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Food Insecurity Individual Experience: A Comparison of Economic and Social Characteristics of the Most Vulnerable Groups in the World

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Abstract

Being at the core of sustainable growth, food insecurity is one of the most important issues in determining a country's level of development. The first aim of this paper is to compare food insecurity in different subpopulations across countries. The second goal is to assess which factors affect individual food insecurity in the world, while taking into account the level of a country's development. This has not been possible until very recently. Through the FAO Food Insecurity Experience Scale (FIES) module of the Gallup World Poll, the same information has been collected with an identical methodology and instrument all over the world of more than 150 thousand individuals from 147 countries. Food insecurity presents marked differences depending on the level of development of the country under consideration. To take this into account, countries have been grouped together using a cluster analysis, based on the indicators from the UN Human Development Index. The model was estimated by means of an ordered logistic regression, both at the global level and for each group of countries. The model permits identification of the economic, social, and demographic characteristics related to food insecurity. Level of education, composition and number of children in the household, and location of dwellings had a significant impact on the risk of food insecurity. These results provide valuable insight into the phenomenon and can support policies aimed at ending hunger and improving the well-being of population.

Keywords Food insecurity · Self-reported scale · Cluster analysis · Ordered logistic regression

JEL Classification Q18 · F63 · C35 · C38

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1 Introduction

Food insecurity is still one of the most significant development challenges that low-income countries face (UN 2015). In the 2030 Agenda for Sustainable Development, food security is a very ambitious, stand-alone goal: 'Goal 2. End hunger, achieve food security and improved nutrition, and promote sustainable agriculture'.

Food insecurity is a concern in most developing countries, in particular in Africa, where one out of four people remain undernourished. In fact, after a decade of decline, there was an increase in the number of undernourished people in 2016. The number of chronically undernourished people in the world is estimated to have increased up to 815 million, up from 777 million in 2015, but still below the high of 900 million in 2000. Economic growth alone is not sufficient to ensure food security. Public action to promote food security is also necessary, particularly in the areas of women's education, health, and expansion of household entitlements for food (FAO 2017).

This study will extend our understanding of social and personal risk of food insecurity. The study analyses an innovative measure of food insecurity based on self-stated information: the FAO's Food Insecurity Experience Scale (FIES). The FIES will be used to investigate factors related to the level and severity of food insecurity within and across the 147 Countries surveyed in the Gallup World Pool (Gallup 2017).

Measures of food insecurity based on individual data on people's direct experience are considered more reliable than model-based macro measures (Coates 2013). Therefore, when analysed together with personal and familial characteristics, FIES data can deepen our understanding of the risk factors and consequences of individual and household food insecurity.

The analysis is carried out by means of an ordered logistic regression. The resulting model is intended to expand our knowledge of individual perception of food insecurity and determine which factors have a significant impact on individual food insecurity. The model also allows us to focus on how the factors affecting food insecurity may vary across countries with varying levels of development. In particular, the study will enhance the understanding of social, gender, and age specific vulnerability to the risk of food insecurity. Moreover, through cluster analysis, the countries have been classified on the basis of the Human Development Index, and this classification—included in the model—allowed us to highlight the effects that different levels of development have on food insecurity. The same analysis has been carried out for every single cluster of countries, thus allowing us to identify the specificities of each cluster.

Since the World Food Conference in 1974, the concept of food security has evolved and diversified (Maxwell 1996). The topic is widely debated in the literature (Burchi and De Muro 2016; Grobler 2016; Misselhorn et al. 2012; Frongillo 1999), and there are as many different definitions and measures of the phenomenon (Cafiero et al. 2014; Allen 2013; Jones et al. 2013; Coates 2013) as there are different types of surveys for its detection and indicators for its synthesis and evaluation (Carletto et al. 2013; Terzi 2013; Alkire and Fang 2018; Allen et al. 2018).

Research on the topic of experienced food insecurity dates back to the 1960s (Kennedy 2003), but it had a further boost after the food price crisis in 2008, and more recently after the publication of the 2030 Agenda of the Sustainable Development Goals (UN 2015). The availability of Gallup World Data on the global level further increased interest in the study of individual determinants of food insecurity (Smith et al. 2017a, b).

The use of self-report indicators to measure food insecurity in different countries has been widely debated, largely because the individual perception of hunger can vary

across individuals due to their history of nutrition or their different psychometric characteristics. However, the importance of obtaining individual data on access to food has been recognised, because the mere presence of food in the economy or in the market does not necessarily guarantee that a household will receive it or that a person will consume it (Barrett 2002; Sen 1981; Anand and Sen 1997).

The scientific literature is very rich in self-report and other subjective measures of poverty, and there is a wide range of self-report-based food security instruments. The interest in the comparison of subjective and objective measures is still very high in many branches of science (Gelman and Hennig 2017). As noted by many scholars, however, a more fruitful way of approaching the issue is 'to follow the path of relatedness rather than opposition' (Brulè and Maggino 2017).

In the paper 'The missing dimensions of Poverty Data' (2007), Alkire highlights the importance of 'psychological and subjective states of well-being, which have clear intrinsic and instrumental value'. In 2015, the same author notes that well-being measures are highly likely to engage subjective and self-report data among other data sources, and happiness is often recognised as a dimension of well-being in the capability approach (Alkire 2015).

In the report of the commission on the Measurement of Economic Performance and Social Progress, Stiglitz et al. (2009) legitimised the use of subjective measures of poverty and well-being. In recommendation 6, they stated that the evaluation of quality of life 'requires both objective and subjective data', while in recommendation 10 they note 'measures of both objective and subjective well-being provide key information about people's quality of life'. More specifically, the fair allocation approach and the capability approach 'have obvious differences, but also certain similarities. For example, subjective well-being is sometimes claimed to encompass all capabilities, in so far as these refer to attributes and freedoms that people value (implying that enhancing their capabilities will improve people's subjective states)'.

Posel and Rogan (2016) note several advantages of self-assessed poverty measures compared with money-metric poverty measures. Subjective assessments of poverty do not depend on a pre-determined, expert-derived poverty threshold, and they do not require assumptions about how to adjust resources for household size economies in consumption and for the different needs of adults and children (Ravallion and Lokshin 2001). Moreover, subjective measures are usually able to take into account longer-term effects of economic status, like accumulated wealth, on the current income and expenditure of the households (Posel and Rogan 2016). Furthermore, subjective assessment can capture the expectation of the household on future economic downturn and opportunities for household members (Posel and Casale 2011).

Barrett (2010) pointed out two important issues related to perceptions-based indicators of food insecurity. First, because most food insecurity is seasonal or aperiodic—correlated with episodes of temporary unemployment, ill-health, or other adverse events—perceptions-based survey measures consistently find food insecurity rates several times higher than related hunger or insufficient-intake measures. Second, qualitative assessments may not suffice to capture the utilization aspect of food insecurity, such as the one associated with lack of micronutrients in the diet.

The recent Atkinson Commission Report (World Bank 2017) encourages scholars to use subjective assessments of personal poverty status. In order to measure the subjective assessment of poverty, the use of the Gallup World Poll is recommended because it covers most countries of the world every year, including more than two-dozen countries in Africa, and asks identical questions throughout the world.

As stated in research by Alexandri (2015), the factors influencing the four main pillars of food security (availability, access, utilization, and stability) are complex. Access to food depends not only on agricultural productivity, but also and mainly on the development of human communities, on their incomes and distribution, as well as on the sanitary and food safety conditions.

Even in countries where food is available, people are affected by food insecurity, due to the lack of tools to access food. So, while at macro level, governments create the conditions for their population to be supplied with available food and to gain the necessary incomes to procure it (availability and access), food insecurity is indeed a problem that refers to households and individuals, because procurement and consumption of food is ultimately a personal behaviour (Alexandri 2015). In this respect, there are frequent situations, in poor countries, but even in the richest countries, where there are communities and persons subject to food insecurity or who are at high nutritional risk. In the same countries, multiple forms of malnutrition coexist, with countries experiencing simultaneously high rates of child undernutrition, anaemia among women, and adult obesity (FAO 2017).

In Sect. 2, we describe the FIES data and give extra attention to the scale used to represent the experience of food insecurity, the resulting measures, and the characteristics of the survey. In Sect. 3, we present the results of a cluster analysis based on the indicators composing the UN Human Development Index; this is done in order to group the available countries by level of development. In Sect. 4, we present the model, and in Sect. 5, its results. Finally, we present our conclusions and policy remarks.

2 Methods and Data

The major experiences in the field of qualitative measures of food insecurity relate to the work of the United States Department of Agriculture on the 'Household Food Security Measurement Scale' (Hamilton et al. 1997); the 'Household Food Insecurity Access Scale' (Coates et al. 2007) and the 'Household Hunger Scale' (Deichtler et al. 2011).

The FAO Voices of the Hungry project (VOH) has developed an experience-based food insecurity scale module called the Food Insecurity Experience Scale (FIES). The FIES originated from an initiative in Latin America and the Caribbean, and it is based on a short form of the Latin American and Caribbean Food Security Scale (Escala Latinoamericana y Caribeña de Seguridad Alimentaria, or ELCSA), with roots in the US HFSSM, as well as the Household Food Insecurity Access Scale (HFIAS) developed by the U.S. Agency for International Development (Ballard et al. 2013).

2.1 FIES Sample Survey Specification

This section describes the characteristics of the survey that produced the data used in this work. Therefore, we refer only to the sampling methodology adopted.

Surveys are conducted in 147 countries all over the world, and they provide the first nationally representative data on the food access dimension of food insecurity at the individual level. It is worth mentioning that this is the first time that the same survey methodology and questionnaire have been used in a very large number of countries, thus allowing scholars to compare the phenomenon at the individual level across different countries.

The study adopted a three-stage sampling procedure (Fuller 2009, pp. 208–233) to select the sample.

The linguistically and culturally adapted FIES questions were directed to adult individuals randomly selected at the third stage who reside in sample households that were randomly selected in the second stage from primary sampling units which were in turn either randomly selected or selected based on probabilities proportional to population size in the first stage (Gallup 2017). Surveys were conducted on national samples of 1000 adult individuals representative of the male and female resident population aged 15 and older. In very large countries such as India and China, sample size increases up to 5000 individuals).

Inclusion of the FIES in the annual GWP enables collection of cross-culturally comparable information from individual respondents at a relatively low cost and also provides country-level estimates of the severity of food insecurity (Nord 2012, 2014). FIES follows the Rasch measurement model (Rasch 1960), thus the level of food insecurity is determined by summing the number of positive answers to the FIES, and this results in a 'raw score' that represent the individual food insecurity status, that we ndifferences would be significant, we rely on amed 'Fies Score'.

2.2 Food Insecurity Measure

FIES is a measure of access to food at the level of individuals or households. It measures severity of food insecurity based on people's responses to questions about constraints on their ability to obtain adequate food. The FIES is based on three aspects of food insecurity: uncertainty/anxiety, changes in food quality, and changes in food quantity (Ballard et al. 2014).

FIES consists of a set of eight short questions asked directly to individual adults. The questions (items) that compose the FIES module ask people whether they have to compromise the quality and quantity of the food they eat due to limited money or other resources for obtaining food. FIES is derived from two of these widely-used experience-based food security scales: the US Household Food Security Survey Module and the Latin American and Caribbean Food Security Scale (Spanish acronym ELCSA), as described in Ballard et al. (2013).

FIES has been simplified in order to make the scale comparable at the international level. In particular, information has been collected at the individual level rather than at the household level; the number of item responses has been reduced to eight; and response categories are only 'Yes' or 'No', rather than ordinal variables. A reference period of 12 months has been chosen to ensure comparability of surveys conducted in different months, capturing the seasonality of the phenomenon.

The FIES questions survey self-reported behaviours and experiences related to food; this captures difficulties in accessing food. Each item refers to a different situation and is associated with a level of severity according to the theoretical construct of food insecurity underlying the scale. The characteristics of the scale (limited number of questions, binary responses, long period of reference) maximize the comparability across countries.

Although the FIES is not the first individual-level, experience-based scale in the field of food security, it is the first individual-level measure that has been applied to a large number of countries in a standardized manner. Therefore, it will be the first tool able to generate comparable disaggregated data on food security at the global level. The choice of taking the individual as the unit of analysis has been driven by the recognition that households do not necessarily distribute resources equitably and should not be conceived as a unique entity (Brunelli and Viviani 2014).

The measure of food insecurity associated with a respondent can be calculated on the scale based on the number of positive responses to the questions (number of behaviours or experiences reported). In this way, we obtain our dependent variable: a 'Fies Score' of the symptoms of food insecurity, ranging from 0 (no symptoms) to 8 (all symptoms). Therefore, the dependent variable indicates whether the interviewee stated none, one or more symptoms of food insecurity. Considering FIES's characteristics, the raw score can be analyzed as an ordinal variable, with values from 0 (no symptoms of food insecurity) to 8 (all symptoms of insecurity).

Given that the sequential order of the categories has a precise meaning (severity of the symptoms of food insecurity), it is also appropriate to use an ordinal (or ordered) logit model for the analysis.

The proportion of food insecure people is very much affected by the economic and social condition of countries, as shown in Fig. 1.

Food insecurity is worst in parts of sub-Saharan Africa, as well as in southeastern and western Asia. This was most notable in areas of conflict, in particular where food security was already impacted by droughts or floods, linked in part to the El Niño phenomenon and climate-related issues (FAO 2017).

The distribution of the Fies Score as defined in Sect. 2.2 shows that the share of individuals with zero symptoms of food insecurity ranges from 92.5% in Switzerland and Singapore to 2.1% in South Sudan. The indicator captures the phenomenon also in wealthy and very wealthy countries. Whether one relies on the measure based on FIES data, other more established metrics, or theoretical knowledge of the phenomenon, food insecurity is more severe in Africa.

We have thus shown that the individual conditions are linked to the economic and social situation of the country where individuals have their dwelling rather than geographical contiguity of territories.

Therefore, in our analysis, we have taken into account the specificity of countries including clusters based on the Human Development Index.

Rawscore 80-100
Rawscore 60-80
Rawscore 40-60
Rawscore 20-40
Rawscore 0-20

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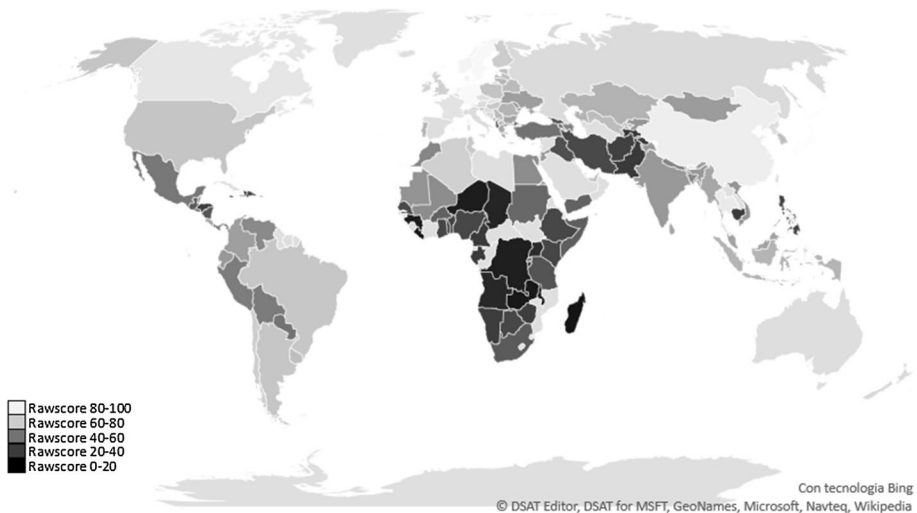© DSAT Editor, DSAT for MSFT, GeoNames, Microsoft, Navteq, Wikipedia

Fig. 1 Proportion of population with no symptoms of food insecurity (*Fies Score* = 0). *Source*: authors' elaboration on FIES GWP data

2.3 Empirical Analysis: Food Insecurity Related Factors

In this section, we present a descriptive analysis of the variables included in the FIES dataset. Following the existing literature and the availability of data, we analyse food insecurity in relation with individual characteristics such as gender, age, education, and household specificity, like the number of children in the family (Bartfeld et al. 2006).

Global level studies on the individual determinants of food insecurity are lacking. However, some studies have analysed food insecurity determinants in specific countries or areas (Akimboade and Adeyefa 2018; Aurino 2016; Brunelli and Viviani 2014; Asenso-Okyere et al. 2013; Nord 2011; Hadley et al. 2008). Only recently, thanks to the availability of FIES data in the GWP, some results have been available at the global level (Smith et al. 2017a, b).

Our data show that a larger proportion of women experience food insecurity than men: 45.3% of the female population present at least one symptom of food insecurity, compared with 43.3% of men. If we consider two or more symptoms, women are food insecure in almost 40% of the population, compared to 32% among men.

The proportion of people younger than 35 years old that are food insecure is around 40%, while among elderly people 30% present symptoms of food insecurity. This result could be related to a lower need of food intake for older people (Smith et al. 2017b).

In our analysis, two thirds of people with a lower degree of education present at least one symptom of food insecurity; that proportion is much lower among more educated people (37%).

The indicator we used to measure extreme poverty (income lower than $1.25 per day) appears to be extremely relevant in vulnerability to food insecurity. Clearly, among households with very low income, the proportion of people with no symptoms of food insecurity is only 20%, while it is 62.2% among other families. This result demonstrates that the two phenomena are correlated, but still distinct. Food insecurity can exist even in households which are not extremely poor, while, in some way, one out of five extremely poor households can afford to have enough food. This result extends at the world level similar research that find out that lower household income is associated with significantly higher rates of food insecurity, as in the United States (Coleman-Jensen et al. 2016). In Africa, where FAO (2017) underlines a very fragile situation due to conflicts and natural disasters, the proportion of people without any symptom of food insecurity is much lower than everywhere else, regardless of whether one is poor or not: less than a third of the African population do not present any symptoms of food insecurity (30.2%), compared to 60.7% in Asia or 76.3% in Europe.

3 FIES Countries by Level of Development

In order to maximize the effects of policies on food insecurity, policy makers have to take into account similarities in the level of development of the population in the areas in question. Starting from this idea, we have grouped countries using three indicators that form the UN Human Development Index (HDI) because this indicator summarizes economic and social aspects of the level of development (Anand and Sen 1997).

Like other socio-economic phenomena, food insecurity depends on latent variables that are not directly measurable. Thus, in the analysis, it is necessary to take into

account the characteristics of countries that can have an indirect impact on food insecurity. In other words, the distribution of food insecurity does not depend exclusively on topographical elements such as spatial proximity and related metrics, but also on characteristics of the population of the areas in question, such as other socio-economic phenomena (Benassi and Naccarato 2016, 2017).

Table 1 presents a dependence analysis of Fies score and personal and household correlates of food insecurity. Geographic differences impact the gravity of the risk factors, but the relationship with food insecurity-related factors does not change. These relationships cut across continents; thus, they are significant regardless of geographic location, which is of great importance in the distribution of the phenomenon.

Taking into account that the relations do not vary significantly with the topographic position, but rather with the level of development, clusters have been identified that are homogeneous with respect to the level of development measured by the indicators from the UN HDI: Life expectancy at birth, mean years of schooling, and gross national income (GNI) per capita (UNPD 2015; Ul Haq 1996).

Instead of using the threshold defined for the index, that present some subjective choices in the aggregation process, we prefer to group the countries with similar level of development using a Hierarchical Cluster Analysis (Ward method), as in Marden (2015). This procedure allowed us to identify similar groups to take into account into the model. The results obtained are robust, varying the aggregation method.

Five clusters have been obtained: 1. "Very rich and developed countries": countries with very high per capita income and high level of development (HDI ranging from 0.816 to 0.944, average 0.888); 2. "Rich and developed countries": high income and very high level of development (West Europe, HDI from 0.824 to 0.935, av. 0.898); 3. "Intermediate countries": medium–high development countries (Eastern Europe and South America, with a HDI from 0.779 to 0.880, and average 0.835); 4. "Less developed countries": lower development (China, some Asia, North Africa, from 0.628 to 0.818, with an average of 0.741); 5. "Least developed countries": low level of development

Table 1 Chi square tests for the analysis of dependence among Fies Score and individual characteristics *(Chi square and p values). Source*: Our elaboration on FIES data

X^2	World	Africa	America	Asia	Europe	Oceania
Gender	71.421	44.969	45.366	41.298	198.400	11.926
	Pr=0.000	Pr=0.000	Pr=0.000	Pr=0.000	Pr=0.000	Pr=0.155
Age class	1900.000	81.981	204.071	179.736	62.255	120.308
	Pr=0.000	Pr=0.000	Pr=0.000	Pr=0.000	Pr=0.000	Pr=0.000
Marital status	1200.000	523.301	421.698	443.319	458.370	59.217
	Pr=0.000	Pr=0.000	Pr=0.000	Pr=0.000	Pr=0.000	Pr=0.000
Number of children	12000.000	1200.000	908.711	1800.000	170.453	136.342
	Pr=0.000	Pr=0.000	Pr=0.000	Pr=0.000	Pr=0.000	Pr=0.000
Education	16000.000	1900.000	1800.000	2300.000	1700.000	41.424
	Pr=0.000	Pr=0.000	Pr=0.000	Pr=0.000	Pr=0.000	Pr=0.123
Poverty	22000.000	4100.000	1200.000	2900.000	525.269	10.728
	Pr=0.000	Pr=0.000	Pr=0.000	Pr=0.000	Pr=0.000	Pr=0.218
Location	4500.000	1800.000	529.805	770.139	92.015	28.520
	Pr=0.000	Pr=0.000	Pr=0.000	Pr=0.000	Pr=0.000	Pr=0.643

(Africa, India, South-Est Asia, HDI ranging from 0.348 to 0.745, with an average of 0.55).

As shown in Fig. 2, as widely known in the literature, less developed countries are present mostly in the southern half of the world.

4 The Model

As shown above (Sect. 2.3), the social and economic characteristics that are related to food insecurity at individual level are gender, age, and education at the individual level as well as household income, household composition (couples, lone parents, with or without children), and location of dwelling.

Our study analyses food insecurity measured by the FIES, in relation to these variables. In this way, we will improve the understanding of how household and individual factors affect food insecurity across countries. Moreover, comparisons of food insecurity in different economic and demographic subpopulations across the world can help identify the groups of population that should be the target of programs and policies.

In order to verify if the observed differences would be significant, we rely on a standard multivariate set-up:

$$
\begin{aligned}
g(y) = \text{logit}(y) = \alpha c &+ \beta_1 \text{ gender} + \beta_2 \text{ age} + \beta_3 \text{ age}^2 + \beta_4 \text{ single} \\
&+ \beta_5 \text{ married} + \beta_6 \text{ widow separated divorced} \\
&+ \beta_7 \text{ other marital status} + \beta_8 \text{ education} + \beta_9 \text{ extreme poverty} \\
&+ \beta_{10} \text{ rural area or farm} + \beta_{11} \text{ small town or village} + \beta_{12} \text{ large city} \\
&+ \beta_{13} \text{ suburb} + \beta_{14} \text{ other location} + \beta_{15} \text{ cluster1} + \beta_{16} \text{ cluster2} + \beta_{17} \text{ cluster3} \\
&+ \beta_{18} \text{ cluster4} + \beta_{19} \text{ cluster5} + \varepsilon
\end{aligned}
$$

Cluster 1 very rich and developed countries
Cluster 2 rich and developed countries
Cluster 3 intermediate countries
Cluster 4 less developed countries
Cluster 5 least developed countries

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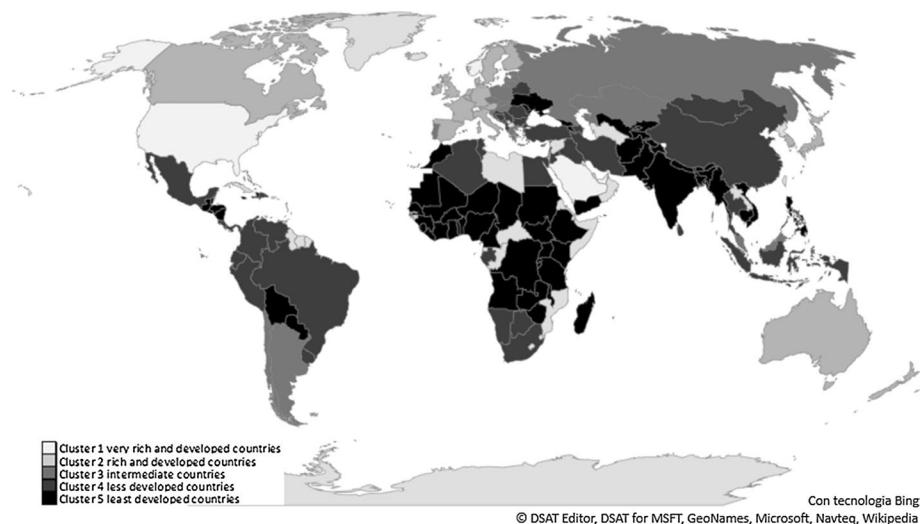© DSAT Editor, DSAT for MSFT, GeoNames, Microsoft, Navteq, Wikipedia

Fig. 2 Countries by cluster. *Source*: our elaboration on UN HDI data

where the dependent variable FIES, measured by the Fies score (score of severity of food insecurity) has been analysed in relation with:

- Observable individual characteristics: a dichotomous variable related to gender, age, age square, dummies for marital status, level of education;
- Household economic and social covariates: urban/rural location (dummies), a dummy for extreme poverty, number of children in the household;
- Country specification: a dummy for each cluster has been included, in order to consider in the model a characterization of the different territorial specificities;

The parameters αc, called thresholds or cut-points, are in increasing order ($\alpha 1 < \alpha 2 < \ldots$). Their number is $c = 1, 2, \ldots, C - 1$, where C is the number of categories of the ordinal variable.

Considering FIES's characteristics, it can be analysed as an ordinal variable, with values ranging from 0 (no symptoms of food insecurity) to 8 (all symptoms of insecurity).

In this case, we analyse the Fies Score, the variable given by the sum of affirmative answers to each of the eight questions composing the FIES.

Given the nature of Fies Score, an ordered logistic regression has been applied to the dependent variable (Wooldridge 2002). We found that the nine categories of the Fies score have a meaningful sequential order: a higher value shows indeed a 'higher' level of food insecurity than the previous one. However, given the presence of numerous zeroes in the distribution of the variable, data have also been analysed through a tobit regression. That analysis provided evidence that the presence of the zero values was not generated by a distribution process different from the one that generated the other values of the distribution. The analysis carried out allows us to conclude that this does not happen. Therefore, an ordered regression model seemed a better choice for our data.

5 Results and Discussion

Our data allow us to analyse factors related to individual food insecurity worldwide, expanding the results of previous works, which were limited to analysis in single countries or geographic areas. Because the survey methodology was the same in all the available countries, analysis at global level has been appropriate. Starting from these comparable data, the model allows us to determine factors significantly related to food insecurity at the individual level and also to link these results to the level of development specified by the clusters identified in Sect. 3.

Our analysis has been able to provide results also in very developed countries, where the phenomenon is less marked and not frequently studied.

5.1 Determinants of Food Insecurity at the Global Level

The exogenous variables (Sects. 3 and 4) appear significantly related to the Fies Score. Gender, age, number of children in the household, marital status, location of the household, and poverty are all associated with the probability of experiencing food insecurity (see "Full model" section in "Appendix").

Table 2 The determinants of FIES at the global level (estimated coefficients and standard errors). *Source*: our elaboration on FIES and UNHDI data

Fies score	Coef.	Robust standard error	z	$p>|z|$	[95% conf. interval]	
Gender (ref. male)	0.066364	0.013814	4.80	0.000	0.039289	0.093439
Age	0.042193	0.002307	18.29	0.000	0.037671	0.046715
Age^2	− 0.00046	2.42E−05	− 19.02	0.000	− 0.00051	− 0.00041
Education	− 0.48055	0.011757	− 40.87	0.000	− 0.50360	− 0.45751
Poverty (ref. extreme poverty)	− 1.09239	0.019507	− 56.00	0.000	− 1.13062	− 1.05416
Number of children	0.087022	0.004597	18.93	0.000	0.078012	0.096031
Marital status (ref. single)						
Married	− 0.2708	0.021123	− 12.82	0.000	− 0.31220	− 0.22940
Widow divorced separ	0.24902	0.028645	8.69	0.000	0.192876	0.305164
Other	0.404658	0.029561	13.69	0.000	0.346719	0.462596
Location (ref. farm, rural location)						
Small_town	0.056921	0.014659	3.88	0.000	0.02819	0.085653
Suburb	0.235091	0.026751	8.79	0.000	0.182659	0.287522
Other_location	0.248219	0.098202	2.53	0.011	0.055747	0.440691
Cluster (ref. cluster 1)						
Cluster3	0.565436	0.030303	18.66	0.000	0.506044	0.624828
Cluster4	0.893671	0.026349	33.92	0.000	0.842028	0.945313
Cluster5	1.66783	0.026622	62.65	0.000	1.615653	1.720008
Threshold values						
/cut1	0.398441	0.057068			0.28659	0.510292
/cut2	0.799815	0.057149			0.687805	0.911826
/cut3	1.124058	0.057213			1.011923	1.236192
/cut4	1.494254	0.057338			1.381873	1.606635
/cut5	1.821687	0.057434			1.70912	1.934255
/cut6	2.148434	0.057511			2.035714	2.261154
/cut7	2.478574	0.057602			2.365678	2.591471
/cut8	3.078648	0.05791			2.965146	3.19215

Despite the heterogeneity of countries, our results identify key characteristics of food insecure population across 147 countries, extending at a global level some relationships already found at the local level.

For women, less educated people, people living in extremely poor households or with a higher number of children, the probability of a higher food insecurity increases (Table 2).

In the literature, the most important and frequently reported factor related to food security is gender. Brunelli and Viviani (2014) report the study of Nord (2011) on data from the National Health and Nutrition Examination Survey (NHANES), where he proved that American women are more likely to experience food insecurity than American men in households with the same food insecurity and income. Results are similar in the study conducted by Hadley et al. (2008). In that study, the authors concluded that, in Ethiopia, girls were more likely than boys to report being food insecure, even when controlling for their households' food insecurity level. Aurino (2016) found similar results for India; a wide pro-boy gap emerges in the middle of adolescence: 15-year-old girls are less likely

to consume quality food. In South Africa, risk of food insecurity appears to be more pronounced in female-headed households (DOA 2002). Furthermore, male-headed, small-scale farm households are more food secure than female-headed households, and this finding is consistent under subjective and objective measures of food security (Tibesigwa and Visser 2016). In particular, considering individual characteristics in our model, gender presents a significant association with food insecurity, and women appear significantly more at risk. In our model, the variable 'age' has a significant effect only by introducing its quadratic term. This last term has a negative sign, indicating a reduction of the intensity of the impact on food insecurity as age increases.

As in the literature (Nord 2011; Smith et al. 2017b), education appears to be an important tool against food insecurity. Th degree of education is a good proxy for social status, and it is related to employment insecurity (Nord 2008). In our analysis, the estimated coefficient presents a negative value, higher than those estimated for other explanatory variables. This confirms that the increase in the degree of education achieved reduces the risk of food insecurity worldwide. As underlined in Sect. 2.3, extreme poverty is a very important risk factor for food insecurity. Income and food security have common determinants, but the two are conceptually distinct. In fact, while income may determine a household's economic access to food, it by no means guarantees household food security, which requires availability, utilization, and stability of food (Coates et al. 2003). Living in an urban area or in the outskirts of a big city determines a higher risk of food insecurity. The 2007 and 2008 rise of food prices caused an increase in hunger worldwide, pointing out the fragility of a very large urban population that have incomes so low that any increase in the price of food puts them at very high risk of food insecurity (Cohen and Garrett 2010).

With regard to the determinants related to the households' characteristics, our analysis confirms that, generally, married individuals are less likely to experience food insecurity (Smith et al. 2017b), while being widowed, divorced or separated increase vulnerability to food insecurity.

The number of children in the household is another factor of interest in the analysis of food insecurity at the household level (Asenso-Okyere et al. 2013; Nord 2008). Our study shows a significant relation of food insecurity with the number of children in the family.

Until now, all these characteristics have been taken into account only in a narrow context. In our study, we can generalize our results to the global level. The model includes also a territorial dimension, using dummy variables that identify clusters of countries. Considering the cluster of the least developed countries as a reference, it appears that a higher level of development implies a lower risk of food insecurity. This result is coherent with previous researches at macro level (FAO 2017; Vos 2015), but it is an original result referring to individual food insecurity.

5.2 Determinants of Food Insecurity at Different Levels of Development

Repeating the analysis in each cluster separately allows us to point out which cluster presents results that are distinct from the global average effect and with respect to which factors. It also highlights the different peculiarities of food insecurity as they vary with the level of development.

Table 3 shows the heterogeneity of the determinants of severe food insecurity by level of human development.

Table 3 The determinants of FIES by level of countries' human development (estimated coefficients, standard errors[a] and threshold values). *Source*: our elaboration on FIES and UNHDI data

Fies score	Cluster 1 Very rich and developed countries	Cluster 2 Rich and developed countries	Cluster 3 Intermediate countries	Cluster 4 Less developed countries	Cluster 5 Least developed countries
Gender (ref. male)					
Female	−.2630781*** (.08070)		.1840099*** (.0437319)	.1302772*** (.0260245)	.0340459*** (.0191424)
Age		.051186*** (.0109697)	.0720847*** (.0076502)	.049331*** (.0042063)	.0313488*** (.0032474)
Age*2		−.0007217*** (.0001198)	−.0007411*** (.000076)	−.0004556*** (.0000444)	−.0003262*** (.0000355)
Education	−.2632614*** (.0571919)	−.3888676*** (.0563767)	−.7104291*** (.0373756)	−.3965883*** (.0227668)	−.5096868*** (.016714)
Number of children	.1060669*** (.02734)	.1825485*** (.0255984)	.1865746*** (.0230239)	.2595726*** (.0109328)	.0306053*** (.0050174)
Marital status (ref. single)					
Married		−.5516659*** (.0824241)	−.2317259*** (.0747907)	−.5170726*** (.0315302)	−.1648107*** (.0280729)
Widow divorced separated		.3775537*** (.1019021)	.3113946*** (.0850492)		.2594293*** .0408578
Other marital status	−.5136737** (.2393449)	−.2218415** (.1095312)	.2034996** (.1004484)	.5051842*** (.0513262)	.445612*** .0407386
Poverty (ref: extreme poverty)					
Not extr poverty			−.7259992*** (.1688518)	−1.082648*** (.0495096)	−1.138635*** (.0223611)
Location (ref. farm or rural area)					
Small_town		.2017148** (.0850932)		.1367195*** (.03512)	.0365229** .0216599
Large_city		.2172271** (.0882432)	.1434978** (.0443477)	.0759397** (.0369639)	−.1178111*** .0266923

Table 3 (continued)

Fies score	Cluster 1 Very rich and developed countries	Cluster 2 Rich and developed countries	Cluster 3 Intermediate countries	Cluster 4 Less developed countries	Cluster 5 Least developed countries
Suburb	.2504938**	.2172522**	.244545**	.1476885***	.424118***
	(.1043353)	(.0967033)	(.0951873)	(.0502547)	.0470277
Other_location	.9885799***	.8602565***			
	(.2156946)	(.3933162)			
Threshold values					
/cut1	1.044259	1.438231	.5928194	.0722373	− 1.635432
	(.1397793)	(.2130796)	(.2291945)	.1049796	.0657578
/cut2	1.45763	1.826107	1.027085	.4733461	− 1.230061
	(.1441845)	(.2125667)	(.2289807)	.1051081	.0655144
/cut3	1.790795	2.156177	1.410558	.7777389	− .9014252
	(.148402)	(.2125475)	(.2294036)	.1052274	.0653999
/cut4	2.435549	2.516353	1.847139	1.124477	− .5199818
	(.1567957)	(.2139002)	(.2308292)	.1053781	.0652874
/cut5	2.823537	2.817355	2.216641	1.437695	− .1859391
	(.1641628)	(.2145619)	(.2316942)	.1057521	.0652331
/cut6	3.363314	3.246638	2.561608	1.728047	.1480627
	(.1759583)	(.2179022)	(.2342384)	.1061074	.0652164
/cut7	4.307895	3.69081	2.969918	2.022043	.4788455
	(.2056352)	(.2217511)	(.2362725)	.1064779	.0652969
/cut8	4.307895	4.437743	3.597198	2.557899	1.093061
	(.2056352)	(.2312771)	(.2416928)	.1076288	.0656553
Pseudo R^2	0.0098	0.0265	0.0273	0.0412	0.0432

*** $p<0.01$; ** $p<0.05$; * $p<0.1$

[a]Robust standard errors in parentheses

The first evidence in the analysis by clusters is related to gender. In cluster 1, including very rich and developed countries, mainly outside Europe, men appear more at risk of food insecurity. In the second cluster, that includes many European countries, gender is not significant Therefore, in high income countries, it is not necessary to focus on women in policies against food insecurity. Instead, in the other clusters, representing countries with a lower level of development, women are significantly more at risk of food insecurity (Table 3). This result is consistent with many studies that have found—in specific populations—a significant relationship between gender and food insecurity in developing countries (Aurino 2016; Brunelli and Viviani 2014; DOA 2002; Hadley et al. 2008; Tibesigwa and Visser 2016).

Age is not a significant factor of risk in cluster 1, even including a quadratic term, while in all the other clusters an increase in age corresponds to a significant increase in the risk of food insecurity. Elderly people are found more often to be food insecure, as in similar studies in single populations (Strickhouser et al. 2014; Nord 2003), as well as in Smith et al. (2017b). In the first cluster that includes the richest and most developed countries, the marital status of the individuals is not significant as a determinant of food insecurity. Nevertheless, in all other clusters, living without a partner (being single, widow, or divorced) appears to be a factor of fragility toward the risk of food insecurity.

As expected, extremely poor individuals present a higher probability of being food insecure. This relationship is not significant in richer countries where the measure is not able to illustrate the phenomenon. Our findings on the relationship between food insecurity and poverty are largely consistent with prior research (Coleman-Jensen et al. 2016; Smith et al. 2017b), even if our results do not appear to be significant for most developed countries.

Results regarding the relationship between location of the household and food insecurity are more mixed. However, we can see that living in a small town increases the risk of being food insecure. Living in a large city is related to a higher probability of being food insecure, except in the least developed countries, where the opposite is true. None of these two characteristics are significant in most developed countries. The only item that remains significant across the five clusters is 'living in the suburb of a large city', and it determines a higher risk of being food insecure.

As in the global model, our model shows that 'education' and 'number of children in the household' have significant effects on food insecurity in all clusters. We can thus conclude that these factors affect food insecurity regardless of a country's level of development.

Even in the richest countries, we have identified the population groups most affected by the risk of food insecurity: people with a low degree of education, families with many children, or those living in the suburbs of large cities.

However, demographic characteristics in very developed countries do not appear to be the key factors in food insecurity. Instead, social and economic variables assume more relevance, which suggests policy makers can make a difference if they intervene. In less developed countries, also age and gender result significant characteristics of food insecure people.

The model replicated across different levels of human development indicates a strong differentiation of the population distribution by values of the FIES. In the cluster of the least developed countries, the proportion of the population not at risk of food insecurity is significantly lower than that of the other clusters, so that half of the population has a very high number of food insecurity symptoms, ranging from 5 to 6 out of the 8 considered.

6 Conclusions

This paper adds further insight into the determinants of individual food insecurity worldwide. Thanks to the FIES measure, surveyed with the same methodology in 147 countries, it has been possible to estimate a model to evaluate the effects of individual characteristics on food insecurity at the global level. We have identified different clusters of countries with homogeneous levels of human development and estimated the model in each cluster. In this way, it has been possible to compare the results obtained at the global level to those of each cluster. In this way, we find out which factors are common determinants, and which are specific to a certain level of development. Population groups most at risk of food insecurity have been identified. They can be made the object of policies against hunger, policies tailored for the different countries' development.

The paper also includes theoretical aspects regarding the measure of food insecurity 'across varied cultural contexts and levels of economic development' (Kennedy 2003). As in other very recent research based on FIES data (Smith et al. 2017a, b), our analysis confirms that it is possible to determine individual characteristics of food insecure people across countries with wide cultural, social, and economic differences.

Empirical issues identify the risk factors and the most vulnerable population subgroups at different level of development of a country, taking into account similarities in social and economic conditions of countries and not only their geographic contiguity.

In the richest and more developed countries (clusters 1 and 2), key determinant of food insecurity is having a lower level of education, often related to having no decent job. As for poverty, households with many children should be made the subject of specific policies against food insecurity.

In addition to these determinants, in less developed countries (clusters 3, 4, 5), gender appears to have a significant impact on food insecurity, and women are more at risk of food insecurity and thus should also be a target of policies.

A higher risk of food insecurity is related to dwelling in the suburbs of large cities. This area is particularly fragile at every level of development.

Identifying the specific characteristics of individuals at risk of food insecurity makes it possible to plan policies against hunger in a more targeted way, both in countries that are more food insecure at the macro level and in the richest countries.

FIES has some limitations. One is it lacks information on children's food insecurity. Data on income and consumption surveyed at the individual level, along with experienced food insecurity, could provide further insight into factors of risk of food insecure people. Furthermore, a shorter period of recall (e.g. the previous 30 days) could be more appropriate, helping recall the experiences of food insecurity. Correspondingly, the survey's administration should be increased to take into account seasonality.

Moreover, with data available for a longer period, the study could achieve more definitive results.

Appendix

FIES Questions

Now I would like to ask you some questions about your food consumption in the last 12 months. During the last 12 MONTHS, was there a time when:

Q1. You were worried you would run out of food because of a lack of money or other resources?

Q2. You were unable to eat healthy and nutritious food because of a lack of money or other resources?

Q3. You ate only a few kinds of foods because of a lack of money or other resources?

Q4. You had to skip a meal because there was not enough money or other resources to get food?

Q5. You ate less than you thought you should because of a lack of money or other resources?

Q6. Your household ran out of food because of a lack of money or other resources?

Q7. You were hungry but did not eat because there was not enough money or other resources for food?

Q8. You went without eating for a whole day because of a lack of money or other resources?

Full Model

Coefficients and standard errors for the determinants of FIES Fies score.

Fies score	Coef.	Robust standard error	z	$p > |z|$	[95% conf. interval]	
Gender (ref. male)						
Female	0.066086	0.013819	4.78	0.000	0.039001	0.09317
Age	0.042176	0.002307	18.28	0.000	0.037654	0.046698
Age^2	−0.00046	2.42E−05	−19.02	0.000	−0.00051	−0.00041
Education	−0.48208	0.011965	−40.29	0.000	−0.50553	−0.45863
Poverty (ref. extreme poverty)						
Not extr poverty	−1.09407	0.019571	−55.90	0.000	−1.13243	−1.05571
Number of children	0.087021	0.004597	18.93	0.000	0.078012	0.096031
Marital status (ref. single)						
Married	−0.26973	0.021164	−12.74	0.000	−0.31121	−0.22825
Widow divorced separ	0.249512	0.028655	8.71	0.000	0.19335	0.305675
Other	0.404982	0.029575	13.69	0.000	0.347017	0.462948
Location (ref. farm, rural location)						
Small_town	0.063482	0.016986	3.74	0.000	0.030189	0.096775
Large city	0.015209	0.019038	0.8	0.424	−0.0221	0.052523
Suburb	0.242334	0.028409	8.53	0.000	0.186653	0.298015
Other_location	0.256065	0.098702	2.59	0.009	0.062612	0.449517
Cluster (ref. cluster 1)						
2	0.00803	0.048576	0.17	0.869	−0.08718	0.103237
3	0.570953	0.045518	12.54	0.000	0.48174	0.660166

Fies score	Coef.	Robust standard error	z	$p > |z|$	[95% conf. interval]	
4	0.899676	0.042917	20.96	0.000	0.815561	0.983792
5	1.675347	0.042975	38.98	0.000	1.591118	1.759576
/cut1	0.407968	0.066122			0.278371	0.537565
/cut2	0.809343	0.066151			0.679689	0.938997
/cut3	1.13359	0.066196			1.003848	1.263332
/cut4	1.503788	0.066311			1.373821	1.633755
/cut5	1.831219	0.066367			1.701142	1.961297
/cut6	2.157965	0.066457			2.027712	2.288219
/cut7	2.488106	0.066519			2.357732	2.61848
/cut8	3.088176	0.066777			2.957295	3.219057

References

Akimboade, O. A., & Adeyefa, S. A. (2018). An analysis of variance of food security by its main determinants among the urban poor in the city of Tshwane, South Africa. *Social Indicators Research: An International and Interdisciplinary Journal for Quality-of-Life Measurement, 137*(1), 61–82.

Alexandri, C. (2015). Population food security assessment: A methodological approach. *Agricultural Economics and Rural Development—Realities and perspectives for Romania*, Vol. 6, No. ISSN 2285–6803 ISSN-L 2285–6803 (20 November 2015) (pp. 2–8). MPRA Paper No. 69258.

Alkire, S. (2007). The missing dimensions of poverty data: Introduction to the special issue. *Development Studies, 35*(4), 347–359. https://doi.org/10.1080/13600810701701863.

Alkire, S. (2015). Capability approach and well-being measurement for public policy. In *OPHI Oxford poverty & human development initiative*. Working paper 94, Oxford University.

Alkire, S., & Fang Y. (2018). Dynamics of multidimensional poverty and uni-dimensional income poverty: An evidence of stability analysis from China. In *Social Indicators Research*. Springer: Berlin.

Allen, P. (2013). Facing food security. *Journal of Rural Studies, 29,* 135–138.

Allen, T., Prosperi, P., Cogill, B., Padilla, M., & Peri, I. (2018). A Delphi approach to develop sustainable food system metrics. *Social Indicators Research*. https://doi.org/10.1007/s11205-018-1865-8.

Anand, S., & Sen, A. (1997). Concepts of human development and poverty: A multidimensional perspective. In *Poverty and human development: Human development papers* 1997 (pp. 1–20). New York: United Nations Development Programme.

Asenso-Okyere, K., Mekonnen, D., & Zerfu, E. (2013). Determinants of food security in selected agropastoral communities of Somali and Oromia regions. *Ethiopia Journal of Food Science and Engineering, 3*(2013), 453–471.

Aurino, E. (2016). *Do boys eat better than girls in India? Longitudinal evidence from young lives*. Working paper 146 © *Young Lives* 2016 ISBN 978-1-9099403-60-4.

Ballard, T.J., Kepple, A.W., & Cafiero, C. (2013). The food insecurity experience scale: Development of a global standard for monitoring hunger worldwide Technical paper. Rome: FAO, Available at: http://www.fao.org/economic/ess/ess-fs/voices/en/.

Ballard, T. J., Kepple, A. W., Cafiero, C., & Schmidhuber, J. (2014). Better measurement of food insecurity in the context of enhancing nutrition. *Ernährungs Umschau Journal, 61*(2), 38–41. https://doi.org/10.4455/eu.2014.007.

Barrett, C. B. (2002). Food security and food assistance programs. *Handbook of Agricultural Economics, 2,* 2103–2190.

Barrett, C. B. (2010). Measuring food insecurity. *Science, 327*(5967), 825–828.

Bartfeld, J., Dunifon, R., Nord M., & Carlson, S. (2006). What factors account for state-to-state differences in food security? *Economic Information Bulletin, 20*. November 2006.

Benassi, F., & Naccarato, A. (2016). Foreign citizens working in Italy: Does space matter? *Spatial Demography*. https://doi.org/10.1007/s40980-016-0023-7.

Benassi, F., & Naccarato, A. (2017). Households in potential economic distress. A geographically weighted regression model for Italy, 2001–2011. *Spatial Statistics*, August 2017 (Vol.21, pp. 362–376).

Brulè, G., & Maggino, F. (2017). *Metrics of subjective well-being: Limits and improvements. happiness studies book series*. New York: Springer.

Brunelli C., & Viviani, S. (2014). *Exploring gender-based disparities with the FAO Food Insecurity Experience Scale*. Global Forum on Gender Statistics. Aguascalientes, Mexico, November 3–5.

Burchi, F., & De Muro, P. (2016). From food availability to nutritional capabilities: Advancing food security analysis. *Food Policy, 60,* 10–19.

Cafiero, C., Melgar-Quiñonez, H. R., Ballard, T. J., & Kepple, A. W. (2014). Validity and reliability of food security measures. *Annals of the New York Academy of Sciences, 1331*(1), 230–248.

Carletto, C., Zezza, A., & Banerjee, R. (2013). Towards better measurement of household food security: Harmonizing indicators and the role of household surveys. *Global Food Security, 2,* 30–40.

Coates, J. (2013). Build it back better: Deconstructing food security for improved measurement and action. *Global Food Security, 2,* 188–194.

Coates, J., Swindale, A., & Bilinsky, P. (2007). Household Food Insecurity and Access Scale (HFIAS) for measurement of food access: Indicator Guide. Version 3. Washington, D.C.: Food and Nutrition Technical Assistance Programme (FANTA).

Coates, J., Webb, P., & Houser, R. (2003). *Measuring food insecurity: Going beyond indicators of income and anthropometry*. Washington, DC: Food and Nutrition Technical Assistance Project, Academy for Educational Development.

Cohen, M. J., & Garrett, J. L. (2010). The food price crisis and urban food (in)security. *Environment & Urbanization, International Institute for Environment and Development, 22*(2), 467–482. https://doi.org/10.1177/0956247810380375.

Coleman-Jensen, A., Rabbitt, M.P., Gregory, C.A., & Singh A. (2016) Household Food Security in the United States in 2015, *Economic Research Report* 215, U.S. Department of Agriculture, Economic Research Service, September 2016.

Deichtler, M., Ballard, T., Swindale, A., & Coates, J. (2011). Introducing a simple measure of household hunger for cross-cultural use: FANTA-2 food and nutrition technical assistance technical note no. 12, February. Washington, D.C.

DOA. (Department of Agriculture). (2002). *The integrated food security strategy for South Africa*. Department of Agriculture. Republic of South Africa, Pretoria.

FAO, IFAD, UNICEF, WFP & WHO. (2017) *The state of food security and nutrition in the world 2017.* Building Resilience for Peace and Food Security. Rome, FAO.

Frongillo, E. A., Jr. (1999). Validation of measures of food insecurity and hunger. *The Journal of Nutrition, 129*(2), 506S–509S. https://doi.org/10.1093/jn/129.2.506S.

Fuller, W. A. (2009). *Sampling statistics*. Hoboken, NJ: Wiley.

Gallup. (2017). *Worldwide research methodology and codebook.* Gallup. https://data-services.hosting.nyu.edu/wp-content/uploads/2017/10/World_Poll_Methodology_102717.pdf.

Gelman, A., & Hennig, C. (2017). Beyond subjective and objective in statistics 180. *Journal of Royal Statistical Society, Series A Statistics in Society, 180*(4), 1–31.

Grobler, W. C. J. (2016). Perceptions of poverty: A study of food secure and food insecure households in an urban area in South Africa. *Procedia Economics and Finance, 35,* 224–231.

Hadley, C., Lindstromb, D., Tessemac, F., & Belachewc, T. (2008). Gender bias in the food insecurity experience of Ethiopian adolescents. *Social Science and Medicine, 66,* 427–438.

Hamilton, W. L., Cook, J., Thompson, W. W., Buron, L. F., Frongillo, E. A., Olson, C. M., & Wehler, C. A. (1997). *Household food security in the United States in 1995*. Summary Report of the Food Security Measurement Project. Washington, D.C.: United States Department of Agriculture.

Haq (Ul), M. (1996). *Reflections on human development*, 1st edn. Oxford: Oxford University Press.

Jones, A. D., Ngure, F. M., Pelto, G., & Young, S. L. (2013). What are we assessing when we measure food security? A compendium and review of current metrics. American Society for Nutrition. *Advances in Nutrition., 4,* 481–505. https://doi.org/10.3945/an.113.004119.

Kennedy, E. (2003). Qualitative measures of food insecurity and hunger. In *Proceeding of FAO International Scientific Symposium* (pp. 165–184), Rome, 26–28 June 2002.

Marden, J. Y. (2015). *Multivariate statistics*. Urbana-Champaign: Department of Statistics, University of Illinois.

Maxwell, S. (1996). Food security: A post-modern perspective. *Food Policy, 21*(2), 155–170.

Misselhorn, A., Pramod, A., Ericksen, P., Gregory, P., Horn-Phathanothai, L., Ingram, J., et al. (2012). A vision for attaining food security. *Current Opinion in Environmental Sustainability, 4,* 7–17. https://doi.org/10.1016/j.cosust.2012.01.008.

Nord, M., (2003), Measuring the food security of elderly persons. In *Family Economics and Nutrition Review*, U.S. Dept. of Agriculture, Vol. 15 N.1.

Nord, M. (2011). *Intra-household differences in food security among adults in NHANES*. Paper presented at the Third North American Congress on Epidemiology, Montreal, Quebec, Canada, June 2010.

Nord, M. (2012). Assessing potential technical enhancements to the U.S. household food security measures, technical bulletin no. TB-1936, USDA, *Economic Research Service*. Available: www.ers.usda. gov/publications/tb-technical-bulletin/tb1936.aspx.

Nord, M. (2014). *Introduction to item response theory applied to food security measurement: Basic concepts, parameters, and statistics. Technical Paper*. Rome: FAO.

Nord, M., & Hopwood, H. (2008). *A comparison of household food security in Canada and the United States.* ERR-67. U.S. Dept. of Agriculture, Econ. Res. Serv. December 2008.

Posel, D., & Casale, D. (2011). Relative standing and subjective well-being in South Africa: The role of perceptions, expectations and income mobility. *Social Indicators Research, 104*(2), 195–223.

Posel, D., & Rogan, M. (2016). Measured as poor versus feeling poor: Comparing money-metric and subjective poverty rates in South Africa. *Journal of Human Development and Capabilities, 17*(1), 55–73. https://doi.org/10.1080/19452829.2014.985198.

Rasch, G. (1960). *Probabilistic Models for some intelligence and attainment tests*. Copenhagen: Danish Institute for Educational Research.

Ravallion, M., & Lokshin, M. (2001). Identifying welfare effects from subjective questions. *Economica., 68*(271), 335–357.

Sen, A. (1981). *Poverty and famines: An essay on entitlement and deprivation*. Oxford: Oxford University Press.

Smith, M. D., Kassa, W., & Winters, P. (2017a). Assessing food insecurity in Latin America and the Caribbean using FAO's Food Insecurity Experience Scale. *Food Policy, 71,* 48–61.

Smith, M. D., Rabbitt, M. P., & Coleman-Jensen, A. (2017b). Who are the world's food insecure? New evidence from the Food and Agriculture Organization's Food Insecurity Experience Scale. *World Development, 93,* 402–412.

Stiglitz, J. E., Sen, A., & Fitoussi, J. P. (2009). *Report by the commission on the measurement of economic performance and social progress*. Paris.

Strickhouser S, Wright JD, Donley AM (2014) Food insecurity among older adults. ꞮAARP foundation, Washington, D.C.

Terzi, S. (2013). How to integrate macro and micro perspectives: An example on human development and multidimensional poverty. *Social Indicators Research, 114*(3), 935–945.

Tibesigwa B., & Visser, M. (2016). *Small-holder farming, food security, and climate change in South Africa*. Male-female and urban-rural differences environment for development. *Discussion Paper Series* February 2016 EfD DP 16-07.

UN General Assembly. (2015). Resolution adopted by the General Assembly on 25 September 2015 n. 70/1. Transforming our world: The 2030 Agenda for Sustainable Development. New York.

UNDP (United Nations Development Programme). (2015). *Human development report*. New York.

Vos, R. (2015). *Thought for food: Strengthening global governance of food security*. CDP Background Paper No. 29. ST/ESA/2015/CDP/29. Department of Economic & Social Affairs. New York.

Wooldridge, J. M. (2002). *Econometric analysis of cross section and panel data*. Cambridge, MA: MIT.

World Bank. (2017). *Monitoring global poverty: Report of the commission on global poverty*. Washington, DC: World Bank. https://doi.org/10.1596/978-1-4648-0961-3.