Psychometric Properties of Food Insecurity Experience Scale as Applied in Eastern Africa: Evidence from National and Rural Surveys

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July 2018

A thesis submitted to McGill University in partial fulfillment of the requirements for the degree of Master of Science

Abstract

The Sustainable Development Goal 2 stands as part of the global commitment to end hunger. In light of this global call to action, there is need for generating valid, useful, and comprehensive global measurements. Measures are needed to identify global trends, provide warnings of early deprivation, evaluate interventions, and design new policies. Food and Agricultural Organization in the Voices of Hungry project (FAO-VoH) developed a new scale for measuring the access dimension of food security, known as, the Food Insecurity Experience Scale (FIES). However, the FIES's latent dimensional structure and psychometric properties have not been fully explored in various population settings, especially within programs and interventions aiming to improve the nutritional and food security status of populations in the developing world. In this study, we address this research gap by assessing the psychometric validity of the FIES applied in four African countries--Ethiopia, Malawi, Mozambique, and Zambia—by using the Rasch modelling approach to analyze datasets drawn from two cross-national surveys varying in sample selection from each country. The *national* survey consists of nationally representative samples of adults (>15 y/o) conducted by Gallup World Poll; whereas the *rural* survey consists of samples of women of reproductive age (15-49 years) participating in nutrition projects implemented in rural areas in the four countries. The pooled, *national* sample totaled 3941 adults (>15 y/o). Additionally, we compare the scale performance within comparable samples of women of reproductive age (WRA) between both surveys for each country. The pooled, *rural* sample totaled 3532 women (15-49 years). Cases with any missing responses to the FIES questions were excluded in the analysis. Data were analyzed using R software. Relative severity of items assessed under the Rasch-model assumptions for the national survey ranged from 1.66 logistic units in Zambia to 2.60 logistic units in Ethiopia. In contrast, relative severity of items for rural survey ranged from 1.88 logistic units in Malawi to 2.68 logistic units in Mozambique. In general, the relative severity items which measures the assumption of conditional independence remained within their respective domains of mild, moderate, and severe. However, few exceptions were seen for Malawi in the national and Mozambique in the rural survey, few items were outside of expected domains of food security. Most importantly to note the last item of the FIES, capturing the experience of not eating for the whole day, is the most severe phenomena and stood as an anchor point for the scale across countries in both national and rural surveys. INFIT statistics which measures the assumption of equal discrimination showed that both surveys were in the acceptable range (0.7–1.3). This indicates items discriminate effectively among respondents experiencing different levels of severity. When WRA were compared between national and rural surveys, response patterns indicated that food insecurity is experienced and described similarly by respondents. Some variations were seen across countries which might be explained by differences in cultural contexts and livelihood arrangements. Despite these concerns, FIES holds an acceptable level of psychometric validity needed to assess food security and may be appropriate for use in comparative studies. To our knowledge, this study is the first to validate the FIES tool among WRA in a rural setting compared against a nationally representative selection of WRA. Results highlights that experience of food insecurity with FIES tool was performed in a similar way in both samples. One recommendation would be to carry further qualitative research to verify the consistency of FIES within specific cultural contexts.

Résumé

L'objectif de développement durable 2 fait partie de l'engagement mondial d'éradiquer la faim. En vue de cet appel mondial, il y a un besoin pressant d'effectuer des mesures mondiales valides, utiles et compréhensibles. Il est nécessaire de prendre des mesures afin d'identifier les tendances mondiales, de mettre en place des mécanismes avertissant rapidement les privations, d'évaluer les interventions et de concevoir de nouvelles politiques. Dans le cadre du projet 'Voices of the Hungry' (VoH), FAO a développé une échelle dénommée 'L'échelle de mesure de l'insécurité alimentaire vécue' (FIES) permettant de mesurer la dimension d'accès de l'insécurité alimentaire. Il y a des inquiétudes que la structure dimensionnelle latente et les propriétés psychométriques de FIES n'aient pas été pleinement explorées au niveau local, en particulier dans le cadre d'interventions visant à améliorer l'état nutritionnel et la sécurité alimentaire des populations dans les pays en voie de développement. Dans cette étude, nous allons adresser cette lacune dans la recherche en évaluant la validité psychométrique de FIES par le biais du modèle de Rasch dans quatre pays africains : Éthiopie, Malawi, Mozambique et Zambie, en utilisant deux enquêtes ayant des tailles d'échantillon différentes. L'enquête nationale, menée par *Gallup World Poll,* était composée d'un échantillon représentatif d'adultes (âgés de plus de 15 ans). L'enquête rurale était composée d'échantillons de femmes en âge de procréer (15 à 49 ans) et participant à des projets nutritionnels implémentés dans les régions rurales des quatre pays visés. L'échantillon groupé national regroupait 3941 adultes (âgés de plus de 15 ans). De plus, nous avons comparé la performance de l'échelle au sein des enquêtes nationale et rurale sur des échantillons comparables de femmes en âge de procréer. L'échantillon groupé rural regroupait 3532 femmes (15 à 49 ans). Les répondants ayant des réponses manquantes aux questions de FIES n'étaient pas inclus dans l'analyse. Les données ont été analysées à l'aide du logiciel R. La sévérité relative des items, évaluée en suivant les suppositions du modèle Rasch, était de 1.66 unités logiques en Zambie et de 2.60 unités logiques en Éthiopie pour l'enquête nationale. En revanche, la sévérité relative des items pour l'enquête rurale était de 1.88 unités logiques au Malawi et 2.68 unités logique au Mozambique. En général, les items ont conservé leur niveau de sévérité relative (mesurant l'hypothèse de l'indépendance conditionnelle), selon leurs domaines respectifs de sévérité légère, modérée et sévère. Cependant, certaines exceptions ont été notées pour le Malawi dans l'enquête nationale, et le Mozambique dans l'enquête rurale, puisque certains de leurs items se sont retrouvés à l'extérieur de leurs domaines respectifs de sévérité de l'insécurité alimentaire. Il est important de noter que le dernier item de FIES, capturant l'expérience de ne pas manger pour une journée complète, représente le phénomène le plus sévère, et a constitué un point d'ancrage de l'échelle aux pays dans les enquêtes nationale et rurale. Les valeurs INFITS, mesurant l'hypothèse d'une discrimination égale, ont démontré que les valeurs des deux enquêtes étaient dans la plage acceptable (0.7–1.3). Ceci indique que les items discriminent efficacement parmi les répondants ayant différents niveaux de sévérité. Lorsque les femmes en âge de procréer ont étaient comparées entre les enquêtes nationale et rurale, le schéma des réponses a indiqué que l'insécurité alimentaire étaient expérimentée et décrite de la même manière par les répondants. Certaines variations ont été notées à travers les pays et peuvent être expliquées par les différences aux niveaux des contextes culturels et des arrangements de subsistance. Cependant, malgré ces inquiétudes, FIES possède un niveau acceptable de validité psychométrique nécessaire pour évaluer la sécurité alimentaire et s'avère approprié pour les études comparatives. A notre connaissance, cette étude est la première permettant de valider l'outil FIES au sein des femmes en âge de procréer en milieu rural, comparé à une sélection nationale représentative de femmes en âge de procréer. Les résultats

démontrent qu'en utilisant FIES, l'expérience de l'insécurité alimentaire a été décrite et comprise de la même manière au sein des deux échantillons. Une recommandation qui peut être émise serait d'effectuer de plus amples recherches qualitatives de validation afin de vérifier la cohérence de FIES dans des contextes culturels spécifiques.

Acknowledgments

This thesis has been made possible with the support of many people. First, I want to thank Professor Hugo Melgar-Quiñonez, my supervisor for accepting me into this thesis program and providing me with continuous support and guidance throughout the entire process. Having him as a food security "Guru" enriched my research experience and widened my understanding of both substantive and methodological issues related to food security. It would not have been possible for me to successfully complete this thesis without his remarkable guidance. Thank you.

I also feel grateful to have had the support of my committee member: Dr. Theresa Thompson-Colón. My gratitude goes out to her insightful guidance, comments and encouragement. Dr. Timothy Schwinghamer, I cannot thank you enough for your statistical guidance, and help with the statistical analysis. I am also much obliged to Dr. Arlette Saint Ville for her constructive feedback, guidance and mentorship, that have greatly improved the quality of my thesis. A genuine thank you to Dr. Patrick Cortbaoui, for trusting my abilities and providing the opportunities inside and outside the lab and encouraging my all-round development as an academic.

I have been fortunate to have wonderful lab mates to work alongside. I want to thank members of the McGill Institute for Global Food Security for their support, collaboration, commiseration, and friendship. I am forever indebted for the influence many of you have had on me as a researcher.

It is important to acknowledge the technical support I received from CARE Canada, especially from Marnie Davidson and Clarissa Teixeira. The staff were very helpful in answering my questions about variables, survey methods, and country contexts.

I would also like to acknowledge all the institutions that made this work possible: Food and Agriculture Organization, Voices of the Hungry project, Gallup World Poll, and CARE Canada. Thank you for providing me such rich data. I am grateful for the financial support from the Government of Canada that allowed me to devote myself to my research over the past year.

Also, I would not have completed this journey without the unconditional love and support of my family and friends. Mummy and Daddy, thank you for trusting me to take on this challenge. Your

unending love and support carried me through. To my sisters Disha and Palak, thank you for the unconditional faith in my abilities, the many hours on the phone, and the fun you bring to my life. My friend Ratika Thakur and Nayan, thanks for your support and love you show me all the time.

Finally, I would like to thank my husband, Hanan Guleria. You simply make every day better. Your enthusiasm and curiosity brings me such happiness. Your unconditional love and support allow me to pursue meaningful work and build a beautiful life.

Contribution of Authors

As the first author, I developed the research questions, selected relevant survey items, conducted extensive review of the literature, analyzed the data, interpreted results, and wrote the text of the manuscript. My supervisor, Dr. Hugo Ramiro Melgar-Quiñonez was responsible for the overall conception of the research and provided guidance and supervision through all the stages of the research, including conceptualizing the analysis and interpreting results. Dr. Theresa Thompson-Colón assisted in the conceptualization of the project and was a committee member and an editor of this thesis. Dr. Timothy Schwinghamer contributed his knowledge and expertise in statistical analysis, and helped with interpreting results. Dr. Arlette Saint Ville provided continual support with editing, structure and refining of the thesis. Dr. Patrick Cortbaoui also helped guide the process of this research project. Marnie Davidson and Clarissa Teixeira as staff of CARE Canada provided technical support with variables, survey methods, and country contexts.

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Abbreviations

CHFSS	Colombian Household Food Security Scale
CML	Conditional Maximum Likelihood
DIF	Differential Item Functioning
EBFSS	Experience-based food security scales
EBIA	Escala Brasileira de Insegurança Alimentar
ELCSA	Escala Latinoamericana y Caribeña de Seguridad Alimentaria
FAO	Food and Agriculture Organization
FIES	Food Insecurity Experience Scale
GDP	Gross Domestic Product
GFSI	Global Food Security Index
GROW	Growing Nutrition for Mother and Children
GWP	Gallup World Poll
GVHs	Group Village Headman's
HDI	Human Development Index
HF	Health Facilities
HFIAS	Household Food Insecurity Access Scale
ICC	Item Characteristic Curve
ICAD	Cuso International, the Interagency Coalition on AIDS and Development
MDGs	Millennium Development Goals
M&E	Monitoring and evaluation
PNAD	Pesquisa Nacional por Amostra de Domicílios
IRT	Item Response Theory
SANI	Southern Africa Nutrition Initiative project
SD	Standard Deviation
SDGs	Sustainable Development Goals
TAs	Traditional Authorities
USHFSSM	United States Household Food Security Survey Module
VoH	Voices of the Hungry Project
WRA	Women of Reproductive Age

CHAPTER 1 INTRODUCTION

1.1 Background

Food security is a basic condition for human wellbeing. It is defined as when "all people, at all times, have physical, social and economic access to sufficient, safe and nutritious food which meets their dietary needs and food preferences for an active and healthy life" (Food and Agriculture Organization, 1996). This suggests that food security is a moral obligation, as food is one of the fundamental universal rights, as stated in Article 25 of the Universal Declaration of Human Rights of 1948 (adopted and proclaimed by General Assembly of the United Nations Resolution 217 A (III)). Assuring food security for all is one of the necessary conditions for a population to be healthy and well-nourished (Danieli, Stamatopoulou, & Dias, 1999).

As a result of its importance, food security is a vital concern among policymakers, practitioners, and academics and led action towards global commitment to eradicate hunger and achieve food security (Smith, Kassa, & Winters, 2017). The year of 2015 marked the end of monitoring for the internationally time-bounded target, the Millennium Development Goals (MDG). One such target pledged to "cut by half the proportion of people who suffer from hunger by 2015". This target, associated with the aim of eradicating hunger, was not reached by many countries in the world (FAO, IFAD, UNICEF, WFP and WHO, 2017), and the problem of global food insecurity is getting worse. According to the recent *State of Food Security and Nutrition in the World* report approximately 815 million people worldwide do not consume enough calories to meet their daily requirements. The prevalence of people affected by chronic food deprivation is highest in Sub-Saharan Africa which accounts for 22.7 percent of the world population (FAO et al., 2017). Given the failure to achieve MDGs by many countries and enormous magnitude of the food insecurity burden worldwide, more work is needed to better understand the food security problem.

In 2015, as part of the global commitment to end hunger, promote sustainability and peace, the United Nations adopted the Sustainable Development Goals (SDGs). These 17 goals represent global priorities that all countries have agreed to meet by 2030. Goal 2 aims to reduce malnutrition and attain food security. It is of key importance because accomplishing food security has been associated directly and indirectly with all 17 goals which range from reduction in poverty, hunger,

gender equity, and planetary sustainability (Pérez-Escamilla, 2017). Therefore, appropriate measures are needed to identify area and characteristics of food insecure populations and meet the SDG 2 target (Smith, Rabbitt, & Coleman-Jensen, 2017).

1.2 Study rationale

The concept of the food security is multifaceted, and there is no single measure that encompasses the whole concept. Measures are needed to identify global trends, provide warnings of early deprivation, evaluate interventions, and develop policies (Jones, Ngure, Pelto, & Young, 2013). Existing food security measurement tools provide emphasis on the availability, access, utilization, and stability dimension of food, or some combination of these different dimensions. These measurement tools range from the simple to comprehensive and draw data from national, regional, household, and/or individual levels (Jones et al., 2013). Experience-based food insecurity scales are micro-level measurements capturing the access dimension of food insecurity, and well suited to understand the determinants of food insecurity concentration and characteristics of the food insecure at individual and national levels (Nord, Cafiero, & Viviani, 2016).

The Food Insecurity Experience Scale (FIES) is the latest development in experience-based scales (Smith et al., 2017). The focus of FIES is to measure the latent traits of food insecurity by capturing behavior and perceptions (such as uncertainty) related to not getting enough food because of lack of resources (Ballard, Kepple & Cafiero, 2013; Nord, 2014). Capturing the latent traits with valid measures is one of the primary objectives of measurement scales (Clark & Watson, 1995). As a result, the need for validation of food insecurity experience scales is an essential step for refining the scale (Webb et al., 2006). The pre-existing experience scales, such as the U.S. Household Food Security Survey Module (USHFSSM), Colombian Household Food Security Scale (CHFSS), the Latin American and Caribbean Food Security Scale (ELCSA), and the Household Food Insecurity Access Scale (HFIAS), have been applied and validated in various ethnographic settings (Hackett, Melgar-Quiñonez, Pérez-Escamilla, & Segall-Corrêa, 2008; Hackett, Melgar-Quiñonez, & Uribe, 2008; Knueppel, Demment, & Kaiser, 2010; Pérez-Escamilla et al., 2004).

As part of a global initiative, FIES has recently been applied in more than 153 countries. Through FAO's *Voices of Hungry* (VoH) project, which partnered with the Gallup World Poll in 2014, FIES

was used in nationally representative surveys conducted in more than 150 countries around the world, allowing cross-country comparison (Cafiero, Viviani, & Nord, 2018). While this data provides a treasure-trove for policymakers, development practitioners and community activists, there are concerns. One concern is that FIES's latent dimensional structure and psychometric properties have not been fully explored (Wambogo, Sahyoun, SheikOmar, & Ghattas, 2017). One reason for this concern of researchers is that the contexts and circumstances of national-level settings may not necessarily represent the heterogeneity of local contexts (de Toledo Vianna, Hromi-Fiedler, Segall-Correa, & Pérez-Escamilla, 2012). When food insecurity status is measured within a single country, some regions, districts and population groups may experience more frequent and severe situations of food insecurity than others (Nord, Andrews, & Carlson, 2005). For example, a recent systematic review and meta-analysis, using experience-based measures, revealed gender differences in reporting self-assessment of prevalence of food insecurity (Jung, de Bairros, Pattussi, Pauli, & Neutzling, 2017). Such findings reveal that incidences of food insecurity reported by females are higher than males. Thus, it is critical to assess gender characteristics with valid and reliable scales within the vulnerable context (Hackett et al., 2008). For all these reasons, additional validation studies are needed, at multiple levels within national settings. Not only are such studies needed at different levels (rural, local), the experiences of critical subgroups within the population also need to be assessed. Examining the psychometric properties of this survey tool among the vulnerable groups such as women in rural areas is necessary to understand whether the FIES is an effective and valid approach for measuring food insecurity globally.

1.3 Overall study aims and research questions

The main objective of this study is to assess the psychometric properties of the FIES as applied in four eastern African countries using cross-national surveys representing national and rural settings. The secondary objective is to compare psychometric characteristics of FIES as applied among rural women of reproductive age (WRA) across two surveys.

The main research questions addressed in this study are:

- How will the FIES function with data drawn from two cross-national surveys conducted in the four eastern African countries?
- Does the FIES work as expected in rural WRA across samples drawn in each of the four counties?

CHAPTER 2 LITERATURE REVIEW

2.1 Defining food security

Understanding of the food security concept has progressed over the past decades. Our understanding on the theoretical construct, cause and consequences of food deprivation, burden of malnutrition (under and over nutrition) and food security dimensions have improved (Hendriks, 2015). Food insecurity is understood as a multidimensional concept and manifested at multiple levels. It goes from the physical sensation of hunger to include adequate food supply, as well as physical, and economic access to food. It also includes all the important factors which influence human nutrition such as water and sanitation, social and mental health care (Weaver & Hadley, 2009). With research and advancement, the concept has integrated into the work of multiple disciplines, leading to changes in the definition and operationalization of food security (Jones, Shrinivas, & Bezner-Kerr, 2014).

In the beginning, the concept was understood as referring mainly to the availability of food. Later the definition expanded to include sufficient access to food for healthy and productive life (Maxwell & Smith, 1992). Further development included the component of adequate nutrition across cultures at the 1996 World Food Summit (Eisinger, 1998). Finally, the current, now well-known definition of food security has been accepted globally, defined as, a state when "all people, at all time, have physical, social and economic access to sufficient, safe and nutritious food which meets their dietary needs and food preferences for an active and healthy life" (FAO, 1996). According to this definition, food security comprises of four separate dimensions: *availability*, *access*, *utilization*, and *stability* (Food and Agriculture Organization, 2008).

Food availability. This dimension of food security is defined as the availability of adequate supply of food over a continuous period (FAO, 2008). Sufficient supply of food for the population is usually at the national level from a macro level perspective, measured using food balance sheets, from which energy requirements for the population is derived. Agriculture production, net trade, and the effect of natural calamities and economic policies role on the price are factors that influence food availability at national levels (Webb et al., 2006). While availability of food through production has increased across the world, this improvement in production has not necessarily

ensured the food security of national and global population (Food and Agriculture Organization, 2015).

Food access. In the 1980, our understanding of food security would later include the dimension of access to food. Now it is widely recognized that economic and physical access to food is a significant determinant of household food security. The work of Amartya Sen (1981), *Poverty and Famines*, conceptualized around the importance of economic access to food, emphasizing that: food deprivation was not due to unavailability of food but mainly due to limited access to food. As a result of Sen's work, gauging food security shifted from measuring national food supply to examining the ability of the household to access to food (Sen, 1981; Smith et al., 2017).

Food utilization. This dimension is commonly understood as how the body utilities nutrients and energy from food, and assumes that food is available and accessible to ensure an active and healthy life. Utilization is essential to ensure food security, and involves efforts that measures the nutritional status of individuals (FAO, 2008).

Food stability. Up to this point, it may be understood that the three dimensions of food security are hierarchical. This means that "food availability is necessary but not sufficient for access, and access is necessary but not sufficient for utilization" (Webb et al., 2006). Nevertheless, stability over time is essential for all three dimensions to ensure food security at the household level. Factors such as high rate of unemployment, food price increases, and political instability can influence the stability dimension of the food security (FAO, 2008).

2.2 Causes and Consequences of Food Insecurity

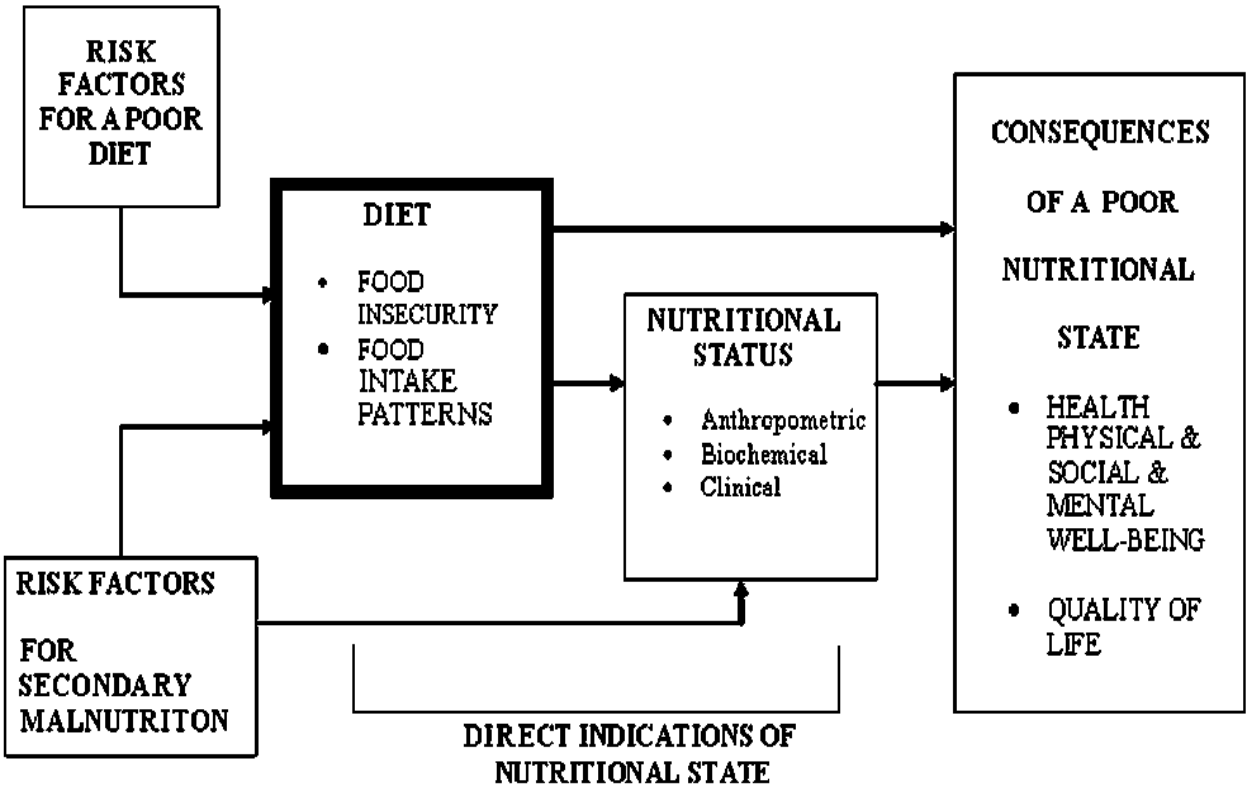
The causes of the food insecurity are multifaceted, linked to a range of factors operating at global, national, household, and individual levels. At a macro-level factors affecting food security can range from political conflict climate change, food waste, to rapid population growth (FAO et al., 2017, Premanandh, 2011); at a micro-level, factors such as gender inequality, low education, and poor health are also linked with food security (Jung et al., 2017; Mutisya, Ngware, Kabiru, & Kandala, 2016). According to Smith et al. in year 2000, these factors can be conceptualized in two categories: 1) a shortage of food availability at the national level and 2) insufficient access to acquire adequate food at household and individual level (Smith, El Obeid, & Jensen, 2000). Although factors influencing food security are widespread, poverty is a significant cause of food security in developed and developing world. This association has been found because it is closely

linked to the household or individual's inability to acquire food due to lack of resources (Hendriks, 2015; Smith et al., 2000).

A vast pool of research shows that food insecurity negatively influences the physical well-being, development, and cognitive health of individuals, and to a larger extent, the economic development of a country (Cook & Frank, 2008). According to the conceptual framework outlined by Campbell (1991), there are two sets of potential indicators for examining consequences of food insecurity (See Figure 1). The first set of indicators capturing nutritional status includes anthropometric, biochemical, and clinical indicators. These are considered as classic symptoms of malnutrition due to sub-optimal nutritional status. The second set of indicators comprises the consequences of poor nutritional status and may include physical, social and mental health, and overall quality of life. Campbell also explains that food insecurity can affect health and quality of life directly or indirectly due to physiological mechanisms which includes possible associations between food security, poorer dietary patterns, nutritional status, and overall well-being (Olson, 1999).

Research has shown that women and children are the most vulnerable groups at risk of food insecurity. A recent study on household food insecurity, measured using access dimension, showed that the occurrence of anemia and overweight among WRA was more likely in mild to moderate food insecure households than WRA in food secure households (Jones, Mundo-Rosas, Cantoral, & Levy, 2017). A review conducted by Pérez-Escamilla and colleague in 2012 examined the association between household food insecurity, mental health well-being, and intellectual development of children. Researchers found that food insecurity is a psycho-emotional family stressor which has negative psychosocial effects among women and children (Pérez-Escamilla & de Toledo Vianna, 2012). Children are adversely affected by food insecurity during their early stages of life which affects their growth and development. Furthermore, the negative effects of the food security on women and children's health outcomes are found worldwide. A recent global food security and nutrition data reported that 23% of children were stunted, 33% of WRA were anemic, and 11% of the world's population is undernourished (FAO et al., 2017).

Figure 1: Campbell's conceptual framework for food insecurity, risk factors, and consequences (Olson, 1999).



2.3 Magnitude and measures of food insecurity

Measures of food security provide information needed to evaluate the effectiveness of policies and programs to reduce food insecurity. Food security, a multi-dimensional concept, captures social, biological, nutritional, and economic phenomenon; thus, there is no definite measure which captures all dimensions of food security with accuracy (Frongillo, 1999). Therefore, this means that food security can be seen through a latent trait. Such traits cannot be seen and measured before its observable manifestation (Cafiero, Melgar-Quiñonez, Ballard, & Kepple, 2014).

While there are different measures of food security, they all have some advantages and disadvantages. At the household level, a number of proxy indicators have been used to measure food insecurity. Some of these include income, dietary diversity, employment status, and anthropometry typically used in household surveys to assess the ability to purchase food. While

these types of indicators have their benefits, they are limited in capturing the direct behaviors and experiences of the food secure (Jones et al., 2013). For example, in the US, when relationship of household food insecurity and poverty is examined, poverty status is conceptualized as surpassing (or not) a set of annual household income thresholds. However, it has been found that some low-income households manage to meet their food requirements better than households with income levels above the poverty line (Nord & Andrews, 2001). Furthermore, while these indicators provide indirect information on food security status of the household by providing large amount of data on the food consumption and nutritional status, they are time-consuming to apply and expensive to monitor in annual national surveys related to food security programs (Pérez-Escamilla, 2012).

The number of food security measures developed reflect the objective and assumptions of the research. Therefore, measurement tools, used by various nations, international organizations, and agencies for program monitoring and evaluation, can range from the simple to comprehensive indicators, drawing upon data and offering a different level of measurement: national, regional, household, and/or individual levels (Jones et al., 2013). All existing measuring tools can be categorized into five major groups: (i) Food and Agriculture Organization's (FAO) method for estimating calories available per capita at the national level; (ii) household income and expenditure surveys; (iii) individual's dietary intake; (iv) anthropometry; and (v) experience-based food insecurity measurement scales (Pérez-Escamilla & Segall-Corrêa, 2008). Detailed description of these methods, their aim, and objective are presented in Table 1.

Table 1: Food security measurements (Adapted from Jones et al., 2013; Pérez-Escamilla & Segall-Corrêa, 2008)

Methods	Description of Methods	Level of Measurement
Food balance sheets (FAO)	Aim - estimates national calories available per capita per day - emphasize on food availability - applied worldwide on an annual basis and benchmark for assessing global food insecurity	National
Household income and expenditure surveys	Aim- measures the economic access, food quantity and quality -collects data on expenditure of household on food and other necessities -examines household food acquisition, poverty, socioeconomic status	National Regional Household
Dietary intake	Aim-measures individual food consumption by counting foods group - examines the access dimension, dietary quality and quantity - estimates the food insecurity status at individual level which further helps in intra-household food patterns	National Regional Household Individual
Anthropometry	Aim- nutritional status indicator of the individual -uses weight and height indicators so it highly standardized. -provides the prevalence rate of malnutrition and identifies population at risk	National Regional Household Individual
Experience-based food insecurity scales	Aim-measures the access dimension of food security by capturing direct experiences -fundamental measure of food security -assesses populations at risk of food insecurity	National Regional Household Individual

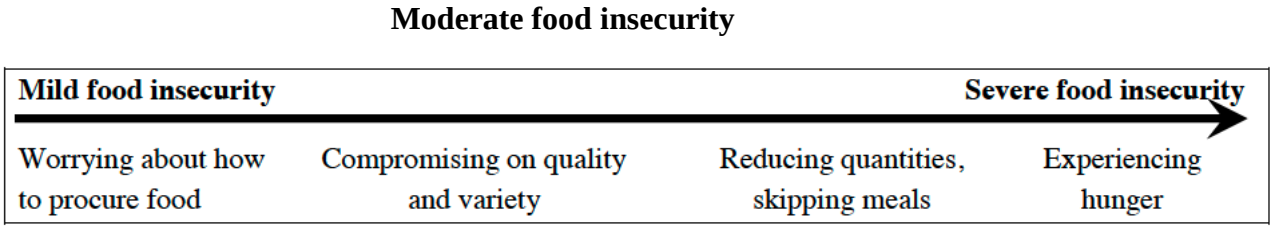
2.3.1 Experience-based food security scales (EBFSS)

Most recent developments have looked at micro-level measures of food insecurity. One of these innovations includes experience-based food insecurity scales. EBFSS capture the access dimension of food insecurity that allows a better understanding of socio-economic determinants, characteristics at the individual and national level, and concentration of food-insecure people (Nord, Cafiero & Viviani, 2016). The theoretical construct of the experience-based food security scales (EBFSS) was first studied by Radmier and colleagues (1990) by performing ethnographic research on women of low-income groups to understand perceptions related to food constraint faced during the times of limited access to resources. Findings showed that households experienced different phases of food insecurity, ranging from worrying about food, to compromising in dietary patterns to manage household food resource, followed by reduction in portion sizes, and finally, as the situation gets worse, skipping meals. The order of these phases was seen to occur first among adults and then in children (Radimer, Olson, & Campbell, 1990; Radimer, Olson, Greene, Campbell, & Habicht, 1992). Further research, conducted by Coates and colleagues on EBFSS in different region of the world, concluded that these core experiences related to food insecurity show commonalities in different cultural contexts (Coates et al., 2006).

Clearly, EBFSSs evolved out of research that showed how experiences related to hunger is a "managed process" involving an array of strategies to survive from mild to severe experiences. A key element of this research has been around experiences of worrying about obtaining food, followed by a reduction in food quality and quantity, and further complementary strategies to manage short and long-term food insecurity and extreme hunger (Ballard et al., 2013; Coates et al., 2006). As such, these coping strategies and behavior have been linked with different domains of food insecurity. For example, early onset strategies such as uncertainty and anxiety related to food access falls in the mild domain of food insecurity. Strategies employed as food insecurity experiences increase such as reduction in food quality, monotonous diets, reduced portions and skipped meals are associated with moderate and severe domains of food insecurity, respectively (Radimer et al., 1990; Radimer et al., 1992; Smith et al., 2017). These responses are together known as food insecurity severity continuum. One of the major contributions of experienced-based scales has been linked to its ability to quantify households or individuals along the continuum by capturing their perception and behaviors (Jones et al., 2013). Figure 2 points out to the different

domains of the food security and their associated food insecurity situation.

Figure 2: Food insecurity severity continuum along a conceptual framework **(**Ballard et al., 2013)



While research has been ongoing to capture the availability and utilization dimensions of food security, there has been a shift to the access dimension. This shifted focus, from measuring national food supply to people's access to food, has resulted in the development of more targeted tools (Sen, 1981; Smith et al., 2017). The interest in access is needed because this dimension of food security is consistent and therefore critical to capture experiences of food deprivation. In 2006, a review conducted by Webb and colleagues highlighted the importance of EBFSSs development and potential use of these measurements at the global level. Three key shifts were emphasized by authors, that makes these scales distinct: 1) A shift from focusing on the dimension of food availability and utilization to capture food access; 2) A change in measurement from objective to subjective; 3) the shift from distal, proxy indicators to a more direct, the subjective experience (Webb et al., 2006).

Thus, the focus of the food insecurity experience scale is to measure the latent trait of food insecurity. As a result of the long trajectory in the development of experience- based measures, these are known as "third generational indicators" of food security (Coates et al., 2006). This is because they measure the behaviors of individuals or households in the time of limited access to food, rather than actual consumption or food intake. These latent traits are attitudes and perceptions, which cannot be observed directly. For example, individuals do not say, "On a scale of 1 to 10, my food insecurity is at level 3," but they do speak about the specific experience or behavior such as uncertainty related to the situations where they do not get enough food because of the lack of resources (Ballard et al., 2013; Nord, 2014). Experience-based scales at individual and household levels can be complement other measures of food security such as nutritional status

and other economic indicators. Together, these tools can better define the consequences and determinants of food insecurity in vulnerable populations before food insecurity become manifest (Cafiero et al., 2014).

For all these reasons EBFSSs are useful, innovative tools. Their characteristics are aligned with SMART qualities (specific and valid), measurable (frequent data collection), achievable (technically possible), and timely (rapid use and sensitive to changes like seasonality) (Pérez-Escamilla, 2012). They are simple to manage, direct and translate, results can be generated in a timely manner, they are cost-effective, and can be used at both household and individual levels (Ballard et al., 2013). Additionally, by measuring physiological effects of food insecurity before the manifestation of nutritional inadequacy, researchers and policy makers are better able to measure, track development, and respond proactively to food security challenges (Food and Agriculture Organization, 2014).

2.3.2 Types of the EBFSS

As already noted, there has been increasing attention on EBFSSs and their use as a global tool for measuring food security. Over the past 20 years, researchers have developed and validated many context-specific experience-based scales to capture the food access dimension (Smith et al., 2017). The theoretical construct of food insecurity became a model for the United States Household Food Security Survey Module (US HFSSM), which has been used to capture food insecurity conditions annually in the US since 1995 (Hamilton & Cook, 1997). This tool consists of 18 questions; the first ten questions are directed to adults in the household and eight are focused on children, with a 12-month reference period. Following the increased use of US HFSSM, other countries have initiated the process of either adapting or developing context-specific scales to measure food security at national-level.

In 2004, Canada adapted the US HFSSM and implemented the annual survey to measure the food insecurity situation at the national-level (Tarasuk, 2005). Brazil further adapted the US HFSSM, translating the survey instrument into Portuguese for use in its local context (Ballard et al., 2013). The whole process was made successful by performing many in-depth focus groups and validation studies of national and subpopulations (de Toledo Vianna et al., 2012; Hackett, et al., 2008; Segall-

Corrêa, Marin-León, Melgar-Quiñonez, & Pérez-Escamilla, 2014). After these developments, in 2004 Brazilian Household Food Insecurity Scale (Portuguese acronym EBIA) was included in the National Household Sample Survey *(Pesquisa Nacional por Amostra de Domicílios*, PNAD). Besides these developments, US Agency for International Development (USAID) developed another tool called, Household Food Insecurity Access Scale (HFIAS), to be used at the international level, which further refined the Household Hunger Scale (Coates, Swindale, & Bilinsky, 2007).

At the same time, many Latin American countries inspired by these innovations initiated work to develop their own food insecurity experience scales. Based on these efforts, several researchers came together to develop the first regional experience-based scale known as the Latin American and Caribbean food security scale or ELCSA (*Escala Latinoamericana y Caribeña de Seguridad Alimentaria*). These scales have been tested in various demographic backgrounds (Ballard et al., 2013; Smith et al., 2017).

However, even though these advancements were made in the use of national and regional EBFSSs, to capture the psychometric viewpoint of food insecurity (Cafiero et al., 2014), there was need for a globally validated tool. In 2013, the Food and Agriculture Organization (FAO), recognised this need and created an internationally validated tool for measuring food insecurity through *the Voices of the Hungry Project* (VoH) called FIES (Brunelli & Viviani, 2014; Cafiero et al., 2018). The theoretical construct of FIES is based on the U.S. Household Food Security Survey Module (HFSSM) and Latin American and Caribbean Food Security Scale (known by its Spanish acronym ELCSA) (Ballard et al., 2013).

FIES is the first scale assessing the direct experiences related to the access dimension of food insecurity at the individual-level tailored for global comparison. FIES consists of eight dichotomous questions, linked to different experiences of severity of food insecurity (see Table 5 in Chapter 3). As part of the VoH, the FIES module was included as part of the Gallup World Poll (GWP) in 2014 to collect data on food security in more than 140 countries. The VoH project and FIES tool will be further discussed in Chapter 3.

2.4 Validation of Experience-based food security scales

Measurement is a significant process in research through which we can determine the magnitude of a phenomenon (and generally entails the assignment of numbers to concepts or variables). A measurement should be valid and reliable, representing two essential criteria for any measurement (Cafiero et al., 2014). Validity refers to how a measurement tool can measure what it is supposed to measure and is being measured correctly; and reliability refers to how consistent is the tool at repeated measurements (Csikszentmihalyi & Larson, 2014). To produce generalizability and to estimate potential biases, reliability and validation of assessment tools are required and even greater when the phenomena is not directly observable especially in qualitative studies (Cafiero et al., 2014).

The need of a valid tool is an issue of fundamental consideration for policy makers, practitioners, researchers and programme managers tasked with monitoring and tracking the progress of food security programs and interventions at regional or household levels (Danieli et al., 1996; Jones et al., 2013). However, in the context of developing country, issues related to measuring tools must be adequately dealt with before addressing the subject prevalence and determinants of food security (Leyna, Mmbaga, Mnyika, & Klepp, 2008).

Validity of a measuring tool is assessed by how it measures the underlying construct (i.e., *latent trait).* It can be evaluated by looking at the relationship of the theoretical concept to the measured expected responses. This means specifically, "that changes in the latent trait induce detectable changes in the data used for measurement." As a result, in the context of experience-based scales, their ability to captures the construct, can be assessed by the relationship formed by the severity of the food insecurity situation and occurrences of experiences (Cafiero et al., 2014).

EBFSS can be validated by looking at the internal and external (criterion) functioning of the scale. The Rasch model approach has been used to analyze the internal functioning of scales by analyzing response patterns on an item scale drawn from survey data. To measures latent traits of a concept, this model assesses the structure of the scale, examining the respondent and scale characteristics. Rasch model has a desirable invariant property, hence it was used for assessing the internal validity of experience-based food insecurity scales by establishing the psychometric characteristics of the

items in the questionnaire (Cafiero et al., 2018; Hamilton & Cook, 1997). Rasch modeling has been used in several validation studies of experimental-based food security questionnaires including US Household Food Security Survey Model, Brazilian Household Food Security Scale (EBIA) and Latin American and Caribbean Food Security Scale (ELCSA) (Opsomer, Jensen, & Pan, 2003; Pérez-Escamilla et al., 2011). An additional strength of the Rasch Model is that it further checks if the tool can establish validity and can be applied ubiquitously in diverse populations. This relationship can be established by testing items within the questionnaire for measuring the latent trait and whether they are independent of one another regardless of group membership (Hackett, 2008). When an experienced-based tool is used in a cross-cultural context, the comparison should be interpreted with caution, since results are based both on the food insecurity situation and also how the respondent understands the items on the behavior-based scale (Hackett et al., 2008).

Further EBFSS validity can be established by looking at criterion validity. This studies the relationship between the measures produced by scales and other determinants and consequences of food insecurity such income, nutritional status health and well-being. Many studies are conducted to explore criterion validity have shown that food insecurity is negatively associated with household income and consumption of nutritious food (de Toledo Vianna et al., 2012; Melgar-Quiñonez et al., 2006). Further, evidence suggests that food insecurity is significantly associated with stunting and overweight (Cafiero et al., 2014; Hackett , et al., 2008)

2.4.1 High risk groups

Monitoring and evaluation (M&E) of food-insecurity levels are important at individual and household levels. Such M&E activities depend on a valid and accurate measure to calculate the extent and magnitude of the problem, and also to track progress at regional and community levels (Webb et al., 2006). It is evident that when food insecurity status is measured, some population sub-groups experiences more frequent and more severe situations of food insecurity than others (Nord et al., 2005). Children might be buffered from food insecurity experiences by mothers; and men because of privilege may receive better food quality and quantity compared to women. Therefore, the classification of a household as food insecure may not represent the status of all its members (Brunelli & Viviani, 2014). A study conducted by Hadley and colleagues (2008)

exploring the association between household and individual level food insecurity and health status among adolescents in Ethiopia found that gender differences exist in food insecure households. Finding show that girls are more food insecure than boys (Hadley, Lindstrom, Tessema, & Belachew, 2008). Similar intra-household differences also exist in developed countries (Nord, 2011). Not only do social and cultural norms create these differences, but research has shown that subjective experiences of hunger and food insecurity experienced by males and females is different. Research suggests that understanding of hunger by males are more physical and females experience appears more diffuse and analytical (Coates, Webb, Houser, Rogers, & Wilde, 2010). A systematic review and meta-analysis aimed to highlight gender differences in prevalence of food insecurity by using experience-based measures revealed that incidence of food insecurity reported by females were higher than males. Further subgroup analysis demonstrated that female headed households were 75% more likely to be food insecure than male headed households (Jung et al., 2017).

Another high-risk population of food insecurity lives in rural areas (FAO 2008). Women of rural areas are especially vulnerable mainly due to limited access to resources and low income, which affect food security situation of the entire household (FAO et al., 2017). A study on household food insecurity in Indonesia found that rural households were more likely to experience food insecurity than urban households (Usfar, Fahmida, & Februhartanty, 2007). These studies demonstrate that prevalence of food insecurity is higher in certain groups. This means that it is critical to assess psychometric characteristics of vulnerable groups and their less vulnerable equivalent because food security conditions and experiences vary widely and severity differences may reflect these variations in the population (Hackett et al., 2008).

2.4.2 Need for FIES validation

The FIES, an 8-item questionnaire, is the global and latest development in experience-based scales; validating FIES's latent traits is essential for improving and refining the scale. There is a need for continual validation of the tool across-nations to bring about a larger discussion in understanding the strength and limitations of this indicator in cross-cultural and cross-national settings. Moreover, the FIES indicator – with the prevalence of undernutrition indicator -- are part of the Sustainable Development Goal (SDGs) framework and will be used to measure the target 2.1 as

part of the 2030 agenda for sustainable development (Pérez-Escamilla, 2017; UN, 2015).
In 2013, FAO piloted FIES, through national surveys, for the first time in four African countries (Angola, Ethiopia, Malawi and Niger) and conducted validation analysis to assess performance of the questions (Ballard et al., 2013). Psychometric assessment of the scale in Malawi was performed using the one parameter logistic, Rash model. Findings showed that the scale performed well and followed the assumption of the model. No discrepancies were found between men and women responses to the items of the scale, which confirmed that the scale functioned similarly for both populations (Brunelli & Viviani, 2014).

Further, FIES was applied globally on nationally representative adult populations by FAO. Internal validity of the scale was assessed at the global level for each country, and results were adequately consistent with the assumptions of the Rasch model (Cafiero et al., 2018). In 2017, these findings on prevalence of food insecurity in each country was published in the annual report of *State of Food Security and Nutrition in the World*, (SOFI) to allow for cross-country comparison at the global level (Cafiero et al., 2014; FAO et al., 2017). Despite the usefulness of FIES, the authors cautioned that when using one tool at the global level for cross-country comparison, it is likely that some food insecurity experiences may be different across countries due to variation in cultural contexts and livelihood arrangements (Cafiero et al., 2018). Also, when researchers measured criterion validity of this tool by using same data from pervious study, results showed that despite the diversity in populations around the world, food insecurity was associated with commonly used determinants and consequences such as national income, health, and well-being (Jones, 2017; Smith et al., 2017).

National surveys are important to provide information on food security at the country and regional level; however, they do not necessarily represent local areas. This occurs because circumstances and environmental conditions of local sub-groups may be different across national and regional areas. For instance, validation of the EBFSS developed for Brazil, known as EBIA, allowed the tool to be refined from 16 to 14 questions after extensive validation research. It has proved its consistency and psychometric validity at national and local levels (de Toledo Vianna et al., 2012; Segall-Corrêa et al., 2014). All pre-existing experience-based scales such as the U.S. Household Food Security Survey Module, Colombian Household Food Security Scale (CHFSS), Latin

America and Caribbean food security scale (ELCSA), and Household Food Insecurity Access Scale (HFIAS) have been validated in various cultural settings (Hackett et al., 2008; Knueppel et al., 2010; Pérez-Escamilla et al., 2004).

To conclude, the FIES is the latest experience-based scale used to measure food insecurity. This tool and its critical latent dimensional structure and psychometric properties have not fully explored. This is a research gap because of the growing prevalence globally especially in Sub-Saharan African countries. To our knowledge, FIES has only been used by Gallup World Poll on a national scale and further evidence is needed from other population-based surveys regarding the functionality of the tool. Therefore, additional validation studies from local and rural settings are necessary to examine the psychometric properties of this tool. It is expected that such studies will provide empirical evidence to support whether FIES is an effective and valid method for measuring food insecurity globally, and able to be used in global monitoring as part of the 2030 agenda for sustainable development.

CHAPTER 3 METHODS

3.1 Research design

The main goal of this study is to analyze the psychometric properties of the Food Insecurity Experience Scale (FIES) using Rasch model as applied to samples from Ethiopia, Malawi, Mozambique, and Zambia, drawn from two cross-sectional national and rural surveys conducted in each country between 2016 and 2017. The *national* surveys are subsets of Gallup World Poll data sets, which are accessible as a courtesy to the McGill Institute for Global Food Security with the *Voices of the Hungry* Project of United Nations Food and Agriculture Organization (FAO). The *rural* household surveys were drawn from baseline surveys from two nutrition projects conducted by CARE Canada in partnership with McGill University. The first CARE project is known as *Growing Nutrition for Mother and Children* (GROW) project, currently taking place in Ethiopia (2016-2020); the second is known as the *Southern Africa Nutrition Initiative* (SANI) project, which is being implemented in Malawi, Mozambique, and Zambia (2016-2020). Further scale performance was explicitly compared to the high-risk population of rural women of reproductive age (15-49) across the two surveys using Rasch analysis. This is conducted by comparing the performance of the FIES among rural WRA across the national survey to assess its match with the rural sample for each country.

This study defines rural as areas where poverty levels are estimated to be high, households highly dependent on agriculture, natural resources, and woodlands for their livelihoods (food provision and income generation) with limited access to basic services (health, roads, piped water and sanitation). The following section will describe the context, surveys, and sampling design in more detail.

3.2 Research context

This validation study is based on survey data collected in four countries of the Eastern African region: Ethiopia, Malawi, Mozambique and Zambia. These countries ranked among the poorest countries in the world (per the Human Development Index)[1], and lack of food and inadequate

[1]HDI ranking are based on three dimensions —economics (GNI index), education (Education Index) and health (Life Expectancy Index) (Jahan, 2017)

nutrition are considered underlying causes of poverty (UNDP, 2017). In 2017, the Global hunger index[2] ranking for Ethiopia, Malawi, Mozambique and Zambia were 104, 115, 90 and 98 respectively, out of 119 countries. The majority of their population lives in rural areas and depend on agriculture for their livelihoods, like other countries in Sub-Saharan Africa (Järnberg, Kautsky, Dagerskog, & Olsson, 2018). Most of these rural-based populations depend on rain-fed subsistence agriculture (Arslan et al., 2018). For example, in Malawi, close to 80% of the population live in rural areas; among them, 93% depend mainly on agriculture for their livelihood (Malawi National Statistical Office, 2017; Kassie, Stage, Teklewold, & Erenstein, 2015). Contribution from the agriculture to Gross Domestic Product (GDP)[3] in Ethiopia (2014), Malawi (2015), Mozambique (2018) and Zambia (2018) stood at 44%, 38%, 29% and 20%, respectively (Arslan et al., 2018; Irish Aid, 2018; Mendola & Simtowe, 2015; World Food Programme, 2014). Main crops produced by smallholder farmers, included maize and other food crops such as rice, cassava, sorghum, millet, and legumes.

The Eastern Africa region has the highest rate of undernourishment in Sub-Saharan Africa (FAO et al., 2017). Furthermore, the Global Food Security Index (GFSI)[4] ranks these countries under those needing improvement in all dimensions of the food security (Econimist Global Intelligence Unit, 2017). Food insecurity is more prevalent in rural than urban areas, and women are more vulnerable as a group than men (FAO et al., 2017). Tables 2 and 3 presents countries' characteristics and nutrition profile.

[2] GHI scores are based on four component indicators—undernourishment, child wasting, child stunting, and child mortality (Grebmer et al., 2011).
[3] GDP calculates the total value of goods produced and services provided in a country over a one year period (Miyajima, 2006),
[4] GFSI uses the affordability (six indicators), availability (eight indicators), and quality and safety (five indicators). (Economist Global Intelligence Unit, 2017).

Table 2: Socio-economics characteristics by country (Economist Global Intelligence Unit, 2017)

Characteristics	Ethiopia	Malawi	Mozambique	Zambia
Population (millions)	105	18.15	29.67	17.1
Land Area (sq. km.)	1,000,000	94,280	786,380	743,390
Gross Domestic Products (GDP)	192.5	22.48	37.2	69.45
Human Development Index	174th	170th	181st	139th

Table 3: Nutritional characteristics by country (FAO et. al., 2017)

Estimates	Ethiopia	Malawi	Mozambique	Zambia
Prevalence of undernutrition in total population (2014-2016)	28.8%	25.9%	26.6%	45.9%
Prevalence of wasting in children under 5 years of age (2016)	9.9%	3.8%	6.1%	6.3%
Prevalence of stunting in children under 5 years of age (2016)	38.4%	42.4%	43.1%	40.0%
Prevalence of anemia among women of reproductive age 15-49 years (2016)	23.4%	34.4%	51%	33.7%

3.3 The National Survey: description of the data, sampling and method

Data for the *national* survey came from the Gallup® World Poll (GWP). This annual survey was initiated in 2005, and is administered in over 150 countries. Questions cover a range of topics such as family income, employment, social support, well-being, and responses are used to generate information on essential issues affecting the lives of people around the world. The conceptual framework which served as the basis for the core questions of the GWP is known as the Gallup Macroeconomic Path, and is characterized as a "leadership model for successful societies" (Gallup Inc., 2008). These questions focus on law and order, food and shelter institution, well-being, and others. In 2014, the Food and Agriculture Organization of the United Nations (FAO) collaborated with Gallup to incorporate the FIES in Gallup's survey as part of the *Voices of Hunger* Project (VoH). Since 2014, GWP has collected data annually on prevalence of food insecurity using FIES 8-item set of questions (Gallup Inc., 2017; FAO, 2014).

Probability-based sampling is used to select a nationally representative sample from the population aged 15 and above. In this survey, rural is defined as the population living in an area under 10,000 people. Towns are defined as areas with populations ranging from 10,000 to 49,999. And urban area is defined as having a population of 50,000 people or more (Gallup Inc., 2006)

The interview mode is either telephone or face-to-face depending on the telephone coverage of each country. A sample size of 1000 is collected in most of the countries, expect for countries with larger populations. Surveys are administrated in the conversational languages of each country, after translation by professional translators. Translations are verified through further translations back to the original language (Food and Agriculture Organization, 2016).

For this study, the GWP data used was drawn from Ethiopia, Malawi, Mozambique and Zambia samples. In these four countries, respondents were surveyed through face-to-face interviews. The sampling involved identifying the 100-135 clusters of households which were obtained from the larger population or geographical unit. After the clusters were formed, a random route procedure was used to select the cluster. The final stage of sampling uses the individuals' birth information and Kish grid method to select a single respondent from each household (Nord et al., 2016). The surveys were conducted in Ethiopia from April to May 2016, in Malawi from May to June 2017, in Mozambique from June to August 2017, and Zambia from June to July 2017.

3.3.1 Sample selection from national survey: Gallup World Poll (GWP)

GWP 2017 provided national samples for Malawi, Mozambique, and Zambia. For Ethiopia, data was collected by GWP in 2016. Data from GWP (national) were selected for these four countries and reference years to match the rural surveys conducted in the same four countries by CARE Canada. The CARE household survey data (rural) was collected in Malawi, Mozambique, and Zambia in 2017, and in Ethiopia in 2016. Matching these datasets provided the opportunity to conduct this research comparing national and rural surveys within the same countries by using same tool (FIES). This also allowed the unique opportunity to compare the performance of tool, when looking at rural women of reproductive age across the two surveys.

In the national survey, FIES questions was used to retrospectively assess the food insecurity of the individual's in the past 12 months. Total sample size generated from pooled data across the four national surveys was n = 3941. (See Table 4 for sample size)

3.4 The Rural Survey: description of the data, sampling and method

Data for the rural survey came from household baseline surveys conducted in two nutrition projects. These projects were implemented by CARE Canada in partnership with Cuso International, the Interagency Coalition on AIDS and Development (ICAD), McGill University, and the Governments of project-countries. The first project, *Growing Nutrition for Mother and Children project* (GROW), currently taking place in Ethiopia, was launched in January 2016 with a scheduled end date of March 2020. The second project, *Southern Africa Nutrition Initiative project* (SANI), is taking place in Malawi, Mozambique, and Zambia. This project began in March 2016 with a scheduled end date of June 2020. The aim of both projects is to improve the nutritional status of WRA (15-49 years) with children under 5 years of age in rural areas.

Both projects surveys were implemented using one standardized questionnaire to gather information on household characteristics, agricultural practices, food security, maternal and child nutrition, and women's empowerment in agriculture. The data was collected using tablets by trained interviewers. These projects took place in rural communities of four African countries, where "rural" was defined as areas with high poverty levels and households highly dependent on agriculture, natural resources, and woodlands for their livelihoods (food provision and income generation) with limited access to basic services (health, roads, piped water and sanitation).

The sampling strategies varied across the four countries taking into consideration cultural and country-specific contexts. Explanation for each country sampling strategy is defined separately.
Ethiopia: In Ethiopia sample selection was done by selecting a total of 39 *Kebeles*. A *Kebele* is the smallest administrative unit in Ethiopia (similar to a ward typically used for electoral purposes). This selection of Kebele involves the use of a probability method, proportionate to the population size in target areas. These samples were selected in two regions of Oromia and Afar. Kebeles were further segmented into small clusters.

Malawi: In Malawi, multi-stage cluster sampling was used to select clusters and then households for the study. Two districts, Dowa and Ntchisi, and four Traditional Authorities (TAs) (TA is a customary informal institution responsible for Area Development Committees) were selected to randomly select fifteen–group village headman's (GVHs) areas. A GVH is used as the smallest administrative unit forming the cluster unit of the study.

Mozambique: In Mozambique, Funahlouro and Homoine districts were purposively selected for the study. The smallest geographic units selected from the two districts were *communidades*, and thus these small units served as the primary sampling units. Further cluster sampling was performed to randomly select *communidades* and distributed fifteen interviews selected within the *communidades*.

Zambia: In Zambia, Mpika and Shiwang'andu districts were purposively selected for the study. Eleven Health Facilities (HF) were selected. Further these HF were divided into segments which were used as primary sampling units to randomly select the household for the study. In all countries, random sampling was used to select households with WRA and children between 0-59 months of age.

3.4.1 Sample selection from rural surveys: GROW and SANI

The primary sample selection criteria for respondents was that they were women of reproductive age with children under 5. The GROW data was collected in October 2016 in Ethiopia. SANI project data were collected in January 2017 for Malawi, May 2017 in Mozambique, and January 2017 for Zambia. FIES questions was used to retrospectively assess women's food insecurity situation in the past 1 month. The total sample size generated from pooled data across the four countries was 3532.

Table 4: Sample size of women by country in national and rural surveys

Country	National sample size n^1	Rural sample size n^2	Year
Ethiopia	994	1146	2016
Malawi	992	706	2017
Mozambique	977	966	2017
Zambia	981	714	2017
Total	3941	3532	

1 GWP
2 GROW/SANI

3.5 Measuring Food Security

3.5.1 Food insecurity experience scale (FIES)

Food security levels were assessed using the FIES in all surveys. This is recently developed experience-based food security scale, developed by the FAO through the VoH project. With a 1-month and 12-months reference period, FIES can be used at both the household and individual level. It has been used in comparing the food insecurity situation across population groups including gender by capturing the access dimension. Careful linguistic adaptation is an important consideration in the development of this food insecurity tool. When used in a different setting and cultural context, questions should be formulated in such a way that their understanding by respondents and the originality of the survey tool are maintained (Ballard et al., 2013). As part of the project, VoH team adapted the linguistic process to produce culturally appropriate versions of the scale and translated the survey module into more than 200 languages and dialects (Frongillo, Nguyen, Smith, & Coleman-Jensen, 2017). FIES is composed of eight psycho-metric questions that are listed in the order of increasing severity.

The sequence of questions captures food insecurity, which can be considered as a latent (unmeasured) variable. In this case, food insecurity is defined as a condition of not having enough access to food for living normal and healthy life due to lack of money or other resources. One of the significant contribution of this tool its ability to measures the psychological consequences that indicate food insecurity, mainly related to the feeling of uncertainty associated by respondent to situations of not getting enough food (Ballard et al., 2013). The eight questions in the FIES capture the latent trait and classify the respondent or household on the food security continuum scale, which ranges from "food secure" to "severe food insecure" (see Table 5). The rank is the sum of the affirmative (yes=1) responses. The ordinal integer variable that was the sum of responses to the items of the FIES is called the "raw score." The raw score can be transformed into a categorical variable with three classes. Those who agreed to one to three questions were classified in the mild category of food insecurity, four to six affirmative answers indicated the category of moderate food insecurity, and seven to eight affirmative answers indicated the severe category of food insecurity. The national and rural surveys used different reference periods to assess experiences of

food insecurity: for the national survey, respondents were asked to recall the past 12, and in the rural household surveys, the reference period was the past one month.

Table 5: Food Insecurity Experience Scale (Ballard et al., 2013)

Now I would like to ask you some questions about your food consumption in the last [one[5]/ 12 month(s)[6]. During the last [one/ 12] month(s), was there a time when:				
Item number	**Question**	**Response**	**Domains of the FI construct**	**Assumed Severity of Food Insecurity (FI)**
Q1	You were worried you would run out of food because of a lack of money or other resources?	0 No 1 Yes	uncertainty and worry about food	Mild FI
Q2	You were unable to eat healthy and nutritious food because of a lack of money or other resources?	0 No 1 Yes	Inadequate food quality	Mild FI
Q3	You ate only a few kinds of foods because of a lack of money or other resources?	0 No 1 Yes	Inadequate food quality	Mild FI
Q4	You had to skip a meal because there was not enough money or other resources to get food?	0 No 1 Yes	Insufficient food quantity	Moderate FI
Q5	You ate less than you thought you should because of a lack of money or other resources?	0 No 1 Yes	Insufficient food quantity	Moderate FI
Q6	Your household ran out of food because of a lack of money or other resources?	0 No 1 Yes	Insufficient food quantity	Moderate FI
Q7	You were hungry but did not eat because there was not enough money or other resources for food?	0 No 1 Yes	Insufficient food quantity	Severe FI (Hunger)
Q8	You went without eating for a whole day because of a lack of money or other resources?	0 No 1 Yes	Insufficient food quantity	Severe FI (Hunger)

3.6 Psychometric assessment of FIES data

The Item Response Theory (IRT) measurement model approach was used to analyze the FIES data across the four countries. This model evolved from a branch of statistics and is used to measures latent traits by analyzing responses on an item scale. More specifically, the IRT model applied to

[5] Rural Survey (GROW/SANI) used the reference period of one month.
[6] National Survey (GWP) used the reference period of 12 months.

the FIES data was the Rasch model, also known as a One-parameter logistic model (Ballard et al., 2013). This statistical approach was developed in the psychometric field and is commonly used in educational testing, but they have been also used in health sciences, as well as to investigate cross-cultural comparability (Smith, Rush, Fallowfield, Velikova, & Sharpe, 2008). Rasch model has a desirable invariant property. Hence, it was used for assessing the internal validity of experience-based food insecurity scales by establishing the psychometric characteristics of the items in the questionnaire (Cafiero et al., 2018; Hamilton & Cook, 1997).

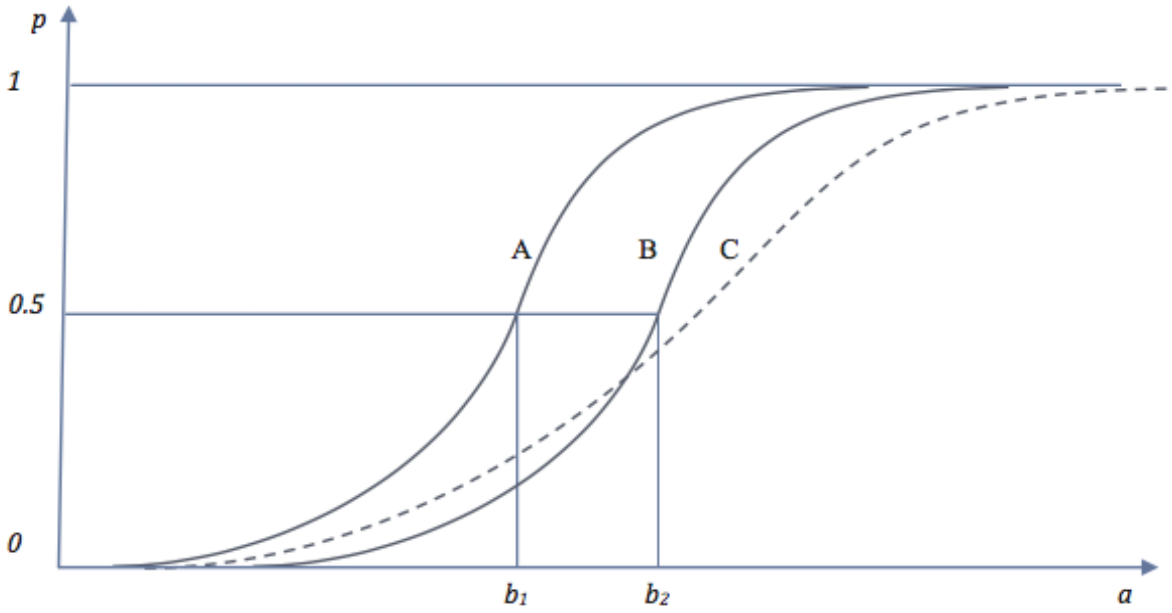
Assessing the performance by Rasch model involves the careful examination of the structure by considering the interaction between respondents and items characteristics on the scale (Cauffman & MacIntosh, 2006). Rasch model uses probability theory to assess the severity parameter of each item in the scale and for each respondent. Therefore, the association between item difficulty and respondent ability assumed by the model is logistic, and the construct can be measured on an equal interval scale (logit-based) (Carlson, Andrews, & Bickel, 1999). This model assumes that "the log-odds of respondent *r* saying "yes" to item *i* is a linear function of the difference between the severity of the food insecurity condition experienced by *r* and the severity of item *i*. By coding $x_{r,i}$ (the answer given by respondent *r* to item *i*) as 1 for 'yes' and 0 for 'no', where a_r represents the location of the respondent, b_i represents the location of the item on the scale (Cafiero et al., 2018), as expressed in this equation:

$$p \equiv \text{Prob}(x_{r,i} = 1) = \frac{e^{(a_r - b_i)}}{1 + e^{(a_r - b_i)}} \Leftrightarrow \ln\left(\frac{p}{1-p}\right) = a_r - b_i$$

The item characteristic curve (ICC) demonstrates invariant properties of Rasch model by plotting probability of yes responses against the severity of the respondent. A probability of an item being answered 'yes' and 'no' remains the same (0.5) and will be defined by the severity experienced by respondent. Rasch model holds many assumptions. One noted assumption is that of equal discrimination. This assumption is explained by the ICC which shows that all items slopes are equal for any given probability. This means that in Figure 3 items A and B have the same discrimination power and are independent of the severity of the respondent's condition. In this hypothetical example item C has a different discrimination power and does not fulfill the equal discrimination assumption. This shows that dependent on the severity of the respondent's condition and will change the order of the severity of the items in the scale, and hence, does not

follow the invariance property of the model.

Figure 3: Item characteristics curves (Cafiero et al. 2018)



3.6.1 Assumptions of Rasch model

The Rasch model framework produces significant assumptions which examine consistency of the various data. The assumptions of the model are: 1) items of the questionnaire will discriminate equally, 2) measure the same construct, and 3) items are conditionally independent for respondents with the same level of severity of food insecurity (Hackett et al., 2008). The model uses the Conditional Maximum Likelihood (CML) procedure to estimate these assumptions by producing various statistics.

The assumption of equal discrimination is evaluated by the INFIT statistics. This is an information-weighted, chi-square-type statistic that examines the observed with an expected misfit of each item. Items and respondents are placed along the same continuum. Therefore, it is implied that both the respondent's understanding and the condition that the item represents will match. INFIT statistics will explore significant mismatches by assessing the item associated with the underlying condition of food insecurity (the latent trait). Smith et al. (1998) illustrated that INFIT statistics showed the best results with multiple situations. These statistics are useful because they are less

profound to person characteristics and different sample sizes on the stability of Type I error rates, and are sensitive to unexpected behavior only, which can be the extreme individual (Smith, Schumacker, & Bush, 1998). It is calculated by averaging the squared delta between actual and expected responses and standardizing the result to approximate a normal unit distribution (Cauffman & MacIntosh, 2006). Expected values for the assumption of the equal discrimination of items is 1. But as a rule, the assumption is considered to be fulfilled if the INFIT values are within a range of 0.8–1.2, while 0.7–1.3 is considered as a broader acceptable range (Cafiero et al. 2018).

The assumption of conditional independence is measured by calculating the relative item severity parameter via extracting the correlation matrix of the items. In order to examine the presence of any gap in the items structure. Independence of the items will be assessed by looking at the difficulty of each item in the questionnaire with the respondent's level of food insecurity (Hackett et al., 2008). Item independence based on the Rasch model assumes that respondents are more likely to agree to less severe items than to more severe ones, and items will be responded affirmatively by a respondent with more food insecurity than by one with less food insecurity. In terms of food security, a food secure respondent will be less likely to answer affirmatively to response items than a mildly food insecure, followed by a moderately and then severely food insecure respondent (Ballard et al., 2013). Severity values can be quantified by using the natural log of the odds of probability within the food security questionnaire on a logit scale (Cauffman & MacIntosh, 2006). If the value of an item on the logit scale is low, it implies that the category is in the mild domain, and when the value is high, the category leans towards severe food insecurity. Comparison between the severity of food insecurity of the respondents and the severity represented by the item can be represented on a logit scale (Na, Gross, & West, 2015). These comparisons allow evaluation of the spread and position of items. When differences between the items are large, it signifies that additional questions are required in the questionnaire. If items show the same value, it implies that both items are depicting the same message and hence, represent the same level of food security (Cauffman & MacIntosh, 2006; Hackett et al., 2008).

3.7 Data Analysis

Data were analyzed using R software (version 3.4.3) and SPSS® Complex Samples software

(version 21). A customized R-package, developed by the VoH team, was used. This package estimates the Rasch model assumptions by producing various statistics to analyze the FIES data. SPSS was used for the descriptive analysis.

3.7.1 Descriptive statistics

Descriptive statistics were carried out to assess the distribution of continuous and categorical variables used in the study. Mean and the standard deviation were calculated to analyze the continuous variables in both surveys such as age and household size, whereas frequencies were generated for categorical variables. Table 6 presents details of all variables used in the analysis.

Table 6: Details of all variables included for descriptive analysis

Variable name	**Type**	**Categorized**
Household size	Continuous	
Age	Continuous	
Education level	Categorical	Primary or less Secondary or more
Marital status	Categorical	Divorced/Widowed Married/Partner Single
Employment Status	Categorical	Employed Unemployed
Religion	Categorical	Muslim Christian others
Urbanicity	Categorical	Rural Small town Urban

3.7.2 Data analysis from Rasch analysis

Rasch analysis is organized into three steps: First step is assessing the FIES performance using the national sample, representing the male and female population aged 15 years and older, for each of the four countries, separately. The second step is assessing the FIES performance among women of reproductive age, 15 to 49 years old, using the rural samples of the selected countries; and final

step of the analysis is to compare the performance of the scale among rural WRA across both surveys by selecting only women (15-49) from the national survey to match the characteristics of age, area and gender with the rural sample for each country.

To perform the Rasch analysis, responses to the eight FIES questions were coded into a binary (1 or 0). "Yes" responses were coded as 1, and "No" responses were coded as 0, for each country dataset and saved into a CSV format, excel file. Analyses were then performed using the R software. Respondents with any missing response to the FIES questions was not included in the sample. Item INFIT and Relative Severity measures were used to estimate the psychometric properties of the FIES in all the countries from both surveys separately. After initial fitting of Rasch analysis, the national database (GWP) was separated into male and female groups. Then further sub-divided so that rural WRA were selected for comparative analysis with the respective countries from rural surveys (see Table 7). Relative severity values of items of WRA in the rural surveys were plotted against the relative severity of rural WRA for the national survey (GWP) to evaluate the performance of the tool which was implemented in different populations of the same country. To make scale items comparable, severity values from both surveys were linearly transformed to adjust the mean and standard deviation.

Table 7: Total sample size by country, after selecting for rural WRA only (15-49) for comparative analysis

Surveys	Ethiopia	Malawi	Mozambique	Zambia
National[1]	304	480	347	366
Rural[2]	1146	706	965	714

Data source: [1]GWP, [2] GROW/SANI

3.6 Ethical consideration

This research is based on secondary data used from two surveys, which presents minimal risk to any of the respondents. Both surveys, GWP and GROW/SANI, were conducted following scientific procedures, ensured confidentiality, and stripped of any identifying information. Information provided by Gallup's survey is founded on research standards which are based on well scientifically grounded and reliable procedure. Gallup states to be "committed to the principle that

accurately collecting and disseminating the ideas and aspirations of people all around the world is important to understanding our world (Gallup Inc., 2016)". Gallup assures priory in maintaining the confidentiality of respondents, as well as their client.

The GROW and SANI projects (rural survey) were approved by the Research Ethics Board of the Faculty of Agriculture and Environmental Sciences at McGill University, and all research procedures were conducted in accordance with the guideline from McGill policy on the Ethical Conduct of Research Involving Human Subjects. Consent was collected from each household before any data were collected. Study participants were informed about the purpose of the study, how the results were to be used, and of their right to refuse, terminate the interview at any point or not answer any questions.

CHAPTER 4 MANUSCRIPT

Psychometric Properties of Food Insecurity Experience Scale as Applied in Eastern Africa: Evidence from National and Rural Surveys

To be submitted to the Journal of Food Security

4.1 Abstract

This research assessed the psychometric validity of the FIES applied in four African countries--Ethiopia, Malawi, Mozambique, and Zambia—by using datasets drawn from two cross-national surveys. Additionally, we compare the scale performance within comparable samples of women of reproductive age (WRA) between both surveys for each country. The *national* survey consists of nationally representative samples of adults (≥15 y/o) conducted by Gallup World Poll. The *rural* survey consists of samples of WRA (15-49) participating in nutrition projects implemented in rural areas in the four countries. The pooled, *national* sample totaled 3941 adults (≥15 y/o). The pooled, *rural* sample totaled 3532 women. Rasch model-based relative severity and INFIT statistics were used to assess the psychometric characteristics of the FIES. Results indicate that the experience of not eating for the whole day is the most severe phenomenon captured in both national and rural surveys. In general, items remained within their respective domains of food security in both surveys, with an exception for Mozambique in the rural survey and Malawi in the national survey. Most INFIT values of items were in an adequate range, which indicates items discriminate effectively among respondents experiencing different levels of severity. When WRA were compared between national and rural surveys, response patterns indicated that food insecurity is experienced and described similarly by respondents. Some variations were seen across countries which might be explained by differences in cultural contexts and livelihood arrangements. Results indicate that FIES holds an acceptable level of psychometric validity needed to assess food security, and may be appropriate for use in comparative studies.

4.2 Introduction

Food security is a basic condition for human wellbeing. It is defined as when "all people, at all times, have physical, social and economic access to sufficient, safe and nutritious food which meets their dietary needs and food preferences for an active and healthy life" (Food and Agriculture Organization, 1996). The year of 2015 marked the end of monitoring for the internationally time-bounded target, the Millennium Development Goals (MDG). One such target pledged to "cut by half the proportion of people who suffer from hunger by 2015". This target, associated with the aim of eradicating hunger, was not reached by many countries in the world (FAO, IFAD, UNICEF, WFP and WHO, 2017), and the problem is getting worse. According to the recent *State of Food Security and Nutrition in the World* report approximately 815 million people worldwide do not consume enough calories to meet their daily requirements. The prevalence of people affected by chronic food deprivation is highest in Sub-Saharan Africa which accounts for 22.7 percent of the world's population (FAO et al., 2017). Given the failure to achieve MDGs by many countries and enormous magnitude of the food insecurity burden worldwide, more work is needed to better understand the food security problem.

In 2015, as part of the global commitment to end hunger, promote sustainability and peace, the United Nations adopted the Sustainable Development Goals (SDGs). These 17 goals represent global priorities that all countries have agreed to meet by 2030 (United Nations, 2015). Goal 2 aims to reduce malnutrition and attain food security. It is of key importance because accomplishing food security has been associated directly and indirectly with all 17 goals which range from reduction in poverty, hunger, gender equity, and planetary sustainability (Pérez-Escamilla, 2017). Therefore, appropriate measures are needed to identify area and characteristics of food insecure populations and meet the SDG 2 target (Smith, Rabbitt, & Coleman-Jensen, 2017).

The concept of food security is multifaceted, and there is no single measure that encompasses the whole concept. Measures are needed to identify global trends, provide warnings of early deprivation, evaluate interventions, and develop policies (Jones, Ngure, Pelto, & Young, 2013). The number of food security measures developed reflect the objective and assumptions of the research. Therefore, measurement tools, used by various nations, international organizations, and agencies for program monitoring and evaluation, can range from the simple to comprehensive

indicators, drawing upon data and offering a different level of measurement at national, regional, household, and/or individual levels (Jones et al., 2013). Experience-based food security scales (EBFSSs) are micro-level measurements capturing the access dimension of food security that allows a better understanding of socio-economic determinants, characteristics at the individual and national level, and concentration of food-insecure people (Nord, Cafiero, & Viviani, 2016).

There has been increasing attention on EBFSSs and their use as a global tool for measuring food security. Over the past 20 years, researchers have developed and validated many context-specific experience-based scales to capture the food access dimension (Smith et al., 2017). The pre-existing experience-based scales, such as the U.S. Household Food Security Survey Module (USHFSSM), Colombian Household Food Security Scale (CHFSS), the Latin American and Caribbean Food Security Scale (ELCSA), and the Household Food Insecurity Access Scale (HFIAS), have been applied and validated in various ethnographic settings (Hackett, Melgar-Quiñonez, Pérez-Escamilla, & Segall-Corrêa, 2008; Hackett, Melgar-Quiñonez, & Uribe, 2008; Knueppel, Demment, & Kaiser, 2010; Pérez-Escamilla et al., 2004).

The need of valid EBFFSs is an issue of fundamental consideration for policy makers, practitioners, researchers and programme managers tasked with monitoring and tracking the progress of food security programs and interventions at regional or household levels (Danieli et al., 1996; Jones et al., 2013). However, in the context of developing country, issues related to measuring tools must be adequately dealt with before addressing the subject prevalence and determinants of food security (Leyna, Mmbaga, Mnyika, & Klepp, 2008). As a result, the need for validation of food insecurity experience scales is an essential step for refining the scale (Webb et al., 2006). Capturing the latent traits with valid measures is one of the primary objectives of validating experience-based scales (Clark & Watson, 1995).

The Food Insecurity Experience Scale (FIES) is the latest development in experience-based scales (Smith et al., 2017). The focus of FIES is to measure the latent traits of food insecurity by capturing behavior and perceptions (such as uncertainty) related to not getting enough food because of lack of resources (Ballard, Kepple & Cafiero, 2013; Nord, 2014). As part of a global initiative, FIES has recently been applied in more than 153 countries through FAO's *Voices of Hungry* (VoH)

project. In 2014, through VoH in partnership with the Gallup World Poll, FIES was included in nationally representative surveys being conducted in more than 150 countries around the world, allowing cross-country comparison (Cafiero, Viviani, & Nord, 2018). One concern is that FIES's latent dimensional structure and psychometric properties have not been fully explored (Wambogo, Sahyoun, SheikOmar, & Ghattas, 2017). One reason for this is that the context and circumstances of national-level settings may not necessarily represent the heterogeneity of local contexts (de Toledo Vianna, Hromi-Fiedler, Segall-Correa, & Pérez-Escamilla, 2012). When food insecurity status is measured, some regions and groups experience more frequent and severe situations of food insecurity than others (Nord, Andrews, & Carlson, 2005). For example, household-level food security measurements are designed to capture the experience of all household members, but food insecurity may be experienced differently among household members. Children might be buffered from food insecurity experiences by mothers; and men because of privilege may receive better food quality and quantity compared to women. Therefore, the classification of a household as food insecure may not represent the status of all its members (Brunelli & Viviani, 2014). This means that it is critical to assess psychometric characteristics of vulnerable groups and their less vulnerable equivalent because food security conditions and experiences vary widely and severity differences may reflect these variations in the population (Hackett et al., 2008).

For all these reasons, additional validation studies of FIES are needed, since it is the latest experience-based scale used to measure food insecurity. This is a research gap because of the growing prevalence globally especially in Sub-Saharan African countries. To our knowledge, FIES has only been used by Gallup World Poll on a national scale and further evidence is needed from other population-based surveys regarding the functionality of the tool. Therefore, additional validation studies from local and rural settings are necessary to examine the psychometric properties of this tool. It is expected that such studies will provide empirical evidence to support whether FIES is an effective and valid measure globally, and able to be used in monitoring as part of the 2030 agenda for sustainable development.

The main objective of this study is to assess the psychometric properties of the FIES as applied in four eastern African countries using cross-national surveys representing national and rural settings. The secondary objective is to compare psychometric characteristics of FIES as applied among

rural women of reproductive age (WRA) across two surveys.

4.3 Methods

4.3.1 Research design

In this study, we assess the psychometric validity of the FIES as applied in four African countries--Ethiopia, Malawi, Mozambique, and Zambia—by using the Rasch modelling approach. Datasets were drawn from two cross-national surveys from each country. Further scale performance was explicitly compared to the high-risk population of rural women of reproductive age (15-49) within two surveys.

The *national* surveys are subsets of Gallup World Poll (GWP) data sets, which are accessible as a courtesy to the McGill Institute for Global Food Security with the *Voices of the Hungry* Project of United Nations Food and Agriculture Organization (FAO). The *rural* household surveys were drawn from baseline surveys from two nutrition projects conducted by CARE Canada in partnership with McGill University. The first CARE project is known as *Growing Nutrition for Mother and Children* (GROW) project, currently taking place in Ethiopia (2016-2020); the second is known as the *Southern Africa Nutrition Initiative* (SANI) project, which is being implemented in Malawi, Mozambique, and Zambia (2016-2020).

This study defines rural as areas where poverty levels are estimated to be high, households highly dependent on agriculture, natural resources, and woodlands for their livelihoods (food provision and income generation) with limited access to basic services (health, roads, piped water and sanitation).

4.3.2 Research context

The four countries of the Eastern African region: Ethiopia, Malawi, Mozambique and Zambia are ranked among the poorest countries in the world (per the Human Development Index). In 2017, the Global hunger index ranking for Ethiopia, Malawi, Mozambique and Zambia were 104, 115, 90 and 98 respectively, out of 119 countries. The majority of their population lives in rural areas and depend on agriculture for their livelihoods, like other countries in Sub-Saharan Africa

(Järnberg, Kautsky, Dagerskog, & Olsson, 2018). Most of these rural-based populations depend on rain-fed subsistence agriculture (Arslan et al., 2018). For example, in Malawi, close to 80% of the population live in rural areas; among them, 93% depend mainly on agriculture for their livelihood (Fourth Intergrated Household Survey, 2017; Kassie, Stage, Teklewold, & Erenstein, 2015). Agriculture sector contribution to Gross Domestic Product (GDP) in Ethiopia (2014), Malawi (2015), Mozambique (2018) and Zambia (2018) is 44%, 38%, 29% and 20%, respectively (Arslan et al., 2018; Winthrop, Kajumba & Mcivor, 2018; Mendola & Simtowe, 2015; World Food Programme, 2014). Main crops produced by smallholder farmers, included maize and other food crops such as rice, cassava, sorghum, millet, and legumes.

The Eastern Africa region has the highest rate of undernourishment in Sub-Saharan Africa (FAO et al., 2017). Furthermore, the Global Food Security Index (GFSI) ranks these countries under those needing improvement in all dimensions of the food security (Econimist Global Intelligence Unit, 2017). Food insecurity is more prevalent in rural than urban areas, and women are more vulnerable as a group than men (FAO et al., 2017). Tables 2 and 3 presents countries characteristics and nutrition profile.

4.4 Sampling and survey methods

4.4.1 The National Survey: description of the data, sampling and method

The national survey (GWP) data drawn from Ethiopia, Malawi, Mozambique and Zambia are used for this analysis. GWP survey is nationally representative for cross country comparisons among the adult population aged 15 and above. Detailed methodology for GWP is available on the Gallup Inc. Web site (Gallup Inc., 2017). In these four countries, respondents were surveyed through face-to-face interviews. The sampling involved identifying the 100-135 clusters of households which were obtained from the larger population or geographical unit. After the clusters were formed, a random route procedure was used to select the cluster. The final stage of sampling uses the individuals' birth information and Kish grid method to select a single respondent from each household (Nord et al., 2016).

4.4.2 The Rural Survey: description of the data, sampling and method

Data for the rural survey came from household baseline surveys conducted in two nutrition projects. These projects were implemented by CARE Canada in partnership with Cuso International, the Interagency Coalition on AIDS and Development (ICAD), McGill University, and the Governments of project-countries. The primary sample selection criteria for respondents was that they were women of reproductive age with children under five years of age. The first project, Growing Nutrition for Mother and Children project (GROW), is taking place in Ethiopia. The second project, Southern Africa Nutrition Initiative project (SANI), is taking place in Malawi, Mozambique, and Zambia. The aim of both projects is to improve the nutritional status of WRA (15-49 years) with children under five years of age in rural areas. The GROW data was collected in October 2016 in Ethiopia. SANI project data were collected in January 2017 for Malawi, May 2017 in Mozambique and January 2017 for Zambia.

The sampling strategies varied across the four countries taking into consideration cultural and country-specific contexts. Explanation for each country sampling strategy is defined separately.

Ethiopia: Sample selection was done by selecting a total of 39 *Kebeles*. A *Kebele* is the smallest administrative unit in Ethiopia (similar to a ward typically used for electoral purposes). This selection of Kebele involves the use of a probability method, proportionate to the population size in target areas. These samples were selected in two regions of Oromia and Afar. Kebeles were further segmented into small clusters.

Malawi: Multi-stage cluster sampling was used to select clusters and then households for the study. Two districts, Dowa and Ntchisi, and four Traditional Authorities (TAs) (TA is a customary informal institution responsible for Area Development Committees) were selected to randomly select fifteen–group village headman's (GVHs) areas. A GVH is used as the smallest administrative unit forming the cluster unit of the study.

Mozambique: Funahlouro and Homoine districts were purposively selected for the study. The smallest geographic units selected from the two districts were *communidades*, and thus these small units served as the primary sampling units. Further cluster sampling was performed to randomly select *communidades* and distributed fifteen interviews selected within the *communidades*.

Zambia: Mpika and Shiwang'andu districts were purposively selected for the study. Eleven Health Facilities (HF) were selected. Further these HF were divided into segments which were used as

primary sampling units to randomly select the household for the study. In all countries, random sampling was used to select households with WRA and children between 0-59 months of age.

GWP 2017 provided national samples for Malawi, Mozambique, and Zambia. For Ethiopia, data was collected by GWP in 2016. Data from GWP (national) were selected for these four countries and reference years to match the rural surveys conducted in the same four countries by CARE Canada. The CARE household survey data (rural) was collected in Malawi, Mozambique, and Zambia in 2017, and in Ethiopia in 2016. Matching these datasets provided the opportunity to conduct this research comparing national and rural surveys within the same countries by using same tool (FIES). This also allowed the unique opportunity to compare the performance of tool, when looking at rural women of reproductive age across the two surveys.

4.4.3 Sample size

In the national survey, FIES questions were used to retrospectively assess the food insecurity of adults (≥15 y/o) in the past 12 months. And in the rural survey, FIES questions were used to assess food insecurity of women of reproductive age (15-49 years) in the past one month. Total sample size generated across the four countries for the national survey was 3941(men and women in both rural and urban areas), and sample generated for the rural survey was 3532 (rural women). In order to undertake a comparative analysis of rural WRA, all rural women were selected from the national survey. This generated sample size of 1497 rural WRA from the national survey.

4.5 Measurement of food security

Food security levels were assessed using the FIES in all surveys. FIES is composed of eight psychometric questions that are listed in the order of increasing severity. The eight questions in the FIES capture the latent trait and classify the respondent or household on the food security continuum scale, which ranges from "food secure" to "severe food insecure" (see Table 5). The rank is the sum of the affirmative (yes = 1) responses. The ordinal integer variable that was the sum of responses to the items of the FIES is called the "raw score." The raw score can be transformed into a categorical variable with three classes. Those who agreed to one to three questions were classified in the mild category of food insecurity, four to six affirmative answers

indicated the category of moderate food insecurity, and seven to eight affirmative answers indicated the severe category of food insecurity. The national and rural surveys used different reference periods to assess experiences of food insecurity: for the national survey, respondents were asked to recall the past 12 months, and in the rural household surveys, the reference period was the past one month.

4.5 Statistical analysis

The Item Response Theory (IRT) measurement model approach was used to analyze the FIES data across the four countries in both surveys. This statistical approach was developed in the psychometric field and is commonly used in educational testing, but they have been also used in health sciences, as well as to investigate cross-cultural comparability (Smith, Rush, Fallowfield, Velikova, & Sharpe, 2008). Assessing the performance by Rasch model involves the careful examination of the structure by considering the interaction between respondents and items characteristics on the scale (Cauffman & MacIntosh, 2006). Rasch model uses probability theory to assess the severity parameter of each item in the scale and for each respondent. Therefore, the association between item difficulty and respondent ability assumed by the model is logistic, and the construct can be measured on an equal interval scale (logit-based) (Carlson, Andrews, & Bickel, 1999).

The Rasch model framework produces significant assumptions which examine consistency of the various data. The assumptions of the model are: 1) items of the questionnaire will discriminate equally, 2) measure the same construct, and 3) items are conditionally independent for respondents with the same level of severity of food insecurity (Hackett et al., 2008).

The assumption of equal discrimination is evaluated by the INFIT statistics. This is an information-weighted, chi-square-type statistic that examines the observed with an expected misfit of each item. Items and respondents are placed along the same continuum. Therefore, it is implied that both the respondent's understanding and the condition that the item represents will match. INFIT statistics will explore significant mismatches by assessing the item associated with the underlying condition of food insecurity (the latent trait). It is calculated by averaging the squared difference between actual and expected responses and standardizing the result to approximate a normal unit

distribution (Cauffman & MacIntosh, 2006). Expected values for the assumption of the equal discrimination of items is 1. But as a rule, the assumption is considered to be fulfilled if the INFIT values are within a range of 0.8–1.2, while 0.7–1.3 is considered as a broader acceptable range (Cafiero et al. 2018).

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Data were analyzed using R software (version 3.4.3) and SPSS® Complex Samples software (version 21). A customized R-package, developed by the VoH team, was used. This package estimates the Rasch model assumptions by producing various statistics to analyze the FIES data. SPSS was used for the descriptive analysis.

Rasch analysis is organized into three steps: First step is assessing the FIES performance using the national sample, representing the male and female population aged 15 years and older, for each

of the four countries, separately. The second step is assessing the FIES performance among women of reproductive age, 15 to 49 years old, using the rural samples of the selected countries; and final step of the analysis is to compare the performance of the scale among rural WRA across both surveys by selecting only women (15-49) from the national survey to match the characteristics of age, area and gender with the rural sample for each country.

To perform the Rasch analysis, responses to the eight FIES questions were coded into a binary (1 or 0). "Yes" responses were coded as 1, and "No" responses were coded as 0, for each country datasets and saved into a CSV format, excel file. Analyses were then performed using the R software. Respondents with any missing response to the FIES questions was not included in the sample. Item INFIT and Relative Severity measures were used to estimate the psychometric properties of the FIES in all the countries from both surveys separately. After initial fitting of Rasch analysis, the national database (GWP) was separated into male and female groups. Then further sub-divided so that rural WRA were selected for comparative analysis with the respective countries from rural surveys (see Table 7). Relative severity values of items of WRA in the rural surveys were plotted against the relative severity of rural WRA for the national survey (GWP) to evaluate the performance of the tool which was implemented in different populations of the same country. To make scale items comparable, severity values from both surveys were linearly transformed to adjust the mean and standard deviation.

4.6 Ethical consideration

This research is based on secondary data used from two surveys, which presents minimal risk to any of the respondents. Information provided by Gallup's survey is founded on research standards which are based on well scientifically grounded and reliable procedure. Gallup states to be "committed to the principle that accurately collecting and disseminating the ideas and aspirations of people all around the world is important to understanding our world (Gallup Inc., 2016)". Gallup assures priory in maintaining the confidentiality of respondents, as well as their client.

The GROW and SANI projects (rural survey) were approved by the Research Ethics Board of the Faculty of Agriculture and Environmental Sciences at McGill University, Consent was collected from each household before any data was collected. Study participants were informed about the

purpose of the study, how the results were to be used, and of their right to refuse, terminate the interview at any point or not answer any questions.

4.7 Results

4.7.1 Sample characteristics and FIES responses

Key characteristics of national and rural samples are listed in tables 8 and 9, respectively. As noted in table 8, the mean and standard deviation (SD) of household size in the national survey ranged from 4.5 (SD=2.2) in Ethiopia to 5.5 (SD=2.5) in Zambia. Most households in all four countries reported Christianity as their family religion. Most respondents resided (between 75% to 88%) in rural areas and small towns as compared to urban areas.

Overall the proportion of women respondents was greater than men in all countries except Mozambique, where women respondents were 47.8% of the sample. The mean age of women in the national survey ranged from 30.5 years old (SD=13.7) in Ethiopia to 34.6 years old (SD=17.6) in Mozambique. In general, male respondents had more schooling and were employed, compared to females. Across the four countries around 50% of all respondents were married or had a partner.

Table 9 shows the characteristics of rural sample of women by country. Among rural respondents in the four countries, the average household size ranged from the lowest, 5.1 (SD=1.9), in Malawi to the highest, 6.8 (SD=3.1), in Mozambique. The mean age of women in the rural survey of 15-49 years ranged from 27.9 years old (SD =5.8), in Ethiopia to 28.6 years old (SD=7.5) in Zambia. In the rural survey, highest employment levels were observed in Malawi at 88.7% and the lowest was found in Mozambique at 21.7%. Nearly half of all women respondents were married. Most women respondents in all four countries reported Christianity as their family religion except in Ethiopia where the dominant religion was Muslim.

Categorical responses to FIES questions for all countries in both national and rural samples are listed in tables 10 and 11. Generally, both surveys showed that, affirmative responses followed a decreasing trend in severity from Item 1 to Item 8. Items within the mild domain and are characterized as less severe experiences of food insecurity *(worried (i1), nutritious (i2) and few kinds(i3))* showed a higher proportion of affirmative responses than those conceptualized as more

severe (e.g., hungry and whole day) across countries.

However, there are few exceptions in the findings of affirmative responses followed a decreasing trend in severity. In the national samples of Malawi and Zambia, one item in the severe domain *Hungry (i7)* showed more affirmative responses than one item in the mild domain which was eating *nutritious (i2)* food.

Further in the rural sample of Mozambique, exceptions are seen in the affirmative responses for item *hungry (i7)* in the severe domain. This item shows more affirmative responses than items in the moderate domain such as *ate less* (i5) and *run out* (i6).

Table 8: Characteristics of national sample of women and men by country

	Ethiopia (994)	Malawi (992)	Mozambique (977)	Zambia (981)
Characteristics	Mean (SD) or %	Mean(SD) or %	Mean (SD)or %	Mean(SD) or %
Household size	4.5 (2.2)	4.5 (2.0)	5.4 (2.7)	5.5 (2.5)
Religion				
Muslim	28.2	13.9	19.7	1.4
Christian	71.4	77.4	70.5	97.6
others	0.3	7.9	6.6	0.5
Urbanicity				
Rural	58.6	59.5	62.5	30.0
Small town	25.5	25.1	25.6	45.5
Urban	16.0	15.4	11.8	24.6
Women	58.7	67.4	47.8	58.7
Age (y)	30.5 (13.7)	33.5 (16.1)	34.6 (17.6)	32.2 (15.4)
Education level				
Elementary or less	73.2	68.0	69.2	42.4

Secondary or more	26.8	31.5	30.4	57.6
Marital status				
Divorced/Widowed	20.1	29.2	16.1	19.8
Married/Partner	57.0	52.5	48.4	44.4
Single	22.7	18.2	35.3	35.8
Employment Status				
Employed	52.9	61.1	53.9	46.0
Unemployed	47.1	38.9	46.1	53.9
Men	41.3	32.6	52.2	41.4
Age (y)	33.18 (14.4)	32.4 (15.04)	36.5 (19.6)	32.5 (14.4)
Education level				
Primary or less	65.2	47.7	62.5	34.1
Secondary or more	34.8	44.2	37.5	65.9
Marital status				
Divorced/Widowed	4.5	8.4	4.8	6.9
Married/Partner	66.0	52.9	48.1	45.6
Single	29.5	38.7	46.5	47.4
Employment Status				
Employed	79.7	77.1	66.6	64.2
Unemployed	20.3	22.9	33.3	35.8

Table 9: Characteristics of rural sample of women by country

	Ethiopia (1146)	Malawi (706)	Mozambique (965)	Zambia (714)
Characteristics	Mean (SD) or %	Mean(SD) or %	Mean (SD)or %	Mean(SD) or %
Household size	6.0 (2.2)	5.1 (1.9)	6.8 (3.1)	5.9 (2.3)
Age (y)	27.9 (5.8)	28.2 (7.1)	28.4 (8.7)	28.6 (7.5)
Education level				
Primary or less	97.6	84.3	73.9	69.3
Secondary or more	2.3	15.7	26.1	30.7
Marital status				
Divorced/Widowed	4.0	12.1	6.1	7.5
Married/Partner	96.0	87.0	63.6	87.4
Single	0.0	1.0	24.1	5.2
Employment Status				
Employed	33.5	88.7	21.7	32.2
Unemployed	66.5	11.3	78.3	67.8
Religion				
Muslim	94.2	0.7	0.0	0.0
Christian	5.8	98.3	68.8	97.6
Others	-	0.8	23.4	2.4

Table 10: Item responses to the FIES scale in national survey by country

Original question		Item description	Ethiopia (991)	Malawi (992)	Mozambique (977)	Zambia (981)
Responses %						
During the last 12 months, was there a time when…			Yes	Yes	Yes	Yes
Item 1	You were worried you would run out of food?	Worried	57.7	82.2	73.0	74.0
Item 2	You were unable to eat healthy and nutritious food?	Nutritious	69.8	74.2	71.8	73.9
Item 3	You ate only a few kinds of foods?	Few kinds	69.8	83.5	76.4	78.8
Item 4	You had to skip a meal?	Skip meal	46.2	84.9	62.4	70.6
Item 5	You ate less than you thought you should?	Ate less	52.4	85.2	71.0	75.7
Item 6	Your household ran out of food?	Runout	31.6	80.1	61.6	72.8
Item 7	You were hungry but did not eat?	Hungry	32.5	80.4	60.6	70.4
Item 8	You went without eating for a whole day?	Whole day	17.0	60.0	42.3	54.7

Table 11: Item responses to the FIES scale in rural survey

Original question		Item description	Ethiopia (1146)	Malawi (706)	Mozambique (965)	Zambia (714)
Responses %						
During the last one month, was there a time when…			Yes	Yes	Yes	Yes
Item 1	You were worried you would run out of food?	Worried	54.5	91.4	54.4	58.5
Item 2	You were unable to eat healthy and nutritious food?	Nutritious	54.6	91.2	55.6	58.7
Item 3	You ate only a few kinds of foods?	Few kinds	60.1	93.2	33.5	59.4
Item 4	You had to skip a meal?	Skip meal	41.8	85.8	57.3	46.8
Item 5	You ate less than you thought you should?	Ate less	50.3	82.0	58.9	54.1
Item 6	Your household ran out of food?	Runout	41.6	83.0	36.8	26.6
Item 7	You were hungry but did not eat?	Hungry	39.6	80.3	50.2	33.2
Item 8	You went without eating for a whole day?	Whole day	32.7	63.5	17.6	18.5

4.7.2 Relative items severity

Relative severity of both surveys is shown in Table 12. Findings of relative severity as distributed on the logit scale. Logit scale can be defined as natural log of the odds of the probability, affirming to the given question on the item scale. If the logit value is low, then items are representing the mild category of food insecurity, and if the value is high it will represent the severe category (Na et al., 2015). The relative severity of national survey countries ranged from 1.66 logistic units in Zambia to 2.60 logistic units in Ethiopia. And severity of rural survey ranges from 1.88 logistic units in Malawi to 2.68 logistic units in Mozambique. Item 8 whole day in all the countries in both survey have high relative severity value.

Relative severity of national survey*:* Overall, Ethiopia, Mozambique, Zambia item responses represent their theoretical sequence of food insecurity which are mild, moderate and severe. However, in Ethiopia, item *runout (i6)* has severity values higher than item *hungry (i7)* and are in the severe domain instead of moderate domain. There is minor difference between these two items (0.08). In Zambia two items are out of sequence item *ate less (i5)* is in the mild domain while item *nutritious(i2)* is in the moderate domain. In Malawi, only a few items are in their respective domains of food security *few kinds (i3), runout (i6) and whole day (i8).* The item most out of the sequence is item 2 (represents quality of food) which is in severe food insecurity domain instead of mild. See Figure 4.

Relative severity of rural survey: In Ethiopia and Malawi, the category structure of the scale is working properly. In both countries, all items are within their respective classes of food security which are mild, moderate and severe. In Zambia, only one item is not in the respective domain. This item is related to the psychological worry of running out of food due to money *(runout (i6))* was found to be more severe than item *hungry (i7).* In Mozambique, the construct of the scale is not working properly, other than *few kinds (i3)* and *whole day (i8),* six items are not in their respective domains of food security. See Figure 5.

Table 12: Summary of relative severity of the items in national and rural surveys by country

Items	Ethiopia		Malawi		Mozambique		Zambia	
	National*	Rural**	National*	Rural**	National*	Rural**	National*	Rural**
Worried (i1)	-0.65	-0.89	-0.32	-1.07	-0.77	-0.39	-0.25	-1.27
Nutritious(i2)	-1.67	-0.90	0.66	-1.04	-0.63	-0.50	-0.24	-1.28
Few kinds(i3)	-2.25	-1.62	-0.52	-1.54	-1.18	-1.37	-0.93	-1.35
Skip meal (i4)	0.04	0.60	-0.77	-0.06	0.30	-0.62	0.15	-0.18
Ate less (i5)	-0.41	-0.38	-0.83	0.46	-0.55	-0.74	-0.48	-0.83
Runout (i6)	1.21	0.62	-0.03	0.33	0.38	1.01	-0.10	1.56
Hungry (i7)	1.13	0.86	-0.07	0.66	0.47	-0.07	0.18	0.98
Whole day (i8)	2.60	1.71	1.88	2.25	1.99	2.68	1.66	2.37

*GWP, **GROW/SANI

Figure 4: Item sequence in the national survey by country

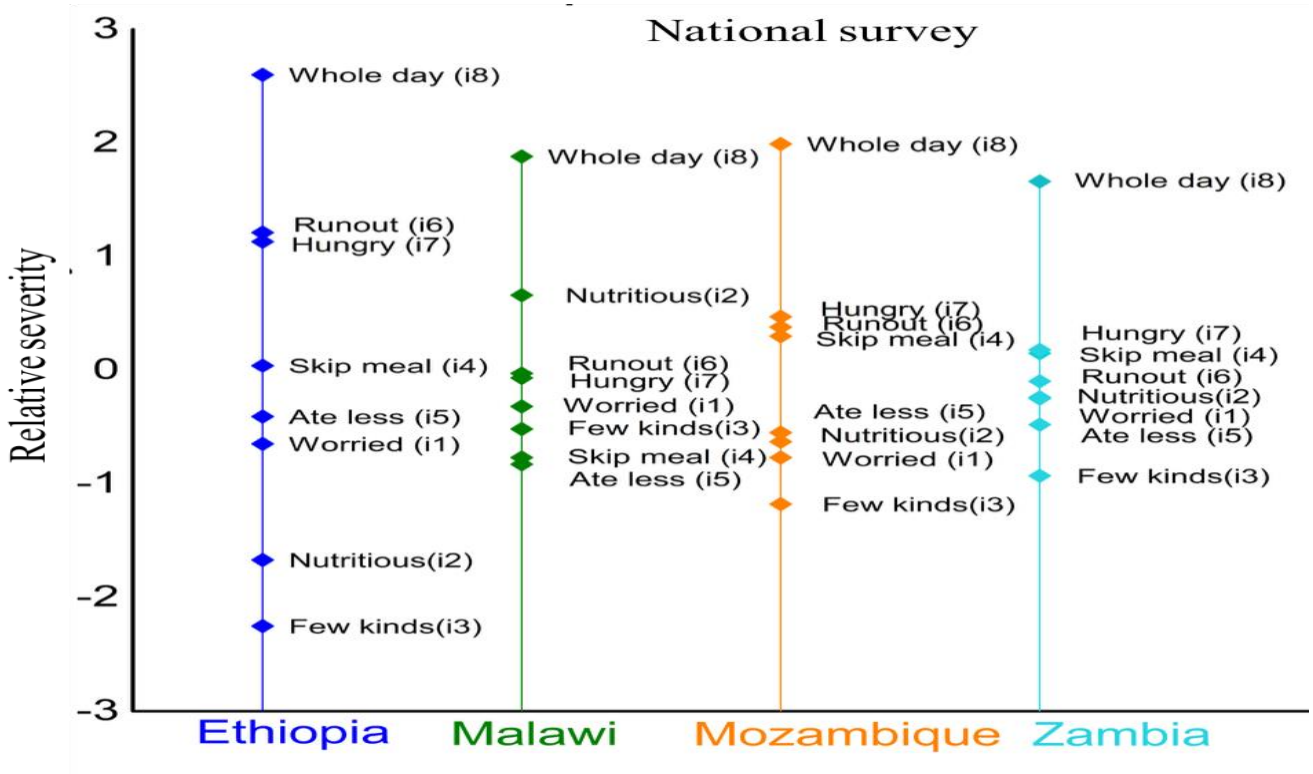
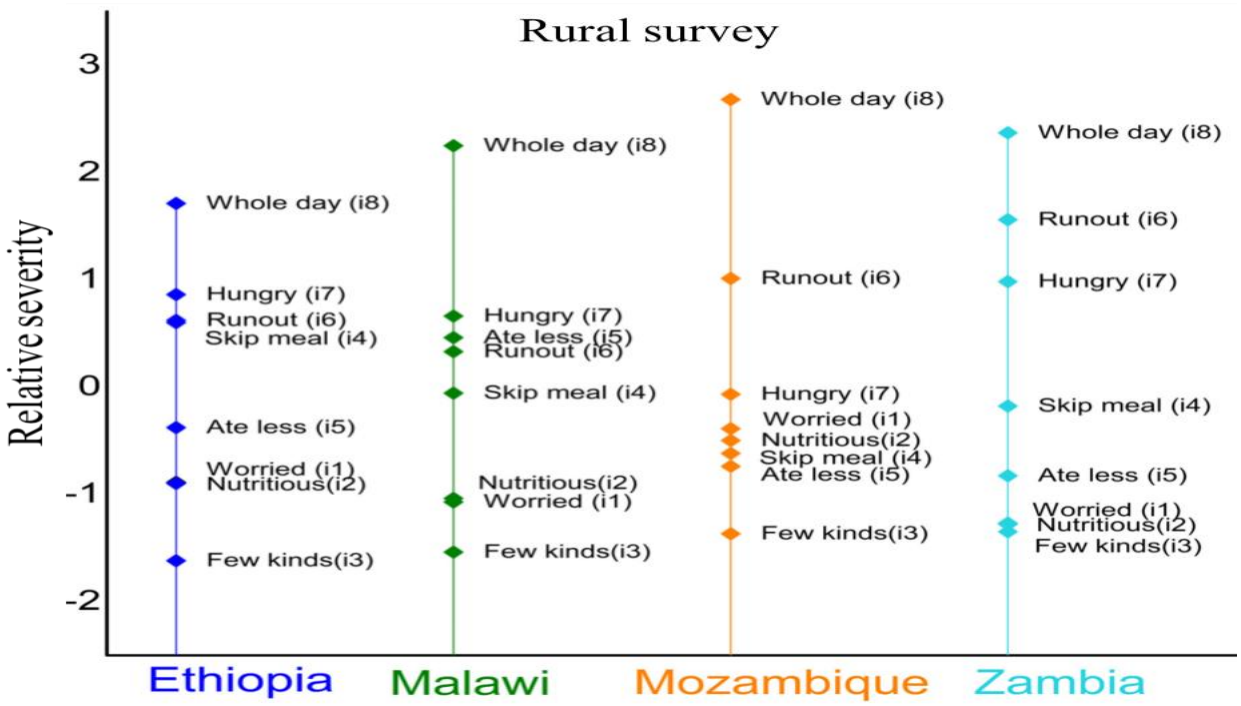


Figure 5: Item sequence in the rural survey by country



4.7.3 INFIT Statistics

As shown in the Table 13 INFIT values of both surveys following the model assumption of equal discrimination by falling the acceptable range (0.7–1.3). It is implied that both the respondent's understanding and the condition that the item representing is matching.

INFIT statistics of national survey: Figures 1, 2, 3 and 4, shows INFIT statistics of the national survey. It can be seen that most items in all countries meet the model assumption of equal discrimination by falling within the acceptable range of INFIT statistics (0.7 to 1.3). However, in Ethiopia four items show INFIT statistics outside the acceptable range (0.7-1.3). One item *worried (i1)* = 2.3, shows a higher value than expected and three items *ate less (i5)* = 0.6, *runout (i6)* = 0.6 and *hungry (i7)* = 0.6 has INFIT values very close to 0.7.

INFIT statistics of rural survey: Figures 5, 6, 7 and 8, shows INFIT statistics in the rural survey, and note that most items were close to unity and were well within the acceptable range (0.7-1.3), except one item *nutritious(i2)* = 1.4 in Mozambique. Generally, none of the items exceeded 1.3,

which implies that most them were associated with the underlying latent trait of food insecurity.

Table 13: Summary of INFIT statistics of the items in national and rural surveys by country

Items	Ethiopia		Malawi		Mozambique		Zambia	
	National[1]	Rural[2]	National[1]	Rural[2]	National[1]	Rural[2]	National[1]	Rural[2]
Worried (i1)	2.3††	1.0	1.1	1.1	1.1	1.0	1.2	1.3
Nutritious (i2)	0.8	1.2	1.2	0.9	1.0	1.4††	0.9	1.1
Few kinds(i3)	0.8	1.2	0.8	1.1	1.2	1.1	1.2	0.9
Skip meal (i4)	0.7	1.0	0.8	1.1	1.0	0.8	0.9	1.1
Ate less (i5)	0.6††	0.9	0.8	1.3	1.0	0.8	0.9	0.8
Runout (i6)	0.6††	0.8	0.9	0.7	0.7	0.8	0.9	1.1
Hungry (i7)	0.6††	0.8	1.0	0.8	0.9	0.8	0.8	0.8
Whole day (i8)	0.9	1.1	1.1	1.0	1.1	1.0	1.2	1.0

1GWP, 2GROW/SANI
†† Outside of acceptable range of 0.7 to 1.3.

Figure 6: INFIT values of FIES items of national survey (GWP) in Ethiopia

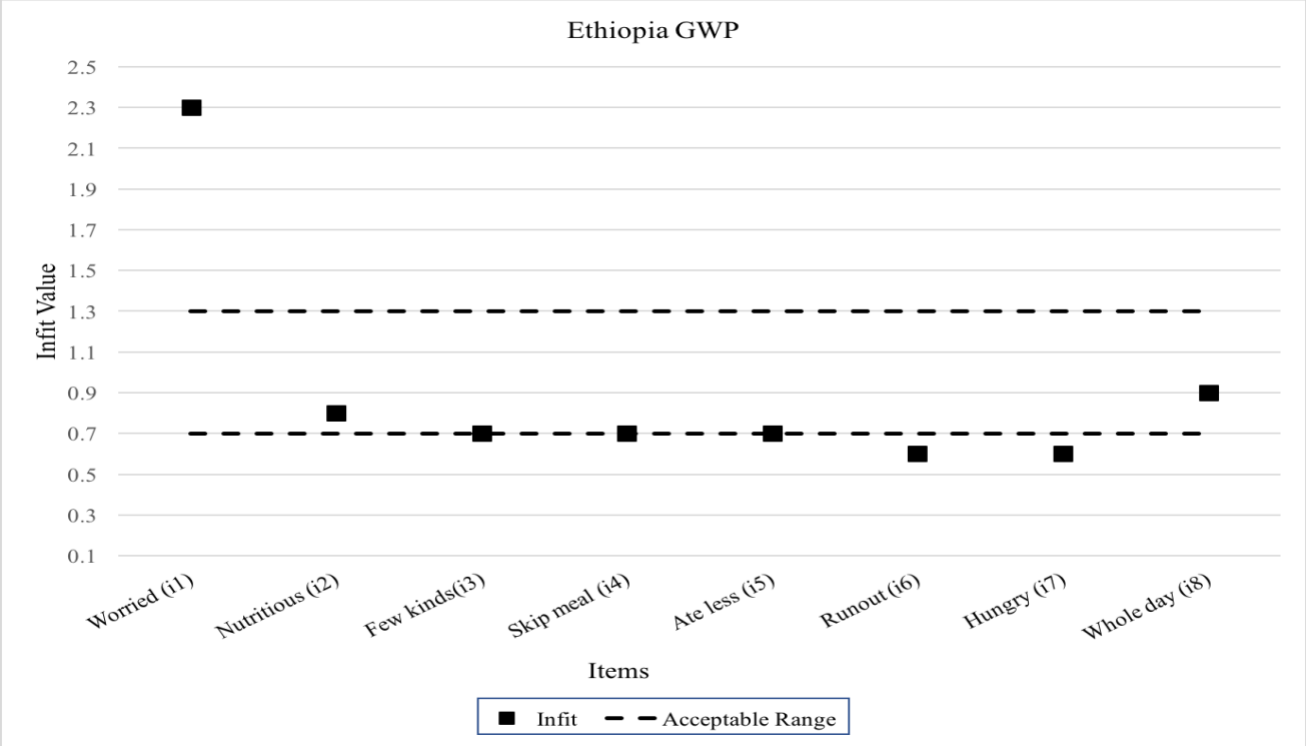


Figure 7: INFIT values of FIES items of national survey (GWP) in Malawi

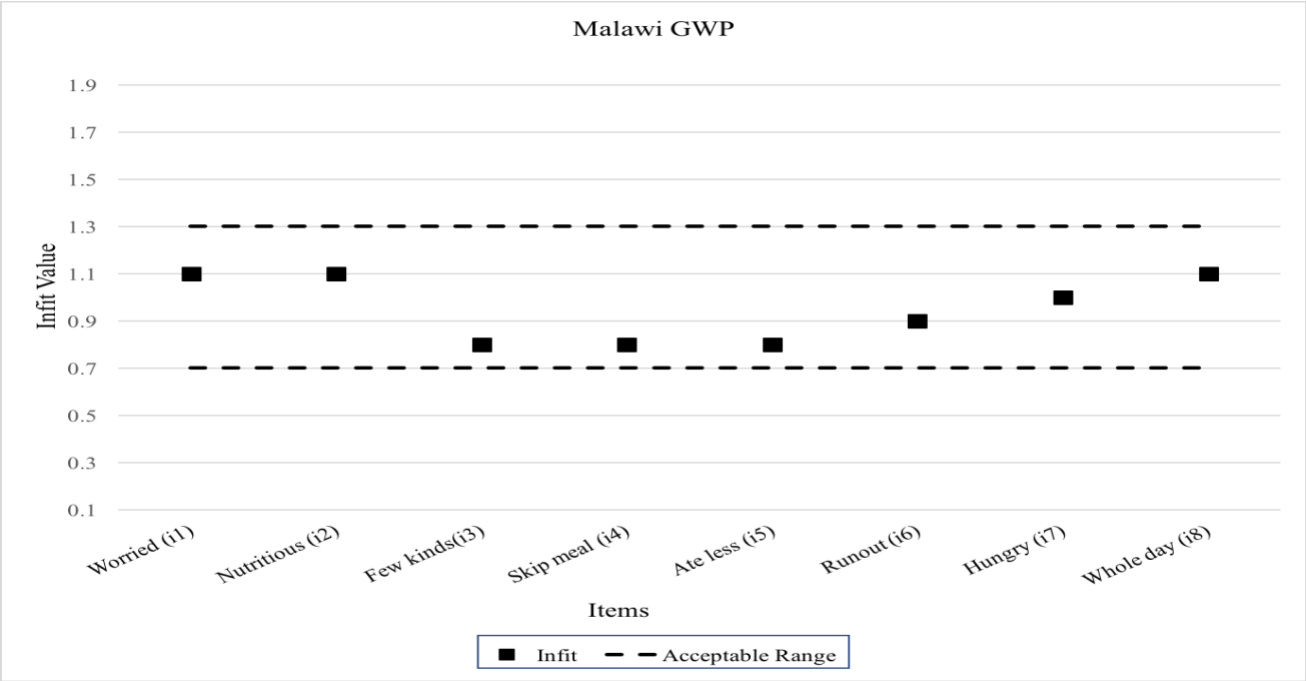


Figure 8: INFIT values of FIES items of national survey (GWP) in Mozambique

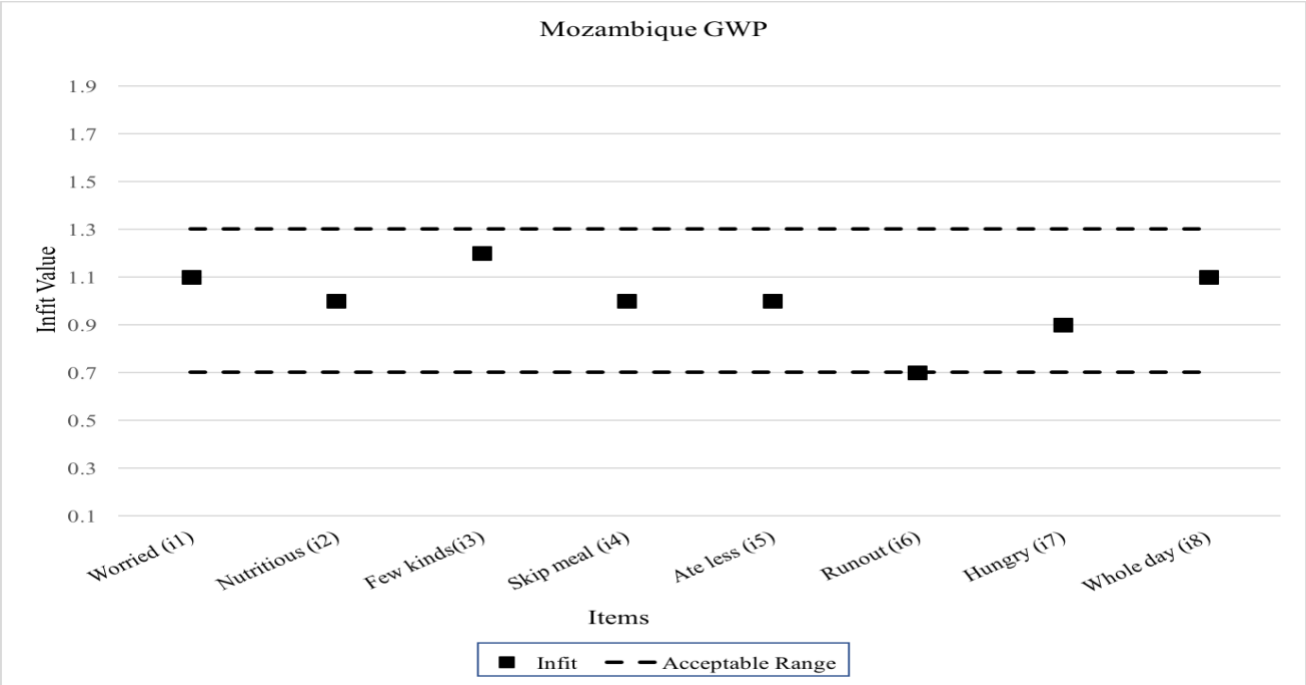


Figure 9: INFIT values of FIES items of national survey (GWP) in Zambia

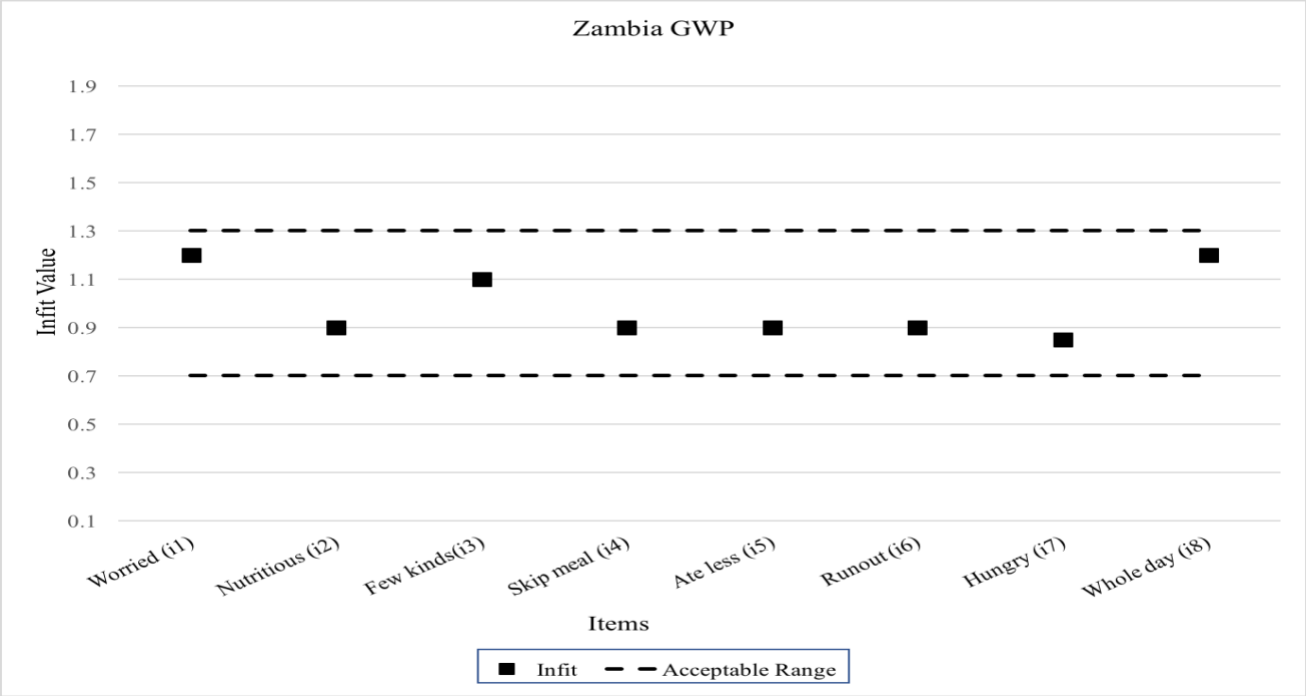


Figure 10: INFIT values of FIES items of rural survey (GROW) in Ethiopia

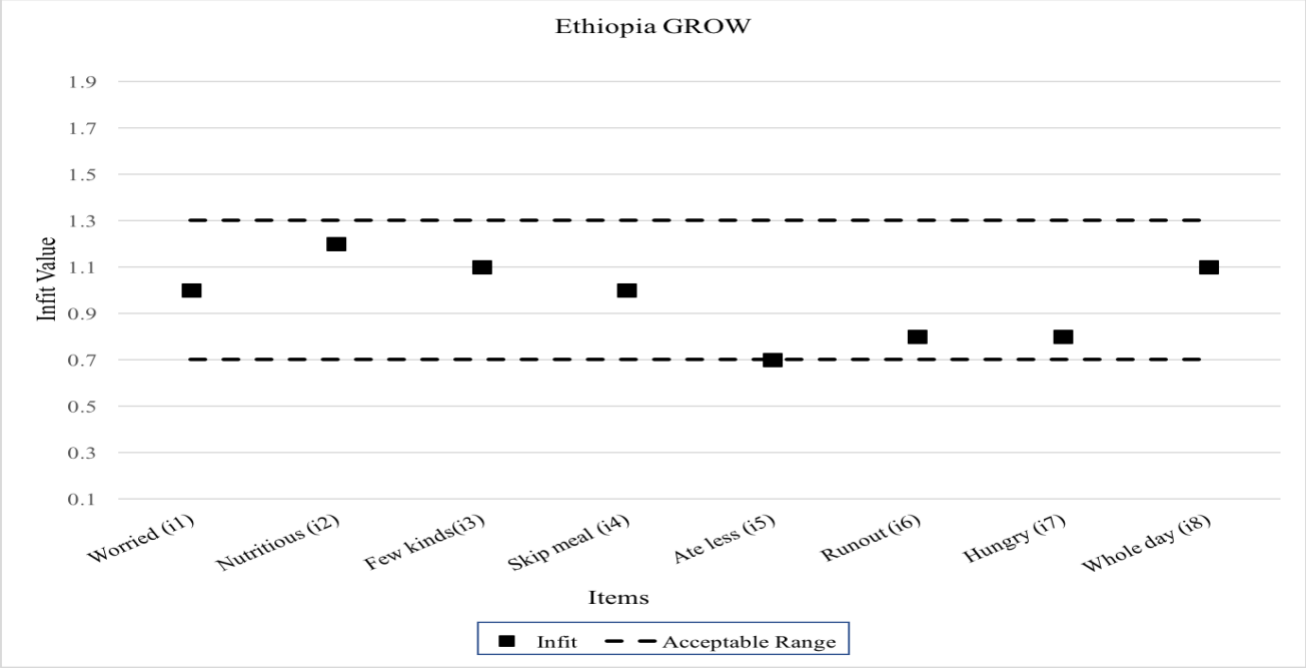


Figure 11: INFIT values of FIES items of rural survey (SANI) in Malawi

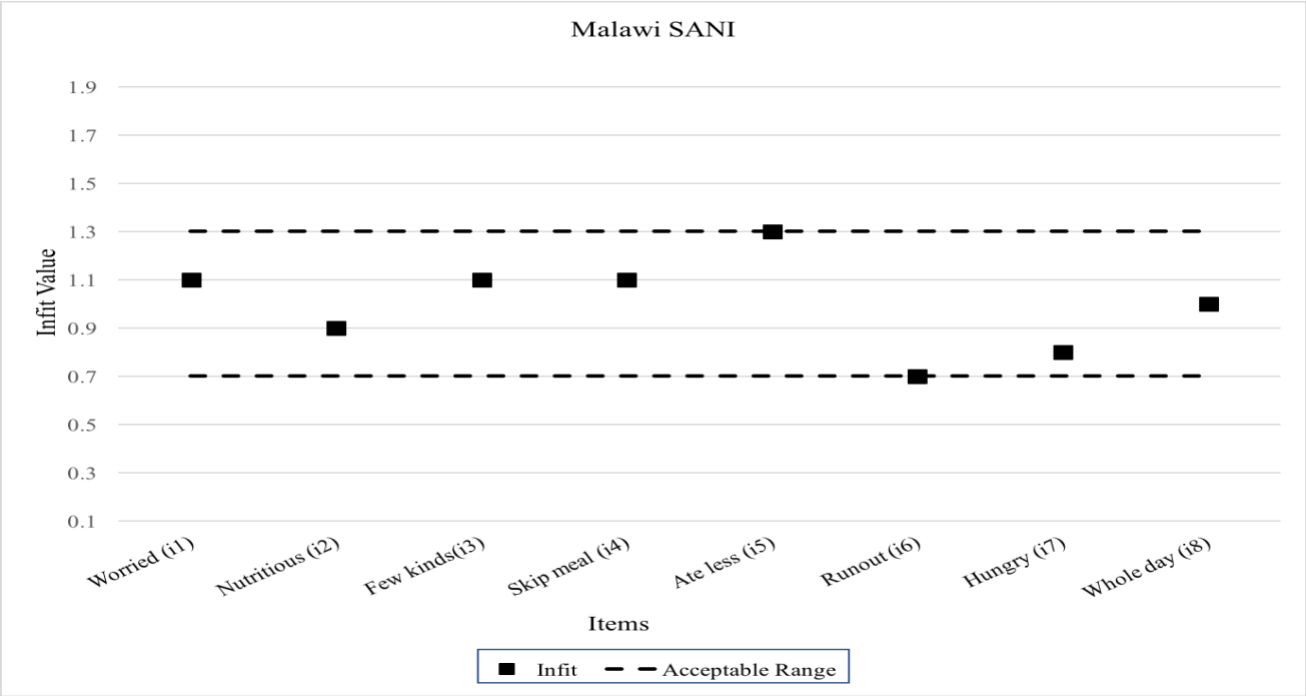


Figure 12: INFIT values of FIES items of rural survey (SANI) in Mozambique

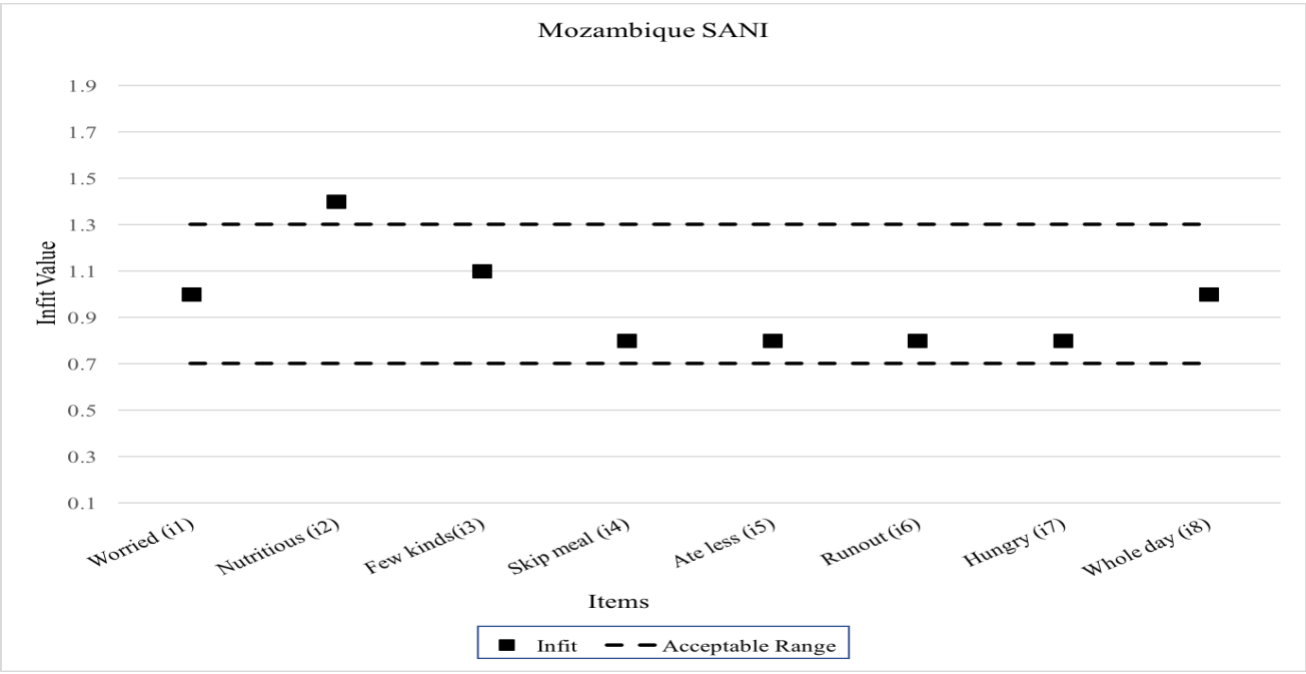
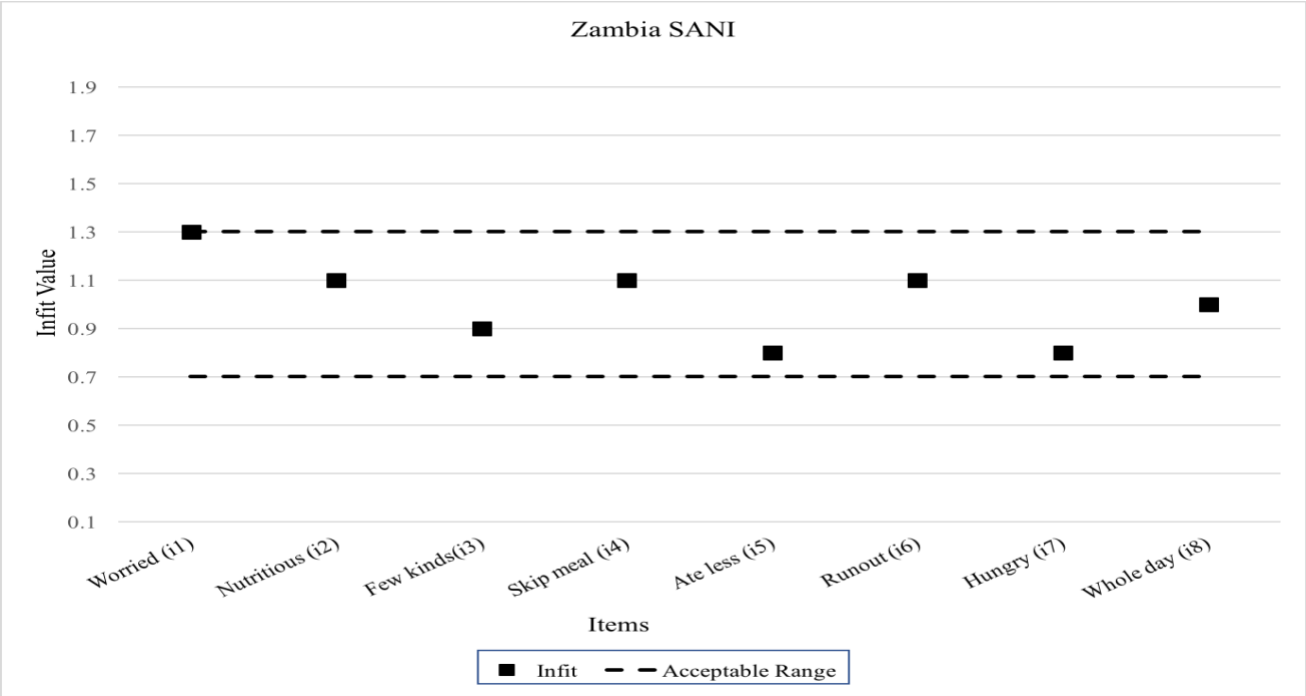


Figure 13: INFIT values of FIES items of rural survey (SANI) in Zambia



4.7.4 Comparison between samples of Women of Reproductive Age (WRA)

In Figures 14, 15, 16 and 17, the relative severity values of WRA in the rural survey were plotted against the relative severity of rural WRA sample selected from national survey to evaluate the performance of the scale among rural WRA in each country.

For the country of Ethiopia (Figure 11), severity scores for both surveys are in the same order for rural WRA. No item has a difference more than 0.5 logit units, showing that, the phenomenon of food insecurity appears to be described and experienced similarly among rural WRA from both surveys. In Malawi (Fig 12) item severity values are not in the same order. Only few items have a difference of less than 0.5 logit units (*worried (i1)* and *few kinds (i3)*). Some items in the surveys such as *nutritious (i2), skip meal (i3) and ate less (i5)* shows contrasts of greater than 1 logit unit from the indicated tolerance value (about 0.5 logit). Results for Mozambique (Fig 11) shows that four items *worried (i1), skip meal (i3), runout (i6) and hungry (i7)* differ substantially (have a difference of more than 0.5 logit units) between the two surveys. In Zambia six items (*worried (i1), nutritious(i2), few kinds(i3), skip meal(i4), runout (i6) and whole day (i8))* are different in the both survey however only one item runout has a difference of greater than 1.0 logit unit.

Figure 14: Relative severity of rural WRA in the national survey (GWP) compared to the rural survey (GROW) in Ethiopia

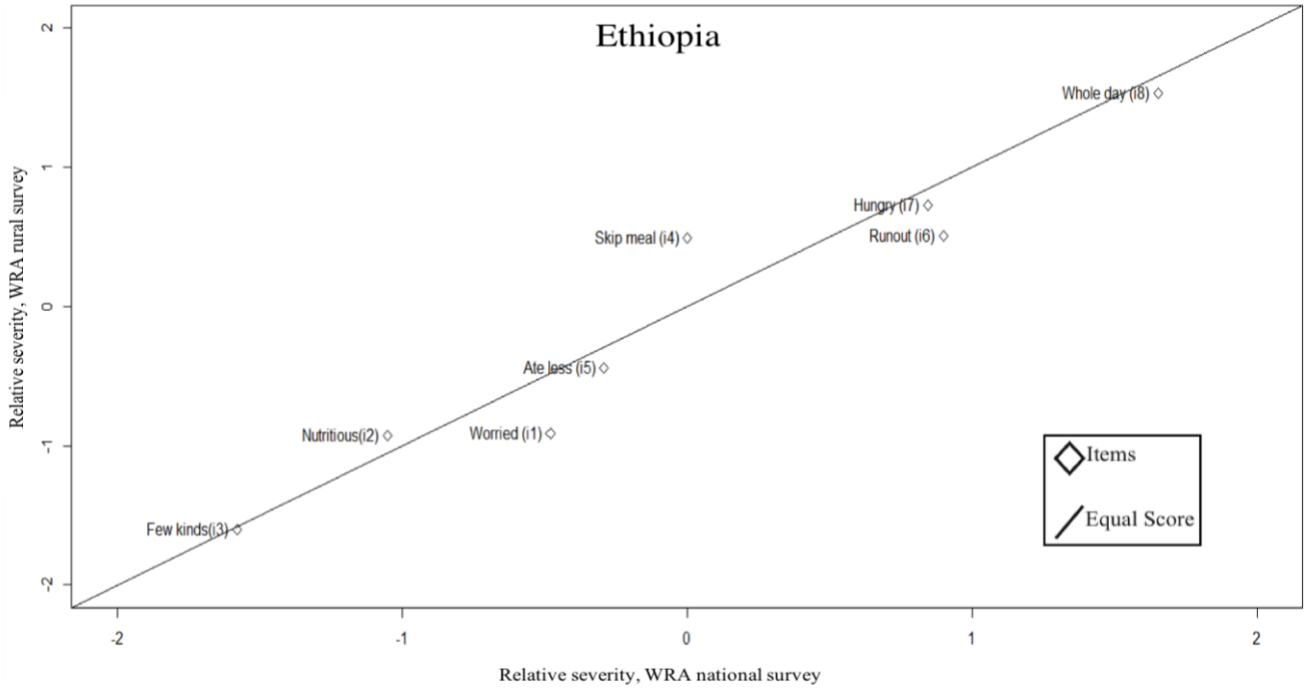


Figure 15: Relative severity of rural WRA in the national survey (GWP) compared to the rural survey (SANI) in Malawi

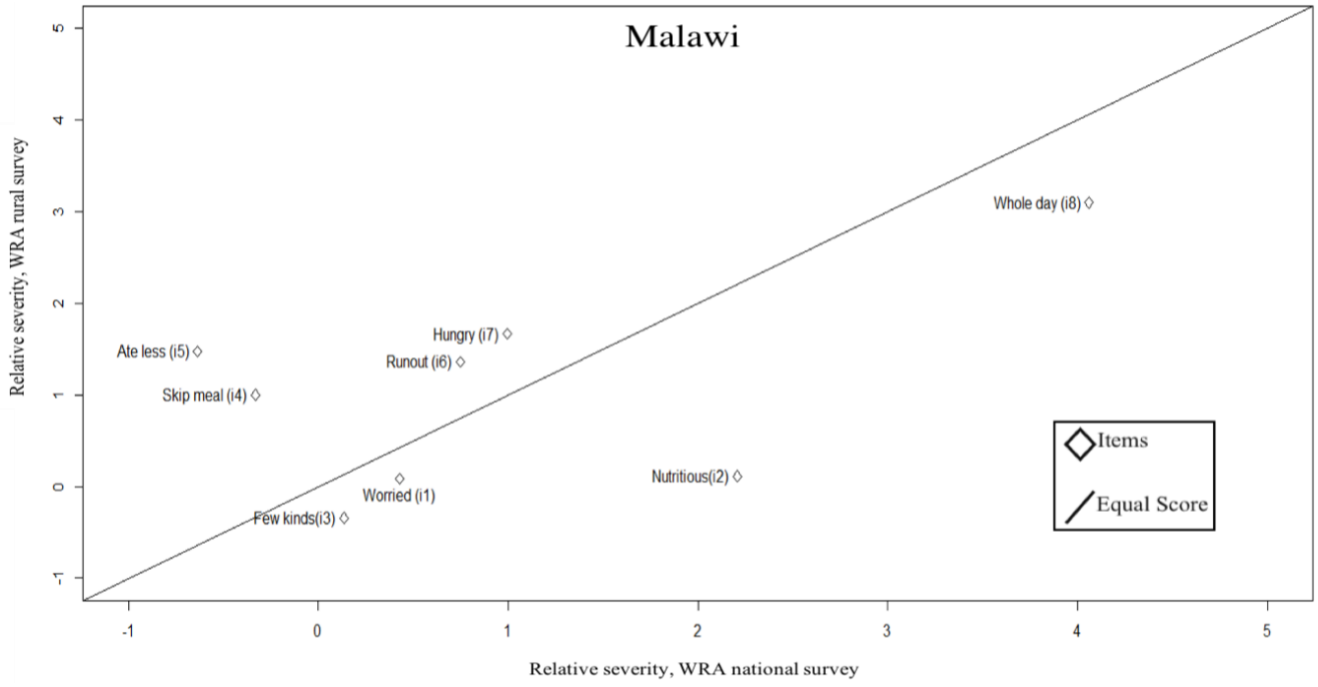


Figure 16: Relative severity of rural WRA in the national survey (GWP) compared to the rural survey (SANI) in Mozambique

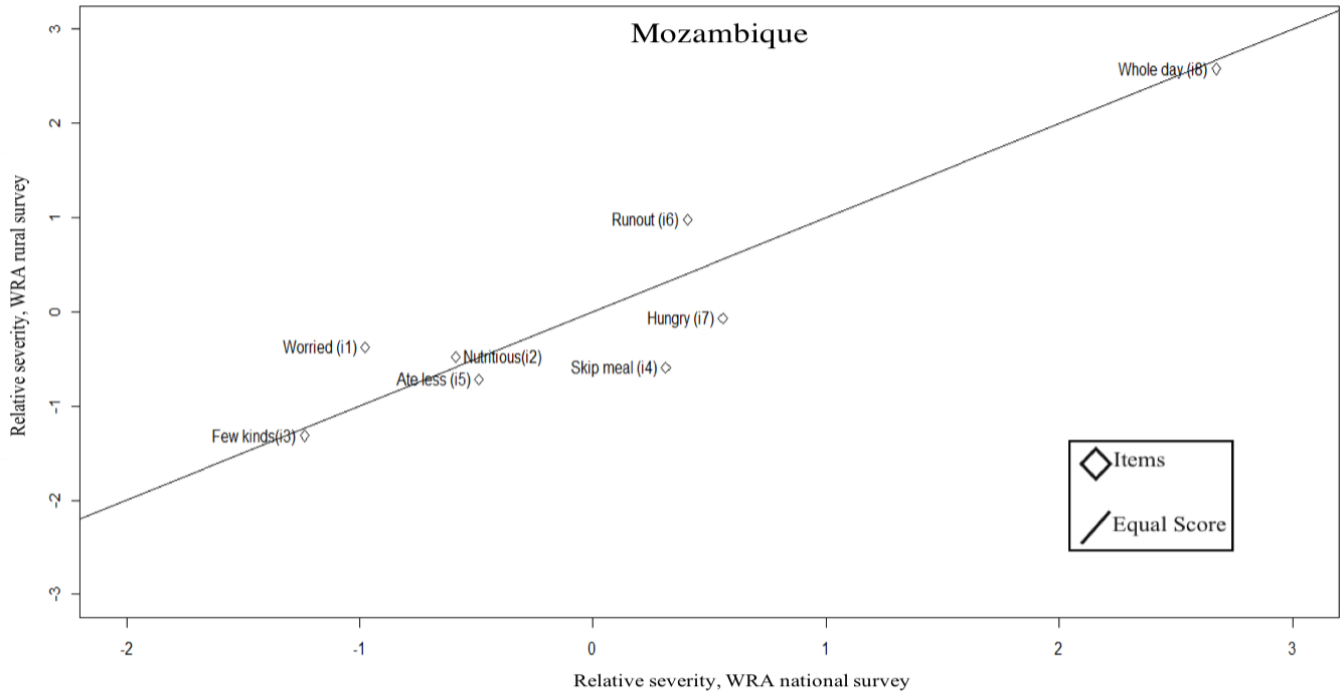
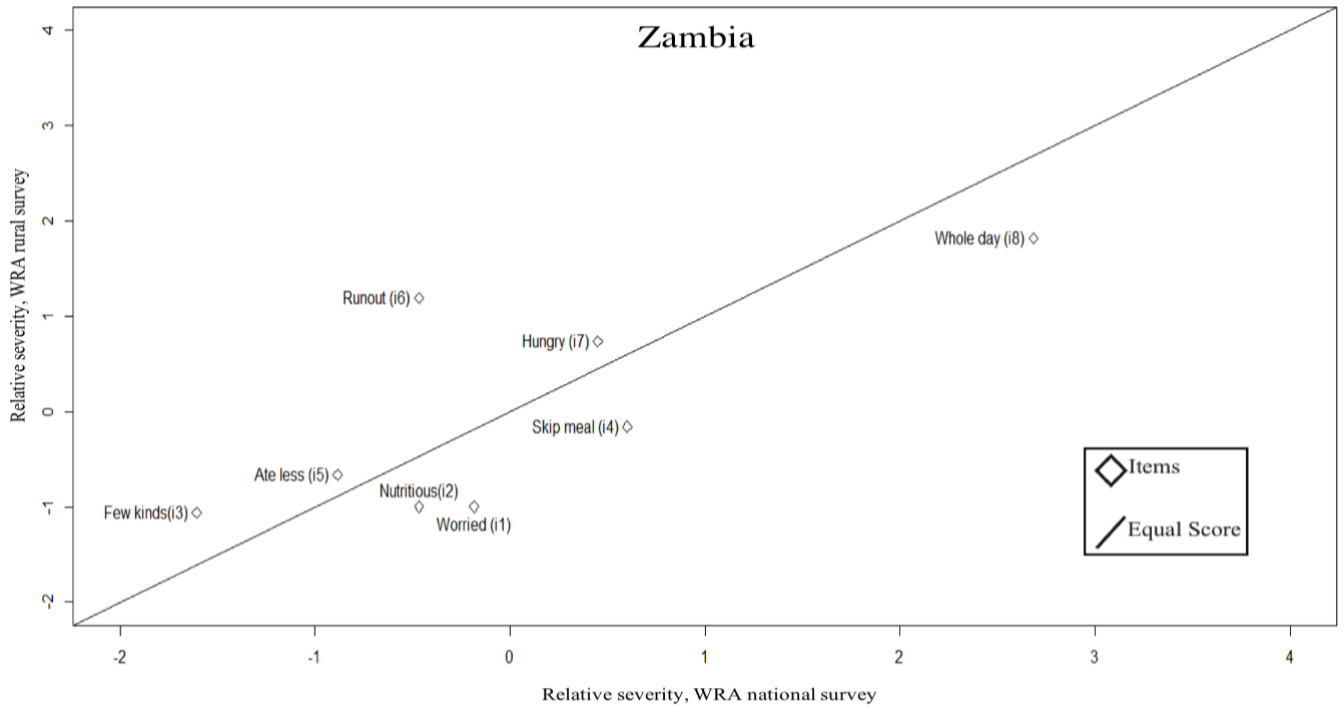


Figure 17: Relative severity of rural WRA in the national survey (GWP) compared to the rural survey (SANI) in Zambia



4.8 Discussion

This study demonstrates the utility of the recently developed experience-based scale FIES for assessing individual food security situation at national and rural survey in Eastern Africa.
Overall, most of the item severity values results were found to be in the expected theoretical sequence of food insecurity. These results confirm the common understanding of food insecurity as managed process, where change in diet quality is preceded, by worry and followed by reductions in quantity and then ultimately severe hunger (Radimer et al., 1992).

Despite the overall findings however, there are a few exceptions. Finding from Malawi in the national survey and Mozambique in the rural survey suggest that the theoretical sequence did not follow the expected food security continuum. In Malawi, only a few items are in their respective class of food security (*Few kinds (i3), Runout (i6) and Whole day (i8)*). Item *nutritious (i2),* which captures the latent trait of experiencing a reduction in quality of food, shows high severity value (0.66 logit unit). This suggests that in Malawi, based on this nationally representative sample, that reducing the quality of food may be seen as more severe than reducing food quantity. However, when the tool was applied in the rural sample, this same question was captured in the expected domain of mild severity with a low severity value (-1.04 logit unit).

There are few explanations for these unexpected findings. Results from a VoH pilot study, using the FIES tool based on national survey conducted by GWP found a similar finding. In Malawi, the severity of item *nutritious (i2)* was found within the moderate domain instead of mild domain of food insecurity (Brunelli & Viviani, 2014). Qualitative research performed during the linguistic adaptation of the FIES tool in Malawi revealed that question 2 which asks the individual whether they are unable to eat healthy and nutritious food was understood by participants as "food that gives energy" needed to perform farming activities (Ballard et al., 2013).

Additionally, due to differences in "linguistics nuances" and variability in food cultures, a few items may not represent the same meaning or domain in the different countries (Nord et al., 2016). These differences can be seen in question ordering in different EBFSS. For example, the Brazilian food security scale (EBIA) which is a precursor of FIES, item 2 which asks households in the last three months whether they "ran out of food before having money to buy more" is in a mild domain

of food insecurity. However, in FIES that same question is in position 6 which measures the moderate domain of food insecurity. It has been researched that Brazilian severity values followed an appropriate monotonic trend of increasing item severity for both adult and child items in separate analyses, which suggests that the order of items used in EBIA correspond better with the theoretical concept within that cultural context. This is a requirement for efficient scale measurement that scale is tailored for the target population (de Toledo Vianna et al., 2012). In contrast, this increasing severity trend was not seen when the same scale was applied in Brazil's National Household Sample Survey, nevertheless the items were found in their respective domain of food insecurity (Segall-Corrêa et al., 2014).

Research conducted in Iran as part of Isfahan Food Security Survey examined the internal validity of U.S. Household Food Security Survey Module (USHFSSM). Results of the US HFSSM revealed that severity items were in the expected range of the food insecurity continuum among adults and children. This demonstrated that the US HFSSM showed acceptable levels of internal validity in Iran (Rafiei, Nord, Sadeghizadeh, & Entezari, 2009). Further, when the adapted Colombian household food security survey was used in the department of Antioquia, the order of severity of items did not correspond to the expected order. In this case, it was found that, conceptually, less severe items had lower severity values than more severe items (Hackett et al., 2008). In a more recent case in Bangladesh and Zambia, when researchers used the adapted Food Access Survey Tool (FAST), item severity showed an increasing trend as questions increased which followed the expected theoretical sequence (Na et al., 2015; Na et al., 2016). These studies suggest that cultural differences may affect theoretical sequences to a minimal degree, but the food insecurity continuum is mostly consistent.

As a result of findings, efforts to measure direct experiences of a food insecurity using one tool at the global level for cross country comparison has shown some variation. This is expected because some food insecurity experiences may possibly be different across countries due to variations in cultural contexts and livelihood arrangements. However, researchers have recognized this challenge and have suggested that some items may be used as global anchors (Cafiero et al., 2018). Further it was interesting to see the results of external validation of the FIES, it revealed that food insecurity was associated with common determinants and consequences such as national income,

health, and well-being (Jones, 2017; M. D. Smith et al., 2017). And further, prevalence rate of severe food insecurity evaluated by using FIES in SOFI report are very similar with the prevalence of undernourishment, both targets are measuring the food assess and indicators of food deprivation (Cafiero et al., 2018; FAO, 2017). Our results support that a possible global anchor of the last item not eating for *whole day (i8).* This was most severe item in both surveys, which is the indicator of severe hunger. In both surveys, it follows the food security continuum and shows that in experience of hunger is the last phenomena which will take place after all food compromising strategies.

Performance of the scale was demonstrated by INFIT statistic, which looks at the assumption of equal discrimination. This assessment is conducted by checking the consistency of each item with the underlying latent trait. Generally, the majority of INFIT values were within the range from 0.7 to 1.3 in both surveys, suggesting acceptable item fit. Except four items in Ethiopia for the national survey and one item in Mozambique for the rural survey which were not in the acceptable range. Two items in both surveys had INFIT values higher than 1.3, item *worried (i1)* (2.3) in Ethiopia and *nutritious (i2)* (1.4) in Mozambique. These findings can be explained because of the cultural differences and small heterogeneous samples. In such cases researchers from Latin America considered further broader ranges of 0.6 to 1.4 to be acceptable (Rafiei et al., 2009). One particular item that is an area of major concern is the item *worried (i1)* in Ethiopia (national survey). The misfit of this item might be explained due to several reasons. First, it might be possible that the particular item lacks performance consistency due to respondent understanding or enumerator intention. As can be seen in the same item showed the perfect score of one. It is possible that local enumerators employed for the rural survey (GROW) were from the area where it was conducted and were able to explain the survey in detail to the women in a way that was easily understood. Another possible reason is that distribution due to recall basis was less in the rural survey because of the shorter reference period of one month as compared 12-month in national surveys.

Researchers suggest that INFIT statistics between 1.3 and 1.5 are still acceptable, but should marked for further examination. They suggest that if the poor INFIT value is reported again for the following year it would be better to remove the item from the survey (FAO, 2016). A pervious FIES validation study in Sub-Saharan Africa, using a large sample size (n=58,325) collected by

Gallup World Poll for the year 2014 and 2015 found that most of the item-infit statistics were less than 1.4. (Wambogo et al., 2017). Carlo Cafiero et al. globally estimated the INFIT values of 2014 Gallup world poll data and found that 94% of the countries had INFIT statistics within the acceptable range. This was exception in nine countries with small number of non- extreme cases had items with INFIT values higher than 1.4 (FAO, 2016). Results of FIES from one of pilot study carried out by VoH in Malawi found that all INFITS were in the appropriate range 0.8-1.2 (Brunelli & Viviani, 2014). When the precursor of FIES 18-item U.S. Household Food Security Survey Module was translated into Farsi and applied to a representative sample of Iranians, it was found that adult and child items values were within the 0.7 and 1.3. range. Similar results were found in the Latin American Food Security Scale (ELCSA) which showed the acceptable fit within the adequate range (0.8–1.2) when applied to nationally representative samples in Colombia and Mexico.

Food insecurity appears to be similarly experienced by rural women sample of reproductive age when measured using a national survey and reference period of twelve months, and rural survey using a reference period of one month. There were a few items exceptions in Malawi, Mozambique, and Zambia. Differences were found to be more than 1-logit unit between the severity of items *nutritious(i2)*, *ate less (i5)* and *whole day (i8)* in Malawi. This finding suggests that items may refer to a somewhat different objective by WRA. One of the possible reasons for this difference in severity values may be because the theoretical construct was not working as expected in the national survey of Malawi. It is also possible that these differences may be partially explained due to variations in languages, as well as differences in sample size of WRA used for this research. However, there are other potential sources of bias. This might involve variation in how the questionnaire was designed. The order in which the questions were asked within the survey instrument. Also, there may have been interviewer effects (age, gender, socio-economic status) on respondents. Also, interviewing training, variance in how interviewing training was conducted across countries, and settings.

However, for Mozambique and Zambia, the difference between severity values for most of the items was above 0.5 but less than 1.0. This suggests that there was some difference in how food insecurity was described and understood by WRA. Nevertheless, these findings are not a large

difference especially since some researchers consider a 1.0 logit unit as a significant difference. For example, Rafiei and colleagues in Iran, used the same method to compare relative severity of Iranian and U.S populations (a linear transformation was used to adjust the mean and standard deviation of the values of relative severity for each one of the items considered equivalent by their content). Authors reported that differences between adjusted values were even slightly higher than 1.0 logit units which indicates that the phenomenon of food insecurity is experienced and described in a similar way between the two populations (Rafiei et al., 2009). Another study from Dominican Republic (DR) compared item severity of the DR adult food security scale with those of corresponding items in the U.S scale. It was found that a few items had higher severity in the U.S and showed the difference in adjusted severity larger than 1.0 logit. Despite this difference, authors concluded that the two modules measured food security similarly in their respective countries (Bezuneh & Yiheyis, 2008). In another study researchers from Latin America used Differential Item Functioning (DIF) statistics to compare the items by adjusting item severities across Colombia, Guatemala and México with the regional scale called Latin American and Caribbean Food Security Scale (Spanish acronym ELCSA). This statistic was quantified by taking the differences of severity measures of the different groups. The value was then converted into standard normal variates using a pooled standard error. Authors found that four items with differences greater than 1.0 logit units and one which showed a difference close to 2 logit units, but despite these differences, ELCSA appeared to show the experience food insecurity in a similar manner (Melgar-Quiñonez et al., 2010)

4.8.1 Study limitation

This study had a number of limitations. The first limitation was the different recall periods used in the national and rural surveys that may affect the reliability of results. In the rural survey, one month recall period was used which is short and would likely provide more reliable data because of reduced recall bias as compared to national survey which used 12-months. It will be interesting to compare national and rural surveys with the same reference period to evaluate the performance of the FIES. Another recommendation for future FIES studies is that they include survey experiments (where a randomly assigned sub-set of the sample) are asked these questions with one short period, and the other sub-set with long recall period.

The second limitation, is the difference in sample sizes of women of reproductive age used for Rasch analysis comparing national and rural surveys. While other comparative studies (Hackett, 2008; Hackett et al., 2008; Melgar-Quiñonez et al., 2010) used for Rasch analysis had differences in sample sizes, it will be interesting to compare national and rural surveys with the same sample size. Another limitation of this study was that the surveys were matched for comparison based on three criteria (gender, age, and rural region only). As a result, effect of the heterogeneity across surveys are not controlled for. Finally, while the availability of national and rural surveys allowed us to compare the FIES across four African countries, the main limitation is that we used survey data from two different populations (nationally representative vs women in rural areas) and both surveys used different sampling strategies.

4.8.2 Implications for policy and food security research

Findings of this study demonstrate that the experience of not eating for the whole day is the most severe phenomena captured across all populations represented in both the national and rural surveys. This confirms that the FIES scale is able to deliver accurate information on the most severe phenomena of food deprivation (not eating for the *whole day (i8)*) to governments and policymakers focusing on capturing and measuring the epidemic of food insecurity. This research is timely because countries around the world have adopted or are in the process of adopting the FIES as a tool for monitoring target 2.1 (end hunger) of the Sustainable Developed Goals in preparation for 2030. Thus, this finding has significant implications for research on food insecurity by adding new evidence to the growing pool of research that confirms the psychometric performance of FIES and its validity at national and rural levels. These findings can be especially applied to the region of Eastern Africa, a region of the world that is plagued with high food insecurity, where ongoing monitoring is needed.

One of the potential areas needing further research is that of the reference period. Selecting a reference period is an important decision related to the researcher's aims and objectives. As suggested by the VoH team, a shorter reference period of the previous one month or three months is preferable in obtaining the most accurate sequence of events related direct experiences of food insecurity. This is even more important when capturing the effect of seasonality on food security is a concern or issue of the study (FAO, 2016). For example, the recommended reference period

for EBIA and ELCSA is 3 months. According to Pérez-Escamilla and colleagues one explanation given for this shorter reference period is that the phenomenon of food insecurity occurs more frequently in Latin American countries. Therefore, respondents when given longer recall period are more likely to be respond in the affirmative and show greater severity than they would with the short reference period (Pérez-Escamilla, Melgar-Quiñonez, Nord, Cecilia Álvarez, & Segall-Correa, 2007).

4.8.3 Conclusion

Overall finding of this research showed that this tool has an acceptable level of validity and can be used to monitor extreme hunger. However, this research suggests that differences may exist in the experiences of hunger due to language and differences in cultural contexts. This may result in variations in understanding of the concepts. It has been recognized by FAO that some country specific changes may be need for improved framing and adding words to better explain the eight question (Cafiero et al., 2018). Therefore, it would be advisable for each country to carry out qualitative and quantitative validation research in order to verify the consistency of this tool in across different cultural contexts.

CHAPTER 5 FINAL CONCLUSION

This research highlights the development of the Food Insecurity Experience Scale tool for measuring the assess dimension of food security as part of the global commitment to end hunger (SDG2). This tool was designed to capture direct experiences related to the latent trait of food insecurity. Because psychometric properties of this global tool are not fully studied at the local and rural level, especially within interventions aiming to improve the nutritional and food security status of populations in the developing world, this research expanded on the validation of FIES by using the Rasch modeling approach to examine samples drawn from two surveys at national and local levels in four African countries. It also examined how FIES functioned within high-risk population of women of reproductive age across surveys. Internal validation shows good fitness of the FIES to the one parameter Rasch Module assumptions. This assessment showed that the items were consistent with the underlying latent trait of food insecurity.

Overall performance of the scale was adequate, with the majority of item severity values were in the expected theoretical sequence of food insecurity. And further performance of the scale was demonstrated by INFIT statistic, that showed items were consistent with the underlying latent trait of food insecurity. However, our findings showed some variation across countries, which might be due to differences in cultural contexts and livelihood arrangements. However, this research showed that the experience of not eating for the whole day is the most severe phenomena and stood as an anchor point for the scale across countries in both national and rural surveys. This confirmed that the FIES scale is able to deliver accurate information on the most severe phenomena of food deprivation (not eating for the *whole day (i8)*) to governments and policymakers focusing on capture and measure the epidemic of food insecurity. In conclusion, FIES holds an acceptable level of psychometric validity needed to assess food insecurity and seems to be appropriate for use in comparative studies. To our knowledge, this study is the first that validates the FIES tool among women of reproductive age in rural areas by comparing with national women of reproductive age in the same country. Results highlights that experiences of food insecurity with the
FIES tool was described and understood in a similar way in both samples. One recommendation is the carrying out further qualitative research to verify the consistency of FIES within specific cultural contexts.

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