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Impact of nutrition sensitive agriculture intervention on household food security outcomes, a systematic review

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B.A, International Studies

Loyola University Chicago

2015

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An abstract of
A thesis submitted to the Faculty of the
Rollins School of Public Health of Emory University
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Abstract

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By Carolina Xiomara Escobar

Abstract

Objective: The aims of this systematic literature review were to understand what metrics have been used to evaluate nutrition sensitive agricultural intervention's household food security outcomes and to understand if current NSA have contributed to household FIS.

Methodology: PubMed, Agricol, AgEcon and grey literature were searched for NSA interventions with household FIS outcomes.

Results: Nine studies met the full inclusion criteria. Four studies had a statistically significant impact on household FIS. Household Food Insecurity Access Scale was the indicator most used.

Conclusion: The low number of studies in this systematic review limited the ability to conduct a meta-analysis. However, evidence suggest that NSA interventions can have a positive impact on household food security and more recent studies used validated indicators to measure FIS.

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Los quiero mucho a todos.

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Chapter 1: Introduction

Introduction and Rationale

According to the Food and Agricultural Organization of the United Nations' (FAO) the State of Food Security and Nutrition in the World 2020 report, Sustainable Development Goal 2 of Zero Hunger is not on target to be met by 2030. In 2019, 25.9% of the world did not have regular access to nutritious and sufficient food or experienced hunger and major regions most impacted are Latin America and the Caribbean; South and Southeast Asia and Africa, specifically the sub-Sahara region.. (I. FAO, UNICEF, WFP and WHO, 2020). Household food insecurity is also an underlying cause of maternal and child undernutrition on the UNICEF conceptual framework to malnutrition (UNICEF, 2013). Some of the consequences of malnutrition include underperforming cardio-respiratory function, pancreatic exocrine disfunction (Saunders & Smith, 2010), risk of birth complications, developmental delays in children, and mortality (UNICEF, 2013; Wells et al., 2020). Nutrition-sensitive agricultural interventions are a potential solution to address household food insecurity and other causes on the pathway to malnutrition on the UNICEF conceptual framework.

Problem Statement

Household food insecurity continues to increase in low and low to middle income countries. This increases the risk of adverse health outcome that result from malnutrition if household food insecurity is not addressed. Nutrition-sensitive agricultural programs have become a way of addressing nutritional needs in developing countries. However, there is lack of consensus on how to measure household food insecurity outcomes in the context of nutrition sensitive interventions. Additionally, a review of the literature has not been completed to

understand whether nutrition sensitive agricultural intervention impact household food insecurity.

Purpose Statement

Reviewing the impacts of nutrition sensitive agricultural interventions on household food insecurity outcomes is critical component to identify effective strategies for combatting food insecurity around the world. Additionally, understanding previous methods used to measure household food insecurity in these interventions can provide insight on successful measures of success for future programs.

Research Question

To understand if nutrition-sensitive interventions are a viable strategy to reducing household food insecurity in low and low to middle income countries, it is important to review current literature. This systematic literature review will answer the following questions:

- *Research Question:* Do nutrition sensitive agriculture projects improve household food security?
- *Secondary Research Question:* What food security metrics are typically included in nutrition sensitive agriculture projects?

Significance Statement

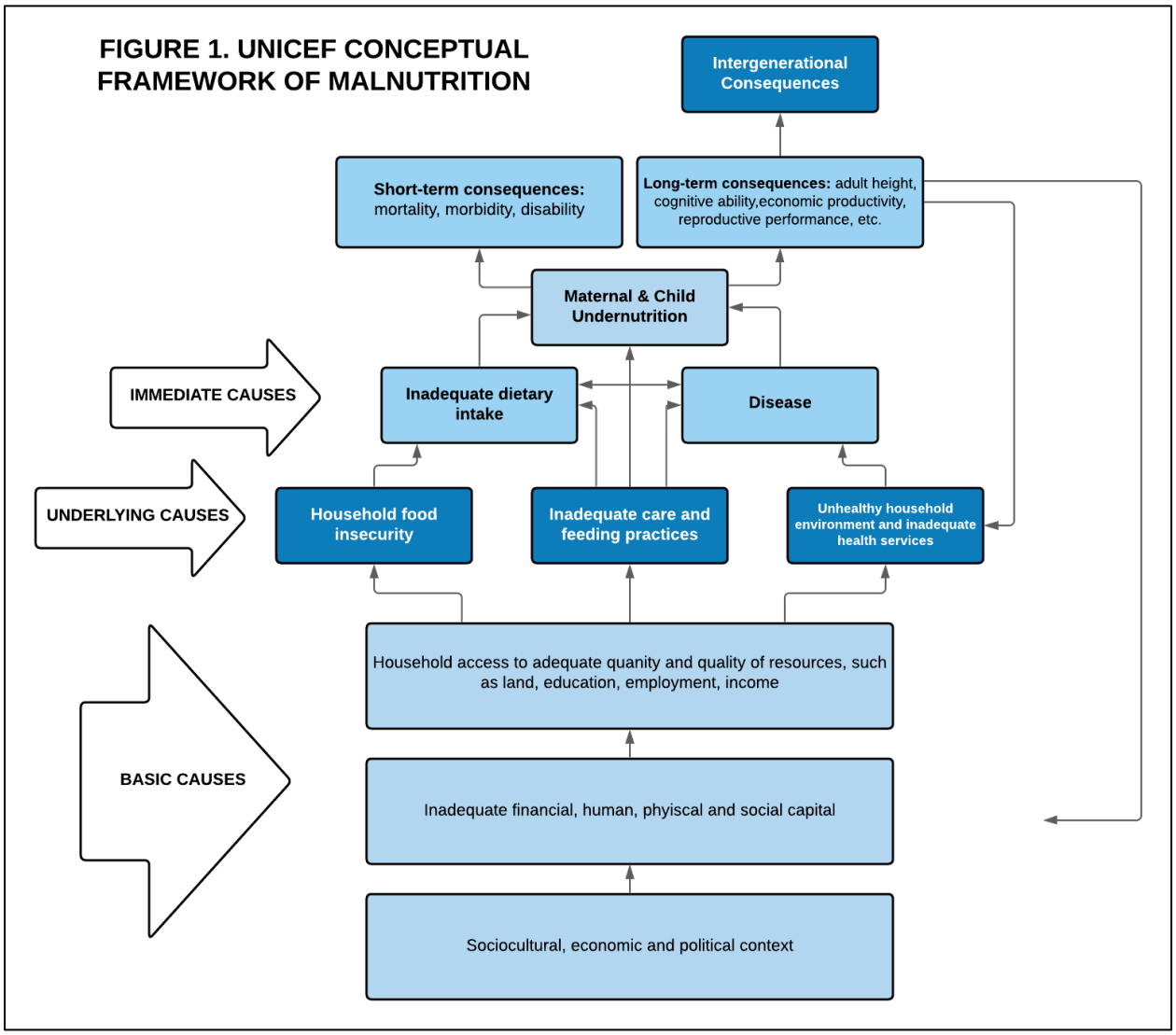
This systematic literature review will provide foundational knowledge as public health experts and funders address Sustainable Development Goal 2 of Zero Hunger. Resources need to be directed towards evidence-based interventions that also address the underlying causes of malnutrition. Failure to do so, will result in mortality and morbidity to increase especially among women and children.

Chapter 2: A Review of the Literature

This comprehensive literature review will provide the reader with an understanding of food insecurity pathway on the UNICEF conceptual framework of malnutrition; overview of the current state of food insecurity in low to low-middle income countries and populations at risk; consequences of household food insecurity; overview of nutrition sensitive agricultural interventions; and overview food security indicators.

UNICEF Conceptual Framework

The UNICEF conceptual framework maps the relationship between basic, underlying, and immediate causes; their pathways to maternal and child undernutrition; and its consequences (see Figure 1) (UNICEF, 2013). The framework is an important tool for comprehensive interventions that aim to improve the wellbeing of maternal and child health. Affordable, diverse, nutrient foods; effective maternal and child-care practices; adequate health services, and sanitized environment are all necessary for children to reach optimal nutritional status (UNICEF, 2013). Interventions linked to the framework target women of reproductive age, mothers, infants and young children and focus on infant and young child feed (IYCF), complementary feeding, exclusive breastfeeding, micronutrition supplementation, nutrition sensitive approaches, communication for behavior change, agriculture, etc. An attractive feature of the framework is that it can be adapted to various settings and context. In an effort to analyze the concept of "nutrition-sensitive agriculture", Balz et al. (2021) adapted the framework to show how nutrition sensitive interventions activities align with underlying causes and suggest that in order to address the underlying causes of malnutrition the framework also needs to consider foods system (Balz, Heil, & Jordan, 2015). Many nutrition sensitive agricultural interventions do address components of food systems through value-chains and increasing communities' access to markets.



Source: Adapted from UNICEF, 2013

The State of Food Insecurity

Food insecurity is a central underlying determinant of nutrition. The FAO defines food security as a "lack of regular access to enough safe and nutritious food for normal growth and development and an active and healthy life. This may be due to unavailability of food and/or lack of resources to obtain food" (FAO, n.d.-c). The State of Food Security and Nutrition in the

World 2020 reported that Sustainable Development Goal 2 of Zero Hunger is not on target to be met by 2030. Additionally, 25.9% of the world population did not have regular access to nutritious and sufficient food (I. FAO, UNICEF, WFP and WHO, 2020). Low and low-middle income countries in Latin America and the Caribbean; South and Southeast Asia; Africa, specifically the sub-Saharan region are affected the most by food insecurity. There have been efforts in attempt to address global food insecurity and undernourishment through aid relief efforts, especially in low-to-middle income countries, but these have not proven to be sustainable interventions. Additionally, global phenomena, such as climate change, political instability and conflict, and economic downturn continue to exacerbate household food insecurity for vulnerable populations (Boliko, 2019; Wheeler & von Braun, 2013). More recently, the COVID-19 pandemic has caused a disruption in supply chains leading to an increase in food prices and agricultural inputs, such as fertilizer, in low and low-middle income countries, which has resulted in another spike in household food insecurity (World Bank, 2021).

Eliminating global food insecurity will require adaptable sustainable interventions that specifically address household level access. Numerous studies have shown that nutrition-sensitive agriculture interventions can improve food security, nutrition security, undernourishment and have been adopted in various context to address countries' developmental goals (Ruel, Quisumbing, & Balagamwala, 2018). Improving food security in low and low-middle income countries will require a clear understanding of the unique context of each and appropriate tools to measure food security.

Food Insecurity in Latin America and the Caribbean

In 2019, 7.4%, or 47.7 million, of the population experienced food insecurity in Latin America and the Caribbean (FAO, PAHO, WFP, UNICEF, & IFAD., 2020). The prevalence of

food insecurity in Latin America and the Caribbean has increased since 2014. According to the FAO et al. (2020), the number of food insecure people in the region increased by 17.9 million between 2014 and 2019. Honduras, Guatemala, and El Salvador were documented to have the highest prevalence of food insecurity at 49.3%, 43.9%, and 40% respectively (FAO, RAHO, WFP, & UNICEF, 2020). This does not include counties in the Caribbean where data was not available at the time. Between the years of 2017-2019, the prevalence of undernourishment in the Caribbean, Meso-America, and South America were 16.7%, 8.7%, and 5.5%, respectively.

Rural and indigenous communities and women are at highest risk for experiencing food insecurity in Latin America and the Caribbean. Reporting show that when the prevalence of food insecurity in LAC rises, so does the prevalence among women; however this is not always the case for men (FAO, PAHO, et al., 2020). Regionally, the prevalence of men and women reported to be food in secured in Mesoamerica is 27.9% and 32%, respectively (FAO, RAHO, et al., 2020). In South America 23.6% of men and 28.9% of women experience food insecurity (FAO, RAHO, et al., 2020). Contributing factors include to this inequity include a lack of financial resources for women and inability to make decision a home where a male is the head of household.

Additionally, rural communities also experience higher prevalence of food insecurity when compared non-rural communities. For example, a study conducted in the state of Nayrit, México found that 76.2% of households were food insecure, in which 81% of insecure households were located in rural areas (Haro-Mota, Marceleño-Flores, Bojórquez-Serrano, & Nájera-González, 2016). In rural Intibucá, Honduras 93% of households were experiencing food insecurity (Ben-Davies, Kinlaw, Estrada Del Campo, Bentley, & Siega-Riz, 2014). Another study found that rural smallholder farmer households in Central America experience food

insecurity on a regular basis as a result of extreme weather and seasonal change (Alpízar et al., 2020). There is limited information on the experiences of rural households and food security. However, the FAO et al. (2020) attributes the increase of poverty to the increase prevalence in rural household food security. Other reasons for increased likelihood of food insecurity in rural communities include the lack of formal rural labor market contributes to food insecurity, therefore formalizing an employment framework is crucial to improving food security in LAC (FAO, n.d.-b). An explanation for the for high food insecurity in rural areas have been linked to low employment and limited access to government safety net program (Ben-Davies et al., 2014).

Finally, increased urbanization and social inequities has contributed to indigenous communities' vulnerability to food insecurity. A cross-sectional study seeking to understand food security and the health implication of the Kuna people in Panamá found that 83% of respondents experienced food insecurity (95 % CI 77.5, 88.0) (Walker, Dawson, Campbell, & Egede, 2021). Another study found that 100% of their participants of a Mayan community in Guatemala experienced food insecurity based on the FANTA scale, which maybe a result of low agriculture production for consumption in the home and large-scale shift towards nontraditional agricultural exports, or NTAEs (Webb et al., 2016). According to an analysis by Carletto, Kilic, & Kirk (2011), NTAE have not resulted in an improvement in welfare or return in investments for participants (as cited Webb et al., 2016). Additionally, changes in indigenous communities' traditional food systems is a threat to their food security (Villena-Esponera, Moreno-Rojas, & Molina-Recio, 2019). For example, the Épera community relocated agricultural plots in order to promote land fertility and presence of wildlife to maintain healthy access to food; however the lack of land access in Ecuador has forced alternative means of work for low pay and a decrease in food quality and quantity (Villena-Esponera et al., 2019).

Food Insecurity in South Asia

The South and South-east regions of Asia experience the highest prevalence of food insecurity within the continent. According to the FAO, in 2019 14.9% of the population suffered from hunger or undernourishment (UNICEF, FAO, WFP, & WHO, 2021). In 2019 South and South-east Asia, had 257.3 and 64.7 millions undernourished individuals, respectively (UNICEF et al., 2021). In Southern Asia, Afghanistan had the highest food insecurity prevalence at 40% (UNICEF et al., 2021). In Southeast Asia, Timor-Leste leads with little over a prevalence of 40% undernourished individuals (UNICEF et al., 2021). Overall, the 86% of majority of food insecure people live in South Asia (UNICEF et al., 2021). The FAO has identified women of reproductive age and the rural to urban migrants to be most vulnerable for food insecurity.

Like other regions, gender inequities make women vulnerable for food insecurity. Broussard (2019) found women were 3.2 points more likely than men to experience moderate food insecurity and 2.0 for severe food insecurity. In some countries, gender or familial hierarchies influence household food insecurity (Ali & Vallianatos, 2017; Smith, Ramakrishnan, Ndiaye, Haddad, & Martorell, 2003). For example, a cross-sectional study of 200 newly married women in Nepal found that in food insecure households women consumed an average of 2.3 fewer high-quality foods in their marital home, compared to their nuclear family home (Diamond-Smith, Shieh, Puri, & Weiser, 2020). The same study found that a newlywed's relationship with her mother-in-law was a mediator for consuming quality foods in her martial home (Diamond-Smith et al., 2020). Additionally, a systematic literature review of intra-household food allocation between adults in South Asia found studies that reported social status within a household determined food allocation, meaning that newly married, younger, and women without children or mothers with daughters only were lower in the hierarchy (Harris-Fry,

Shrestha, Costello, & Saville, 2017). However, it should be noted that many of these studies are dated back to late 1980s and early to mid 1990s and future research is needed to re-assess the role of intrahousehold food allocation and gender in a food insecure setting.

Finally, rural to urban migrants are also most vulnerable for food insecurity in South Asia. The increase prevalence in poverty in rural areas and urbanization encourages women to migrant to urban areas to seek job opportunities, especially in female head households. However, due to income status and lack of social support, they are more prone to experience food insecurity. For example, in Myanmar young women will move to urban areas to work in the ready-made garment industry with the sole purpose of sending money back to their families (Goudet, Hlaing, & Griffiths, 2020). Women reported challenges with food access, such as variety of nutritious diverse foods and adequate food quantity (Goudet et al., 2020). The lack of social support and shift from rural to urban cultural food systems contributed to food insecurity. For example, an analysis of the causes of food security in Malaysia identified Orang Asli women found food insecurity ranged between 81.2% to 88.0%, and was attributed to them being unable to practice traditional food customs (Sulaiman, Yeatman, Russell, & Law, 2021). These constraints included failure in agriculture, ineffectiveness in traditional food-seeking activities, weather, and water issues (Sulaiman et al., 2021).

Food Insecurity in Africa

Individuals experiencing food insecurity has continued to rise on a yearly bases in Africa. According to the FAO report, 426 millions of individual experienced moderate food insecurity in 2019 (FAO, ECA, & AUC, 2021). Additionally, the number of undernourished individuals on the continent has steadily increased throughout the last few years. Most recently, the FAO (2021) reported 250.3 million undernourished individuals in 2019 (FAO et al., 2021). Approximately

16.6 millions of those reside in Northern Africa and 234.7 million in sub-Saharan Africa (FAO et al., 2021). Similarly, to LAC and South and Southeast Asia, those who experience food insecurity face detrimental health outcomes. Women and children, and populations that live in areas of conflict, and climate and/or economic shock are most vulnerable to experience food insecurity.

The increase in food insecurity has been attributed to conflict and climate and economic shock (FAO et al., 2021). Populations most affected by household food insecurity as a result from climate shock are rural household, including smallholder farmers. Droughts have been become increasingly common in Sub-Saharan countries primarily impacting rural communities that depend on subsistence agriculture as their primary sources of food (Labbé et al., 2016; Oluoko-Odingo, 2011). A systematic literature review on drought and food insecurity in Africa, found evidence to support that rural populations, especially smallholder farmers, residing in areas susceptible to drought remain vulnerable to household food insecurity due to inability to predict weather for agricultural planning (Ngcamu & Chari, 2020). According to a study aimed to understand smallholder farms perception and experience with climate change in the Niger Republic, farmers attempted to adapt to the new conditions; however faced barriers to accessing inputs, new knowledge and government aid (Assoumaa, Diourte, Diourte, Ndiaye, & Van der Puije, 2016). The lack of resources limits rural agricultural areas' ability to respond to continuing climate change exacerbating food security. The unpredictable climate change disrupts local food systems thus reducing food supply for communities. Additionally, populations residing in areas of conflict or political instability are increasingly vulnerable to food security (Anderson et al., 2021). A reason for this is a disruption in food production (Anderson et al., 2021; Deaton & Lipka, 2015), which in one of the primary pathways of food security (Deaton & Lipka, 2015).

Poverty, gender discrimination and low social status puts women at a greater chance of experiencing food insecurity. In households with food insecurity, mothers have reported giving up their portion of food to ensure that children eat. For example, a mix method study in South Sudan conducted focus group participants shared that when household foods supplies begins to run low, women will decrease their portion to first feed children, then men (Tappis, Doocy, Paul, & Funna, 2013). In a cross-sectional study completed in Ethiopia, being a female head of household was significantly associated with food insecurity (Endale, Mengesha, Atinafu, & Adane, 2014). Another longitudinal study of food insecurity trends among adolescents found the proportion of food insecure among female was significantly higher than males (Belachew et al., 2012). In addition to that, a different study sited that girls in food insecure households were more likely to report being food insecure than boys, including within siblings groups (Hadley, Lindstrom, Tessema, & Belachew, 2008)Women may also face increased vulnerability during pregnancy. In qualitative evaluation of a livelihood intervention for HIV positive pregnant women in Western Kenya, participants shared that they were not able to follow dietary recommendations due to decreased ability to work and lower household income (McDonough et al., 2020). Multiple studies in Sub-Sahara Africa have found that due to HIV stigma, women may lack social support systems, which is a protective factor for food insecurity (McDonough et al., 2020; Nagata et al., 2015). Ultimately, there are various risk factors women in African countries face to achieve household food security that require empowerment and community centered approach in order to achieve Zero Hunger.

Consequences of Food Insecurity

Research documents negative health consequences of food insecurity, especially among vulnerable populations in low and low-middle income countries. Among children, studies

conducted in low and high income countries have found that food insecurity impedes on a child's development and contributes to malnutrition, stunting, mental health challenges, and academic outcomes (Baig-Ansari, Rahbar, Bhutta, & Badruddin, 2006; Ben-Davies et al., 2014; Saha et al., 2010; Velardo, Pollard, Shipman, & Booth, 2021; Weinreb et al., 2002). A three year longitudinal study in Ghana found that household food insecurity was associated with low child development outcomes among pre-school and early primary years (Aurino, Wolf, & Tsinigo, 2020). In an intervention trial, 1639 children at 18 months of age in rural Bangladesh were found to have positive association with household food security and language development ($\beta = 0.19$, 95% CI = (0.09, 0.30), $p < 0.001$) (Saha et al., 2010). Language development has been found to be predictor of childhood development (Saha et al., 2010), which implies that food insecurity could have lifelong consequences on children. These long consequences will impact a child's quality of life as they grow into adulthood, perpetrating the cycle the intergenerational cycle of malnutrition as provided by UNICEF's framework. Food insecurity could also have long term mental health impacts. A qualitative study exploring the experiences of children from food insecure households in Australia found that their awareness of the household stressors and financial circumstance led to feelings of sadness (Velardo et al., 2021), which can manifest into depression, anxiety or other feeling of distress. Overall, research of the long-term health consequences among children in low and low-middle income countries is limited. In fact, a systematic literature review found that there is limited research to understand how experiences of food insecurity impacts life course influence on non-communicable disease morbidity and cognitive outcomes (Ward, Harrison, Viner, Costello, & Heys, 2018). This may also limit scientific understanding of the health consequences of food insecurity in adolescents into their adulthood.

As previously stated in this literature review, food insecurity is a gendered experience in which women are at highest risk for experiencing the negative consequences of food security. This is especially true when the women was the head of household in low and low-middle income countries. A literature review found an analysis which stratified the head of household by gender and found that women head of holds were 75% more likely to experience household food insecurity (Jung, de Bairros, Pattussi, Pauli, & Neutzling, 2017). A consequences of household food insecurity among women is food insecurity is anemia. A study in Mexico found that the adjusted odds of having anemia was 31-43% higher among women 21-49 years living in mild to severely food insecure households than women residing in food secure households ($p < 0.05$) (Fischer, Shamah-Levy, Mundo-Rosas, Méndez-Gómez-Humarán, & Pérez-Escamilla, 2014). In Bangladesh, a study that sampled, collected household food insecurity status, and hemoglobin concentration of 5,666 married women between the ages of 13 – 40 found that household food insecurity was predictor of anemia (Ghose, Tang, Yaya, & Feng, 2016). Indeed, food insecurity negatively impact the health of women; however, when provided with resources, women prioritized to invest in strategies to reduce household food insecurity for their children. For example, decision making power within a home reduces the odds of food insecurity (Kammi K. Schmeer, Piperata, Rodríguez, Torres, & Cárdenas, 2015), because they are more likely to spend it on food and items that meet needs of children in household (Kammi K Schmeer, 2005). Resources to reduce household insecurity include nutrition sensitive agricultural interventions that also prioritize women leadership in communities to reduce household food insecurity.

Research has shown that chronic food insecurity can lead to negative mental health consequences. A systematic review and meta-analysis that included previous studies of food insecurity through the world found that there was a positive relationship between food insecurity

and risk of depression among adults (OR = 1·40; 95 % CI: 1·30, 1·58) (Pourmotabbed et al., 2020). The same study found a positive relationship between food insecurity and risk of stress among adults (OR = 1·34; 95 % CI: 1·24, 1·44) (Pourmotabbed et al., 2020). Specifically among vulnerable populations to food insecurity research has established that there is a positive relationship between food insecurity and negative mental health consequences in women and/or mothers (Ivers & Cullen, 2011; Maynard et al., 2018; Pedroso, Buccini, Venancio, Pérez-Escamilla, & Gubert, 2020; Zekeri, 2019). For example, an investigation of maternal mental health and food insecurity in a low-resource neighborhood in Quito, Ecuador found that household food insecurity was associated with stress and depression (Weigel, Armijos, Racines, Cevallos, & Castro, 2016).Studies solely exploring the relationship between food insecurity and mental health outcomes in low and low-to middle income countries are scarce. One study, using the Gallup World poll findings of mental health, wellbeing, and food insecurity experience of 160 countries found that there was a positive relationship between food insecurity and mental health symptoms (Elgar et al., 2021). While the study included high to low-income countries, it still provides insight on the mental health consequences.

Finally, increased risk of chronic diseases is well associated with food insecurity. Exposure to food insecurity makes individuals susceptible to the chronic disease outcomes, especially when health outcomes can be attributed to undernourishment (Seligman, Laraia, & Kushel, 2010). Food insecurity has been found to be a risk factor for diabetes and more likely to lead to poor diabetes management (Laraia, 2013). Laraia's (2013) review of the literature found that individuals in food insecurity household have a difficult time managing diabetes due to limited control to glucose food access or limited ability to reject glucose dense foods, ultimately leading to hypoglycemic events (Laraia, 2013). In 2009, Tayie & Zizza conducted a study to

estimate the prevalence of dyslipidemia among food insecure populations. Their finding indicated that women experiencing food insecurity had a higher risk of developing dyslipidemia in the United States (Tayie & Zizza, 2009). Additionally, when compared to those that are food secure, food insecure older adults are at increased risk for peripheral arterial disease in adults among the (Redmond, Dong, Goetz, Jacobson, & Collins, 2016). While research has clearly established an associate between food insecurity and negative health consequences, most studies are focus on higher and middle-income countries. However, this should not dismiss the severity of potential health outcomes in low to low-middle income countries.

Nutrition Sensitive Agriculture Interventions

When implemented correctly, nutrition sensitive agricultural (NSA) interventions have the potential to address food insecurity in low and low to middle countries. The FAO (2017) defines nutrition sensitive agriculture interventions as "an approach that seeks to ensure the production of a variety of affordable, nutritious, culturally appropriate and safe foods in adequate quantity and quality to meet the dietary requirements of populations in a sustainable manner." NSA interventions can be implemented through various methods and can provide a systems and community level approach to food insecurity by provide solutions at various levels of the food chain. For example, the Solar Market Garden program provided solar-power drip irrigation systems in Benin to promote crop diversification to increase access to nutritional foods (Alaofè, Burney, Naylor, & Taren, 2016). Another example is the eKutir Rural Management Services Private Limited, which implements value chains and market-based strategies for smallholder farmers to have reliable access to sell their harvest (Dubé et al., 2019). Other NSA interventions approaches include biofortification, homestead food production, livestock/poultry interventions, and agricultural extension.

According to Ruel et al. (2018) nutrition sensitive interventions can address the determinants of fetal and child nutrition and development, increase access to resources at multiple levels of the socio-ecological level, address food security and increase access to health services, which also align with UNICEF's conceptual framework. A systematic review exploring the impact pathways of nutrition sensitive agricultural and nutritional outcomes found studies that reported positive effect on food security (Sharma, Di Prima, Essink, & Broerse, 2021). The same systematic review reported positive long-term effects on dietary diversity, food consumption and nutrient intake (Sharma et al., 2021).These benefits make them attractive interventions, especially at a global scale because they can be adapted for the most vulnerable population for food insecurity and malnutrition.

Household Food Insecurity Indicators

There are numerous methods and metrics for measuring household food insecurity. A possible explanation for this multitude is the evolving definition of food insecurity (Jones, Ngure, Pelto, & Young, 2013). Household food measures also need to consider contextual adaptability to remain relevant. Regardless of evolving definition, there is consensus that achieving food security includes of food to maintain a nutrition diet and overall well-being (FAO, PAHO, et al., 2020; Jones et al., 2013; Leroy, Ruel, Frongillo, Harris, & Ballard, 2015). Literature review that there were nine indicators to measuring household food insecurity's access dimension (Leroy et al., 2015). A successful indicator of household security will have validity and equivalence to compare across regions (Leroy et al., 2015). When measuring the impact of nutrition-sensitive agriculture on food security outcomes it is important that it is adaptable in various cultural setting. This will help contribute to formative research, program evaluation, and inform future research. Leroy et al., recommend experience based indicator for this objective.

Common experience-based indicators of household food insecurity outcomes applied in a global setting include the US Household Food Security Survey Module (US HFSSM), Household Food Insecurity Access Scale (HFIAS), Household Hunger Scale, Food Insecurity Experience Scale (FIES), and Latin America and the Caribbean have been linked to the Latin American and Caribbean Food Security Scale (or its Spanish abbreviation ELCSA). The HFIAS was developed through the USAID and has been used implemented in both domestic and international settings. The HHS derived from the HFIAS to captures universal experiences of the quantity dimension of food access and also includes measurement of experiencing severe food shortages and hunger (Leroy et al., 2015). The ELCSA is an adoption from the United States Household Food Security module and derived from Brazilian Food Insecurity Scale (Leroy et al., 2015)

In some projects researchers may decide to use proxies as a measurement of household food insecurity. A common proxy is food consumption, which includes dietary diversity and consumption frequency. Anthropometry measures, the gold standard for nutritional status, have become popular proxies for household insecurity. However, the prevalence of stunting among children under 5 years has been identified as a poor indicator of household food insecurity. One study found that in households with food insecurity, adults will ration food to increase the likelihood of children meeting energy needs more (Ben-Davies et al., 2014; Kammi K. Schmeer et al., 2015). Another study conducted in Honduras found that anthropometric measures were the same in food secure and food insecure households (Ben-Davies et al., 2014), which indicate that proxies may lead to bias results.

Conclusion

Increasing household food insecurity continues to threaten the livelihoods of vulnerable populations in Latin America and the Caribbean, Africa, and south and southeast Asia. Nutrition-sensitive interventions are a potential solution on that address this underlying cause of malnutrition. However, an extensive review has not been completed to understand the impact of household interventions on household food security.

Chapter 3: Manuscript

Abstract

Objective: The aims of this systematic literature review were to understand what metrics have been used to evaluate nutrition sensitive agricultural intervention's household food security outcomes and to understand if current NSA have contributed to household FIS.

Methodology: PubMed, Agricol, AgEcon and grey literature were searched for NSA interventions with household FIS outcomes.

Results: Nine studies met the full inclusion criteria. Four studies had a statistically significant impact on household FIS. Household Food Insecurity Access Scale was most popular among studies.

Conclusion: The low number of studies in this systematic review limited the ability to conduct a meta-analysis. However, evidence suggest that NSA interventions can have a positive impact on household food security and more recent studies used validated indicators to measure FIS.

Keywords: Nutrition-sensitive agriculture, household food insecurity, food insecurity indicators

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1. Introduction

According to the Food and Agricultural Organization of the United Nations' (FAO) the State of Food Security and Nutrition in the World 2020 report, Sustainable Development Goal 2 of Zero Hunger is not on target to be met by 2030. In 2019, 25.9% of the world did not have regular access to nutritious and sufficient food or experienced hunger and major regions most impacted are Latin America and the Caribbean; South and Southeast Asia and Africa, specifically the sub-Sahara region. (I. FAO, UNICEF, WFP and WHO, 2020). Household food insecurity is also an underlying cause of maternal and child undernutrition on the UNICEF conceptual framework to malnutrition (see Figure 1) (UNICEF, 2013). Some of the consequences of malnutrition include underperforming cardio-respiratory function, pancreatic exocrine disfunction (Saunders & Smith, 2010), risk of birth complications, developmental delays in children, and mortality (UNICEF, 2013; Wells et al., 2020). Nutrition-sensitive agricultural (NSA) interventions are a potential solution to address household food insecurity and other causes on the pathway to malnutrition on the UNICEF conceptual framework.

Global phenomena, such as climate change, political instability and conflict, and economic downturn continue to exacerbate household food insecurity for vulnerable populations (Boliko, 2019; Wheeler & von Braun, 2013). This increases the risk of dangerous health outcome that will result from malnutrition if household food insecurity is not addressed. Nutrition-sensitive agricultural programs have become a way of addressing nutritional needs in developing countries. However, a gap of knowledge exists in understanding of understanding how nutrition sensitive interventions impact household food insecurity (FIS) and a consensus of best practices for food insecurity outcomes. Previous systematic reviews on

Eliminating global food insecurity will require adaptable sustainable interventions. Numerous studies have shown that NSA agriculture interventions can improve food security, nutrition security, undernourishment and have been adopted in various context to address countries' developmental goals (Ruel et al., 2018). However, there has not been a consensus on how to measure household FIS or of how NSA interventions impact food insecurity. Previous systematic literature reviews on NSA interventions have focused on nutritional outcomes and diet diversity, but to our knowledge its impact on household food security has not been explored this capacity.

The objectives of this systematic literature review are to (1) To understand what metrics have been used to evaluate NSA interventions and (2) To understand if current nutrition sensitive interventions have contributed to household food insecurity.

Reviewing the impacts of NSA interventions on household food insecurity outcomes is critical component of combatting FIS around the world. Additionally, understanding previous methods used to measure household FIS in these interventions can provide insight on successful measures of success for future programs

2. Methods

2.1 Literature Review

This systematic review included peer-reviewed and grey literature. The searches for peer reviewed literature were completed on PubMed, Agricola, and AgEconSearch. The sources for grey literature were International Food Policy Research Institute's (IFPRI) publications and IFPRI Library and Knowledge, and the Consortium of International Agricultural Research Centers (CGIAR).

The search strategy was guided by four conceptual terms (i) “agriculture”, (ii) “nutrition”, (iii) “nutrition-sensitive agriculture”, and (iv) “food security” (see Table 1) Each term included a range of key words that were relevant to the desired intervention and outcome. Key words for nutrition-sensitive agriculture were adapted from Ruel et al. (2018)

Table 1 Search Terms

Concept	Keywords
Agriculture	**Biofortification:** biofortify; bio-fortif; harvestplus; harvest plus **Homestead production:** homestead food production; home garden; home gardening **Dairy:** livestock programs; livestock production; livestock ownership; dairy production; dairy program; Agriculture Extension **Irrigation** **Aquaculture:**Aquaculture; fisheries; fishpond **Value chains:** value chain; agriculture inputs
Nutrition	Nutrition; Diet diversity; Nutrition status; Malnutrition; Undernourishment; Nutrition sensitive
Nutrition-sensitive agriculture	Nutrition sensitive agriculture; Nutrition Smart Agriculture
Food security	Household food supply; Food Supply; Diet diversity; Food insecurity; Food production

Adapted from Ruel et al, (2018)

Key words were then combined for preliminary searches. For example, key words for the concept “agriculture” captured methods included in nutrition sensitive interventions, such as

"homestead food production", "livestock production", and "agriculture extension". This concept term was then combined with another concept term such as "food security", which included the key words "household food supply", "food supply" and "food security".

Example of Search Term
Agriculture AND (biofortify OR bio fortify OR harvestplus OR harvestplus) AND (diet diversity OR malnutrition OR nutrition smart OR nutrition sensitive OR nutrition OR undernutrition) AND ("household food supply" OR "food security" OR "food insecurity" OR hunger)

There were 29 final terms used for peer-reviewed literature searching. The final search terms per database were as follows: PubMed 15; Agricola 11; and AgEconSearch 3. There were 4 search terms for grey literature, which included 1 search combination for CGIAR and 3 for IFPRI.

2.2 Inclusion Criteria

The final literature selected were required to meet the following conditions (i) published on or after January 1, 2000; (ii) published in English; (iii) set in low-income or lower-middle income countries per World Bank designation; (iii) reported food security as primary or secondary outcomes; (iv) evaluation design included a counterfactual; and (vi) agricultural interventions included nutritional component, meaning that interventions had the objective or goal to improve household or community nutritional outcomes such as malnutrition, nutritional status, and diet quality.

2.3 Data Abstraction

All database search results were imported and stored on EndNote (X9.3.3). 2,689 search

results from databases were uploaded to EndNote. Duplicates (n=1533), studies published before January 1, 2000 (n=112), and titles that contain “United States” (n=12), “Europe” (n=14), “China”(n=150) and “Australia” (n=12) were removed.

A total of 1459 studies were imported to Covidence (See Figure 2 for PRISMA). Covidence was used to complete title screenings to remove any obvious literature that did not meet the inclusion criteria. This was done by two research team members. Any disagreement during title review screening was revisited for a final decision as to exclude or include. After title screening, one team member reviewed abstracts and excluded any studies that clearly did not meet requirements followed by full text review.

The title screening for grey literature was completed directly from the results page from the search engines. When relevant titles were identified the full citation for the study was entered into a Microsoft Excel spreadsheet and abstracts were reviewed for inclusion. Nine final studies were identified and uploaded into Covidence for full text review.

Covidence and Excel were used for data abstraction. Studies’ intervention details and all qualitative information was abstracted in Covidence. This included intervention goals/objective, study setting, activities for intervention, description of nutrition sensitive agriculture strategy and notable program context. Excel was used to abstract study evaluation design and outcomes. Studies were identified and matched by their Covidence generated ID. Once Covidence data abstraction was completed the data were exported into a spreadsheet.

2.4 Data Analysis

All studies’ intervention details and qualitative data were analyzed in MAXQDA (2020). The spreadsheet exported from Covidence was uploaded to MAXQDA as survey data. Codes from each abstraction object were generated (e.g. “summary of activities”, “program goals”) and

automatically coded. Study details for each study were reviewed and summarized by code. Then, summarized data was transferred to MAXMAPS to visualize and begin to understand the relationships and overlap between nutrition sensitive agriculture, activities, and other study details. In Excel, study outcomes reviewed, condensed, and imported into MAXMAPS for further analysis. The results will be presented in a narrative format.

3. Results

3.1. Overview

After full text review there were nine studies representing nine unique interventions that fully met inclusion criteria. Details of these studies are summarized in Table 3. The interventions were set in 13 different countries. A majority took place in African countries (n=9). There were two programs in Asia and one in Latin America and the Caribbean. Tanzania was represented in three separate interventions and Malawi, twice. All other countries were represented once. Four interventions implemented two NSA strategies. Five implemented one unique NSA strategy.

The most common NSA strategy was homestead gardening and crops diversification, which appeared seven times. Livestock strategy was the second most common and was implemented twice and in combination with home gardening. Three studies used two NSA strategies: two with homestead gardening/crop diversification and livestock and the other homestead gardening/crop diversification and agroecology in their interventions and the rest adapted one. Across the nine studies, six different indicators were used to measure household food insecurity. Four studies used the Household Food Insecurity Scale (HFIAS), one Household Hunger Security (HHS) indicator, one months of adequate household food provisioning (MAHFP), household dietary diversity, one study used food production/harvest yield and Engel

coefficient, one used food consumption from NSA harvest and expenditure data. One study did not report how food security was measured.

3.2. NSA Impact on Food Security.

Five of the nine included interventions reported statistically significant improvements in household food insecurity status. However, included studies were too heterogeneous in intervention approaches and measures of food insecurity to conduct a meta-analysis, of those reporting positive findings one used a homestead gardening/crop diversification strategy, one used agroecological and homestead gardening/crop diversification strategy, one used homestead gardening/crop diversification and livestock strategy, one used a value chain and market-based strategy and one used a farm intensification strategy. Two studies that applied homestead gardening/crop diversification, one study that applied homestead gardening/crop diversification and livestock production, and one that applied agricultural extension and homestead gardening/crop diversification approaches reported null findings. Studies are further characterized by strategy below.

3.2.1 Homestead gardening / crop diversification only

Three nutrition sensitive interventions implemented solely implemented a homestead gardening and crop diversification strategy without other NSA strategies. Homestead gardening and crop diversification refers to interventions that support the establishment and maintenance of home gardens for consumption and/or income generating activity.

The first intervention was set in Tanzania (M. M. Blakstad et al., 2021). Agricultural training for participants included fertilizer and pest management/safety, composting, irrigation support, nursery and raised bed preparation, and marketing support for vegetables. All participants also received seeds. An overview of non-agricultural activities included nutrition

education and complimentary feeding practices for participants. It was evaluated through a cluster randomized control trial and included 503 households in the intervention and control arm each. The Household Food Insecurity Access Scale was used to measure food insecurity outcomes. Impact was accessed through linear regression modeling where risk differences were then calculated. The model adjusted for treatment weights include baseline response variable, baseline wealth quintiles, baseline education level and baseline livestock ownership. No statistically significant impact on food security was observed. The adjusted risk difference with treatment and censoring weights was -0.58 (95% CI[-1.50, 0.35], p-value = , 0.222)

The second intervention to implement this strategy was set in Nepal (Osei et al., 2017). This intervention also incorporated a women's empowerment framework and facilitated educational opportunities about nutrition and complementary feeding practices. There were 21 intervention and 20 control village development committees (or clusters), which results in 2,106 and 2,614 mothers and children at baseline and endline. Household food insecurity was measured using the Household Food Insecurity Access Scale and impact was assessed through bivariate comparison between the intervention and counterfactual group using Rao and Scott w2 test of proportions. At endline both control and interventions control and intervention arms were measured to have a decrease prevalence of food insecurity; therefore, change the change cannot be attributed to the intervention. the prevalence of household food insecurity was lower at follow-up compared to baseline in both the treatment (53.6% vs 79.7%) and control (78.3% vs 87.4%) groups ($P < .05$). The findings showed there was not an improvement in household food insecurity.

The final intervention was set in Bangladesh (Bushamuka et al., 2005). The evaluation provided limited information on intervention activities. The interventions encouraged households

to start gardens to produce foods to lower vitamin A deficiency. This was a quasi-experimental evaluation design and included 2,160 households (603 controls, 683 former participants, and 711 participants); however, the intervention itself reached 860,000 households. Household FIS was measured by estimating household consumption of harvest production from the intervention activities and on household expenditure of food items purchased with garden income.

3.2.2 Homestead gardening / crop diversification + livestock

Three studies implemented homestead gardening, crop diversification and livestock production interventions. Livestock intervention refers to interventions that include supported animals such as chickens, cattle, sheep, ducks, goats, and pigs for household substance or income generating activities.

An intervention in Nicaragua (Arnés, Díaz-Ambrona, Marín-González, & Astier, 2018), implemented homestead gardening and crop diversification, and livestock production strategies. The intervention included a WASH component, and lessons on soil- and water-conservation techniques, nutrition, seasonal crop management, and marketing. Quasi-experimental design was used to evaluate the intervention. The evaluation groups are as followed: Terrero had 9 participant and 11 control households out of 42 household; Llanitos had 15 participant and 9 nonparticipant families out of 64 households; and Angel II had 11 participants and 12 nonparticipant households of 60 households participate in the evaluation. Household food insecurity was measured through harvest production and animal breeding quantity that resulted from participating in the interventions. Data for 13 separate indicators were collected. Its impact was assessed in three different communities at different lengthen of time. The different intervention lengths were 8 years, 5 years, and 3 years. Researchers utilized three different statistical comparison in the analysis process. Analysis of the variance (ANOVA) and means

comparison with the least significant difference test were first conducted within participants of each community groups, and then with the counterfactual of each group. In the third analysis the counterfactual and intervention groups within each community, a t-test for the significance of the difference between means was applied. The results of the Engel coefficient indicated that the most improvement of household food insecurity was seen in the community where the program had been established for 8 years with a mean of 46 vs. 66 in intervention and control. Means for the intervention and control group for the 5 year program were 66 vs. 56, and 57 vs. 46 for the 3 year program. However, all three communities experienced improvements in household food insecurity.

A multi-country intervention (Pronyk et al., 2012) was implemented in Nigeria, Mali, Senegal, Ghana, Malawi, Kenya, Tanzania, Rwanda, Uganda. Agricultural activities included agronomic training, natural resource management, livestock introduction and improvement, and irrigation system for dry season installment. In addition to agricultural activities, the intervention implemented WASH activities in all intervention communities. This intervention was evaluated through a cluster randomized controlled design of 9 village clusters in the intervention arm and nine in the control arm for a total of 2592 and 2,825 women contributing data to the intervention and control arms, respectively. Household FIS was measured using the months of adequate household food provisioning indicator (Pronyk et al., 2012) and impact was assessed with logistic regression on the effects of the year 3 of outcomes between intervention communities and counterfactual. A statistically significant increase in food security was observed in the intervention clusters from baseline and year 3 measurement. However, a baseline measurement for food insecurity was not available in the control group, as such improvements in food security cannot be attributed to the intervention.

A nutrition-sensitive intervention in Ethiopia (Kim et al., 2019) implemented a homestead gardening/crop diversification and livestock strategies. Agricultural activities included resource management, training on agroecological methods, and seed banks. This intervention encouraged complementary feeding practices to improve nutrition status of infants and young children. Messages encouraging complementary feeding practices were also incorporated into radio programming. Details on how household food insecurity was measured were not provided. Evaluation applied a difference in difference analysis of baseline and endline between intervention and controls. No statistically significant impacts were observed for food security (prevalence of FIS in intervention vs control 42.10% vs 41.63%), though dietary diversity improved among the intervention group (impact estimate 2.71, 95% CI [1.60 – 4.59], p-value = 0.0004).

3.2.3 *Homestead gardening / crop diversification + agroecology*

Agroecology refers to "a holistic and integrated approach that simultaneously applies ecological and social concepts and principles to the design and management of sustainable agriculture and food systems" (FAO, n.d.-a). A NSA study in Malawi (Kangmennaang et al., 2017) implemented homestead gardening/crop diversification applying specific agroecology strategies. Primary activities for this intervention included agroecological training methods, seed banks, resource management and crop diversity. In addition to agricultural activities, the intervention had a strong focus on community engagement and leadership development. The intervention also intentionally dedicated opportunities for discussions on social inequalities, nutrition education workshops, and introductions to complementary feeding practices. The intervention was evaluated through a quasi-experimental study design with a sample size of 6,000 participants for both intervention and control groups. Impact of the intervention was

assessed through difference in difference estimation applying kernel-based propensity score matching. Food insecurity was measured using the Household Food Insecurity Access Scale. A statistically significant improvement in household food insecurity was found among intervention participants with an average effect 1.173 (SE: 0.033; t-statistic: 35.09).

3.2.4 Market / value chain interventions

A value chains and market-based strategy nutrition sensitive intervention was implemented in Sierra Leon (Bonuedi, Kornher, & Gerber, 2020). Market and value change interventions refers to when "all the stakeholders who participate in the coordinated production and value-adding activities that are needed to make food products" (FAO, 2014). Activities included supporting farmers in reaching markets, nursery establishment, training in agricultural methods and support accessibility to inputs. This intervention centralized community engagement and provided opportunities for leadership development and discussion about social equalities. In addition, the intervention had a nutrition and complimentary feeding practices education component. A quasi-experimental study design was used, and 251 households received the full intervention and 262 served as the control group. Household FIS was measured through household dietary diversity. Impact was assessed by using the inverse-probability-weighted regression adjustment and the intervention was found to have a statistically significant improvement in household FIS.

3.2.5 Farm intensification & technology

Farm intensification and technology was only utilized in one study that took place in Tanzania (Mia M. Blakstad et al., 2021). The FAO (n.d.) defines farm intensification as "as an increase in agricultural production per unit of inputs (which may be labor, land, time, fertilizer, seed, feed or cash)." Primary agricultural activities included agricultural experimentation, seed

inputs, and addressing climate change impact. In addition to the NSA strategy, the intervention incorporated general health and nutrition education, leadership development and community engagement. This was evaluated through a cluster randomized control trial with 20 intervention villages (259 households) and 20 control villages (296 households). Household food insecurity was measured using the HFIAS during post-harvest and growing season. Linear regression was used to calculate program impact on household food security adjusting for household and village level clustering. Results indicated that the intervention improved household food security during both the post-harvest -2.48 ($p < 0.01$) and growing season -1.91 ($p<01.01$).

4. Discussion

There were nine final studies and reports included in this systematic literature review. Four interventions implemented more than one NSA strategy. The most used NSA strategy was homestead gardening and crop diversification. The most common household FIS indicator was HFIAS. Five studies were found to have a statistically significant impact of on household FIS outcomes. The NSA strategies implemented in those interventions also varied.

4.1 Food Insecurity Indicators & Seasonality

The low number of studies of this review limited the ability to conclude whether NSA interventions improve household FIS. While the majority of the included studies noted significant substantial heterogeneity across studies with respect to both intervention approach and outcome measure, there were limits to comparability. For example, there were various approaches to measuring the impact of household FIS in interventions in the included interventions. The HFIAS was the most consistently applied measure of food insecurity and is validated (INDDEX Project, 2018) but it was only used in four studies. Among studies using

other measures, five used a validated measure; three used nonvalidated measures and one did not describe how it measured food security.

A common concern for indicators is its validity and transferability in multiple contexts. According to Leroy (2015), the absence of a gold standard for food insecurity indicators poses a challenge to validating. An indicator's validity and transferability may be dependent on respondents and the different factors that influence food. Research has documented that household FIS is a gendered experience, in this context it means that experiences-based indicators such as HFIAS and HHS may not be valid across individuals and should caution evaluators for response bias. For example, within one household a man may not experience the physical and psychological impact of food insecurity and incorrectly measure the home as food secure. Most studies in this review assessed women, mothers and children who are more likely to experience household FIS. However, if husbands or men in the household were assessed at follow-up, it is possible that household FIS status would be incorrect recorded. Additionally, it is important that indicators used in cross-cultural settings can capture a holistic picture of the experiences of household FIS.

In evaluating agricultural intervention, seasonality also needs to be considered. For example, measuring household FIS outcomes during harvest season may show that the intervention was successful; however, if the intervention does is only implemented for part of the year, households may experience seasonal FIS. Research has documented that seasons can influence household FIS. For example, a study in Dinajpur, Bangladesh found that malnutrition and food insecurity were consistently higher during monsoon season in urban areas (Hillbruner & Egan, 2008). In this study, mechanisms included changes in food availability for purchase and an increase in food prices (Hillbruner & Egan, 2008). Additionally, a NSA intervention with a

livestock strategy in Nepal that measured child nutritional status found that dietary diversity fluctuated in between seasons (Darrouzet-Nardi et al., 2016). In this study, researchers found that there was a statistically significant difference between harvest and hunger season dietary diversity scores (Darrouzet-Nardi et al., 2016). Ideally, evaluations on NSA interventions would also measure household FIS status, both, during and outside harvest season. This would also give implementers the opportunity to modify their interventions and adapt to seasonal conditions (e.g., add irrigation system for dry seasons). In this systematic review, only one study captured FIS measurements at two different points during the harvest cycle: pre-harvest and post-harvest.

The HFIAS, the most used indicator in this review, was developed to be cross cultural (Coates, Swindale, & Bilinsky, 2007). The scale captures feelings (or anxieties) of household food supplies; perceptions of food variety and food preference; and sufficient food intake and any physically consequences within the last 30 days (Coates et al., 2007). Multiple studies document the tool's contextual validity, such as in rural Tanzania, rural and urban Ethiopia, rural Lebanon and urban Iran (Gebreyesus, Lunde, Mariam, Woldehanna, & Lindtjørn, 2015; Knueppel, Demment, & Kaiser, 2010; Mohammadi et al., 2012; Naja, Hwalla, Fossian, Zebian, & Nasreddine, 2015). These studies provide evidence that the HFIAS was an appropriate tool to measure impact of NSA interventions. Surprisingly, only one study used the HHS to measure food insecurity. The HHS is an attractive instrument because it has been validated for cross cultural use (Deitcheler, Ballard, Swindale, & Coates, 2010).

Only one study in this review measured household FIS through HDD and was found to improve household FIS. However, HDD does not capture all the dimension of food security, such as stability. HDD as an indicator for household FIS is problematic because it only captures food consumption information for the previous 24-48 hours. Additionally, the Food and

Nutritional Technical Assistance (2002), states that while household dietary diversity is a valid measurement of food access, it should only be used as a proxy for household FIS when "resources for measure are scarce".

Other household FIS indicators measure consumption, production, and expenditure. In general, food consumption provides data on the diversity and frequency over the course of a week (INDDEX Project, 2018). In the context of the NSA interventions reviewed here, foods counted towards consumption were restricted to those harvested or sourced through the intervention. The limitation of this approach is that it does not capture seasonality and limits its impact to harvest season. Additionally, expenditure and harvest production measurements also encounter seasonality limitation and have not been validated. Additionally, proportion of household expenditure on food may fluctuate if the NSA has income generating activities.

4.2. Impacts of nutrition sensitive agricultural on food insecurity

A total of 138 studies were excluded because they did not meet the study design inclusion criteria. Most of the excludes studies used a cross-sectional study design or had no or inappropriate counterfactuals. As a result, only 9 studies were included, and heterogeneity prohibited meta-analysis. To evaluate impacts of NSA approaches on food security, there is a clear need to implement stronger evaluation designs that include a counterfactual group. NSA interventions are multi-dimensional, impacts may shift with seasons and thus require intensive data collection throughout the year to accurately assess their impacts on food security; without this information it becomes difficult to understand if NSA are a long-time solution that address all the dimensions of household FIS.

4.2.1. Pathways to Malnutrition

The listed activities of NSA interventions have the potential to address underlying causes of malnutrition mapped out on UNICEF's conceptual framework. For example, a listed cause on the framework is "household access to adequate quantity and quality of resources: land, education, employment, income, and technology", NSA strategies such as homestead gardening, enhanced value chains, agroecology, farm intensification and livestock production address those issues at a certain capacity. Non-agricultural activities such as women empowerment groups, discussion on social inequalities and leadership development begin to address another basic cause of the framework: sociocultural, economic, and political context. Many interventions target the immediate causes of malnutrition (e.g., inadequate dietary intake), but do not adequately address basic causes. While basic causes are certainly more complex (e.g. structural and institutional barriers), addressing them can have a large and stable impact as long-term solution.

4.4. Strengths and Limitations

A strength of this research was an exhaustive search strategy. The foundation of the search strategy was built on a previous review by Ruel's et al. (2018). This helped us capture a wide net on NSA strategies. There were a few limitations to this systematic literature review. First, the number of studies and reports that met the final inclusion criteria was low. This limited our ability to complete a meta-analysis. Language capacity was also a limitation. Only English literature was reviewed, which may have limited our results. It is likely that additional literature from Latin America and the Caribbean is available in Spanish and literature from Africa is available in French. This systematic literature review could be built upon by widening language criteria. A methodological limitation was that only one member of the research team reviewed full text. Finally, we cannot rule out reporting bias as a limitation in this review. Pocock (1987) and Tannock (1996) found that the range of outcomes that are recorded are not always included

in published literature (as cited in Cochrane, n.d.). Many NSA interventions consist of multiple activities and therefore have a range of outcomes that cannot all be published at one time. It is possible that authors find it more attractive to publish outcomes that were found to be statistically significant. Additionally, some studies had to be excluded because FIS outcomes were only reported at baseline and reasons for exclusion were not provided. According to Kirkham et al. (2010), this is common. After examining the prevalence of outcome reporting bias in randomized trials from Cochrane reviews, Kirham et al. (2010) found that 55% of the systematic literature reviews were missing results for primary outcomes of interest from eligible trials (Kirkham et al., 2010). These results suggest that this systematic literature review was also subjected to outcome reporting bias.

5. Conclusion

The FAO (2020) has reported that the goal of Zero Hunger is not on target to be met by 2030. With 25.9% of the world with unstable access to nutritious and sufficient food, resources need to be redirected towards interventions that have a proven impact on household FIS and that can provide long-term solutions for undernutrition. Research should continue to examine how NSA specific strategies and activities address basic and underlying causes of undernutrition on the conceptual framework of malnutrition.

In summary, this systematic literature review allowed us to see that household FIS outcomes are not frequently published. A meta-analysis could not be completed due to the low number of studies and reports. This limited our ability to fully answer our research question: do NSA interventions have a positive impact on household FIS? Researchers and implementers should prioritize study designs that include a control group and publishing food insecurity results regardless of if they are statistically significant or not. The low number of included studies and

reports prevented us from understanding if there is a consensus or best practices for reporting household FIS for NSA interventions. However, in this review, it seems that the HFIAS was the preferred method and is, fortunately, a validated indicators for FIS.

Appendix

Figure 1. Source: Adapted from UNCEF, 2013

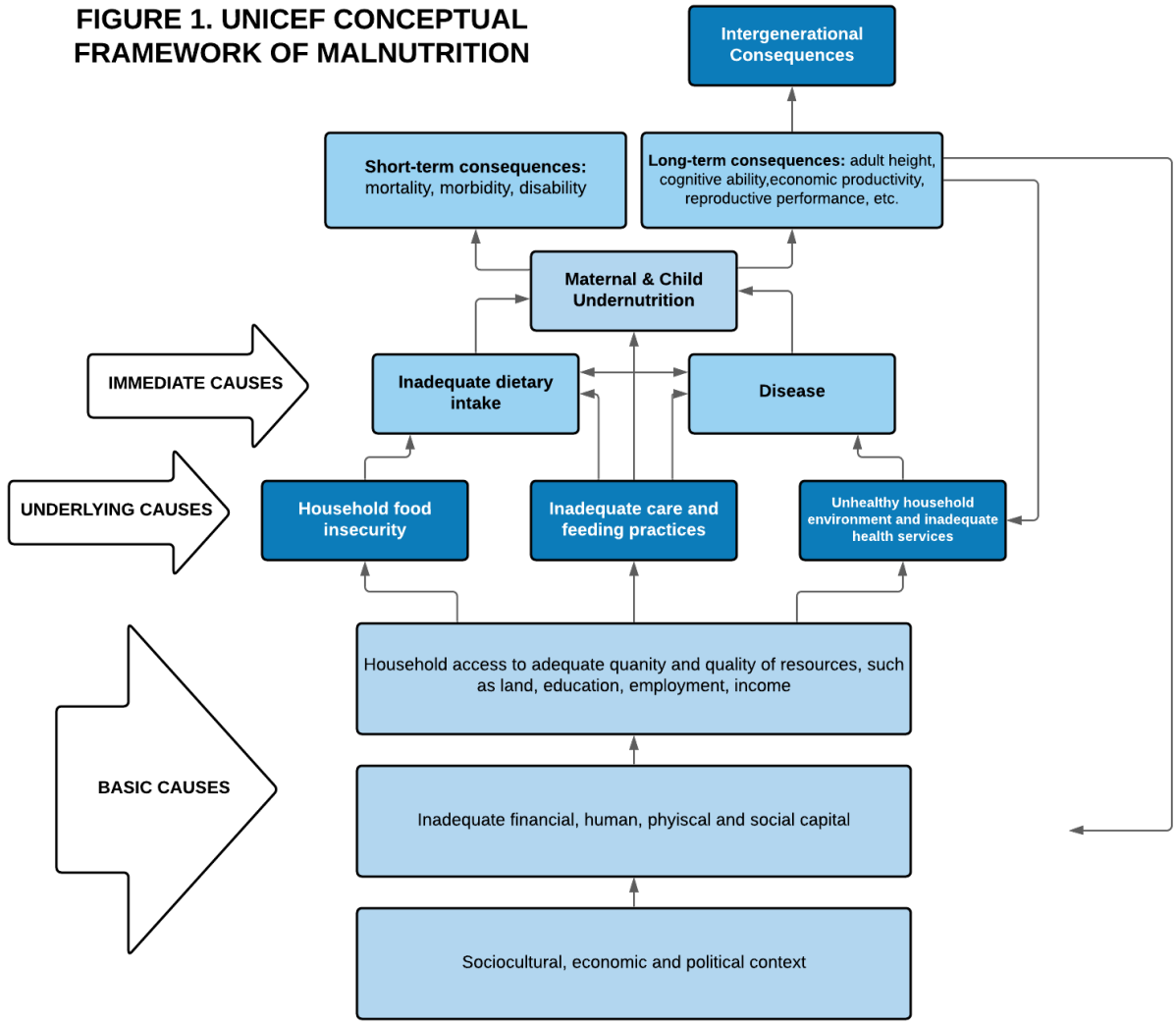
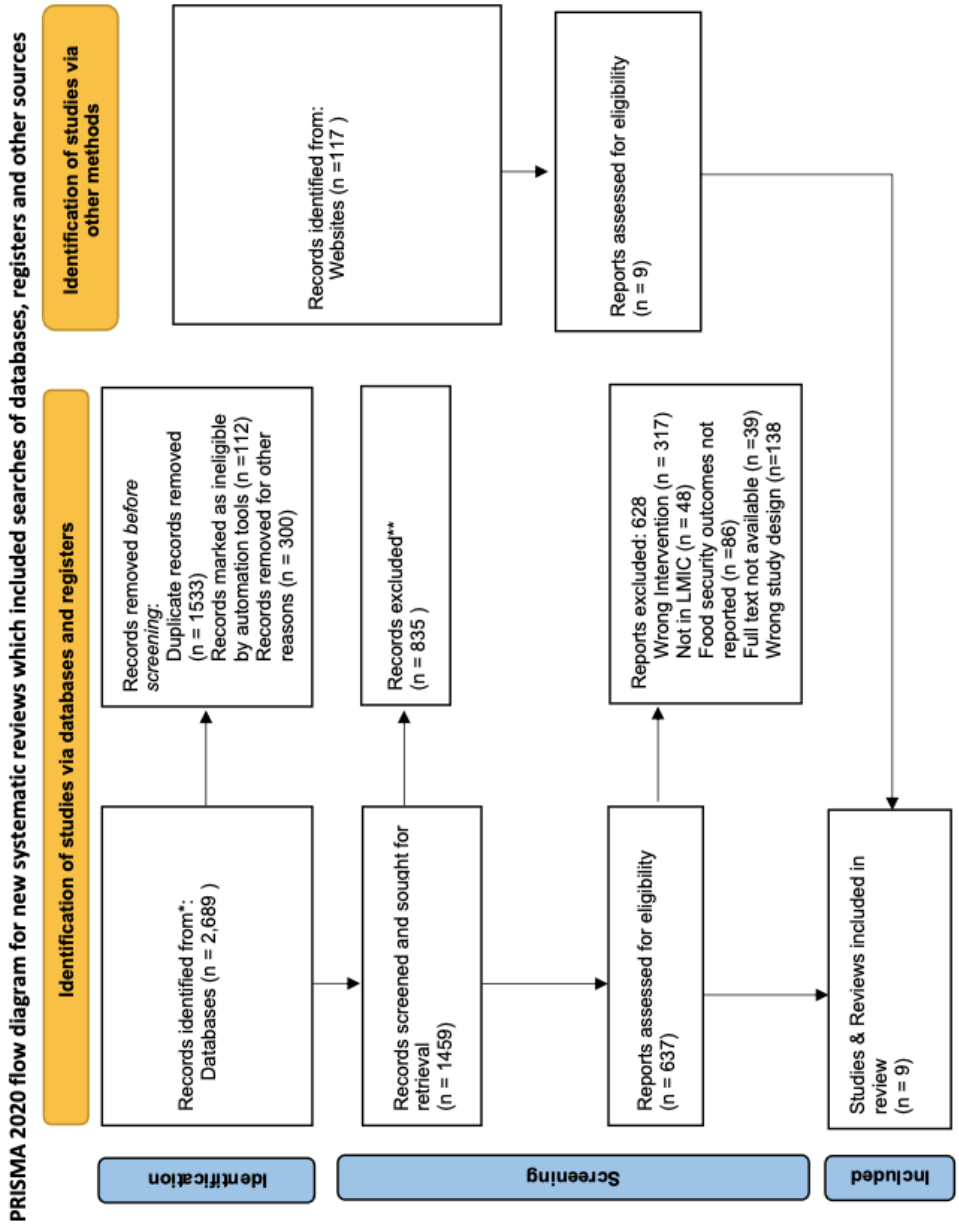


Figure 2. PRISMA Flow Chart



From: Page MJ, McKenzie JE, Bossuyt PM, Boutron I, Hoffmann TC, Mulrow CD, et al. The PRISMA 2020 statement: an updated guideline for reporting systematic reviews. BMJ 2021;372:n71. doi: 10.1136/bmj.n71. For more information, visit: http://www.prisma-statement.org/

Table 2. Overview of Studies and Nutrition-Sensitive Agriculture Strategies

STUDY ID	COUNTRY	Homestead gardening; Diversification	Livestock; Poultry; Dairy; Fisheries	Agriculture Extension	Agroecology	Value Chains; market-based strategies	Farm intensification; technologies
MVD2012	Nigeria, Mali, Senegal, Ghana, Malawi, Kenya, Tanzania, Rwanda, Uganda	✓	✓				
*K2017**	Malawi	✓			✓		
K2019	Ethiopia	✓	✓				
*B2020**	Sierra Leon					✓	
*S2021**	Tanzania						✓
B2021	Tanzania	✓					
*B2005**	Bangladesh	✓					
O2017	Nepal	✓					
*A2018**	Nicaragua	✓	✓				

* Indicates a statistically significant impact on household food insecurity

Chapter 4: Discussion and Conclusion

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A total of 138 studies were excluded because they did not meet the study design inclusion criteria. Most of the excludes studies used a cross-sectional study design or had no or inappropriate counterfactuals. As a result, only 9 studies were included, and heterogeneity prohibited meta-analysis. To evaluate impacts of NSA approaches on food security, there is a clear need to implement stronger evaluation designs that include a counterfactual group. NSA interventions are multi-dimensional, impacts may shift with seasons and thus require intensive

data collection throughout the year to accurately assess their impacts on food security; without this information it becomes difficult to understand if NSA are a long-time solution that address all the dimensions of household FIS.

These finding provide general evidence that NSA intervention do improve household FIS. However, the impact of NSA interventions should continue to be examined and there should a consensus of valid household food insecurity indicators. The positive impact on household food insecurity indicate that NSA interventions have the potential to address underlying causes of malnutrition mapped out on UNICEF's conceptual framework. For example, a listed cause on the framework is "household access to adequate quantity and quality of resources: land, education, employment, income, and technology", NSA strategies such as homestead gardening, enhanced value chains, agroecology, farm intensification and livestock production address those issues at a certain capacity. Non-agricultural activities such as women empowerment groups, discussion on social inequalities and leadership development begin to address another basic cause of the framework: sociocultural, economic, and political context. Many interventions target the immediate causes of malnutrition (e.g., inadequate dietary intake), but do not adequately address basic causes. While basic causes are certainly more complex (e.g. structural and institutional barriers), addressing them can have a large and stable impact as long-term solution.

The low number of studies of this review limited the ability to conclude whether NSA interventions improve household FIS. While most of the included studies noted significant substantial heterogeneity across studies with respect to both intervention approach and outcome measure, there were limits to comparability. For example, there were various approaches to measuring the impact of household FIS in interventions in the included interventions. The HFIAS was the most consistently applied measure of food insecurity and is validated (INDDEX

Project, 2018) but it was only used in four studies. Among studies using other measures, five used a validated measure; three used nonvalidated measures and one did not describe how it measured food security.

A common concern for indicators is its validity and transferability in multiple contexts. According to Leroy (2015), the absence of a gold standard for food insecurity indicators poses a challenge to validating. An indicator's validity and transferability may be dependent on respondents and the different factors that influence food. Research has documented that household FIS is a gendered experience, in this context it means that experiences-based indicators such as HFIAS and HHS may not be valid across individuals and should caution evaluators for response bias. For example, within one household a man may not experience the physical and psychological impact of food insecurity and incorrectly measure the home as food secure. Most studies in this review assessed women, mothers and children who are more likely to experience household FIS. However, if husbands or men in the household were assessed at follow-up, it is possible that household FIS status would be incorrect recorded. Additionally, it is important that indicators used in cross-cultural settings can capture a holistic picture of the experiences of household FIS.

In evaluating agricultural intervention, seasonality also needs to be considered. For example, measuring household FIS outcomes during harvest season may show that the intervention was successful; however, if the intervention does is only implemented for part of the year, households may experience seasonal FIS. Research has documented that seasons can influence household FIS. For example, a study in Dinajpur, Bangladesh found that malnutrition and food insecurity were consistently higher during monsoon season in urban areas (Hillbruner & Egan, 2008). In this study, mechanisms included changes in food availability for purchase and

an increase in food prices (Hillbruner & Egan, 2008). Additionally, a NSA intervention with a livestock strategy in Nepal that measured child nutritional status found that dietary diversity fluctuated in between seasons (Darrouzet-Nardi et al., 2016). In this study, researchers found that there was a statistically significant difference between harvest and hunger season dietary diversity scores (Darrouzet-Nardi et al., 2016). Ideally, evaluations on NSA interventions would also measure household FIS status, both, during and outside harvest season. This would also give implementers the opportunity to modify their interventions and adapt to seasonal conditions (e.g., add irrigation system for dry seasons). In this systematic review, only one study captured FIS measurements at two different points during the harvest cycle: pre-harvest and post-harvest.

There is an urgency to respond to the increasing prevalence of household food insecurity around the globe. Resources need to be directed towards evidence-based interventions and policies that can provide sustainable solutions. Research should continue to examine how NSA specific strategies and activities address basic and underlying causes of the conceptual framework of malnutrition. Researchers and implementers should prioritize study designs that include a control group and publish food insecurity results regardless of if they are statistically significant or not. Finally, funders should provide enough financial support both delivery of successful interventions and robust evaluations.

References

Alaofè, H., Burney, J., Naylor, R., & Taren, D. (2016). Solar-Powered Drip Irrigation Impacts on Crops Production Diversity and Dietary Diversity in Northern Benin. *Food and Nutrition Bulletin, 37*(2), 164-175. doi:10.1177/0379572116639710

Ali, H. M. A., & Vallianatos, H. (2017). Women's Experiences of Food Insecurity and Coping Strategies in the Chittagong Hill Tracts, Bangladesh. *Ecology of Food and Nutrition, 56*(6), 462-478. doi:10.1080/03670244.2017.1381604

Alpízar, F., Saborío-Rodríguez, M., Martínez-Rodríguez, M. R., Viguera, B., Vignola, R., Capitán, T., & Harvey, C. A. (2020). Determinants of food insecurity among smallholder farmer households in Central America: recurrent versus extreme weather-driven events. *Regional Environmental Change, 20*(1), 22. doi:10.1007/s10113-020-01592-y

Anderson, W., Taylor, C., McDermid, S., Ilboudo-Nébié, E., Seager, R., Schlenker, W., . . . Markey, K. (2021). Violent conflict exacerbated drought-related food insecurity between 2009 and 2019 in sub-Saharan Africa. *Nature Food, 2*(8), 603-615. doi:10.1038/s43016-021-00327-4

Arnés, E., Díaz-Ambrona, C. G. H., Marín-González, O., & Astier, M. (2018). Farmer Field Schools (FFSs): A Tool Empowering Sustainability and Food Security in Peasant Farming Systems in the Nicaraguan Highlands. *Sustainability, 10*(9), 3020. Retrieved from https://www.mdpi.com/2071-1050/10/9/3020

Assoumaa, B. T., Diourte, M., Diourte, M., Ndiaye, M., & Van der Puije, G. (2016). Comparative Assessment of Local Farmers' Perceptions of Meteorological Events and Adaptations Strategies: Two Case Studies in Niger Republic. *Journal of Sustainable Development, 9*. doi:10.5539/jsd.v9n3p118

Aurino, E., Wolf, S., & Tsinigo, E. (2020). Household food insecurity and early childhood development: Longitudinal evidence from Ghana. *PLOS ONE, 15*(4), e0230965-e0230965. doi:10.1371/journal.pone.0230965

Baig-Ansari, N., Rahbar, M. H., Bhutta, Z. A., & Badruddin, S. H. (2006). Child's Gender and Household Food Insecurity are Associated with Stunting among Young Pakistani Children Residing in Urban Squatter Settlements. *Food and Nutrition Bulletin, 27*(2), 114-127. doi:10.1177/156482650602700203

Balz, A., Heil, E., & Jordan, I. (2015). Nutrition-sensitive agriculture: New term or new concept? *Agriculture & Food Security, 4*. doi:10.1186/s40066-015-0026-4

Belachew, T., Lindstrom, D., Gebremariam, A., Jira, C., Hattori, M. K., Lachat, C., . . . Kolsteren, P. (2012). Predictors of chronic food insecurity among adolescents in Southwest Ethiopia: a longitudinal study. *BMC public health, 12*, 604-604. doi:10.1186/1471-2458-12-604

Ben-Davies, M. E., Kinlaw, A., Estrada Del Campo, Y., Bentley, M. E., & Siega-Riz, A. M. (2014). Risk factors associated with the presence and severity of food insecurity in rural Honduras. *Public Health Nutr, 17*(1), 5-13. doi:10.1017/s1368980013002048

Blakstad, M. M., Mosha, D., Bellows, A. L., Canavan, C. R., Chen, J. T., Mlalama, K., . . . Fawzi, W. W. (2021). Home gardening improves dietary diversity, a cluster-randomized controlled trial among Tanzanian women. *Maternal & child nutrition, 17*(2), e13096. doi:10.1111/mcn.13096

Blakstad, M. M., Mosha, D., Bellows, A. L., Canavan, C. R., Chen, J. T., Mlalama, K., . . . Fawzi, W. W. (2021). Home gardening improves dietary diversity, a cluster-randomized controlled trial among Tanzanian women. *Maternal & child nutrition, 17*(2), e13096-e13096. doi:10.1111/mcn.13096

Boliko, M. C. (2019). FAO and the Situation of Food Security and Nutrition in the World. *Journal of Nutritional Science and Vitaminology, 65*(Supplement), S4-S8. doi:10.3177/jnsv.65.S4

Bonuedi, I., Kornher, L., & Gerber, N. (2020). *Making cash crop value chains nutrition-sensitive: Evidence from a quasi-experiment in rural Sierra Leone*. Retrieved from https://ageconsearch.umn.edu/record/303638

Bushamuka, V. N., de Pee, S., Talukder, A., Kiess, L., Panagides, D., Taher, A., & Bloem, M. (2005). Impact of a homestead gardening program on household food security and empowerment of women in Bangladesh. *Food Nutr Bull, 26*(1), 17-25. doi:10.1177/156482650502600102

Coates, J., Swindale, A., & Bilinsky, P. (2007). Household Food Insecurity Access Scale (HFIAS) for measurement of food access: indicator guide: version 3.

Cochrane. (n.d.). Reporting Biases. Retrieved from https://methods.cochrane.org/bias/reporting-biases

Darrouzet-Nardi, A. F., Miller, L. C., Joshi, N., Mahato, S., Lohani, M., & Rogers, B. L. (2016). Child dietary quality in rural Nepal: Effectiveness of a community-level development intervention. *Food Policy, 61*, 185-197. doi:https://doi.org/10.1016/j.foodpol.2016.03.007

Deaton, B. J., & Lipka, B. (2015). Political Instability and Food Security. *Journal of Food Security, 3*(1), 29-33. doi:10.12691/jfs-3-1-5

Deitcheler, M., Ballard, T., Swindale, A., & Coates, J. (2010). *Validation of a Measure of Household Hunger for Cross-Cultural Use*. Retrieved from Washington, DC:

Diamond-Smith, N., Shieh, J., Puri, M., & Weiser, S. (2020). Food insecurity and low access to high-quality food for preconception women in Nepal: the importance of household relationships. *Public Health Nutrition, 23*(15), 2737-2745. doi:10.1017/S1368980020000579

Dubé, L., McRae, C., Wu, Y.-H., Ghosh, S., Allen, S., Ross, D., . . . Moore, S. (2019). Impact of the eKutir ICT-enabled social enterprise and its distributed micro-entrepreneur strategy on fruit and vegetable consumption: A quasi-experimental study in rural and urban communities in Odisha, India. *Food Policy, 90*, 101787. doi:10.1016/j.foodpol.2019.101787

Elgar, F. J., Pickett, W., Pförtner, T.-K., Gariépy, G., Gordon, D., Georgiades, K., . . . Melgar-Quiñonez, H. R. (2021). Relative food insecurity, mental health and wellbeing in 160 countries. *Social Science & Medicine, 268*, 113556. doi:https://doi.org/10.1016/j.socscimed.2020.113556

Endale, W., Mengesha, Z. B., Atinafu, A., & Adane, A. A. (2014). Food insecurity in Farta District, Northwest Ethiopia: a community based cross-sectional study. *BMC research notes, 7*, 130-130. doi:10.1186/1756-0500-7-130

FAO. (2014). *Second International Conference on Nutrition, 19-21 November 2014*. Retrieved from Rome, Italy:

FAO. (n.d.-a). Agroecology Knowledge Hub. Retrieved from https://www.fao.org/agroecology/home/en/

FAO. (n.d.-b). Food and nutrition security in Latin America and the Caribbean. Retrieved from https://www.fao.org/americas/priorities/seguridad-alimentaria/en/

FAO. (n.d.-c). Hunger and food insecurity. Retrieved from https://www.fao.org/hunger/en/

FAO, ECA, & AUC. (2021). *Africa regional overview of food security and nutrition 2020: Transforming food systems for affordable healthy diets*. Retrieved from Accra, Ghana:

FAO, PAHO, WFP, UNICEF, & IFAD. (2020). *Regional Overview of Food Security and Nutrition in Latin America and the Caribbean 2020 – Food security and nutrition for lagged territories*. Retrieved from https://iris.paho.org/handle/10665.2/53263

FAO, RAHO, WFP, & UNICEF. (2020). *Regional Overview of Food Security in Latin America and the Caribbean*. Retrieved from Santiago, Chile https://www.fao.org/documents/card/en/c/ca6979en/

FAO, I., UNICEF, WFP and WHO. (2020). *Transforming food systems for affordable healthy diets*. Retrieved from Rome, Italy: http://www.fao.org/documents/card/en/c/ca9692en/

Fischer, N. C., Shamah-Levy, T., Mundo-Rosas, V., Méndez-Gómez-Humarán, I., & Pérez-Escamilla, R. (2014). Household food insecurity is associated with anemia in adult Mexican women of reproductive age. *J Nutr, 144*(12), 2066-2072. doi:10.3945/jn.114.197095

Gebreyesus, S. H., Lunde, T., Mariam, D. H., Woldehanna, T., & Lindtjørn, B. (2015). Is the adapted Household Food Insecurity Access Scale (HFIAS) developed internationally to measure food insecurity valid in urban and rural households of Ethiopia? *BMC Nutrition, 1*(1), 2. doi:10.1186/2055-0928-1-2

Ghose, B., Tang, S., Yaya, S., & Feng, Z. (2016). Association between food insecurity and anemia among women of reproductive age. *PeerJ, 4*, e1945. doi:10.7717/peerj.1945

Goudet, S., Hlaing, L. M., & Griffiths, P. L. (2020). Exploring food security and nutrition among young women in the formally regulated garment sector of Myanmar. *Annals of the New York Academy of Sciences, 1468*(1), 35-54. doi:https://doi.org/10.1111/nyas.14370

Hadley, C., Lindstrom, D., Tessema, F., & Belachew, T. (2008). Gender bias in the food insecurity experience of Ethiopian adolescents. *Soc Sci Med, 66*(2), 427-438. doi:10.1016/j.socscimed.2007.08.025

Haro-Mota, R., Marceleño-Flores, S., Bojórquez-Serrano, J. I., & Nájera-González, O. (2016). [Food insecurity in the state of Nayarit, Mexico, and its association with socioeconomic factors]. *Salud Publica Mex, 58*(4), 421-427.

Harris-Fry, H., Shrestha, N., Costello, A., & Saville, N. M. (2017). Determinants of intra-household food allocation between adults in South Asia - a systematic review. *International journal for equity in health, 16*(1), 107-107. doi:10.1186/s12939-017-0603-1

Hillbruner, C., & Egan, R. (2008). Seasonality, Household Food Security, and Nutritional Status in Dinajpur, Bangladesh. *Food and Nutrition Bulletin, 29*, 221-231. doi:10.1177/156482650802900308

Hoddinott, J., & Yohannes, Y. (2002). *Dietary Diversity as a Household Food Security Indicator*. Retrieved from https://www.fantaproject.org/sites/default/files/resources/DietaryDiversity-HH-FS-Indicator-2002.pdf

INDDEX Project. (2018). Data4Diets: Building Blocks for Diet-related Food Security Analysis. Retrieved from https://inddex.nutrition.tufts.edu/data4diets

Ivers, L. C., & Cullen, K. A. (2011). Food insecurity: special considerations for women. *The American Journal of Clinical Nutrition, 94*(6), 1740S-1744S. doi:10.3945/ajcn.111.012617

Jones, A. D., Ngure, F. M., Pelto, G., & Young, S. L. (2013). What Are We Assessing When We Measure Food Security? A Compendium and Review of Current Metrics. *Advances in Nutrition, 4*(5), 481-505. doi:10.3945/an.113.004119

Jung, N. M., de Bairros, F. S., Pattussi, M. P., Pauli, S., & Neutzling, M. B. (2017). Gender differences in the prevalence of household food insecurity: a systematic review and meta-analysis. *Public Health Nutrition, 20*(5), 902-916. doi:10.1017/S1368980016002925

Kangmennaang, J., Kerr, R. B., Lupafya, E., Dakishoni, L., Katundu, M., & Luginaah, I. (2017). Impact of a participatory agroecological development project on household wealth and food security in Malawi. *Food Security, 9*(3), 561-576. doi:10.1007/s12571-017-0669-z

Kim, S. S., Nguyen, P. H., Yohannes, Y., Abebe, Y., Tharaney, M., Drummond, E., . . . Menon, P. (2019). Behavior Change Interventions Delivered through Interpersonal Communication, Agricultural Activities, Community Mobilization, and Mass Media Increase Complementary Feeding Practices and Reduce Child Stunting in Ethiopia. *J Nutr, 149*(8), 1470-1481. doi:10.1093/jn/nxz087

Kirkham, J. J., Dwan, K. M., Altman, D. G., Gamble, C., Dodd, S., Smyth, R., & Williamson, P. R. (2010). The impact of outcome reporting bias in randomised controlled trials on a cohort of systematic reviews. *Bmj, 340*, c365. doi:10.1136/bmj.c365

Knueppel, D., Demment, M., & Kaiser, L. (2010). Validation of the Household Food Insecurity Access Scale in rural Tanzania. *Public Health Nutrition, 13*(3), 360-367. doi:10.1017/S1368980009991121

Labbé, J., Ford, J. D., Berrang-Ford, L., Donnelly, B., Lwasa, S., Namanya, D. B., . . . Team, I. R. (2016). Vulnerability to the health effects of climate variability in rural southwestern Uganda. *Mitigation and Adaptation Strategies for Global Change, 21*(6), 931-953. doi:10.1007/s11027-015-9635-2

Laraia, B. A. (2013). Food insecurity and chronic disease. *Advances in nutrition (Bethesda, Md.), 4*(2), 203-212. doi:10.3945/an.112.003277

Leroy, J. L., Ruel, M., Frongillo, E. A., Harris, J., & Ballard, T. J. (2015). Measuring the Food Access Dimension of Food Security: A Critical Review and Mapping of Indicators. *Food Nutr Bull, 36*(2), 167-195. doi:10.1177/0379572115587274

Maynard, M., Andrade, L., Packull-McCormick, S., Perlman, C. M., Leos-Toro, C., & Kirkpatrick, S. I. (2018). Food Insecurity and Mental Health among Females in High-Income Countries. *International journal of environmental research and public health, 15*(7), 1424. doi:10.3390/ijerph15071424

McDonough, A., Weiser, S. D., Daniel, A., Weke, E., Wekesa, P., Burger, R., . . . Cohen, C. R. (2020). "When I Eat Well, I Will Be Healthy, and the Child Will Also Be Healthy": Maternal Nutrition among HIV-Infected Women Enrolled in a Livelihood Intervention in Western Kenya. *Current developments in nutrition, 4*(4), nzaa032-nzaa032. doi:10.1093/cdn/nzaa032

Mohammadi, F., Omidvar, N., Houshiar-Rad, A., Khoshfetrat, M.-R., Abdollahi, M., & Mehrabi, Y. (2012). Validity of an adapted Household Food Insecurity Access Scale in urban households in Iran. *Public Health Nutrition, 15*(1), 149-157. doi:10.1017/S1368980011001376

Nagata, J. M., Fiorella, K. J., Salmen, C. R., Hickey, M. D., Mattah, B., Magerenge, R., . . . Cohen, C. R. (2015). Around the Table: Food Insecurity, Socioeconomic Status, and Instrumental Social Support among Women Living in a Rural Kenyan Island Community. *Ecol Food Nutr, 54*(4), 358-369. doi:10.1080/03670244.2014.995790

Naja, F., Hwalla, N., Fossian, T., Zebian, D., & Nasreddine, L. (2015). Validity and reliability of the Arabic version of the Household Food Insecurity Access Scale in rural Lebanon. *Public Health Nutrition, 18*(2), 251-258. doi:10.1017/S1368980014000317

Ngcamu, B. S., & Chari, F. (2020). Drought Influences on Food Insecurity in Africa: A Systematic Literature Review. *International journal of environmental research and public health, 17*(16), 5897. doi:10.3390/ijerph17165897

Oluoko-Odingo, A. A. (2011). Vulnerability and Adaptation to Food Insecurity and Poverty in Kenya. *Annals of the Association of American Geographers, 101*(1), 1-20. doi:10.1080/00045608.2010.532739

Osei, A., Pandey, P., Nielsen, J., Pries, A., Spiro, D., Davis, D., . . . Haselow, N. (2017). Combining Home Garden, Poultry, and Nutrition Education Program Targeted to Families With Young Children Improved Anemia Among Children and Anemia and Underweight Among Nonpregnant Women in Nepal. *Food Nutr Bull, 38*(1), 49-64. doi:10.1177/0379572116676427

Pedroso, J., Buccini, G., Venancio, S. I., Pérez-Escamilla, R., & Gubert, M. B. (2020). Maternal mental health modifies the association of food insecurity and early child

development. *Maternal & child nutrition, 16*(4), e12997-e12997. doi:10.1111/mcn.12997
Pourmotabbed, A., Moradi, S., Babaei, A., Ghavami, A., Mohammadi, H., Jalili, C., . . . Miraghajani, M. (2020). Food insecurity and mental health: a systematic review and meta-analysis. *Public Health Nutrition, 23*(10), 1778-1790. doi:10.1017/S136898001900435X
Pronyk, P. M., Muniz, M., Nemser, B., Somers, M.-A., McClellan, L., Palm, C. A., . . . Sachs, J. D. (2012). The effect of an integrated multisector model for achieving the Millennium Development Goals and improving child survival in rural sub-Saharan Africa: a non-randomised controlled assessment. *The Lancet, 379*(9832), 2179-2188. doi:10.1016/S0140-6736(12)60207-4
Redmond, M. L., Dong, F., Goetz, J., Jacobson, L. T., & Collins, T. C. (2016). Food Insecurity and Peripheral Arterial Disease in Older Adult Populations. *J Nutr Health Aging, 20*(10), 989-995. doi:10.1007/s12603-015-0639-0
Ruel, M. T., Quisumbing, A. R., & Balagamwala, M. (2018). Nutrition-sensitive agriculture: What have we learned so far? *Global Food Security, 17*, 128-153. doi:https://doi.org/10.1016/j.gfs.2018.01.002
Saha, K. K., Tofail, F., Frongillo, E. A., Rasmussen, K. M., Arifeen, S. E., Persson, L. A., . . . Hamadani, J. D. (2010). Household food security is associated with early childhood language development: results from a longitudinal study in rural Bangladesh. *Child Care Health Dev, 36*(3), 309-316. doi:10.1111/j.1365-2214.2009.01049.x
Saunders, J., & Smith, T. (2010). Malnutrition: causes and consequences. *Clinical medicine (London, England), 10*(6), 624-627. doi:10.7861/clinmedicine.10-6-624
Schmeer, K. K. (2005). Married women's resource position and household food expenditures in Cebu, Philippines. *Journal of Marriage and Family, 67*(2), 399-409. doi:https://doi.org/10.1111/j.0022-2445.2005.00124.x
Schmeer, K. K., Piperata, B. A., Rodríguez, A. H., Torres, V. M. S., & Cárdenas, F. J. C. (2015). Maternal resources and household food security: evidence from Nicaragua. *Public Health Nutrition, 18*(16), 2915-2924. doi:10.1017/S1368980014003000
Seligman, H. K., Laraia, B. A., & Kushel, M. B. (2010). Food insecurity is associated with chronic disease among low-income NHANES participants. *J Nutr, 140*(2), 304-310. doi:10.3945/jn.109.112573
Sharma, I. K., Di Prima, S., Essink, D., & Broerse, J. E. W. (2021). Nutrition-Sensitive Agriculture: A Systematic Review of Impact Pathways to Nutrition Outcomes. *Advances in nutrition (Bethesda, Md.), 12*(1), 251-275. doi:10.1093/advances/nmaa103
Smith, L. C., Ramakrishnan, U., Ndiaye, A., Haddad, L., & Martorell, R. (2003). The importance of Women's status for child nutrition in developing countries: international food policy research institute (IFPRI) research report abstract 131. *Food and Nutrition Bulletin, 24*(3), 287-288.

Sulaiman, N., Yeatman, H., Russell, J., & Law, L. S. (2021). A Food Insecurity Systematic Review: Experience from Malaysia. *Nutrients, 13*(3), 945. doi:10.3390/nu13030945

Tappis, H., Doocy, S., Paul, A., & Funna, S. (2013). Food security and development in South Sudan: a call to action. *Public Health Nutrition, 16*(9), 1631-1636. doi:10.1017/S1368980013000669

Tayie, F. A., & Zizza, C. A. (2009). Food insecurity and dyslipidemia among adults in the United States. *Prev Med, 48*(5), 480-485. doi:10.1016/j.ypmed.2009.03.003

UNICEF. (2013). *Improving Child Nutrition: The achievable imperative for global progress*. Retrieved from New York, NY:

UNICEF, FAO, WFP, & WHO. (2021). *Asia and the Pacific Regional Overview of Food Security and Nutrition*. Retrieved from https://www.unicef.org/rosa/reports/asia-and-pacific-regional-overview-food-security-and-nutrition

Velardo, S., Pollard, C. M., Shipman, J., & Booth, S. (2021). How Do Disadvantaged Children Perceive, Understand and Experience Household Food Insecurity? *International journal of environmental research and public health, 18*(8). doi:10.3390/ijerph18084039

Villena-Esponera, M. P., Moreno-Rojas, R., & Molina-Recio, G. (2019). Food Insecurity and the Double Burden of Malnutrition of Indigenous Refugee Épera Siapidara. *Journal of Immigrant and Minority Health, 21*(5), 1035-1042. doi:10.1007/s10903-018-0807-5

Walker, R. J., Dawson, A. Z., Campbell, J. A., & Egede, L. E. (2021). Prevalence of food insecurity and association with mental health in an indigenous population in Panamá. *Public Health Nutrition*, 1-8. doi:10.1017/S1368980021003554

Ward, J. L., Harrison, K., Viner, R. M., Costello, A., & Heys, M. (2018). Adolescent cohorts assessing growth, cardiovascular and cognitive outcomes in low and middle-income countries. *PLOS ONE, 13*(1), e0190443. doi:10.1371/journal.pone.0190443

Webb, M. F., Chary, A. N., De Vries, T. T., Davis, S., Dykstra, M., Flood, D., . . . Rohloff, P. (2016). Exploring mechanisms of food insecurity in indigenous agricultural communities in Guatemala: a mixed methods study. *BMC Nutrition, 2*(1), 55. doi:10.1186/s40795-016-0091-5

Weigel, M. M., Armijos, R. X., Racines, M., Cevallos, W., & Castro, N. P. (2016). Association of Household Food Insecurity with the Mental and Physical Health of Low-Income Urban Ecuadorian Women with Children. *J Environ Public Health, 2016*, 5256084. doi:10.1155/2016/5256084

Weinreb, L., Wehler, C., Perloff, J., Scott, R., Hosmer, D., Sagor, L., & Gundersen, C. (2002). Hunger: Its Impact on Children's Health and Mental Health. *Pediatrics, 110*(4), e41-e41. doi:10.1542/peds.110.4.e41

Wells, J. C., Sawaya, A. L., Wibaek, R., Mwangome, M., Poullas, M. S., Yajnik, C. S., & Demaio, A. (2020). The double burden of malnutrition: aetiological pathways and consequences for health. *The Lancet, 395*(10217), 75-88. doi:https://doi.org/10.1016/S0140-6736(19)32472-9

Wheeler, T., & von Braun, J. (2013). Climate change impacts on global food security. *Science, 341*(6145), 508-513. doi:10.1126/science.1239402

World Bank. (2021). Food Security and COVID-19. Retrieved from https://www.worldbank.org/en/topic/agriculture/brief/food-security-and-covid-19

Zekeri, A. A. (2019). Food Insecurity and Maternal Mental Health among African American Single Mothers Living with HIV/AIDS in the Alabama Black Belt. *J Health Care Poor Underserved, 30*(4s), 151-159. doi:10.1353/hpu.2019.0124