

Food Insecurity and Mental Health in Low- and Middle-Income Countries: A Systematic Review
of Longitudinal Studies.

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Abstract

Background

Both food insecurity and mental health issues are growing global concerns with wide-ranging consequences, and previous reviews suggest that an association between both variables exists. However, less is known regarding the direction of the effect, especially in low- and middle-income countries. The present systematic review therefore aimed to provide an update on the current evidence base for the relationship between food insecurity and mental health in low- and middle-income countries, establish the directionality of that relationship, and identify potential intervention targets.

Methods

CAB Abstracts, CINAHL, Embase, Global Health, MEDLINE, PsycINFO, Scopus, and the Web of Science Core Collection, as well as ProQuest Dissertations and Theses Global, Open Grey, and WorldCat Dissertations and Theses, were systematically searched from their inceptions to April 2019. Retrieved records were subjected to title and abstract screening, and potentially eligible articles were examined in detail. English full-text articles of longitudinal studies measuring the relationship between food insecurity and mental health in low- and middle-income countries were included. Standardised forms were used for data extraction and quality appraisal, and results were synthesised narratively.

Results

15 studies, characterised by heterogeneous settings, populations, measures, and analyses, were reviewed. One third of these received a quality rating of ‘fair’, while remaining studies were considered ‘weak’. Most studies investigated the effect of food insecurity on mental health, generally providing evidence for such a relationship, although moderating variables, differentiated effects, and unresolved inconsistencies were identified. Since only a single weak-quality study assessed the potential effect of mental health on food insecurity, no firm conclusions could be drawn regarding this relationship.

Discussion

Overall, a more nuanced understanding of the nature of the investigated relationship was attained. Findings need to be considered with regards to strengths and limitations of the systematic review. Future research should address the shortcomings of existing studies and provide information on remaining knowledge gaps. This is likely to inform novel preventative interventions in policy and practice, which should aim to be sustainable, locally relevant, and involve inter-sectoral collaboration.

Introduction

Social Determinants of Mental Health

‘Mental health’ (MH) is commonly used as an umbrella term encompassing various aspects of positive psychological wellbeing (Galderisi, Heinz, Kastrup, Beezhold, & Sartorius, 2015). Issues surrounding MH affect diverse people of all sexes and ages worldwide (James et al., 2018). Afflicted individuals often experience substantial consequences, as MH issues can not only lead to high levels of disability (World Health Organisation [WHO], 2017), but also increase risk of mortality due to co-morbid physical conditions or suicide (Walker, McGee & Druss, 2015). In addition, caring for a family member with MH issues may impose significant emotional, financial, and physical strain on relatives (Von Kardorff, Soltaninejad, Kamali & Shahrabaki, 2016). Even more broadly, economic effects may result from work absenteeism or loss of productivity (Evans-Lacko & Knapp, 2016). The adverse impact of MH issues can thus extend beyond concerned individuals to families and society as a whole.

Consequently, the true global burden of MH issues is likely to exceed reports of more than a billion people with diagnosable psychiatric disorders alone (Rehm & Shield, 2019). Some have argued that such numbers still represent underestimations owing to the challenges associated with large-scale epidemiological studies (Vigo, Thornicroft & Atun, 2016). While others have criticised the validity of any prevalence approximations by highlighting the limitations of applying psychiatric diagnoses cross-culturally and categorically (Baxter et al., 2014), it is nevertheless widely accepted that different forms of psychological distress and suffering amount to a considerable global concern (Patel, 2014). Factors including population growth and increased life expectancies, which particularly affect low- and middle-income countries (LMIC), are predicted to compound the situation in the future, emphasising the urgent need for effective interventions (Baingana, al’Absi, Becker & Pringle, 2015).

Intervention strategies have usually reflected the contemporary understanding of MH issue aetiology (Patel, 2016). One of the most influential, yet also contested, ideas has been George Engel’s biopsychosocial model, according to which illnesses including MH issues are a product of multiple causal factors acting at biological, psychological, and social levels (Davies & Roache, 2017). Engel intended to place a particular emphasis on the often-dismissed need to address psychosocial factors (Álvarez, Pagani & Meucci, 2012). While the model witnessed wide recognition in academic, institutional, and public realms, it has found little implementation in MH practice, where the biomedical model still predominates (Wade & Halligan, 2017). In line with this, MH issues are primarily treated after their development by means of medication and, less commonly, psychological therapy (Ingleby, 2014). Originating in Western high-income countries (HIC), this approach is increasingly being adopted in LMIC following promotion by the ‘Movement for Global Mental Health’ (MGMH; White & Sashidharan, 2014).

Proponents of the biomedical approach state that intervening on all levels of the biopsychosocial model would not only be redundant, but also unfeasible (Bolton & Gillett, 2019),

especially since biomedical treatments alone require significant quantities of human, material, and financial resources (Selamu et al., 2015). Indeed, a key concern of the MGMH has been the current discrepancy between the supposed need for and actual delivery of formal MH treatment, termed the ‘treatment gap’, in many regions and LMIC in particular (Whitley, 2015). Yet critics of a predominantly biomedical approach assert that it is reductionist and thus ineffective or even harmful (Summerfield, 2012), alleging that it may be motivated by political and economic interests instead of a robust evidence base (Kirmayer & Pedersen, 2014). Despite sparking controversy, the latter claims are supported by the finding that increases in traditional MH care provision over the past decades have produced little improvement in several countries (Jorm, Patten, Brugha & Mojtabai, 2017).

While debates concerning the value of biomedical interventions continue, a substantial body of evidence now supports the notion that the social component of the biopsychosocial model does exert a considerable impact on MH (Clark, 2014). Initially, this was based on the observation that the prevalence of many MH issues follows a social gradient, in which individuals experiencing the highest cumulative social disadvantage are also at the highest risk of poor MH (Fisher & Baum, 2010). According to the ‘social causation hypothesis’, a wide range of factors or conditions, commonly referred to as ‘social determinants of MH’, are thought to be responsible for this phenomenon (Silva, Loureiro & Cardoso, 2016). Increasingly, the concept has also incorporated further external factors of an economic, cultural, political, or environmental nature (Carod-Artal, 2017). Examples of proposed determinants include social cohesion, housing, gender equality, armed conflict, or natural disasters (Lund et al., 2018).

An in-depth knowledge of specific social determinants and the settings and populations they apply to may aid the identification of new intervention targets (Alegría, NeMoyer, Bagué, Wang & Alvarez, 2018). While such an intervention could take the form of an individual treatment, it could also manifest as a preventative approach benefiting communities or whole societies (Donkin, Goldblatt, Allen, Nathanson & Marmot, 2018). The cost-effectiveness of preventing MH issues, as opposed to treating them, may be especially advantageous in low-resource settings (Cuijpers, Beekman & Reynolds, 2012). However, while some progress towards commitment to such strategies has been made (Allen, Balfour, Bell & Marmot, 2014), large knowledge gaps still impede their implementation (Deferio, Breitingner, Khullar, Sheth & Pathak, 2019).

Food Insecurity and Mental Health

A potential social determinant of MH that has only recently been disentangled from poverty more generally is food insecurity (FI; Gundersen & Ziliak, 2018). According to the definition set out in the World Food Summit Plan of Action of 1996, ‘food security’ denotes a state at which ‘all people, at all times, have physical and economic access to sufficient, safe and nutritious food to meet their dietary needs and food preferences for an active and healthy life’ (Food and Agriculture Organisation of the

United Nations [FAO], 1996). Following this delineation, the concept can be further broken down into hierarchical dimensions, namely food availability, access, utilisation, and stability (Stringer, 2016). FI, in turn, refers to the lack of food security (Barrett, 2010). This may occur to varying degrees starting with mild FI, at which stage individuals experience uncertainty regarding food. At moderate FI levels, they may first reduce food quality and variety, and later the quantity of their food and meal times. Eventually, severe FI, characterised by the actual experience of hunger, occurs (Ballard, Kepple & Cafiero, 2013).

Even though the FAO description is the most widely endorsed one, various alternative definitions and classifications of FI exist, further highlighting the complexity of the construct (Coates, 2013). For example, while the United States Department of Agriculture's (2018) conceptualisation of FI is similar to the one proposed by the FAO, it distinguishes differentially between high, marginal, low, and very low levels of food security. In addition, the FAO definition does not consider that FI may be experienced at different levels, such as the individual, household, regional, national, or even global level (Sassi, 2018). This lack of consensus, which is reflected in heterogeneous measurement approaches (McKay, Haines & Dunn, 2019), complicates precise assessments of the global scale of FI (Hendriks, 2016). The most recent FAO (2018) numbers, which state that 770 million people or approximately 10% of the global population are severely food insecure, therefore only represent estimates. Furthermore, a significantly larger number of people may meet criteria for less severe FI (Pinstrup-Andersen, 2009).

While FI is omnipresent in all regions of the world, the majority of food-insecure individuals reside in LMIC (Smith, Rabbit & Coleman-Jensen, 2017). The problem has persisted in spite of improvements in global agricultural productivity over the past few decades, refuting the idea that this, by itself, would counteract FI (McKenzie & Williams, 2015). In fact, it has been posited that unsustainable food production practices contribute to environmental degradation and climate change, which pose a threat to food security (Campbell et al., 2016). FI is predicted to further increase in the future as a result of additional pressures on food systems, which include increased demands due to population growth (Godfray et al., 2010) or the rising popularity of biofuels (Koizumi, 2015). Following the present trajectory, it is hence likely that FI will remain one of the 'major challenge[s] of humanity in this century' (Chaudhary, Gustafson & Mathys, 2018), especially in LMIC (Nooghabi et al., 2018).

These predictions are concerning, primarily because the basic human need of food intake is not met among individuals who are severely food insecure for a prolonged period of time (Sage, 2019), elevating their mortality risk (Uchendu, 2018). This may be exacerbated by the fact that even those experiencing less severe FI are at a higher risk of various associated health conditions across the lifespan, ranging from iron deficiency anaemia to diabetes and hypertension (Gundersen & Ziliak, 2015). Many of these physical health problems are theorised to be the product of FI through dietary mechanisms involving nutritional deficiencies, unhealthy diets, or obesity (Weaver & Fasel, 2018). Yet

even though dietary factors can also affect MH (Lim et al., 2016), comparatively little research has examined the potential role of FI as a social determinant of MH specifically (Whittle et al., 2019).

Besides acting as a biological stressor, additional psychosocial mechanisms through which FI could uniquely impact MH have been proposed (Pryor et al., 2016). The chronic experience of FI may constitute toxic levels of psychological stress that can give rise to common mental disorders (CMD) including depression and anxiety (Ke & Ford-Jones, 2015). Indeed, it has been stated that the profound effect of ordinary everyday stressors has often been underestimated in the literature, especially in comparison to stress resulting from distinct traumatic events (Miller & Rasmussen, 2010). Another theoretical mechanism is that of social stress, which is particularly linked to the important cultural functions of food (Moffat, Mohammed & Newbold, 2017). For example, emotional distress may be caused by feelings of shame and guilt as a result of having to obtain food in culturally unacceptable ways or being unable to fulfil the religious obligations associated with food in some cultures (Weaver, Meek & Hadley, 2014).

Previous Reviews

Five existing reviews have considered aspects of the presumed relationship between FI and MH. The first of those was a mixed-methods review by Weaver and Hadley (2009), which specifically focused on LMIC. Their searches retrieved 11 qualitative studies, all of which suggested that FI is strongly and directly related to MH. This notion was supported by the fact that all of the 16 included quantitative studies also found significant positive relationships of varying strengths between the two variables. Overall, the authors therefore stated that the research available on the subject, albeit being limited in volume, indicated the presence of a consistent association between FI and MH. Similar conclusions were drawn by Lund et al. (2010) following a review of the literature examining the relationship between different dimensions of poverty and MH in LMIC. Among all poverty indicators considered, FI had one of the strongest and most consistent associations with MH.

The authors of both reviews emphasised that a large majority of their included studies employed cross-sectional designs, which is commonly the case in the initial stages of new research, given that such studies are less expensive and time-consuming (Omair, 2015). However, since they involve measurements at a single point in time, cross-sectional studies are, by themselves, insufficient to demonstrate the temporal order of the occurrence of two variables, and thus do not provide information regarding the direction of a potential effect (Carlson & Morrison, 2009). Retrospective studies, such as the one investigating the effects of famine exposure on MH (St Clair et al., 2005) included in Weaver and Hadley's (2009) review, may provide some insight into directionality. Yet their findings should be interpreted with caution owing to methodological challenges, such as recall bias, a significant risk of confounding, and mortality attrition (Ahmad, Marwat & Khan, 2013). In order to establish the sequence of events at a lower risk of bias, prospective longitudinal studies are required (Caruana, Roman,

Hernández-Sánchez & Solli, 2015). As the reviews by Weaver and Hadley (2009) and Lund et al. (2010) only included a total of five longitudinal studies, it was not possible to determine whether FI is indeed likely to cause MH.

This knowledge gap presents an issue of particular concern in the specific case of FI and MH, as reverse causality and alternative explanations are, theoretically, both plausible (Tarasuk, Mitchell, McLaren & McIntyre, 2013). In accordance with the less-researched ‘social drift hypothesis’ taken from the wider literature on poverty and MH, which states that MH issues may provoke a progression into adverse social circumstances (Lund, 2012), individuals could also remain or become food insecure as a consequence of MH issues. To illustrate, it is conceivable that MH-related disability may interfere with an individual’s ability to generate the income necessary to purchase food (Garthwaite, Collins & Bamba, 2015), to obtain or produce food directly (Melchior et al., 2009), or to apply coping skills in case of FI due to external causes (Tarasuk et al., 2013). Similar effects may be observed on a household level, as the economic strain of caring for a relative with MH issues could render a family unable to afford food (Hadley & Crooks, 2012). Social drift and social causation do not have to be mutually exclusive, and it is, in fact, likely that the relationship between FI and MH could be bi-directional (Lepière, Reynaert, Jacques & Zdanowicz, 2015).

Since research interest in the topic has increased over the past decade, three more recent reviews have included additional longitudinal studies. Mirroring general trends in health research (Stein & Wegener, 2017), however, all of these had a primary focus on specific populations in high-income countries (HIC). Althoff, Ametti and Bertmann (2016) reviewed studies investigating the relationship between FI, child psychopathology, and its risk factors including parental MH. They described evidence for an impact of FI on both child and parental MH, as well as the possibility of bi-directionality. However, the review had several limitations, as it constituted a narrative overview of the topic, and therefore did not employ systematic review methods.

The review by Maynard et al. (2018) employed more rigorous methods, focusing on the relationship between FI and MH among women living in HIC. While most of the included studies were cross-sectional, they found 11 longitudinal studies, most of which considered FI as an exposure and MH as an outcome in line with the social causation hypothesis. Nevertheless, some studies also examined the reverse, and a few investigated both. Results did indeed appear to indicate a bi-directional relationship, which resembled the findings of a review by Bruening, Dinour and Chavez (2017) that had a specific focus on longitudinal studies from the United States. However, it is unclear to what extent these findings may be generalised to LMIC, especially in light of conflicting evidence regarding the cross-cultural consistency of the association between FI and MH from recent studies (Frongillo, Nguyen, Smith & Coleman-Jensen, 2018; Jones, 2017), and studies indicating that both FI (Renzaho & Mellor, 2010) and MH (Carpenter-Song et al., 2010) are experienced differentially across settings and populations.

Aims and Research Question

To summarise, both FI and MH are pressing global issues with a wide range of direct and indirect consequences. LMIC are, and are likely to continue to be, particularly affected, but current intervention strategies have shown little effect. However, a better understanding of the relationship between FI and MH could facilitate the development of novel preventative interventions. Previous reviews on FI and MH in LMIC have predominantly included cross-sectional research, from which it cannot be determined whether the observed association may be explained by the social causation or the social drift hypothesis. Reviews with a focus on specific populations in HIC support both notions, yet it is unclear to what extent this applies to different settings and populations in LMIC.

Another review of the literature would be a particularly useful technique to address this gap, as it enables the integration of available information, recognition of patterns, and provision of a stronger basis for recommendations than individual empirical studies. Building upon the initial review by Weaver and Hadley (2009), the present review therefore aimed to (1) provide an update on the current evidence base regarding the relationship between FI and MH in LMIC, (2) extend the literature by establishing the direction of the relationship between the two variables via a specific focus on longitudinal studies, and thereby (3) identify potential targets for interventions. Hence, the research question was: What is the nature of the relationship between FI and MH in LMIC according to longitudinal research?

Methods

Methodology

To ensure comprehensiveness, objectivity, and replicability, the review employed systematic methods. These were detailed in a protocol based upon an initial project outline (Appendix A) prior to commencement of research activities, thus reducing potential bias (Stewart, Moher & Shekelle, 2012). Due to the anticipated heterogeneity of included studies in terms of constructs examined and measures used, a quantitative synthesis in the form of a meta-analysis was deemed unsuitable (Charrois, 2015), and results were synthesised narratively instead. The final report incorporates all applicable sections of the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) guidelines (Moher, Liberati, Tetzlaff & Altman, 2009).

Ethical Approval

Since the review did not involve the collection of primary data from human subjects, approval by an ethics committee was not required.

Information Sources

Given the interdisciplinary nature of the research question, the selection of information sources aimed to ensure coverage of a variety of subjects including the social sciences, medicine, healthcare, psychology, global health, agriculture, and environmental science. Accordingly, the following eight electronic databases were searched: CAB Abstracts, CINAHL, Embase, Global Health, MEDLINE, PsycINFO, Scopus, and the Web of Science Core Collection. Where possible, searches were not limited to articles published in peer-reviewed journals, and hence also encompassed grey literature such as conference proceedings, dissertations, and official reports. This was done to minimise the impact of publication bias (Adams et al., 2016). Further efforts to retrieve relevant academic grey literature were made by searching ProQuest Dissertations and Theses Global, Open Grey, and WorldCat Dissertations and Theses. All databases were searched from their inception to 16 April 2019, and no language restrictions were applied because of the possibility that translations of non-English records were accessible elsewhere. To complement database searches, additional backward and forward citation searches were conducted using Google Scholar (Hinde & Spackman, 2015). These involved scanning the reference lists and citations of all included articles and previous reviews.

Searches

Based on the search strategies of previous reviews and informal examination of the literature, the search strategy for MEDLINE (Box 1) was developed with assistance from a college librarian, piloted, and adapted for the remaining databases. Search terms included a wide range of subject headings and keywords relating to FI, MH, and longitudinal study designs, accounting for different word forms and spelling variants through wildcards and truncation. However, terms denoting LMIC were not entered, as income classifications of countries may change over time (Fantom & Serajuddin, 2016). Moreover, in contrast to the review by Weaver and Hadley (2009), searches were not limited by ‘not eating disorders’, as this could have resulted in the loss of articles containing the term in any context, and eating disorders were considered to pertain to the MH category. Instead of searching titles and abstracts only, search field tags specifying the generally more inclusive default keyword search mode of each database were used. Overall, the search strategy was thus designed to be sensitive rather than specific in an attempt to avoid the erroneous omission of studies.

1. food supply/
2. hunger/
3. starvation/
4. (food adj4 (secur* or insecur* or adequa* or inadequa* or supply or supplies or availab* or unavailab* or access* or inaccess* or certain* or uncertain* or scarc* or shortage? or hardship?)).mp.
5. (famine or hunger or starvation).mp.
6. 1 or 2 or 3 or 4 or 5
7. exp mental disorders/
8. mental health/
9. ((mental* or psych* or behavi* or emotion*) adj4 (disorder? or diagnos* or condition? or disturbance? or morbidit* or symptom* or disease? or illness* or health or wellbeing or stress or distress)).mp.
10. (depress* or anxi* or mood? or emotion*).mp.
11. 7 or 8 or 9 or 10
12. (longitudinal* or cohort? or prospective* or panel or follow?up? or quasi?experiment*).mp.
13. 6 and 11 and 12

Box 1. Search strategy used in MEDLINE (Ovid).

Study Selection

All records yielded by the searches were imported into EndNote (version X7.7.1) to simplify data management. Following the removal of duplicates, missing abstracts were gathered. Titles and abstracts were then screened for eligibility by the first reviewer, who was blind to author names, journal titles, and publication statuses in order to diminish bias in study selection. For all studies that appeared to meet eligibility criteria, full-text articles were retrieved and reviewed in more detail. If full texts were unavailable online, requests were sent to corresponding authors. To ensure objectivity, a second reviewer independently completed the same selection procedure for a random sample of 100 records, whereupon any discrepancies were resolved through discussion. Inter-rater reliability was evaluated by calculating agreement percentages and the Cohen's kappa (κ) statistic (McHugh, 2012) via the GraphPad Software (2018) 'Quantify Agreement with Kappa' tool.

Eligibility Criteria

Any articles satisfying the following four eligibility criteria were considered for inclusion in the review:

1. Articles were required to describe a study in which the relationship between FI and MH was measured directly, regardless of whether this was a primary or secondary study outcome. As both variables have been defined inconsistently in previous research, a broad range of conceptualisations were permitted. These comprised various constructs related to FI at different levels, as well as to MH in the form of diagnosed psychiatric disorders, indicators of psychological wellbeing, and local idioms of distress.
2. Studies needed to employ a longitudinal design, which, for the purposes of this review, was defined as any observational or quasi-experimental research in which data was prospectively collected at two or more time points using quantitative methods.
3. Studies must also have been conducted in a LMIC, which was established by means of the respective World Bank classification at the time of data collection.
4. Finally, an English version of the full-text article had to be available, since this was the only language understood by both reviewers. Moreover, the translation of non-English articles was impracticable owing to a lack of funding for translation services and the inaccuracy of free web-based services (Balk et al., 2012).

Data Extraction Process

To aid the consistent collection of data from included studies, a standardised data extraction template (Appendix B) was drafted. After pre-piloting, the refined form contained items relating to general study information, the study setting, baseline sample characteristics, FI and MH constructs and measures, and study findings.

Risk of Bias Assessment

The ‘Quality Assessment Tool for Quantitative Studies’, developed by the Effective Public Health Practice Project (EPHPP; 1998a), was used to determine risk of bias in studies included in this review. While a small number of standardised risk assessment tools are considered the ‘gold standard’ for systematic reviews of randomised controlled trials (RCT), a similar consensus has not been reached for reviews of observational or quasi-experimental research (Jarde, Losilla & Vives, 2012; Shamliyan, Kane & Dickinson, 2010). Nevertheless, the EPHPP tool was selected for this review, as it can be applied to a variety of quantitative study designs (Armijo-Olivo, Stiles, Hagen, Biondo & Cummings, 2012), and has been used to evaluate longitudinal studies in previous reviews (Ehsan & DeSilva, 2015; Moore, Ford & Farah, 2014; Saunders, Green, Petticrew, Steinbach & Roberts, 2013). Furthermore, it has been shown to exhibit high levels of content validity, construct validity, and test-retest reliability (Thomas, Ciliska, Dobbins & Micucci, 2004). The tool comprises six sections, appraising selection bias, study design, confounders, blinding, data collection methods, and withdrawals and drop-outs.

Assessors may classify study quality as ‘strong’, ‘fair’, or ‘weak’ on each of these individual sections. In doing so, they are instructed to judge the clarity of reporting rather than inferences about the authors’ intentions. Studies with no weak rating are assigned a ‘strong’ global rating, while those with one weak rating are considered ‘fair’, and those with two or more individual ratings of weak receive an overall ‘weak’ rating. The standardised application of these criteria is enhanced by a detailed guidance document (EPHPP, 1998b), and in this review, the quality of 20% of the included studies was assessed in duplicate by the second reviewer.

Results

Study Selection

A detailed flow chart of the study selection process is depicted in Figure 1. The initial database searches yielded 3,645 records, and five additional records were later identified in the reference lists of included studies and previous reviews. Following the elimination of duplicates, a total of 1,858 records remained, and a further 1,742 of these were excluded during title and abstract screening. Primary reasons were that reported studies did not directly measure the relationship between FI and MH ($n = 1,537$), employed a design that was not longitudinal ($n = 91$), or had been conducted in a HIC ($n = 114$). Full texts for the other 116 records were accessed and examined in more detail. Two abstracts published in online supplemental issues of the FASEB Journal (Natamba et al., 2015; Sackey, Chui & Tang, 2015) appeared to meet all eligibility criteria, however full-text reports were unavailable. Upon correspondence with study authors, it was determined that neither of the studies could be included in the review, as the published journal article resulting from one of the abstracts only presented cross-sectional data (S. Mehta, personal communication, 17 May 2019), and the other abstract had never been succeeded by a full published article (J. Sackey, personal communication, 18 May 2019). Of the remaining 114 articles, 99 were excluded, either on grounds of their language ($n = 3$), the relationship measured in the reported study ($n = 58$), the study type ($n = 31$), or the country of data collection ($n = 7$). Ultimately, therefore, 15 studies were included in the review. The agreement between the first and second reviewers on the randomly selected subset of records was 84% ($\kappa = .34$, 95% CI [0.10, 0.57]), indicating fair levels of agreement.

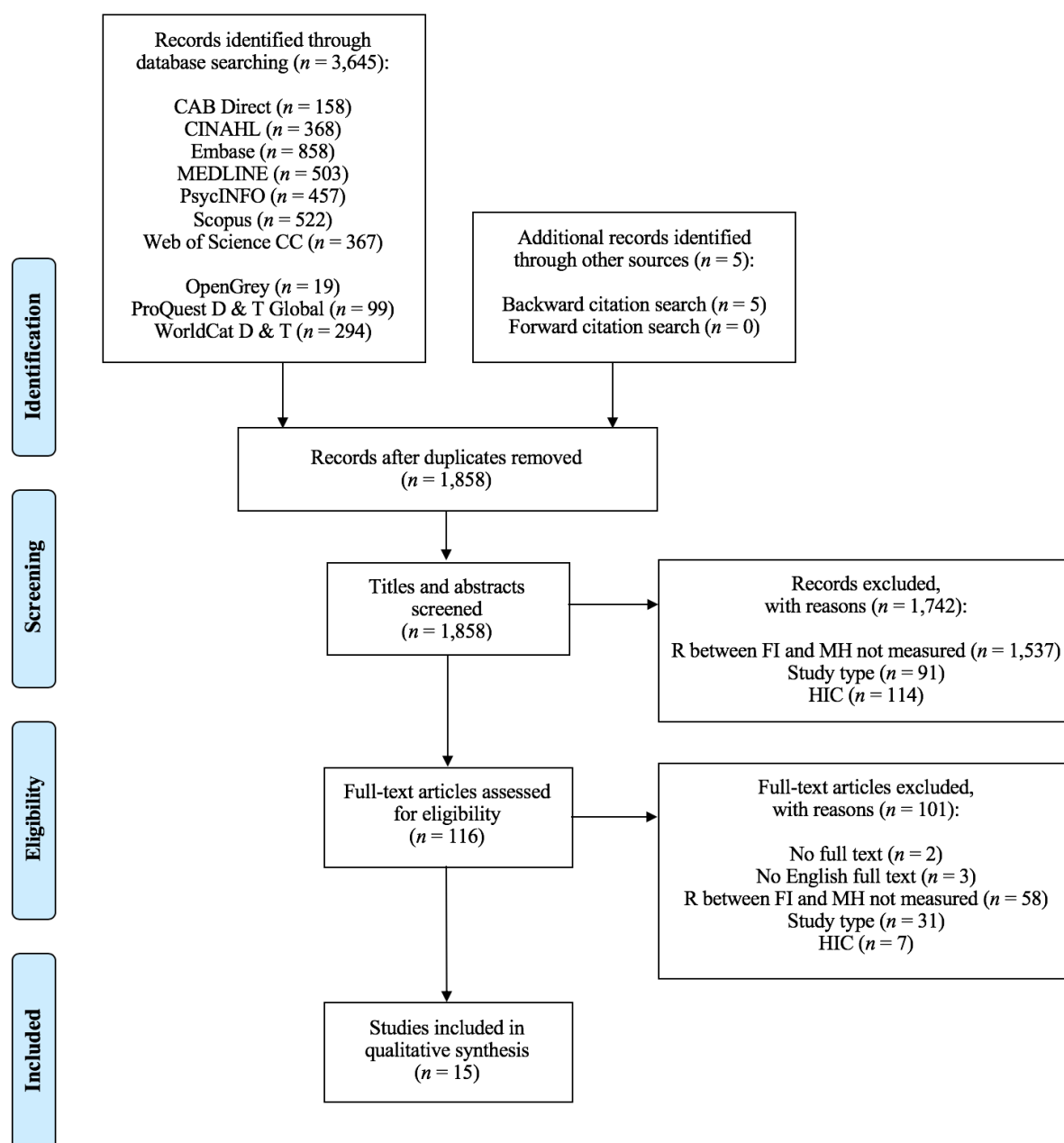


Figure 1. PRISMA flow diagram of study selection.

Study Characteristics

Methods. Information on study characteristics is presented in Table 1. All included articles were published in academic peer-reviewed journals between 1998 and 2016. Ten studies utilised primary data specifically collected for the purposes of the study, while five performed a secondary analysis of pre-existing data. Two of the latter were based on data gathered in larger cohort studies, namely the ‘Research to Improve Infant Nutrition and Growth’ (RIING) study and the ‘Uganda AIDS Rural Treatment Outcomes’ (UARTO) study. Data collection for 12 of the studies took place between

2001 and 2014, although dates were not specified for the other three. Follow-up timings varied widely, ranging from six weeks to four years. Most studies conducted two ($n = 5$) or three ($n = 7$) waves of data collection, but there were three studies that carried out four, five, and more than six waves, respectively.

Settings. The majority of studies ($n = 11$) took place in Sub-Saharan Africa. Three of these were from South Africa, two from Zimbabwe, and there was one study each from Ethiopia, Ghana, Malawi, Tanzania, Uganda, and Zambia. Three studies were from India, and another one from Haiti, representing the geographical areas of South Asia and the Caribbean. Therefore, according to the World Bank classification of countries, 12 studies from low-income, and three studies from an upper-middle-income country, were included. Within these contexts, most participants were residing in urban ($n = 3$) or peri-urban ($n = 3$) regions, while five studies were from rural areas, and four studies did not specify.

Participants. Sample sizes varied widely, with nine smaller studies involving between 110 and 637 participants, and six studies with more than 1,000 participants. Most studies ($n = 12$) focused on adult populations. Three studies investigated populations of children, however only two of these also employed children as participants. In one of these two, adults served as corroborative informants, and in an additional study, adults were the sole participants providing information about their children. Several studies considered specific subpopulations, such as three studies on mothers during the postpartum period, two studies involving orphaned children, one study on community AIDS healthcare volunteers, and another study on adults initiating antiretroviral therapy. Participants were predominately female, as six studies focused on female populations only, and females accounted for a large majority of the participants in three further studies. In five studies, gender distributions were approximately equivalent, and one article did not report on this. Based on the information provided, the overall range of ages was at least nine to 88 years. Other demographic characteristics, including ethnicity, education, income, or assets, were reported inconsistently and therefore omitted from data extraction.

FI measures. About half of the studies ($n = 7$) considered FI on a household level, while seven others did so on an individual level, and one study assessed both. Although six studies focused on the FI construct itself, others used related conceptualisations including hunger ($n = 5$), food insufficiency ($n = 2$), or, conversely, food security ($n = 1$). Only one study distinguished between different domains of FI. To measure these constructs, seven studies applied standardised scales. The Household Food Security Access Scale (HFIAS) was most commonly utilised ($n = 4$), followed by the Household Food Security Survey Module (HFSSM; $n = 3$). In six studies, adaptations were made to these scales, which included the elimination of items irrelevant to the research question, or the addition of culturally specific probes. Three studies only employed single-item questions, such as ‘In your life until now, how often did your family not have enough food to feed everyone?’ (DeSilva et al., 2012), and one article reported using a modified version of a scale developed for a previous study by Maxwell (1996). In four reports, the method used to measure FI was not further specified.

MH measures. 13 of the 15 included studies only focused on a single MH construct. Most commonly, depression and anxiety were simultaneously considered as CMD ($n = 5$), followed by

depression alone ($n = 3$). More general psychiatric symptomatology, post-traumatic stress disorder (PTSD), suicide, emotional distress, and perceived stress were observed by one study each. An additional study measured depression, anxiety, PTSD, conduct problems, delinquency, and suicidality, but conceptualised their combined absence as MH resilience. Only one study conducted separate analyses for different constructs. In line with the variety of constructs investigated, a wide range of measures was used. Almost all of the included studies ($n = 13$) utilised standardised scales, while one employed a structured diagnostic interview, and another one focused on incident cases of attempted suicide. The only four scales that were used more than once were the Edinburgh Postnatal Depression Scale (EPDS), the Hopkins Symptom Checklist (HSCCL), the Self-Reporting Questionnaire (SRQ), and the Shona Symptom Questionnaire (SSQ). In five studies, scale adaptations, such as the removal of culturally inappropriate items or the introduction of items querying local idioms of distress, were made.

Table 1. Characteristics of included studies.

Study	Data source	Time points	Setting	Baseline sample characteristics	Measures	
					FI	MH
Cole et al. (2011)	Primary data collection	2009 T1: Apr. / Jul. T2: Oct. / Nov.	Zambia LIC (World Bank, 2009) Rural	Household heads $N = 151$ Female: N/A Age: $Mdn = 41$ y. $IQR = 25 - 51$ y.	Household FI Maxwell (1996; 7-item; modified)	Psychiatric symptoms SRQ (20-item)
Collishaw et al. (2016)	Study on psychological distress in AIDS-orphaned children	2005 – 2009 T1: Baseline T2: 4 y.	South Africa UMC (World Bank, 2009) Urban	Orphaned and non-orphaned children and adolescents $N = 1,025$ Female: 47% Age: $M = 14$ y. $Range = 10 - 19$ y.	Individual food security Single-item question	Mental health resilience CDI (10-item) RCMAS (14-item) CPTSDC (28-item) SDQ (5-item) CBCL-YSR (11-item) MINI-kid (2-item) Self-report of suicidal intent
DeSilva et al. (2012)	Primary data collection	2004 – 2007 T1: Baseline T2: 1 y. T3: 2 y.	South Africa UMC (World Bank, 2007) N/A	School-attending orphaned and non-orphaned children $N = 637$ Female: 47% Age: $Range = 9 - 15$ y.	Household FI Single-item question (child) Two items (primary caregiver)	Depression, anxiety, worries RADs-2 (21-item; modified) Self-esteem

Study	Data source	Time points	Setting	Baseline sample characteristics	Measures	
					FI	MH
				Primary caregivers <i>N</i> = N/A Female: N/A Age: N/A		CFSEI (11-item; modified) Resilience TSCC (7-item; modified) Oppositional behaviour TSCC (10-item; modified)
Garcia et al. (2013)	RIING study	2004 – 2009 T1: Birth T2: 3 m. T3: 6 m. T4: 9 m. T5: 12 m.	Ghana LIC (World Bank, 2009) Peri-Urban	Mothers of young children <i>N</i> = 285 Female: 100% Age: <i>M</i> = 28 y.	Household FI HFSSM (7-item; modified)	Perceived stress PSS (4-item)
Hadley et al. (2008)	Primary data collection	2005 – 2006 T1: Jun. / Jul. T2: Dec. / Jan.	Tanzania LIC (World Bank, 2006) Rural	Sukuma and Pimbwe caretakers <i>N</i> = 211 Female: 100% Age: <i>M</i> = 29 y.	Household FI HFSSM (15-item; modified)	CMD symptoms HSCL (24-item; modified)
Hutson	Primary data collection	2009 – 2010 T1: Before	Haiti LIC (World	Adult household members <i>N</i> = 1,800	Child food insufficiency HFSSM (3-item)	Post-traumatic stress disorder symptoms

Study	Data source	Time points	Setting	Baseline sample characteristics	Measures	
					FI	MH
et al. (2014)		earthquake T2: 6 w. after earthquake	Bank, 2010) Urban	Female: N/A Age: N/A Children <i>N</i> = 3,596 Female: 53% Age: <i>M</i> = 11 y.		HTQ (16-item)
Littrell et al. (2011)	Trial of Orphan Support Africa (OSA) programme	2007 – 2009 T1: Baseline T2: 2 y.	Malawi LIC (World Bank, 2009) Rural	Primary caregivers <i>N</i> = 1,581 Female: Nearly all Age: <i>M</i> = 38 y. <i>Range</i> = 17 – 88 y.	Household food security anxiety, household insufficient food quality, household insufficient food quantity HFIAS (6-item; modified)	Emotional distress WHOQOL-100 (7-item; modified)
Maes et al. (2010)	Primary data collection	2008 T1: February T2: July T3: November	Ethiopia LIC (World Bank, 2008) Urban	Community AIDS healthcare volunteers <i>N</i> = 110 Female: 90% Age: <i>M</i> = 28 y. <i>Range</i> = 18 – 45 y.	Household FI HFIAS (9-item; modified)	CMD caseness SRQ (29-item; modified)

Study	Data source	Time points	Setting	Baseline sample characteristics	Measures	
					FI	MH
Maselko et al. (2008)	Primary data collection	2001 – 2004	India	Registered women	Hunger	Attempted suicide
		T1: Baseline	LIC (World Bank, 2004)	$N = 2,494$	Single-item question	caseness
		T2: 6 m.		Female: 100%		Single-item question
		T3: 12 m.	N/A	Age: $M = 33$ y.		
Patel et al. (1998)	Primary data collection	N/A	Zimbabwe	Primary care attenders	Hunger	CMD caseness
		T1: Baseline	LIC (World Bank, 1998)	$N = 199$	N/A	SSQ (14-item)
		T2: 2 m.		Female: 65%		
		T3: 12 m.	N/A	Age: $M = 35$ y.		
Patel et al. (2002)	Primary data collection	N/A	India	Pregnant women	Hunger	Postnatal depression
		T1: Pregnancy	LIC (World Bank, 2002)	$N = 270$	N/A	caseness
		T2: 6 – 8 w. PP		Female: 100%		EPDS (10-item)
		T3: 6 m. PP	N/A	Age: $M = 26$ y. $Range = 18 – 40$ y.		
Patel et al. (2006)	Primary data collection	2001 – 2004	India	Women	Hunger	ICD-10 CMD caseness
		T1: Baseline	LIC (World Bank, 2004)	$N = 2,494$	N/A	CIS-R
		T2: 6 m.		Female: 100%		
		T3: 12 m.	Rural	Age: $Range = 18 – 45$ y.		
Todd et al. (1999)	Primary data collection	N/A	Zimbabwe	Primary care attenders	Hunger	CMD caseness
		T1: Baseline	LIC (World Bank, 1999)	$N = 197$	N/A	SSQ (14-item)
		T2: 2 m.		Female: 55%		
		T3: 12 m.	Peri-Urban	Age: $M = 32$ y.		

Study	Data source	Time points	Setting	Baseline sample characteristics	Measures	
					FI	MH
Tsai et al. (2012)	UARTO study	2007 – 2010	Uganda	Adult HIV patients	Household FI	Depressive symptoms
		Every 3 m. (2.1 y. median duration)	LIC (World Bank, 2010) Rural	initiating ART <i>N</i> = 456 Female: 71% Age: <i>Mdn</i> = 34 y. (female) <i>IQR</i> = 28 – 38y. (female) <i>Mdn</i> = 39 y. (male) <i>IQR</i> = 33 – 45y. (male)	HFIAS (9-item; modified)	HSCL (16-item; modified)
Tsai et al. (2016)	Trial of a home visiting intervention	2009 – 2014	South Africa	Pregnant women	Individual food insufficiency	Depressive symptoms
		T1: Pregnancy	UMC	<i>N</i> = 1,238		EPDS (10-item)
		T2: 6 m. PP	(World Bank, 2014)	Female: 100%	Single-item question	
		T3: 18 m. PP	Peri-Urban	Age: <i>Range</i> = 18 – 25 y. (50%), 26 – 35 y. (43%), ≥ 36 y. (7%)	Household FI HFIAS (9-item)	

Note. CBCL-YSR = Child Behaviour Checklist Youth Self Report; CDI = Child Depression Inventory; CFSEI = Culture Free Self-Esteem Inventory; CIS-R = Revised Clinical Interview Schedule; CPTSDC = Child Post Traumatic Stress Disorder Checklist; EPDS = Edinburgh Postnatal Depression Scale; HFIAS = Household Food Insecurity Access Scale; HFSSM = Household Food Security Survey Module; HSCL = Hopkins Symptom Checklist; HTQ = Harvard Trauma Questionnaire; LIC = low-income country; MINI-kid = Mini International Neuropsychiatric Interview for Children and Adolescents; N/A = not available; PP = postpartum; PSS = Perceived Stress Scale; RADS-2 = Reynolds Adolescent Depression Scale; RCMAS = Revised Children's Manifest Anxiety Scale; SDQ = Strengths and Difficulties Questionnaire; SRQ = Self-Reporting Questionnaire; SSQ = Shona Symptom Questionnaire; TSCC = Trauma Symptom Checklist for Children; UMC = upper-middle-income country; WHOQOL-100 = World Health Organisation Quality of Life scale.

Risk of Bias Within Studies

Table 2 shows the outcomes of the risk of bias assessment by means of the EPHP tool. Overall, the majority of studies ($n = 10$) were regarded to be of weak quality, while five studies were categorised as ‘fair’, and none received a rating of ‘strong’. In terms of individual components, every study was at least assigned a rating of ‘fair’ for selection bias, and five studies were even rated ‘strong’. The latter applied methods to identify all members of the study population, from which they then obtained a random sample. In ‘fair’-rated studies, participants were referred by organisations such as clinics and schools, and none of the studies engaged self-referred participants. Most studies ($n = 9$) achieved a ‘strong’ rating for confounders, controlling for a large number of extraneous variables such as age, sex, education, income or assets, health status, or household size in their analyses. However, four ‘weak’ studies failed to do so, and two ‘fair’ studies only controlled for a small number of possible confounders. Ratings for the withdrawals and drop-outs component were mixed, with seven ‘strong’, three ‘fair’, and five ‘weak’ studies. Follow-up rates were generally moderate to high, ranging between 70% and 97%. Yet studies of ‘strong’ quality in this category additionally reported reasons for participant attrition, which included moving away, loss of interest, or participant death. Scores for data collection methods were also varied, but only two studies were classified as ‘strong’ and seven as ‘fair’, while the remaining six were ‘weak’. Studies rated as ‘strong’ on this component demonstrated or at least referenced research showing both the reliability and validity of their measures. Weaker ratings were mainly received by studies in which the reliability or validity of a new scale remained unassessed following adaptation. Finally, all studies were assigned a ‘fair’ rating for study type due to their longitudinal designs, and a rating of ‘weak’ for the blinding component as none of the studies mentioned relevant procedures. Agreement with the second assessor on scores for the subsample generated was 71% ($\kappa = .57$, 95% CI [0.30, 0.85]) and hence moderate.

Table 2. EPHPP quality assessment ratings for individual studies.

Study	Component scores						Global score
	SB	SD	C	B	DCM	WD	
Cole et al. (2011)	Strong	Fair	Strong	Weak	Fair	Strong	Fair
Collishaw et al. (2016)	Fair	Fair	Weak	Weak	Weak	Fair	Weak
DeSilva et al. (2012)	Fair	Fair	Strong	Weak	Weak	Weak	Weak
Garcia et al. (2013)	Fair	Fair	Strong	Weak	Fair	Weak	Weak
Hadley et al. (2008)	Fair	Fair	Strong	Weak	Fair	Strong	Fair
Hutson et al. (2014)	Strong	Fair	Weak	Weak	Fair	Strong	Weak
Littrell et al. (2011)	Fair	Fair	Strong	Weak	Weak	Strong	Weak
Maes et al. (2010)	Fair	Fair	Strong	Weak	Strong	Weak	Weak
Maselko et al. (2008)	Strong	Fair	Weak	Weak	Weak	Strong	Weak
Patel et al. (1998)	Fair	Fair	Fair	Weak	Fair	Fair	Fair
Patel et al. (2002)	Fair	Fair	Weak	Weak	Fair	Weak	Weak
Patel et al. (2006)	Strong	Fair	Strong	Weak	Weak	Strong	Weak
Todd et al. (1999)	Fair	Fair	Fair	Weak	Fair	Fair	Fair
Tsai et al. (2012)	Fair	Fair	Strong	Weak	Weak	Weak	Weak
Tsai et al. (2016)	Strong	Fair	Strong	Weak	Strong	Strong	Fair

Note. B = Blinding; C = Confounders; DCM = Data Collection Methods; SB = Selection Bias; SD = Study Design; WD = Withdrawals and Drop-outs.

Results of Individual Studies

The main findings of all included studies are summarised in Table 3. In terms of the direction assessed, studies almost exclusively ($n = 14$) investigated the effect of FI on MH, while only one study examined the reverse, and none considered bi-directionality. All studies utilised regression models in their data analysis. The most commonly used ($n = 9$) method was logistic regression, yet other techniques such as generalised estimating equations or time-lagged linear regression were also applied. Consequently, studies modelled the relationship between FI and MH in different ways, and more than one relevant analysis was extracted from most ($n = 10$) studies. Several ($n = 11$) studies examined whether FI measured at one time point predicted MH at a later time point. Two of these specifically assessed the impact of FI on a sustained MH status, and one the impact of sustained FI on MH. Two studies differentiated between different levels of FI, and thereby investigated a potential dose-response relationship. In addition, six studies focused on the effect of changes in FI on changes in MH. Amongst these, two studies examined whether seasonal changes in FI affected MH. Only two studies explicitly investigated the moderating effect of an additional variable, namely social support, and three studies conducted stratified analyses of subgroups. With the exception of one study, every study reported a statistically significant positive relationship between FI and MH problems in at least one of its analyses. However, in eight studies, there was also at least one analysis that failed to observe a statistically significant effect. No study reported a negative relationship between the two variables.

Table 3. Results of included studies.

Study	Direction assessed	Relevant results
Cole et al. (2011)	FI effect on MH	Multi-level linear regression The effect of household FI on psychiatric symptoms was significantly greater during the dry season than during the rainy season, $\beta = 0.448$, $SE = .196$, $p < .05$. *
Collishaw et al. (2016)	FI effect on MH	Bivariate logistic regression Food security at baseline significantly predicted sustained mental health resilience across both study time points among AIDS-orphaned children, $OR = 5.96$, 95% CI [2.4, 14.8], $p < .01$. Food security at baseline significantly predicted sustained mental health resilience across both study time points among AIDS-orphaned children, other-orphaned children, and non-orphaned children, $OR = 4.66$, 95% CI [2.7, 8.2], $p < .01$. Multivariate logistic regression Food security at baseline no longer significantly predicted sustained mental health resilience across both study time points among AIDS-orphaned children, other-orphaned children, and non-orphaned children, $OR = 1.80$, 95% CI [0.93, 3.5], $p < .10$.
DeSilva et al. (2012)	FI effect on MH	General linear mixed models Caregiver-reported household FI at wave two did not significantly predict anxiety and depressive symptoms over waves two and three, $AOR = 1.46$, 95% CI [1.00, 2.14], $p = .0499$. * Child-reported household FI at wave two significantly predicted resilience over waves two and three, adjusted effect estimate = -0.48, $SE = .23$, $p = .0398$. * Child-reported household FI at wave two significantly predicted worries about getting enough to eat over waves two and three, $AOR = 2.27$, 95% CI [1.39, 3.71], $p = .0010$. *

Study	Direction assessed	Relevant results
		Child-reported household FI at wave two significantly predicted worries about getting money at waves two and three, $AOR = 1.83$, 95% CI [1.16, 2.89], $p = .0094$. *
Garcia et al. (2013)	FI effect on MH	Multivariate logistic regression The risk of experiencing stress at 12 months postpartum were significantly higher among women living in households that had been persistently food insecure for the past year compared to those who did not live in these households, $OR = 3.55$, 95% CI [1.13, 11.13], $p < .05$. *
Hadley et al. (2008)	FI effect on MH	Ordinary least squares regression Women who reported an increasingly severe FI in the wet season relative to their dry season value also experienced an increased severity of anxiety and depression, $\beta = 0.79$, $SE = .21$, $p < .0001$. *
Hutson et al. (2014)	MH effect on FI	Multivariate logistic regression The level of PTSD symptoms among adult household members prior to the earthquake did not significantly predict the likelihood of child food insufficiency after the earthquake, $OR = 1.53$, 95% CI [1.10, 2.11], $p < .1$.
Littrell et al. (2011)	FI effect on MH	Bivariate logistic regression Caregivers who remained ($OR = 4.88$, 95% CI [3.14, 7.59], $p < .001$) or became ($OR = 2.93$, 95% CI [1.82, 4.71], $p < .001$) anxious regarding food security were significantly more likely to experience increases in distress compared to those who remained certain regarding food security. Caregivers who remained ($OR = 5.10$, 95% CI [3.07, 8.45], $p < .001$) or became ($OR = 3.53$, 95% CI [2.32, 5.36], $p < .001$) certain regarding food security were significantly more likely to experience decreases in distress than those who remained anxious regarding food security. Caregivers who remained ($OR = 6.62$, 95% CI [3.79, 11.56], $p < .001$) or became ($OR = 3.66$, 95% CI [1.93, 6.94], $p < .001$) insecure in terms of food quality were significantly more likely to experience increases in distress compared to those who remained secure in terms of food quality.

Study	Direction assessed	Relevant results
		<p>Caregivers who remained ($OR = 4.79$, 95% CI [2.29, 10.01], $p < .001$) or became ($OR = 3.28$, 95% CI [2.19, 4.93], $p < .001$) secure in terms of food quality were significantly more likely to experience decreases in distress compared to those who remained insecure in terms of food quality.</p> <p>Caregivers who remained ($OR = 6.60$, 95% CI [4.17, 10.45], $p < 0.001$) or became ($OR = 3.99$, 95% CI [2.55, 6.24], $p < .001$) insecure in terms of food quantity were significantly more likely to experience increases in distress compared to those who remained secure in terms of food quantity.</p> <p>Caregivers who remained ($OR = 4.29$, 95% CI [2.06, 8.96], $p < 0.001$) or became ($OR = 2.93$, 95% CI [1.94, 4.41], $p < 0.001$) secure in terms of food quantity were significantly more likely to experience decreases in distress compared to those who remained insecure in terms of food quantity.</p> <p>Multivariate logistic regression</p> <p>Caregivers who remained ($AOR = 1.28$, 95% CI [0.68, 2.41], $p > .05$) or became ($AOR = 1.16$, 95% CI [0.64, 2.11], $p > .05$) anxious regarding food security were not significantly more likely to experience increases in distress compared to those who remained certain regarding food security.</p> <p>Caregivers who remained ($AOR = 1.65$, 95% CI [0.78, 3.47], $p > .05$) or became ($AOR = 1.42$, 95% CI [0.78, 2.58], $p > .05$) certain regarding food security were not significantly more likely to experience decreases in distress than those who remained anxious regarding food security.</p> <p>Caregivers who remained ($AOR = 2.37$, 95% CI [1.37, 5.46], $p < .01$), but not those who became ($AOR = 1.98$, 95% CI [0.93, 4.22], $p > .05$), insecure in terms of food quality were significantly more likely to experience increases in distress compared to those who remained secure in terms of food quality.</p> <p>Caregivers who remained ($AOR = 1.13$, 95% CI [0.41, 3.10], $p > .05$) or became ($AOR = 1.41$, 95% CI [0.80, 2.51], $p > .05$) secure in terms of food quality were not significantly more likely to experience decreases in distress compared to those who remained insecure in terms of food quality.</p>

Study	Direction assessed	Relevant results
		<p>Caregivers who remained ($AOR = 2.40$, 95% CI [1.26, 4.56], $p < .01$) or became ($AOR = 1.91$, 95% CI [1.07, 3.42], $p < .05$) insecure in terms of food quantity were significantly more likely to experience increases in distress compared to those who remained secure in terms of food quantity.</p> <p>Caregivers who remained ($AOR = 4.50$, 95% CI [2.03, 10.00], $p < .001$) or became ($AOR = 2.89$, 95% CI [1.58, 5.29], $p < .01$) secure in terms of food quantity were significantly more likely to experience decreases in distress compared to those who remained insecure in terms of food quantity.</p>
Maes et al. (2010)	FI effect on MH	<p>Multivariate generalised estimating equations</p> <p>Compared to severe household FI, participants reporting moderate household FI (effect estimate = -0.86%, $SE = .33$, $p < .01$), mild household FI (effect estimate = -1.93%, $SE = .47$, $p < .0001$), or household food security (effect estimate = -4.31%, $SE = .83$, $p < .0001$) were significantly less likely to have a CMD. *</p>
Maselko et al. (2008)	FI effect on MH	<p>Bivariate logistic regression</p> <p>Having experienced hunger in the past three months at baseline significantly predicted an increase in the risk of attempting suicide over the one-year follow-up period, $OR = 6.59$, 95% CI [1.83, 19.77], $p = .003$. *</p> <p>Multivariate logistic regression</p> <p>Having experienced hunger in the past three months at baseline no longer significantly predicted an increase in the risk of attempting suicide over the one-year follow-up period, $OR = 2.02$, 95% CI [0.46, 7.53], $p > .05$. *</p>
Patel et al. (1998)	FI effect on MH	<p>Multivariate logistic regression</p> <p>Having experienced hunger in the past month at baseline significantly predicted persistence of CMD at the two month follow up, $AOR = 2.1$, 95% CI [1.1, 3.9], $p = .02$.</p> <p>Having experienced hunger in the past month at baseline did not significantly predict persistence of CMD at the 12-month follow up, $AOR = 1.2$, 95% CI [0.6, 2.3], $p = .05$.</p>

Study	Direction assessed	Relevant results
Patel et al. (2002)	FI effect on MH	<p>Multivariate logistic regression</p> <p>Antenatal experience of hunger significantly predicted postnatal depression, relative risk = 2.5, 95% CI [1.6, 3.8], $p < .001$.</p> <p>Antenatal experience of hunger significantly predicted chronic postnatal depression, relative risk = 1.9, 95% CI [1.3, 2.8], $p = .003$.</p>
Patel et al. (2006)	FI effect on MH	<p>Bivariate logistic regression</p> <p>Having experienced hunger in the past three months at baseline significantly predicted incidence of CMD over the study period, $OR = 3.37$, 95% CI [1.3, 8.8], $p = .01$. *</p> <p>Multivariate logistic regression</p> <p>Having experienced hunger in the past three months at baseline no longer significantly predicted incidence of CMD over the study period, N/A. *</p>
Todd et al. (1999)	FI effect on MH	<p>Multivariate logistic regression</p> <p>Having experienced hunger in the past month at baseline significantly predicted the onset of CMD at the two month follow up, $AOR = 4.2$, 95% CI [1.6, 10.9], $p = .003$.</p> <p>Having experienced hunger in the past month at baseline no longer significantly predicted the onset of CMD at the 12-month follow up, $AOR = 1.7$, 95% CI [0.7, 4.8], $p = .2$.</p>
Tsai et al. (2012)	FI effect on MH	<p>Time-lagged linear regression</p> <p>Lagged household FI significantly predicted depression symptom severity among women living in severely food insecure households ($b = 0.070$, 95% CI [0.017, 0.123], $p = .01$), but not among those living in moderately ($b = -0.004$, 95% CI [-0.050, 0.043], $p > .05$) or mildly food insecure households ($b = 0.028$, 95% CI [-0.041, 0.097], $p > .05$). *</p> <p>Lagged household FI did not significantly predict depression symptom severity among men living in severely</p>

Study	Direction assessed	Relevant results
		<p>($b = 0.044$, 95% CI $[-0.014, 0.102]$, $p > .05$), moderately ($b = 0.026$, 95% CI $[-0.023, 0.074]$, $p > .05$), or mildly ($b = 0.038$, 95% CI $[-0.016, 0.093]$, $p > .05$) food insecure households. *</p> <p>No category of household FI significantly predicted depression symptom severity among women with the highest level of instrumental social support, N/A. *</p> <p>Severe household FI significantly predicted depression symptom severity among women with the lowest level of instrumental social support, $b = 0.127$, 95% CI $[0.057, 0.196]$, $p = \text{N/A}$. *</p> <p>Fixed-effects regression</p> <p>Increases in household FI significantly predicted increases in depression symptom severity among women, $b = 0.005$, 95% CI $[0.001, 0.009]$, $p = .008$. *</p> <p>Changes in household FI did not significantly predict changes in depression symptom severity among men, $b = 0.002$, 95% CI $[-0.002, 0.007]$, $p > .05$. *</p> <p>Moderation analysis</p> <p>Instrumental social support significantly moderated the effect of food insufficiency on depression symptom severity among women, $F = 2.95$, $p = .03$. *</p> <p>Emotional social support did not significantly moderate the effect of food insufficiency on depression symptom severity among women, $F = 1.41$, $p = .24$. *</p>
Tsai et al. (2016)	FI effect on MH	<p>Time-lagged linear regression</p> <p>Lagged food insufficiency significantly predicted depression symptom severity, $\beta = 0.70$, 95% CI $[0.46, 0.94]$, $p = \text{N/A}$. *</p> <p>Lagged food insufficiency significantly predicted depression symptom severity among women with a level of instrumental social support below the median, $\beta = 0.79$, 95% CI $[0.51, 1.07]$, $p = \text{N/A}$. *</p> <p>Lagged food insufficiency did not significantly predict depression symptom severity among women with a level</p>

Study	Direction assessed	Relevant results
		of instrumental social support above the median, $\beta = 0.12$, 95% CI [-0.35, 0.59], $p = \text{N/A}$. *
		Quantile regression
		The effect of food insufficiency on depression symptom severity was larger among women in the 80th percentile ($\beta = 2.09$, 95% CI [1.30, 2.87], $p = \text{N/A}$) compared to women in the 20th percentile ($\beta = 0.18$, 95% CI [0.07, 0.29], $p = \text{N/A}$) of the depression symptom distribution. *
		Fixed-effects regression
		Changes in food insufficiency significantly predicted changes in depressive symptom severity, $\beta = 0.94$; 95% CI [0.67, 1.22], $p = \text{N/A}$. *
		Fixed-effects quantile regression
		The effect of changes in food insufficiency on changes in depression symptom severity was larger among women in the 80th percentile ($\beta = 1.68$, 95% CI [1.45, 1.91], $p = \text{N/A}$) compared to women in the 20th percentile ($\beta = 0.59$, 95% CI [0.39, 0.80], $p = \text{N/A}$) of the depression symptom distribution. *
		Moderation analysis
		Instrumental social support significantly moderated the effect of food insufficiency on depression symptom severity, $F = \text{N/A}$, $p = .009$. *
		Emotional social support did not significantly moderate the effect of food insufficiency on depression symptom severity, $F = \text{N/A}$, $p = .22$. *

Note. Effects explicitly reported as statistically significant or non-significant in the article, either directly through description in the text or indirectly through stating the significance level used for all analyses in the study, are marked with an *. If statistical significance was not explicitly reported in the article, effects at $p < .05$ were deemed significant for the purposes of this review and described as such in the table. N/A = not available.

Synthesis of Results

Effect of FI on MH. Overall, the results support the notion that FI leads to an increased likelihood of MH problems, given that every included study considering this direction obtained at least one statistically significant analysis despite heterogeneity in study settings, populations, measures, and analytic approaches. Accordingly, FI appears to promote MH issues in countries of different income groups and regions of different urbanicity levels, at least in Sub-Saharan Africa and South Asia, where all included studies on this direction were conducted. The finding also seems to apply to a broad range of populations, including pregnant women, patients with HIV, and community health workers. Outcomes of FI at both individual and household level may be different manifestations of MH issues, with most evidence suggesting an effect on CMD and depression in particular.

Nevertheless, individual analyses in several studies also produced non-significant results, warranting an examination of potential underlying patterns. The study by Tsai et al. (2012) was one of only two that explicitly tested whether the effect of FI on MH may be moderated by an additional variable. In stratified analyses, it was found that the effect only remained statistically significant for participants with low levels of social support, indicating that social support may act as an effect moderator. However, this only applied to instrumental as opposed to emotional social support, which demonstrates the complexity of the relationship. Both of these findings were later replicated, and thereby corroborated, by Tsai, Tomlinson, Comulada and Rotheram-Borus (2016).

In further stratified analyses, Tsai et al. (2012) also found that household FI affected depression symptom severity only in females, but not in males, which may imply the gender specificity of the effect. This idea is reinforced by the observation that many of the studies that only obtained significant results used female-only samples (Garcia et al., 2013; Hadley & Patil, 2008; Maes, Hadley, Tesfaye & Shifferaw, 2010; Patel, Rodrigues & DeSouza, 2002; Tsai et al., 2016), whereas the samples of several studies with inconsistent results tended to be more balanced with respect to gender (Collishaw, Gardner, Aber & Cluver, 2016; DeSilva et al., 2012; Patel et al., 1998; Todd et al., 1999). Consequently, gender may be considered an additional moderating factor.

In addition to subgroups of participants, Tsai et al. (2012) also distinguished between different levels of household FI. They noted that only severe FI, but not moderate or mild levels of FI, predicted depression severity. These findings were reflected in the study by Maes et al. (2010), which observed a dose-response relationship between household FI and the risk of meeting criteria for a CMD. Instead of quantitative levels, Littrell, Boris, Brown, Hill and Macintyre (2011) conducted separate analyses for different qualitative dimensions of FI. They found that mere anxiety regarding food security did not lead to emotional distress, while actual insecurity in terms of food quality did, and insecurity regarding food quantity had the strongest effect. It therefore appears that the effect FI has on MH is contingent on the quantity and quality of the former.

The notion that FI does not affect MH uniformly is further supported by the fact that both Patel et al. (1998) and Todd et al. (1999) failed to find a statistically significant effect of hunger on CMD risk at a 12-month follow up, even though an effect existed at a two-month follow up. This could signify that the effect of FI on MH is also time-dependent, only exerting an impact for a relatively short amount of time. Indeed, many of the studies with significant results only conducted their final follow up at a shorter interval of a year or less (Cole & Tembo, 2011; Hadley & Patil, 2008; Maes et al., 2010; Patel et al., 2002), while some of the studies reporting non-significant results followed their participants for several years (Collishaw et al., 2016; DeSilva et al., 2012; Tsai et al., 2012).

However, other inconsistent results were not explained by similarly evident patterns. DeSilva et al. (2012) did not find caregiver-reported household FI to have a significant effect on child anxiety and depression, but described that household FI, as reported by children themselves, significantly predicted resilience and worries. This could imply the divergent impact of FI on different types of child MH problems or, alternatively, differences between the reports of caregivers and children. Yet Collishaw et al. (2016) obtained inverse findings, failing to observe a significant impact of child-reported FI on sustained MH resilience for orphaned as well as non-orphaned children in their final analysis. From these two studies alone, it is therefore not clear to what extent the effect of FI on MH applies to children.

Indeed, several studies, including the one by Collishaw et al. (2016), initially obtained significant results for the relationship between FI and MH in bivariate analyses, but found the effect to be attenuated and thus no longer significant in multivariate analyses (Maselko & Patel, 2008; Patel, Kirkwood, Pednekar, Weiss, & Mabey, 2006). While this may imply that FI mediates the relationship between an unknown variable and MH, it could also demonstrate the impact of confounding. However, this is in conflict with other studies in which the effect of FI on MH remained significant despite controlling for various potential confounders in multivariate analyses (Garcia et al., 2013; Littrell et al., 2011; Maes et al., 2010; Patel et al., 2002). Without further investigation, it is therefore not possible to ascertain the mechanisms underlying the relationship between FI and MH.

Finally, there were few differences between studies that only achieved significant results and those that were mixed in terms of study quality, making it unlikely that this could explain the inconsistencies. One observable distinction was that a high proportion of the studies with non-significant results employed single-item questions (Collishaw et al., 2016; DeSilva et al., 2012; Maselko & Patel, 2008), or did not specify the methods used (Patel et al., 1998; Patel et al., 2006; Todd et al., 1999), to measure FI. Although this is indicative of weak study quality, it should be noted that data collection methods were one of the most prominent concerns across all studies. Indeed, one should consider that the overall quality of the body of evidence was only regarded ‘weak’ to ‘fair’ in accordance with the EPHPP tool, which may compromise the informative value of its findings.

Effect of MH on FI. The only study examining a potential effect of MH on FI was the one conducted by Hutson, Trzcinski and Kolbe (2014), which found that PTSD symptoms among household

members before an earthquake did not significantly predict child food insufficiency following the earthquake. However, since the study took place in the specific context of a natural disaster, it is unclear to what extent its findings can be generalised to more ordinary circumstances. Moreover, the measurement of MH and FI in two related, yet separate, populations impedes the examination of a direct link between the two variables. Finally, the study was also considered to be of weak quality, primarily due to its failure to adjust for potential confounders. No firm conclusions regarding the effect of MH on FI can therefore be deduced from this single study.

Discussion

Summary of Evidence

To the best of the author's knowledge, the present systematic review was the first to investigate the nature of the relationship between FI and MH in LMIC based on longitudinal studies. This was done to provide an update on relevant research, establish the directionality of the relationship, and identify possible targets for interventions. Altogether, the review included 15 studies meeting the eligibility criteria. 14 of these focused on the effect of FI on MH, generally supporting the idea that FI predicts a higher risk of MH issues. This finding appeared to apply across a range of settings, populations, measures of both FI and MH, and analytic approaches. However, while every study reported at least one significant analysis, several studies also obtained non-significant results. Some of these inconsistencies seemed to be explained by the moderating effects of instrumental social support and gender, as well as differences between quantitative and qualitative domains of FI, or follow-up lengths. Yet it remained unclear whether findings extended to children, and through which mechanisms FI impacts MH. Studies did not differ to a great extent in terms of their quality, indicating that this was unlikely to have caused the observed inconsistencies. Study quality was generally only weak to fair, negatively affecting the strength of the evidence. The single study examining the effect of MH on FI failed to find a statistically significant effect, but due to its specific characteristics, as well as its low quality, this was considered insufficient to preclude a possible causal relationship.

Relation to Previous Research

Overall, the findings of the present review provide further support for the association between FI and MH in LMIC, and are therefore consistent with those of the two previous reviews (Lund et al., 2010; Weaver & Hadley, 2009). Over the decade since their publication, the amount of longitudinal research has tripled, reflecting an increase in research interest. However, compared to HIC, the amount of available research, and primary research in particular, from LMIC is still relatively small. This is demonstrated by the fact that 12 longitudinal studies from the United States alone were included in the

review by Bruening et al. (2017). It is likely that this disproportion is a consequence of the high cost of longitudinal research, which may represent a particular obstacle in LMIC (Holmes et al., 2010).

Through the focus on longitudinal studies, the review was additionally able to substantiate a causal relationship between FI and MH. Specifically, it provided evidence for the applicability of the social causation hypothesis from the broader literature on poverty and MH (Silva et al., 2016). The observation that the effect of FI on MH was conditional on the quantity and quality of FI does indeed resemble the notion of a social gradient (Fisher & Baum, 2010). In contrast to other social determinants of MH (Allen et al., 2014), however, it appears that FI only exerts an impact on MH in the short term. The near-absence of research on the potential reverse effect of MH on FI corresponds to trends in poverty research more generally (Alegría et al., 2018), but does not necessarily indicate the absence of an effect.

Furthermore, the present review revealed additional factors influencing the relationship between FI and MH in LMIC, which could support the targeting of interventions. In accordance with the review by Maynard et al. (2018) that focused on women in HIC, it was found that in LMIC the effect of FI on MH is also stronger among females. Ivers and Cullen (2011) have suggested that women may be more affected by FI because they are often primary caregivers of their children and responsible for the provision of food to the family, especially in regions with greater gender inequality. Similarly, FI only affected individuals with low levels of instrumental social support, corroborating the previously theorised idea that social support may ‘buffer’ against the adverse effects of FI (Natamba et al., 2017).

Finally, the review also identified remaining knowledge gaps. While evidence regarding the applicability to children was inconsistent, the previous review by Althoff et al. (2016) found that FI was associated with developmental psychopathology, at least in HIC. These differences may be explained by the results of a study conducted in Zambia, which highlighted not only that children, and younger children in particular, may be protected from household FI by their parents, but also that reports of FI differ between adults and children (Kuku, Gundersen & Garasky, 2011). Little empirical research has addressed the mechanisms of action underlying the relationship between FI and MH, yet qualitative evidence included in the review by Weaver and Hadley (2009) suggested that FI affects MH directly.

Recommendations

Further research. Owing to the small number of studies retrieved and the low quality of the body of evidence, further well-designed longitudinal studies on FI and MH in LMIC are requisite to confirm the results of this review and advance a more nuanced understanding of the relationship. In particular, the current dearth of research on the effect of MH on FI, as well as the unexplained inconsistencies regarding the applicability to child populations and possible mechanisms, need to be addressed. Studies conducted in other geographical areas and among different populations could provide further support for generalisability. Any future research should employ robust methods that

rectify the shortcomings of previous studies. In particular, they should seek to utilise measures that are both reliable and valid. Resultant findings will likely inform the development of effective, more targeted interventions. Eventually, it will be vital to carry out high-quality trials evaluating the effectiveness of potential interventions.

Policy. On a regional, national, or even global level, such interventions are likely to take the form of reformed policies (Tarasuk, Cheng, Dachner, Gundersen & Kurdyak, 2015). Based on the evidence for an effect of FI on MH, the findings of this review tentatively suggest that there is a need for policies with an aim of eliminating FI as a measure to reduce and ultimately prevent MH issues. The elaboration of such policies will be a highly complex task requiring a concerted international effort to improve systems of food production, distribution, and consumption (McCarthy et al., 2018). In light of the challenges predicted to be faced by LMIC in particular, such as climate change and population growth, a focus on long-term sustainability will be crucial (Griggs et al., 2013).

A more immediate aim for policymakers could be the adoption of a ‘health in all policies’ approach (WHO, 2014). Derived from the wider literature on social determinants of MH, this term captures the principle that one should consider potential MH impacts in the development and implementation of all new policies (Baum et al., 2014), including those relating to food security. In order for this strategy to be effective, the lack of a political commitment to health concerns, which prevails in many LMIC, has to be overcome (Woolcock, 2018). This will likely call for advocacy efforts and the collaborative action of various stakeholders (Awenwa et al., 2010).

Practice. Even though the primary means of addressing social determinants of MH are often policies, it is also possible to intervene on a community, family, or individual level (Gottlieb, Sandel & Adler, 2013). Indeed, as is the case with policies, any programme acting on FI is also a measure to prevent the development of MH issues in the longer term. These may include direct interventions, such as the establishment of urban agriculture projects to promote food availability (Poulsen, McNab, Clayton & Neff, 2015), as well as indirect methods, including the strengthening of rural communities (Andersson & Gabrielsson, 2012). As different interventions are likely to be effective in different settings and populations, it is important that these are targeted to local contexts (Vermeulen et al., 2012).

Since such programmes are currently not universally accessible, a more short-term solution could be the screening of individuals presenting to healthcare professionals with MH issues for potential FI in order to prioritise those with the highest need (Gottlieb, Sandel & Adler, 2013). However, this is only ethical if appropriate referral systems for food security programmes exist (Garg, Boynton-Jarrett & Dworkin, 2016). Additionally, it may be necessary to institute connections with community leaders or religious healers, as these are often preferentially sought for treatment in LMIC (Hanlon et al., 2014). This, again, highlights the value of collaboration between professionals of different disciplines, the importance of which is receiving increasing acknowledgement (Karunasagar & Karunasagar, 2016).

Strengths

The findings of the review are supported by the strengths of its methodology, which comprised several features of a high-quality systematic review (Siddaway, Wood & Hedges, 2019). In order to be as comprehensive as possible, it employed an extensive search of interdisciplinary databases using a variety of search terms. In addition, it involved academic grey literature and citation searches. Aiming to minimise subjectivity and bias, the review was further directed by objectives and a research question, as well as corresponding eligibility criteria, that were defined *a priori*. Moreover, proportions of study selection and quality appraisal were done in duplicate, and standardised tools were used for data extraction and quality appraisal. Finally, the detailed description of methods in line with the PRISMA guidelines (Moher et al., 2009) intended to ensure replicability.

Limitations

Notwithstanding, the findings of the review should also be scrutinised in light of its methodological limitations. Since it was unfeasible to employ translation services, articles in any language other than English could not be included. It may be argued that this was unlikely to have significantly affected the results of this review, given that English has become the ‘*de facto* global language of science’ (Drubin & Kellogg, 2012). Indeed, Morrison et al. (2012) were unable to find evidence for the existence of a general systematic language bias due to the exclusion of non-English articles. Yet since LMIC were the specific focus of this review, and researchers from many LMIC still prefer to publish articles in their native languages (Meneghini, 2012), it is conceivable that a substantial part of the literature has been missed. It should be noted, however, that some non-English publications do not feature English keywords or search terms and are therefore unsearchable, even if translators are available (Amano, González-Varo & Sutherland, 2016).

Another indication that relevant studies could have been missed is that a third of all included studies were found in the reference lists of previous reviews, rather than through database searching. This may have occurred for several reasons. Most importantly, both FI and MH are complex and broadly defined concepts. Even though an attempt to search various synonyms was made, it is therefore possible that further terminology could have been included. Furthermore, some studies in which the relationship between FI and MH is a secondary outcome may not mention related terms in their titles, abstracts, or keyword sections, in which case they would not appear in search results. This could be a particular issue since FI and MH may be considered subcomponents of poverty and health, respectively. The challenges associated with researching this specific topic are highlighted by the fact that only one of the five studies obtained from the previous reviews by Weaver and Hadley (2009) and Lund et al. (2010) was included in both reviews.

The inclusion of grey literature constitutes another element of a comprehensive search. The author initially intended to conduct a search of non-academic sources of grey literature, such as the website of the FAO and the WHO Institutional Repository for Information Sharing. However, due to the large volume of search results obtained, it was unfeasible to implement this. Grey literature searches in reviews are, in fact, often limited, since they require the exploration of various sources that may lack features for an advanced search and the exportation of results (Saleh, Ratajeski & Bertolet, 2014). Besides making the search more time-intensive, these disadvantages can also hinder the application of systematic search methods and thus reduce transparency (Godin, Stapleton, Kirkpatrick, Hanning & Leatherdale, 2015). Although overcoming these challenges would have rendered the review more exhaustive, it could also have impacted its quality negatively, as grey literature has often not been subjected to a peer review process (Corlett, 2011).

While the quality of the studies that were included in the review was only ‘weak’ to ‘fair’ according to the EPHPP tool, some limitations surround the application of this instrument to observational studies. For example, all studies received a ‘weak’ rating for blinding, even though this is not usually practicable in observational research (Gerhard, 2008). Moreover, none of the studies could be rated ‘strong’ for its design as this is only assigned to RCT, despite the fact that it would be unethical to conduct RCT on the specific research question in this review (Faraoni & Schaefer, 2016). Although observational studies therefore represented the best possible evidence, they are still at an inherently higher risk of bias than RCT, given that it is only possible to control for a small range of known confounders without randomisation (Gilmartin-Thomas, Liew & Hopper, 2018). In line with a ‘hierarchy of evidence’ based on internal validity (Murad, Asi, Alsawas & Alahdab, 2016), the EPHPP tool therefore legitimately regards observational studies to be of lower quality than RCT. Nonetheless, one should acknowledge other advantages of observational research, such as the ability to include larger sample sizes and a higher external validity, which make its findings more generalisable (Booth & Tannock, 2014). Consequently, it might be argued that the EPHPP tool underestimated the overall quality of the studies included.

At the same time, several studies were compromised by issues regarding their data collection methods that are unique to research in LMIC and are therefore not taken into account by the instrument. While the EPHPP tool requires a generic assessment of reliability and validity, it does not, for example, contain questions relating to the translation of scales, which can alter study results if done inaccurately (Sousa & Rojjanasrirat, 2011). Indeed, several studies failed to describe their translation strategy, representing an additional limitation. In any case, even if a scale has been accurately translated verbatim, its content may not be culturally relevant (Byrne, 2016). This is a particular issue since the applicability of Western scales measuring FI (Nord, 2014) and MH (Arnold & Smith, 2013) in LMIC has been questioned. To take such review-specific quality criteria into account, modifications or the creation of a new quality tool should be deliberated, although it may be implemented at the expense of validation and standardisation (Hoy et al., 2012).

Finally, a further concern relating to the EPHPP tool was that the judgements of the first and second reviewers only corresponded moderately. This also applied to the study selection process, where the calculation of Cohen's kappa indicated fair levels of inter-rater agreement. Flight and Julious (2015) have stated that the statistic can produce unreliable results and should therefore be interpreted with caution. Nevertheless, the repeated occurrence of disagreements may signify divergent interpretations of criteria, errors of judgement, or reviewer fatigue (McDonagh, Peterson, Raina, Chang & Shekelle, 2014). These factors may also have led to inaccuracies in data extraction, which was not done by a second reviewer (Li et al., 2015). Even though the first reviewer attempted to exert diligence when completing the full study selection, data extraction, and quality appraisal, it would therefore have been beneficial to conduct all of these in duplicate and discuss any discrepancies (Perestelo-Pérez, 2013).

Reflections on Learning

Upon reflection, most of the limitations of the review resulted from the fact that it was conducted as part of an MSc dissertation, and that available resources were therefore restricted. If funding had been available, it would have been possible to employ translation services to include non-English articles, and access systematic review software to enhance accuracy. Without time constraints, a comprehensive search of the grey literature could have been conducted, and it would have been feasible to create and test a more suitable risk-of-bias tool. Finally, if a whole research team had worked on the review, the search strategy could have been peer reviewed, and the processes of study selection, data extraction, and quality appraisal could have been completed in full by several reviewers. As a consequence, the author learned that compromises between ideal review methods and pragmatic considerations often need to be reached. A complicating factor in the case of this particular review was that it focused on studies that were not RCT, as comparatively little guidance on best practice is available for reviews of such nature. Nevertheless, given that the review attempted to utilise methods in the most systematic manner possible, it is unclear whether the investment of further resources would have significantly altered its findings, highlighting the need for a careful consideration of costs and benefits when planning a systematic review.

Conclusions

In conclusion, the present systematic review focused on longitudinal studies investigating the nature of the relationship between FI and MH in LMIC. It found relatively consistent evidence for the effect of FI on MH, however there was a lack of research investigating the reverse. These findings appeared to apply widely, but were impacted by specific features of participants and FI, indicating that a more nuanced understanding of the relationship may be necessary to advance knowledge in this field. Since some inconsistencies remained unexplained, and results from included studies were limited by

weak to fair levels of study quality, further high-quality research is required. This will also inform approaches to intervene through policy and practice, which should be sustainable, targeted to local contexts, and involve intersectoral collaboration. In broader terms, this review demonstrated the value of bringing together perspectives from different disciplines, something which is likely to be increasingly important in tackling some of the most pressing issues facing humanity at present and in the future.

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Appendix A: Project Outline

Title: Food insecurity and mental health in low- and middle-income countries: A systematic review of longitudinal studies.

1. Summary of existing literature

Food security has been defined as a state of universal “physical and economic access to sufficient, safe and nutritious food to meet [...] dietary needs and food preferences for an active and healthy life” (World Food Summit, 1996). Food insecurity, in turn, is a pressing global issue, and even though some improvements have been achieved in recent years (Kakwani & Son, 2016), it is predicted to remain a challenge in the future due to factors including population growth (Godfrey et al., 2010), increased demands for biofuels (To & Grafton, 2015), and climate change (Tai, Martin & Heald, 2014). Research has associated food insecurity with various adverse consequences, including a broad range of negative health outcomes (Gundersen & Ziliak, 2015). In particular, the relationship between food insecurity and mental health issues has recently attracted increasing research interest, with review articles reporting a link among specific populations, namely children and parents (Althoff, Ametti & Bertman, 2016), females (Maynard et al., 2018), and people residing in the United States (Bruening, Dinour & Chavez, 2017). However, previous reviews primarily focused on studies conducted in high-income countries, which may not generalise to low- and middle-income countries. The only systematic review with a specific focus on developing countries did also find an association between food insecurity and common mental disorders (Weaver & Hadley, 2009). Yet, its authors cautioned that a lack of research existed on the subject. Furthermore, the few included studies almost exclusively employed a cross-sectional design, and therefore provided little information about the nature of the relationship.

2. Aims and research question

Building upon the review conducted by Weaver and Hadley (2009), the aims of the proposed systematic review are threefold:

1. To provide an update on the current evidence base regarding the relationship between food insecurity and mental health in low- and middle-income countries.
2. To establish directionality between the two variables by specifically focusing on longitudinal research.
3. To consider recommendations for policy and practice, as well as future research.

To achieve these aims, the present review will address the research question: What is the nature of the relationship between food insecurity and mental health in low- and middle-income countries according to longitudinal research?

3. Proposed methodology

3.1 Information sources

The databases Ovid MEDLINE, EBSCOhost, PsychINFO, and CINAHL will be searched to obtain a comprehensive list of published articles relating to the research question. ProQuest Dissertations and Theses will further be used to retrieve relevant grey literature. Additional studies will be located by means of scanning reference lists of all included articles, and through forward citation searching via Google Scholar.

3.2 Search strategy

The following search strategy will be employed, subject to change following consultation with college librarians:

1. food
2. *secur*
3. *sufficien*
4. *adequa*
5. suppl*
6. *availab*
7. *certain*
8. scarc*
9. shortage
10. hardship
11. hunger
12. mental health
13. mental disorder*
14. mental illness*
15. emotional disorder*
16. psych*
17. *stress
18. wellbeing

19. mood*
20. anxi*
21. depress*
22. longitudinal
23. cohort*
24. follow-up*
25. 2 OR 3 OR 4 OR 5 OR 6 OR 7 OR 8 OR 9 OR 10 OR 11
26. 12 OR 13 OR 14 OR 15 OR 16 OR 17 OR 18 OR 19 OR 20 OR 21
27. 22 OR 23 OR 24
28. 1 AND 25 AND 26 AND 27

3.3 Selection of studies

All articles appearing in the search results will be screened for eligibility. The first reviewer will initially examine titles, then abstracts and full texts. A second reviewer will complete the same process independently, after which any discrepancies concerning the selection of studies will be resolved through discussion. Individual studies will be included if they meet the following criteria:

1. Investigates the relationship between a measure of food insecurity and any measure(s) related to mental health or wellbeing.
2. Conducted in a low- or middle-income country in accordance with the current classification used by the World Bank (2018).
3. Employs a longitudinal study design.
4. Published before 1 January 2019.
5. Written in English or German.

Studies will be excluded on grounds of the following:

1. Does not investigate the relationship between a measure of food insecurity and any measure(s) related to mental health or wellbeing.
2. Conducted in a high-income country.
3. Employs a cross-sectional, qualitative, or case-study design.
4. Published after 1 January 2019.
5. Written in a language other than English or German.

3.4 Data extraction

Using the software DistillerSR (Evidence Partners, 2018), a data extraction form will be created, gathering information on:

1. Author names
2. Year of publication
3. Country
4. Sample characteristics
5. Sample size
6. Years of data collection
7. Measure of food insecurity used
8. Measure of mental health used
9. Direction of relationship assessed
10. Main findings

3.5 Write up

Following data interpretation, the systematic review will be written up in accordance with the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) Statement (Moher, Liberati, Tetzlaff, & Altman, 2009).

4. Potential barriers

Given that the systematic review will be conducted as part of a course requirement for a master's degree programme, the barriers potentially encountered mainly concern practical constraints. As it is difficult to accurately estimate the number of studies that will meet the eligibility criteria a priori, the research question may prove to be too broad in scope to be reviewed within the limited time frame given. Besides strictly adhering to the project timetable, it may therefore be necessary to further refine the question at a later stage. In terms of financial constraints, it may not be possible to obtain free access to all articles, or to specialised review software. However, articles can often be requested at the library, and it is possible to conduct a review with common word processing software, although meticulous record keeping and organisation will be required. Finally, it may not be feasible to compare data selection and extraction outcomes with a second reviewer, in which case the first reviewer needs to exert particular caution when completing these tasks.

5. Proposed timetable

Start date	Time	Task
14 January	2 weeks	Refine proposal; obtain access to materials *
28 January	11 weeks	Literature search; study screening and selection *
15 April	6 weeks	Data extraction
27 May	5 weeks	Write up
1 July	1 week	Submit first draft; wait for feedback
8 July	2 ½ weeks	Edit according to feedback; finalise report; proofread
25 July		Submit final report

* These tasks will be completed during term time alongside other assignments, however at least one day a week will be devoted to the review.

6. References

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- To, H., & Grafton, R. Q. (2015). Oil prices, biofuels production and food security: past trends and future challenges. *Food Security*, 7(2), 323-336.
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Appendix B: Data Extraction Form

General study information	
Author(s)	
Year of publication	
Data source	
Year(s) of data collection	
Study time points	
Contextual information	
Country of data collection	
Setting	
Baseline sample characteristics	
Population	
Sample size	
Age	
Gender	
Measures	
FI construct(s)	
FI measure(s)	
MH construct(s)	
MH measure(s)	
Results	
Direction assessed	
Analytic strategy	
Main findings	
Quality assessment	
Sampling method	
Refusal rate	
Study design	
Confounders controlled for	
Blinding of assessors	
Blinding of participants	

Reliability of measures	
Validity of measures	
Follow-up rate	
Reasons for withdrawal	

Appendix C: Author Instructions for Target Journal

Author instructions for the target journal, Social Science & Medicine, are available here:

<https://www.elsevier.com/journals/social-science-and-medicine/0277-9536/guide-for-authors>