
Short Form Survey (SF-12 Depression Domain)
Single-Item Questions (e.g., Depression Question from the CDC Healthy Days Measure or self-report of previous depressive/mood disorder diagnosis)
ANXIETY SCALES
Composite International Diagnostic Interview-Short Form (WHO-CIDI-SF Anxiety Module)
Spielberger State-Trait Anxiety Inventory (STAI-20)
Hopkins Symptom Checklist (HSCL-25 Anxiety Subscale)
MINI Neuropsychiatric Interview (MINI Plus) (Anxiety Module)
Generalized Anxiety Disorder Screener (GAD-2)
Single-Item Questions (e.g., Anxiety Question from the CDC Healthy Days Measure or self-report of previous generalized anxiety disorder diagnosis)
PTSD SCALES
Diagnostic Interview Schedule from DSM 4 (PTSD Criteria)
PTSD Checklist – Civilian Version (PCL-C-17)
MINI Neuropsychiatric Interview (MINI Plus) (PTSD Module)
Primary Care PTSD Scale (PC-PTSD-4)
Trauma Screening Questionnaire (TSQ-10)
PSYCHOSOCIAL STRESS SCALES
Perceived Stress Scale (PSS-4, PSS-14)
Single-Item Questions (e.g., self-reported stress or feeling overwhelmed)
POOR MENTAL HEALTH OR UNSPECIFIED CMD
Mental Health Inventory (MHI-5)
Colorado Symptom Index (CSI-14)
Short Form Survey (SF-12, SF-36 Subscales: Mental Health Composite Scores [MCS] and Mental Health Inventory [MHI-5])
Primary Care Evaluation of Mental Disorders Patient Health Questionnaire (PRIME-MD PHQ - SADS)
Self-Reporting Questionnaire (SRQ-20)
Composite International Diagnostic Interview-Short Form (WHO-CIDI-SF Depression & Anxiety Modules)
Hopkins Symptom Checklist (HSCL-25 Depression & Anxiety Subscales)
Kessler Psychological Distress Scale (K5, K6, K10)
Clinical Interview Schedule-Revised (CIS-R)
Single-Item Questions (e.g., self-reported poor mental health or self-report of previous CMD diagnosis
FOOD INSECURITY
Household Food Security Survey Module (HFSSM-6, [Adult]-FSSM-10, USDA-HFSSM-18, Canada-HFSSM-18)
Radimer/Cornell Questionnaire
Latin American and Caribbean Food Security Scale (ELCSA-15)

| Household Food Insecurity Access Scale *(HFIAS)* |
| Coping Strategies Index (CSI) |
| Study-Specific Multi-Question Measures (e.g., modified HFSSM that includes 2, 4, or 7 items) |
| Single-Item Questions (e.g., experience of hunger within the past month, concern over one's food resources, or undescribed measures)[1] |

Table 3. All mental health scales categorized by analytic outcome: depression, anxiety, PTSD, psychosocial stress, and self-reported poor mental health or unspecified CMD. Only scales used in the associations selected for inclusion in the meta-analyses are listed. Scales included in the reviewed papers but not used in the selected associations are not listed (e.g., those used in unadjusted associations only). [1]This includes single-item questions with multiple response options that could be analyzed for different levels of severity.

Label	Sampling Quality	Food Measure Quality	MH Measure Quality	Variable Quality	Model Quality	Total Quality Score
Whitaker2006	1	1	1	1	1	5
Hadley2012	1	1	1	1	1	5
Hernandez2014	1	1	1	1	1	5
Leung2015	1	1	1	1	1	5
Garg2015	1	1	1	1	1	5
Ghattas2015	1	1	1	1	1	5
Mulusew2015	1	1	1	1	1	5
Becerra2015	1	1	1	1	1	5
Brucker2016	1	1	1	1	1	5
DeCastro2017	1	1	1	1	1	5
Montgomery2017	1	1	1	1	1	5
Tseng2017	1	1	1	1	1	5
OCampo2017	1	1	1	1	1	5
Bekele2018	1	1	1	1	1	5
Gebreyesus2018	1	1	1	1	1	5
Ezzeddin2018	1	1	1	1	1	5
Lund2018	1	1	1	1	1	5
Tong2018	1	1	1	1	1	5
Wattick2018	0	1	1	1	1	4
Anema2011	0	1	1	1	1	4
Siefert2001	1	0	1	1	1	4
Siefert2004	1	0	1	1	1	4
Laraia2006	0	1	1	1	1	4
Siefert2007	1	0	1	1	1	4
Seino2008	1	0	1	1	1	4
Melchior2009	1	1	1	0	1	4
Rajkumar2009	1	0	1	1	1	4
Anema2010	1	0	1	1	1	4

Carter2011	1	0	1	1	1	4
Kollannoor2011	0	1	1	1	1	4
Sorsdahl2011	1	0	1	1	1	4
Willows2011	1	1	0	1	1	4
Chung2012	1	0	1	1	1	4
Palar2012	0	1	1	1	1	4
Ramsey2012	1	1	1	0	1	4
Cunningham2012	1	0	1	1	1	4
Muldoon2013	1	1	0	1	1	4
Dibaba2013	1	0	1	1	1	4
Garcia2013	0	1	1	1	1	4
Peterman2013	1	1	1	1	1	5
Pitpitan2013	0	1	1	1	1	4
Siriwardhana2013	1	0	1	1	1	4
Tarasuk2013	1	1	0	1	1	4
Dewing2013	0	1	1	1	1	4
DaveyRothwell2014	0	1	1	1	1	4
Palar2015	0	1	1	1	1	4
Dipnall2015	1	0	1	1	1	4
Silverman2015	0	1	1	1	1	4
Wang2015	0	1	1	1	1	4
Heyningen2016	1	1	1	0	1	4
Anema2016	0	1	1	1	1	4
Pryor2016	1	0	1	1	1	4
Jayasuriya2016	1	0	1	1	1	4
Pulgar2016	0	1	1	1	1	4
Shiue2016	1	1	1	0	1	4
Weigel2016	0	1	1	1	1	4
VanHeyningen2017	1	1	1	0	1	4
Brostow2017	1	0	1	1	1	4
Davison2017	1	1	0	1	1	4
Huang2017	0	1	1	1	1	4
Khan2017	0	1	1	1	1	4
Maharaj2017	0	1	1	1	1	4
Pellowski2017	0	1	1	1	1	4
Ippolito2017	0	1	1	1	1	4
Clay2018a	1	0	1	1	1	4
Abrahams2018	1	1	1	0	1	4
Ayyub2018	1	1	1	0	1	4
Bruening2018	0	1	1	1	1	4
Clay2018b	1	0	1	1	1	4
Dong2018	0	1	1	1	1	4
Gregorio2018	1	1	1	0	1	4
Vozoris2003	1	0	0	1	1	3
Patel2006	1	0	1	0	1	3
HromiFiedler2011	0	1	1	1	1	4
German2011	1	0	1	1	1	4
Sharkey2011	1	0	0	1	1	3

Vogenthaler2011	0	0	1	1	1	3
Waitzkin2011	1	0	1	0	1	3
Kuo2012	1	0	1	0	1	3
Okechukwu2012	0	0	1	1	1	3
Mugisha2015a	1	0	1	0	1	3
Goldberg2015	1	1	0	0	1	3
Kapulsky2015	0	1	1	1	1	4
Mugisha2015b	1	0	1	0	1	3
Chung2016	1	1	0	0	1	3
Decaro2016	0	1	1	1	1	4
Parpouchi2016	0	1	1	0	1	3
Schure2016	1	0	0	1	1	3
Golin2016	0	0	1	1	1	3
Hessol2017	0	1	1	1	1	4
Cox2017	0	1	1	0	1	3
Yeneabat2017	0	1	1	0	1	3
Azale2018	1	0	1	0	1	3
Barreto2018	1	1	0	0	1	3
Temple2018	1	0	1	0	1	3
Davison2018	1	1	0	0	1	3
Patel2002	0	0	1	0	1	2
Casey2004	0	1	0	0	1	2
Weigel2007	0	1	0	1	1	3
Wu2008	0	0	1	1	1	3
Kinyanda2011	0	0	1	0	1	2
Cook2013	0	1	0	0	1	2
Islam2014	1	0	0	0	1	2
Davison2015	1	0	1	0	1	3
Mayston2015	0	0	1	0	1	2
Bruening2016	0	0	1	0	1	2
Fahey2016	1	0	0	0	1	2
Brucker2017	1	0	0	0	1	2
Gibbs2018	0	0	1	0	1	2
Scanlon2018	0	0	1	1	1	3
Steiner2018	0	0	1	1	0	2
Farahbakhsh2017	0	1	0	0	1	2

Table 4. Quality score assessments for each paper included in the meta-analyses. Higher quality papers were assumed to indicate lower bias.