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Validity of the Food Insecurity Experience Scale for Use in Sub-Saharan Africa and Characteristics of Food-Insecure Individuals

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Abstract

Background: The Food Insecurity Experience Scale (FIES) is a UN FAO—Voices of the Hungry project (FAO-VoH) metric of food insecurity (FI). The FAO-VoH tested the psychometric properties of FIES with the use of global 2014 Gallup World Poll (GWP) data. However, similarities in its psychometric structure in sub-Saharan Africa (SSA) to allow aggregation of SSA results were untested.

Objectives: We aimed to *1)* assess the validity of FIES for use in SSA, *2)* determine the prevalence of FI by country, age group, and gender, and *3)* examine the sociodemographic and economic characteristics of individuals with FI.

Methods: The Rasch modeling procedure was applied to data collected by GWP in 2014 and 2015 on 57,792 respondents aged ≥19 y in SSA.

Results: FIES largely met the Rasch model assumptions of equal discrimination and conditional independence. However, 34.3% of countries had high outfits (≥2.0) for the item "went without eating for a whole day." Four countries had significant correlations for the items "were hungry but did not eat" and "ran out of food." The overall prevalence of severe FI (SFI) was 36.4%, ranging from 6.0% in Mauritius to 87.3% in South Sudan. Older adults were at significantly higher risk of SFI than younger adults (38.6% and 35.8%, respectively, $P < 0.0001$), and women more than men (37.3% and 35.4%, respectively, $P < 0.0001$). Higher proportions of individuals with SFI were rural residents, less educated, lower income, unemployed, and lived in households with many children under the age of 15 y.

Conclusions: FIES has acceptable levels of internal validity for use in SSA. However, the item "went without eating for a whole day" may need cognitive testing in a few SSA countries. For countries with correlated items, 1 of the items may be excluded. *Curr Dev Nutr* 2018;2:nzy062.

Keywords: Rasch modeling, food insecurity, sub-Saharan Africa, older adults, younger adults

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Supporting data obtained through a data license from FAO-VoH. Part of the data is not available for public access, data used for this analysis will be furnished upon request.

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Abbreviations used: FI, food insecurity; FIES, the Food Insecurity Experience Scale; FS, food secure; GWP, Gallup World Poll; MFI, moderate food insecurity; SFI, severe food insecurity; SSA, sub-Saharan Africa; VoH, Voices of the Hungry project.

Introduction

Despite research and effort to tackle food insecurity (FI) in sub-Saharan Africa (SSA), its prevalence in this region remains high. A recent UN report indicates that the absolute number of food-insecure individuals in SSA increased from 176 million in 1990–1992 to 220 million in 2014–2016 (1, 2). This highlights the need for continued monitoring, and for appropriate and targeted interventions. A tool widely used in SSA is the Household Food Insecurity Access Scale (3), which measures FI at the household level, but does not account for seasonality and requires tailoring to local contexts, thus limiting comparability of results (4, 5).

Measuring FI is, however, quite complex, with no single internationally agreed-upon indicator for its measurement, often requiring the use of different indicators (6). Therefore, several indicators exist, each capturing a dimension of FI (4, 6–8). Despite the progress in developing these indicators, the search continues for a broadly applicable, multidimensional, and cross-culturally comparable tool (7). To meet the demand for such a tool, the UN FAO-Voices of the Hungry

project (FAO-VoH) developed the Food Insecurity Experience Scale (FIES) (9, 10). It is the first tool to be used to measure FI at the individual level globally (11). FIES was validated by FAO-VoH in 151 countries with the use of the 2014 Gallup World Poll (GWP) data (9, 10). However, because a global standard was used, the similarity of its psychometric structure across SSA countries—which would allow aggregation of data and exploration of the comparability of results—was untested. Our overall goal is to define a common metric for SSA that can be used to identify common determinants of FI in its countries.

This study aims to *1)* assess the internal validity of FIES for measuring individual-level FI in SSA, *2)* examine the extent to which FIES measures the same phenomenon across SSA countries, in younger (19–49 y) and older adults (≥50 y), and across subregions, *3)* examine the prevalence of severe food insecurity (SFI) by age group and gender, and *4)* determine the sociodemographic and economic characteristics of individuals with SFI.

TABLE 1 The FIES questions[1]

	During the last 12 MONTHS, was there a time when because of a lack of money or other resources? (*YES/NO*)	(Short reference)
(Q1)	You were worried you would not have enough food to eat	(WORRIED)
(Q2)	You were unable to eat healthy and nutritious food	(HEALTHY)
(Q3)	You ate only a few kinds of foods	(FEWFOODS)
(Q4)	You had to skip a meal	(SKIPPED)
(Q5)	You ate less than you thought you should	(ATELESS)
(Q6)	You ran out of food	(RANOUT)
(Q7)	You were hungry but did not eat	(HUNGRY)
(Q8)	You went without eating for a whole day	(WHLDAY)

[1] FIES, Food Insecurity Experience Scale; Q, question.

Methods

Data

This analysis uses GWP 2014 and 2015 SSA data. GWP is an annual survey conducted in civilian, non-institutionalized populations aged 15 y and older. The 2014 survey included 36 countries from 5 SSA regions: 9 East African, 2 Central African, 16 West African, 7 Southern African, and 2 Island countries, whereas the 2015 survey included 32 countries: 7 East African, 2 Central African, 16 West African, 6 Southern African, and 1 Island country. Most countries surveyed in 2014 were also surveyed in 2015; however, in 2015 Angola, Burundi, Mauritius, Namibia, and Sudan were excluded, and Mozambique was added. Data were collected through face-to-face interviews from randomly selected respondents (12). The total sample was 36,044 in 2014 and 32,000 in 2015. We excluded the data of individuals under age 19 y, and those with missing age or FIES data. The final sample included 57,792 respondents.

FIES

Beginning in 2014, FAO-VoH included FIES in the GWP survey as a client module. FIES elicits self-reported experiences and behaviors related to food access due to lack of money or other resources, over a 12-mo recall period, irrespective of frequency of occurrence (**Table 1**). FIES is comprised of 8 questions ranging in the severity of FI they measure, from low FI (question 1) to SFI (question 8) (Table 1). Respondents answer yes/no to the 8 questions and the responses are aggregated to give raw scores ranging from 0 to 8. FI was classified into 3 categories: *1)* food secure (FS) with raw scores = 0–3; *2)* moderate FI (MFI), with raw scores = 4–6; and *3)* SFI, with raw scores = 7–8. The development of these thresholds is discussed below.

Sociodemographic and economic variables

Sociodemographic and economic variables used in these analyses include gender, residence, marital status, age, household headcount, number of household residents older than 15 y of age, number of children below 15 y of age, educational attainment, employment, and income. To calculate income, respondents in GWP were asked to report their household income in local currency from wages and salaries, remittances, and all other sources. GWP converts the household income in local currency to international dollars via the World Bank's purchasing power parity conversion factor, making them comparable across countries. The income is divided by the annual household headcount to derive per capita incomes. Respondents experiencing difficulty in providing the information chose from income ranges provided in their local currency (12).

Statistical analysis

The Rasch model. We used Rasch modeling to examine the psychometric properties of FIES. Rasch applies principles of Item Response Theory to analyze survey tools (13). Although a range of statistical techniques can be used to develop survey instruments, Rasch is the most useful in evaluating individual items and their functioning (14). Rasch estimates the locations of people and items separately, but on the same scale, determining the probability of responses to items, which allows for the generalization of results across samples and items (9, 13–17). The response is a logistic function of the difference between the severity of a respondent's latent trait and the difficulty of items such that if the severity of one's latent trait is below the difficulty of an item, the probability of affirming the item is lower (9, 13, 18–20).

Based on standard procedure, extreme raw scores (0 and 8) were excluded to avoid potential bias resulting from large proportions of these raw scores (9, 21). We assessed Rasch assumptions that *1)* items discriminate equally, meaning that they are strongly related to the latent trait; and *2)* items are conditionally independent and unidimensional, meaning that responses to items are independent, and only 1 latent trait determines the responses (21). Rasch transforms ordinal raw scores into continuous data with equal interval units (logits), which indicate the severity of the latent trait measured by the raw scores, thus allowing for raw score summation (22). Therefore, if these assumptions are met, the raw scores are meaningful and considered sufficient statistics, and an ordinal measure of FI severity (14, 21–24).

Rasch modeling outputs also include the calculation of infit and outfit statistics, which are chi-square type statistics that compare observed and expected responses (19, 20). These show how well items in a scale perform and identify those that need attention. We assessed the assumption of equal discrimination primarily with the use of infits, and examined outfits to identify items with unusual occurrence of erratic responses (9). The ideal value for fit statistics is 1.0. Values between

0.7 and 1.3 are considered adequate to meet the assumption of equal discrimination; higher values indicate weaker discrimination (25). However, because high outfits can result from few random responses, they require careful interpretation to determine problematic items (19). As long as the infit statistics are reasonable, high outfits are not usually criteria for eliminating items (18). In contrast, lower infits may indicate the presence of redundant items (9, 26).

To provide comparable information about the discriminatory power of FIES, we performed a modified Rasch reliability test (9, 21). Reliability scores ≥0.7 indicate reasonably good overall model fit (18). Finally, we assessed conditional independence and dimensionality via the items' residual correlations. Correlations ≥0.40 between pairs of items indicate that responses to the items are not independent of each other (dependence), and lower correlations (≥0.25 to <0.40) among adjacent groups of 3 or 4 items indicate the items measure multiple latent traits (multidimensionality) which is not intended (14, 17, 22).

Equating FIES for SSA. We constructed and assessed scales for SSA subregions, for younger and older adults, and for each country. To obtain comparable prevalence rates, we developed a standard metric based on Rasch modeling results of aggregated SSA data. We calibrated the item severities of the subregions, of younger and older adults, and for each country against this SSA standard, equating their means and SDs, adjusting them to a common metric. After adjusting for the differences in item dispersion between all scales and the SSA standard metric, we compared the relative positions of item severity parameters to the standard metric using a minimum critical value of 0.4, allowing a maximum of 3 items to deviate in their severity parameters from the standard metric (unique items) (21). We then specified the thresholds for MFI and SFI based on this metric, allowing the determination of comparable prevalence of FI.

Most scales, except for Congo Brazzaville, Congo Kinshasa, and Somalia, had ≤3 unique items. This similarity in the item severities suggests that FIES measures the same level of FI severity across SSA and justifies a common metric. Owing to the higher number of unique items in Congo Brazzaville, Congo Kinshasa, and Somalia, and the small size of non-extreme responses for Mauritius, we excluded data from these countries in the construction of the final SSA standard metric. Nevertheless, we computed the prevalence rates for these countries using the determined SSA FI thresholds.

Data were analyzed through the use of R (version 3.2.3; R Foundation, Vienna, Austria) and SAS (version 9.3; SAS Institute Inc., Cary, NC). Descriptive summaries were determined and compared with the use of chi-square tests. We used logistic regression analysis to examine associations between FI and sociodemographic and economic characteristics, accounting for the complex survey design, and controlled for country and survey year as fixed effects. The analyses were stratified by age group (adults aged 19–49 y compared with ≥50 y) and by gender.

Results

Sample characteristics

The study included 46,564 (79.5%) younger adults and 11,228 (20.5%) older adults (**Table 2**). Slightly more than half of the sample were women (51.2%), and 60% were married or partnered (Table 2). Most respondents had households consisting of ≤6 members (60.1%) and ≤3 children (70.1%), were rural residents (69.4%), and had ≤8 y of education (66.9%); more than a third of them lived on <$2/d (39.0%) and were unemployed (39.6%) (Table 2).

TABLE 2 Sociodemographic and economic characteristics of respondents (n = 57,792)

Variables	*n*	Weighted %
Age		
Young adults (ages 19–49 y)	46,564	79.5
Older adults (age ≥50 y)	11,228	20.5
Gender		
Male	28,655	48.8
Female	29,137	51.2
Marital status		
Married or with domestic partner	33,227	59.9
Single[1]	24,478	40.1
Household composition		
Household size		
1–6 members	40,506	60.1
≥7 members	17,286	39.9
Children under 15 y old		
0–3 children	43,342	70.1
≥4 children	14,450	29.9
Residence		
Urban	18,663	30.6
Rural	39,129	69.4
Education		
0–8 y of education	31,736	66.9
High school education	17,893	24.8
≥1 y of college	8008	8.4
Income <$2/d		
Yes	19,259	39.0
No	35,493	61.0
Formal or self-employment		
Employed full-time	22,014	36.3
Employed part-time	13,762	24.1
Unemployed	22,016	39.6

[1]Never married, divorced, separated, widowed.

Fit statistics and overall reliability of FIES

Table 3 shows countries with infit statistics outside the acceptable range of 0.7–1.3, a range generally considered to adequately approximate the Rasch model assumption of equal discrimination (18). In total, 91.7% of countries had acceptable infits for all items, indicating that FIES measures the same underlying condition across SSA. In Namibia and Sudan, the item "worried" had infits of 1.4 and 1.46, respectively (Table 3). High infits can occur because of small sample sizes as seen in these 2 countries, which had 347 and 329 non-extreme responses, respectively. Small samples provide less precise and unreliable estimates because of their potential to inflate margins of error. However, infit SEs for the item "worried" in these countries were 0.07 and 0.08, respectively, indicating reliable infits. Nevertheless, infits in the range 1.3–1.5 identify items that can still be used, but improvements for such questions may be desirable (9). Chad, in contrast, had low infits for the item "hungry", signaling possible redundant items in this country's scale (9, 18). For all other scales, all item infits were near unity.

TABLE 3 SSA countries, grouped by SSA subregion, whose fit statistics are outside the acceptable range for certain FIES items[1]

		worried		healthy		fewfoods		skipped		ateless		ranout		hungry		whlday	
	n (non-extreme)	Infit	Outfit	Infit	Outfit	Infit	Outfit	Infit	Outfit	Infit	Outfit	Infit	Outfit	Infit	Outfit	Infit	Outfit
Eastern																	
Burundi	437	1.2	2.3*	1.2	2.6	1.0	2.2*	0.8	0.8	0.9	1.2	0.8	0.8	0.7	0.6	1.1	1.4
Ethiopia	1166	1.2	1.8	1.0	2.0*	1.0	3.1*	0.8	0.8	0.9	0.8	0.9	0.9	0.8	1.1	1.1	3.2*
Somalia	736	1.0	1.0	1.1	1.1	1.0	1.0	0.9	0.9	0.8	0.6	1.0	1.0	0.8	0.7	1.3	2.2*
Sudan	329	1.5*	2.1*	1.1	1.8	0.9	1.0	0.9	0.7	0.7	0.5	0.9	0.9	0.8	0.6	1.1	1.0
Western																	
Chad	1093	1.1	1.4	0.9	1.2	1.1	1.8	0.9	0.8	1.0	1.3	0.9	0.8	0.6*	0.5	1.3	1.7
Ghana	1146	1.0	0.7	1.0	0.9	0.9	1.0	1.1	1.1	0.8	0.8	0.9	0.7	0.9	0.8	1.2	4.5*
Guinea	1071	1.1	1.5	1.0	1.2	1.1	2.0*	0.9	1.0	0.9	1.1	0.8	0.8	0.7	0.6	1.2	2.1*
Ivory Coast	1208	1.2	1.5	1.0	0.9	1.1	1.5	0.9	0.8	0.9	0.9	0.9	0.8	0.8	0.8	1.2	2.3*
Liberia	687	1.2	1.5	1.1	1.4	0.9	0.6	0.9	1.0	0.9	0.8	0.8	0.7	0.8	0.8	1.1	2.5*
Mali	900	1.3	1.6	1.0	1.0	0.9	1.3	1.1	1.1	0.8	0.8	0.8	0.6	0.8	0.8	1.2	2.5*
Nigeria	1143	1.0	1.2	0.9	0.9	1.0	1.0	0.9	0.8	0.9	0.8	0.9	0.9	1.0	1.0	1.2	3.2*
Senegal	1092	0.9	0.9	1.1	1.1	1.3	1.7	1.0	0.9	0.9	0.9	0.8	0.7	0.7	0.6	1.2	2.7*
Togo	1084	1.2	2.6*	1.1	1.2	1.1	1.8	0.9	0.9	0.9	0.8	0.8	0.7	0.7	0.6	1.1	2.6*
Southern																	
Angola	511	1.1	0.8	1.0	1.3	0.9	0.8	0.9	0.9	0.9	0.9	0.9	1.1	1.0	1.2	1.2	2.1*
Namibia	347	1.4*	1.7	1.1	1.2	1.0	1.1	0.9	0.8	0.8	0.7	0.9	0.8	0.7	0.6	1.1	1.2
Island																	
Madagascar	1472	1.1	1.7	0.9	0.8	0.9	4.3*	0.9	0.9	1.0	0.9	0.8	0.6	1.0	1.0	1.1	7.6*

[1]Asterisks on infit statistics and outfit statistics indicate infits <0.7 or >1.3, and outfits >2.0. FIES, Food Insecurity Experience Score; Infit, item-infit mean square statistic; Outfit, item-outfit mean square statistic; SSA, sub-Saharan Africa.

Table 3 also shows countries with high outfits ≥2.0. These were for the items "worried", "healthy", "fewfoods", and "whlday". They suggest that at least a few respondents in these countries gave highly improbable responses to these questions based on predictions from their responses to other questions. The item "worried" had high outfits in Burundi, Sudan, and Togo, whereas "fewfoods" had high outfits in Sudan and Togo, and "healthy" in Ethiopia. These high outfits resulted from >30 unexpected responses in these countries (results not shown). The item "whlday", on the other hand, had high outfits in 12 countries (32.4%) (Table 3), most prominently in Madagascar where the outfit value was 7.56. Further analysis indicated that the high outfits for Madagascar, Ethiopia, Mali, Ghana, Somalia, and Senegal were due to unexpected responses from >60 respondents in these countries, and for the remaining countries they were from <40 but >10 unexpected responses (results not shown). No major violations in outfits were seen for the remaining countries, and for both age groups. However, analysis by subregions revealed high outfits of 4.03 and 6.75 in the Island subregion for the items "fewfoods" and "whlday", respectively, and an outfit value of 2.0 for the item "whlday" in the Western subregion. These high outfits resulted from unexpected responses from >90 respondents in these subregions (results not shown). Finally, the overall fit of FIES to the Rasch model was good; the scores were ≥0.7 for SSA individual countries, subregions, and age groups (results not shown).

The ordering of FIES items and correlations

Item severity parameters locate items on a continuum in relation to the level of the underlying latent construct they measure, therefore, items with lower severity parameters would be affirmed by subjects with lesser degrees of FI than for items with higher severity parameters (24). The item severity parameters ranged from −1.24 to 2.14 (3.38 logits). We found similar ranges of item severities in most countries (**Figure 1**), younger (3.34) and older adults (3.46), and subregions—Southern (3.19), Western (3.44), Eastern (3.6)—all like the SSA standard metric (results not shown). The Island subregion had the highest range (5.92) and the Central subregion had the lowest (2.78).

The FIES item severity parameters indicate that in most cases, only items 6–8, those measuring more severe FI, performed as expected, and only the item "whlday" measuring the most severe FI consistently performed as expected, and was the least likely to obtain a response of "yes" (Figure 1). However, this item "whlday", as previously reported, had high outfits in several countries. On the other hand, the predicted order of item difficulty for items 1–5 was different from their actual order of difficulty, which indicates disordering of the items. This disordering was seen in the aggregated SSA data (**Table 4**), for most countries (Figure 1), the subregions, and for both age groups (results not shown). In general, the item "fewfoods" measured the least severe FI instead of "worried". In addition, the item "ateless" measured more severe FI compared with "skipped", although the latter was predicted to measure more severe FI (Figure 1). Nonetheless, because the disordering of item relative severities is similar across all countries, it indicates that FI is experienced similarly across SSA.

Our results of the item severity order were consistent with the results of response patterns. That is, our results show that as severity of FI measured by the items increased, the proportion of affirmative responses decreased (Table 4). For the items measuring less severe FI, although there were inconsistencies in their severity parameters, their proportions of affirmative responses were still generally lower than those of items measuring more severe FI (Table 4). About a third of all respondents (32.9%) reported going a whole day without food, whereas 63.8% reported worrying that they would not have enough to

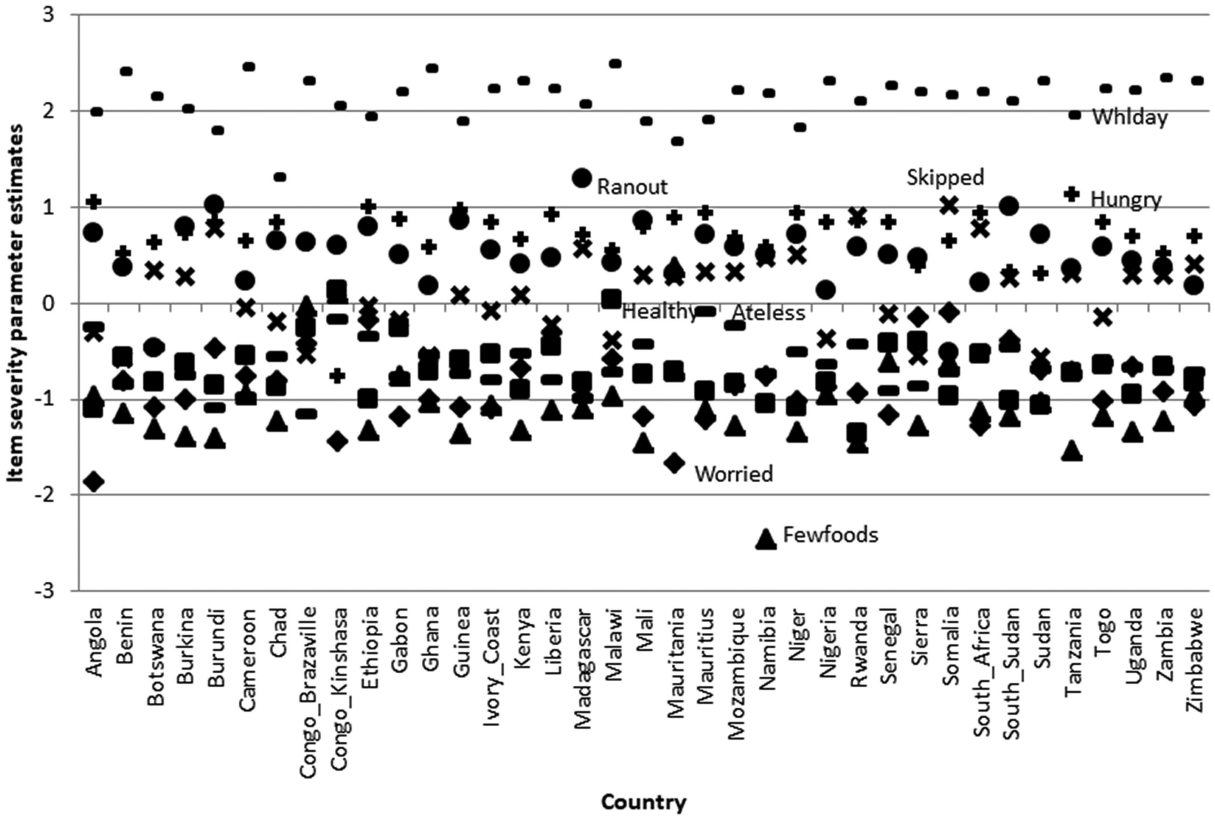

FIGURE 1 Relative order of item severity parameter estimates of FIES for SSA countries. FIES, Food Insecurity Experience Score; SSA, sub-Saharan Africa.

eat (Table 4). Finally, assessment of the items' conditional independence only showed significant correlations of 0.4 for 3 item pairs: "hungry" and "ranout" in Chad, Guinea, Senegal, and Togo, and "fewfoods" and "skipped" and "hungry" and "whlday" in Mauritania (results not shown). There were no other indications of problematic correlations, or indications of multidimensionality.

TABLE 4 Proportion of affirmative responses to FIES items, item severity parameters, and item fit statistics in SSA (overall)[1]

Item	Affirmative responses (weighted %)[2]	Severity ± SE[3]	Infit	Outfit
worried	63.5	–1.14 ± 0.02	1.1	1.4
healthy	61.0	–0.84 ± 0.02	1.0	1.1
fewfoods	64.4	–1.27 ± 0.02	1.1	1.3
skipped	50.9	0.19 ± 0.02	0.9	0.9
ateless	58.8	–0.63 ± 0.02	0.9	0.9
ranout	45.8	0.70 ± 0.02	0.9	0.9
hungry	44.4	0.85 ± 0.02	0.8	0.8
whlday	32.2	2.14 ± 0.03	1.2	1.7

[1]The items measure FI in the previous 12 mo, specifying that the condition occurred owing to lack of money or other resources. FI, food insecurity; FIES, Food Insecurity Experience Score; Infit, item-infit mean square statistic; Outfit, item-outfit mean square statistic; SSA, sub-Saharan Africa.
[2]Percent weighted affirmative responses (%) of respondents.
[3]Severity parameter of the FIES items. The calibrations were estimated on a logit scale (with equal discrimination = 1), mean set to 0, and SD of 1.

Prevalence of SFI in SSA. Respondents were classified into 3 FI levels following the FAO-VoH recommended FIES thresholds of FI: scores of <4 representing food security, and raw scores ≥7 representing SFI (27). The following raw scores measured approximately equal severity of FI in SSA: FS (0–3); MFI (4–6); and SFI (7, 8), at the severity level of the item "hungry", apart from Sierra Leone and South Sudan which had SFI scores of 6–8, at the severity level of the item "ranout".

Overall, about one-third (36.4%) of respondents experienced SFI. Older adults experienced a higher prevalence of SFI than younger adults (38.6% compared with 35.8%, respectively, $P < 0.0001$). Also, women, overall, had a higher prevalence of SFI than men (37.3% and 35.4%, respectively, $P < 0.001$). There was higher prevalence of SFI among younger women than among younger men (36.5% compared with 35.0%, respectively, $P = 0.007$), and among older women than among older men (41.0% compared with 36.5%, respectively, $P < 0.0001$) (**Table 5**). The prevalence of SFI at country level ranged from 6.0% to 87.3% (**Figure 2**). In East Africa, the prevalence of SFI ranged from 20.7% in Ethiopia to 87.3% in South Sudan. In Central Africa, SFI prevalence rates for Congo Kinshasa and Congo Brazzaville were 40.4% and 48.4%, respectively, and for the Island countries of Mauritius and Madagascar, 6.0% and 17.2%, respectively. The highest prevalence of SFI in Southern Africa was in Malawi (64.5%) and South Africa had the lowest prevalence of SFI (19.0%). West Africa had the widest range of SFI, 6.6% to 71.5% in Mali and Liberia, respectively.

SFI was significantly more prevalent among rural residents, the unemployed, those with lower income, and the less educated (Table 5).

TABLE 5 Sociodemographic and economic characteristics of severely food insecure respondents, analysis stratified by age group, within-group comparisons[1]

	Overall		Younger adults 19–49 y (n = 46,564)		Older adults >50 y (n = 11,228)	
	n	%	*n*	%	*n*	%
Gender						
Male	9226	35.3***	7199	35.0**	2027	36.5***
Female	10,326	37.3	8235	36.5	2091	41.0
Residence						
Urban	5353	30.9***	4437	30.7***	916	31.8***
Rural	14,199	38.8	10,997	38.1	3202	41.2
Marital status						
Married or partnered	11,103	36.2	8712	36.1	2391	36.5***
Single[2]	8418	36.6	6696	35.3	1722	42.7
Household composition						
Small household[3]	13,803	36.9*	10,950	36.1	2853	40.3**
Large household[4]	5749	35.5	4484	35.3	1265	36.2
Number of children <15 y in the household						
0–3 children	13,766	34.3***	10,891	33.7***	2875	37.0***
≥4 children	5786	41.1	4543	40.9	1243	42.1
Education						
0–8 y of education	12,773	40.7***	9302	40.6***	3471	41.0***
High school education	5153	29.9	4702	30.2	451	25.9
≥1 y of college	1561	20.3	1384	20.1	177	21.9
Formal employment or self-employed						
Employed full-time	6404	32.2***	5319	31.6***	1085	34.8***
Employed part-time	5005	38.9	3933	38.6	1072	40.2
Unemployed	8143	38.7	6182	38.2	1961	40.1
Income <$2/d						
Yes	8419	44.8***	6449	44.1***	1970	47.7***
No	9306	28.5	7533	28.2	1773	29.6
Income quintiles						
Poorest 20%	4476	49.8***	3270	48.8***	1206	53.0***
Second 20%	3788	41.5	2967	41.6	821	41.4
Middle 20%	3649	35.8	2855	35.4	794	37.8
Fourth 20%	3386	29.8	2806	30.4	580	27.5
Richest 20%	2817	19.8	2360	19.5	457	21.3

[1] *n* (weighted %), unless otherwise specified. Chi-square tests were used to evaluate the distributions. *,**,***Significantly different: *$P \leq 0.05$, **$P \leq 0.01$, ***$P \leq 0.0001$.
[2] Never married, divorced, separated, widowed.
[3] Households composed of ≤6 members.
[4] Households with >6 members.

Older adults with these characteristics were at significantly higher risk of SFI than younger adults. For both age groups, income and educational attainment were most significantly associated with SFI, but the association between rural residence and SFI was no longer significant when controlled for income (results not shown). There were no significant differences in the prevalence of SFI by marital status for younger adults, but a significantly lower proportion of married or partnered older adults experienced SFI compared with those who were single (36.5% compared with 42.7%, respectively, $P < 0.001$) (Table 5). The prevalence of SFI was also higher among individuals in households with more children (Table 5), and the presence of children increased the risk of SFI for older adults more than for younger adults (results not shown). Finally, the prevalence of SFI was also higher among older adults in smaller households compared with younger adults, and among older adults living alone, compared with other respondents (41.7% compared with 32.0%, respectively, $P < 0.0001$) (results not shown).

Discussion

FI continues to be highly prevalent in SSA and has been measured by different tools, limiting comparability between countries and monitoring. Existing indicators measure various FI aspects, but given their variability and localization, it can be daunting to decide which tools to use to obtain the desired information (6). The FIES, developed to provide cross-cultural, multicountry, comparable FI information, provides a unique opportunity to obtain the prevalence of FI across countries through the use of a single metric (9, 10). This study used Rasch modeling to explore the validity of FIES for use in SSA in a sample of 57,792 adult respondents aged ≥19 y, and our results provide evidence for the validity of FIES for use in adults in SSA with some caveats.

The overall acceptable infits for all FIES items, except for 3 countries, indicate equal discrimination and good fit of FIES to the Rasch model.

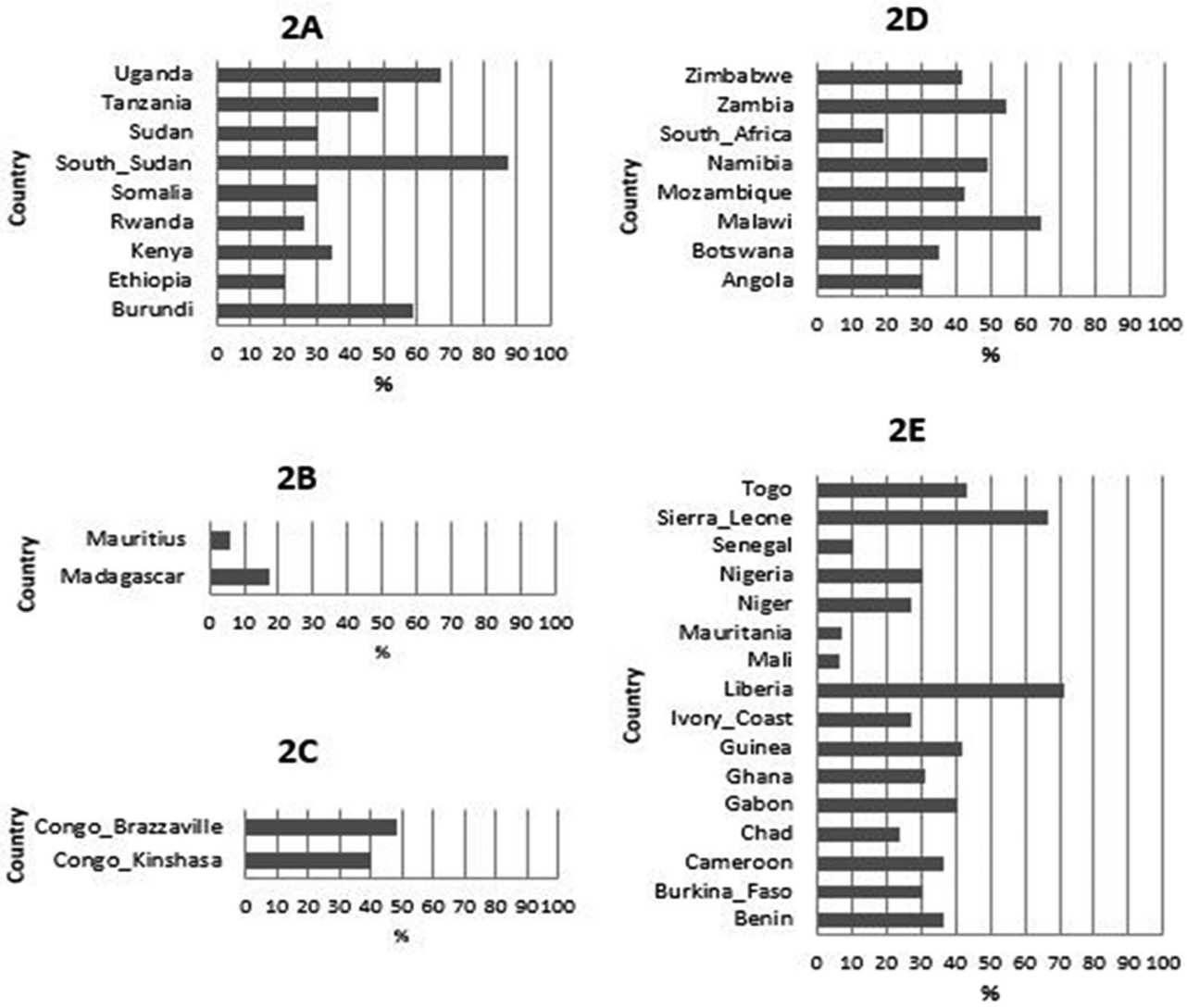

FIGURE 2 Prevalence of severe food insecurity in SSA countries included in the combined GWP 2014 and 2015 surveys with the use of the SSA standard thresholds. (A) Eastern Africa region, (B) Island region, (C) Central Africa region, (D) Southern Africa region, and (E) Western Africa region. GWP, Gallup World Poll; SSA, sub-Saharan Africa.

The expectation is, therefore, that FIES will function as expected for most SSA countries. The reliability scores, which indicate overall model fit, were $\geq$0.7 for all countries, subregions, and age groups. These good overall reliability scores indicate consistently ordered items among respondents, and that responses are related to respondents' food security status. However, there were notably high outfits for the items "worried" and "fewfoods" in a few countries, and for "whlday" in about one-third of the countries. Similar results for the item "whlday" were reported by FAO in the global 2014 GWP data analysis (9).

These higher outfits, particularly for the item "whlday", suggest that improvement of these items should be attempted through cognitive testing. Cognitive testing is a qualitative research method used to investigate whether respondents understand questions as intended, focusing on the reasoning behind the responses (18, 28, 29). However, even for the items with high outfits, because they had good infits, they are not indicative of any serious violation of the Rasch assumptions (25). Outfits outside the acceptable range present less threat to validity because outfits measure the extent of highly improbable responses on items that are not close to the latent trait of respondents, those considered relatively easy or difficult for them (30). In this study, the high outfits for the item "whlday" may have resulted from the fact that 71.4% of respondents who affirmed this item had raw scores of 8 and were dropped from the Rasch analysis, which could lead to less precise outfits. Nonetheless, cognitive testing may better identify reasons for these high outfits, especially because of their occurrence in many countries. Cognitive testing should also be done for the item "worried", which had high infits in Namibia and Sudan, and for the item "hungry", with low infits in Chad. The high infits suggest that in Namibia and Sudan, the item "worried" is weakly associated with FI, whereas the low infits for the item "hungry" in Chad imply that the data are more

predictable than expected, and some items may be redundant. In both cases, improvement of the items should be attempted, or they could be excluded in future studies that use FIES in these countries.

Based on comparability of the item severities in most countries, FIES measured the same severity of FI. Our results also showed no significant correlations in most countries, and the measure was unidimensional. Because FIES met the assumptions of conditional independence and equal discrimination in most countries, we conclude that FIES has satisfactory psychometric properties, and is a valid tool for use in SSA. If these assumptions are met, other Rasch model assumptions are less likely to be problematic. However, for Congo Brazzaville, Congo Kinshasa, and Somalia, the large number of items with significantly different severities compared to the SSA standard metric, even after several adjustments, need attention. In these countries, these items may be understood differently and may measure different severity levels of FI compared with the rest of SSA. Reporting the prevalence of FI in these 3 countries, with the use of the SSA standard metric, should be done with caution. In Chad, Guinea, Senegal, and Togo, cognitive testing may be necessary to assess whether in these countries the correlated items "hungry" and "ranout" assess the same level of FI. These countries are from Western SSA, hence, they are likely to be more culturally homogeneous, therefore, these 2 items may be understood similarly in all of them. For these countries, 1 of the items could be dropped from the scale or modified to capture a different dimension of FI.

The main element of concern noted in all countries was the disordering of items, which is related to construct validity (13). The 5 lower-severity items did not always perform as expected. The item "fewfoods" indicated the lowest level of FI. This suggests that eating few types of food might be commonplace, probably related to cultural food patterns among other factors (31, 32). Experiencing worry in SSA, on the other hand, indicates a more severe level of FI. A plausible explanation for this finding might be religiosity, i.e., people believe in divine providence, hence they may not be prone to worrying until they are in dire circumstances (33). Owing to this item severity disordering, the expected proportion of affirmative responses to FIES items was inconsistent, although there were fewer affirmative responses for items measuring more severe FI. Despite this concern, because the Rasch criteria are very strict, results need to be taken as a whole, and no one criterion is disqualifying (17). A potential reason for disordering of items may be difficulty in consistently discriminating categories due to too many response options or confusing labelling (34). However, FIES does not have too many response options. To overcome the limitation of the disordering of the threshold items measuring less severe FI, we combined scores for the FS and the MFI categories. In using FIES for any future studies in SSA, attention should be paid to these items measuring lower severity of FI.

This study found high prevalence of SFI in SSA, indicating a need for intervention and continued monitoring. Burundi, South Sudan, Uganda, Sierra Leone, and Liberia have some of the highest prevalence of SFI. These countries share a recent history of political instability. More in-depth assessment of SFI determinants in these countries is necessary. Our results showed significant associations between FI and sociodemographic and economic characteristics that were previously reported in other studies (35–54). In our study, those who experienced higher prevalence of SFI tended to have lower incomes, higher dependency levels indicated by having many children, and lower educational attainment; lived in rural areas; were women; and were older adults. The higher prevalence of SFI among older adults may be due to the associations between income and ageing, and income and rural residence found in this study. A larger proportion of older adults, than younger adults, were poorer, and more of them were rural residents. These older rural residents were at significantly higher risk of SFI than younger rural residents. The lower incomes of older adults in our study may be related to limited livelihood strategies in rural SSA, the rural economies being mostly subsistence economies. Older adults have traditionally been respected and cared for in SSA, and they still are. However, owing to economic conditions, there has been rapid rural-urban migration of younger people in SSA, leaving older adults on their own. Because of this, older adults in rural SSA may be more likely to experience insufficient household farm labor and dwindling extended family support (55), increasing their vulnerability to FI. Africa has experienced the highest urban growth during the last 2 decades. As of 2014, the urban population was only 37% (56), but it is projected to increase to 50% and 60% by 2030 and 2050, respectively (55). Our findings show that older adults in smaller households compared with larger ones, and those who lived alone, were at higher risk of SFI. It is possible that in larger households, the risk of SFI among older adults may have been lower owing to the buffering role of social support or to additional income from adults in the same household still in the workforce. These results indicate the need for paying more attention to the living arrangements of older adults and to the attendant impact on food security.

This is the first study to validate FIES for use in SSA, and to report the cross-cultural and multicountry comparability of FI estimates. Our results show that despite heterogeneity in the populations examined, common FI thresholds and common determinants of SFI for adults in SSA can be determined with the use of FIES. The similarity of item severities across SSA countries, SSA subregions, and for older and younger adults is evidence of the stability of FIES across languages and cultures. The results suggest that FIES measures the same trait, and that FI is experienced similarly across SSA with few exceptions, therefore, results can be meaningfully compared. Also, the similarity in FIES FI thresholds determined for SSA improves ease of monitoring, providing a unique opportunity to inform targeted interventions and improved planning across SSA.

The strengths of our study include the large nationally representative sample from the 37 SSA countries, which makes our results generalizable to this region. The in-person interviews also decreased coverage bias. In addition, the same tool (FIES) was used to assess the prevalence of FI, making prevalence rates comparable across countries. FIES contains a limited number of questions, with simple responses, reducing interview time, fatigue, and bias. However, limitations of this study include response bias that may arise from cross-sectional studies. In addition, FIES, like other tools, does not provide information on causes of FI, therefore, the utilization of mixed methods, both qualitative and quantitative, remains important in order to delve into the local causes of FI.

For Burundi, Ethiopia, Somalia, Sudan, Chad, Ghana, Guinea, Ivory Coast, Liberia, Mali, Nigeria, Senegal, Togo, Angola, Namibia, and Madagascar, we recommend cognitive testing of FIES to possibly guide improvements of items with high outfits, especially for the item "whlday". This is especially important for Ethiopia, Ghana, Ivory Coast,

Madagascar, and Mali, because high outfits for the item "whlday" were seen in these countries in both 2014 and 2015. Cognitive testing of FIES in Chad, Guinea, Senegal, and Togo could also determine whether the items "hungry" and "ranout" measure the same FI level, in which case, 1 of the items could be eliminated for these countries in the future. For Congo Brazzaville, Congo Kinshasa, and Somalia, because >3 items had significantly different severity parameters from those of the SSA metric, they should be examined to determine if the questions are understood as intended and the level of FI they may reflect. We also recommend closer examination of the order of FIES items for SSA. Our findings suggest that for SSA, FIES items may need to be ordered differently to better measure lower levels of FI.

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