Children Effect on Household Food Insecurity: An application of the Classical Rasch Model to Household Survey in Uganda

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ABSTRACT

Food security has been a phenomenon of interest worldwide because population groups in several parts of practically all continents are said to experience some form of food insecurity, hunger or related phenomena. Ability to measure the extent or magnitude and severity of food insecurity makes it possible to come up with more realistic, adequate and robust ways of solving the problem. This study applied the Rasch model to measure food insecurity in Uganda. The dataset used was generated using the 18 USDA food security assessment questions. Model Testing was done using the Infit and the outfit test statistics with the range 0.7 to 1.3 considered acceptable.

An algorithm for the Rasch model was developed and run using the R-programming software which also generated the Infit/Outfit statistics, Beta coefficients and probabilities. The households were then classified into three categories; food insecure (0.0 to 0.49, moderately food insecure (0.5 to 0.79) and food secure (0.8 to 1.0). Most households (46.6%) were found to be moderately food insecure and one third (33.5%) were found to be food insecure.Children 5 to 17 years have a significant influence on the food insecurity status of a household.

Keywords: Household Food Insecurity, Infit/outfit, Household Classification, Rasch Model

PAPER

1. Introduction

Food security has been a phenomenon of interest worldwide because population groups in various continents are said to experience some form of food insecurity. The challenge has been how to measure it. Ability to measure the extent or magnitude and severity of food insecurity makes it possible to come up with more realistic, adequate and robust ways of solving the problem. Correct measurement of food insecurity is hinged on a clear understanding of its multi-faceted nature. Years of research and discussion led scientists to generally agree that food insecurity is constituted by four major components namely food availability, food access, food utilization and food stability. It has also been shown that macro level analysis results in outcomes that may reflect a large community as food secure when pockets of communities or individual community members are food insecure. One of the best ways of analyzing food insecurity is therefore the household as it is representative of community characteristics at micro level.

The household is the best unit to measure food insecurity due to the following reasons: Food security dynamics are at play at all levels from global community to individuals. Measurement at higher levels has led to wrong conclusions as many communities said to be food secure would still have many individuals or households in dire need of food. Whereas the ideal would be analysis at individual level, it is very cumbersome and expensive. The household has a good mix of individuals including infants, children, adults, males and females, young and old. It therefore provides a good representation of social economic and cultural characteristics of community. Household food security status can be aggregated to obtain food security status of bigger entities like villages, districts, nations, regions up to global level. According to Jones, Ngure and Young (2013), the food acquisition behaviors of households are important for translating physical and economic access to food into food security. All food security components namely food availability, access, utilization and stability as well as coping strategies are best assessed at household level. *It can be considered the best micro-level reflection of the global community.*

When the Rasch Model was introduced as an approach for measuring food insecurity by the United States Department of Agriculture (USDA), it attracted a lot of interest and has since been used in a number of countries to measure food insecurity. The 18 USDA food security questions include the 10 questions for adults and 8 questions for households with children. In West Africa, Obayelu (2012) disaggregated the 18items into 10 adult-referenced items and 8 child-referenced items (children were those less than 15 years) and found that household food security status with respect to adults and children showed a differential pattern. For instance, in Kogi rural, a lower proportion of adults (25.8%) were food secure compared to the children (40.6%). The pattern is similar for the urban with 24.4 per cent of the adults food secure compared to 29.9 percent of children. This is contrary to the findings of Esturk and Oren (2014) who in their study in Adana region in Turkey found that food insecurity was higher for households with children (69%) compared to households without children (39.6%). Lori Reid (1997) in the USA found that Prevalence of food insecurity among children zero to 12 years of age was not significantly different from that of households in general. The three studies resulted in differing outcomes. Could it be the consideration of which ages the children are that affected level of food security arrived at (One considered 15 years and below,This study considered adults and children below 18 years as they constitute a big proportion of Uganda's population. The 2012 Uganda's population report showed that over half of Uganda's population, (56.1%) are children (↓18 years). Unemployment rate for Uganda's youth aged 15–24 is very high, reported by World Bank (2008) to be 83%. This makes them vulnerable to food insecurity given that income is a decisive variable for household food security (Esturk and Oren, 2014). Other youth challenges are lack skills and market access for income generation to maintain food security.

The analysis involved determination of food security status using the 18 items and the 8 children-referenced items (Table 1). The dataset is from two Ugandan districts involved in fishing, livestock and crop farming for their livelihoods. The study also analysed the relationship between food security and three age categories – children below five years, five to below 18 years and adults (18 yearsand above).

Table 1 - Food Coping Questions: Variable Description

E1	Worried whether food would run out before getting money to buy more.
E2	Food harvested or bought just didn't last, and we didn't have money to get more.
E3	Couldn't afford to eat balanced meals.
E4	*Relied on only a few kinds of low-cost food to feed our child/children because we were running out of food and money to buy food.*
E5.	*Couldn't feed our children a balanced meal, because we couldn't afford.*
E6.	*Our children were not eating enough because we just couldn't afford enough food.*
E7	Did you/or other adults in your household ever cut the size of your meals or skipmeals because there wasn't enough food or money for food?
E8.	If Yes to E7, how often did this happen?
E9.	Ever eaten less than you felt you should because there wasn't enough money to buy food?
E10.	Were you ever hungry but didn't eat because you couldn't afford enough food?
E11.	Did you lose weight because you didn't have enough money for food?
E12	Did you(or other adults in your household) ever not eat for a whole day because there wasn't enough food or money for food?
E13.	If Yes to E12, how often?
E14	*Ever cut the size of (any of your children's) meals because there wasn't enough food or money for food?*
E15	*Did any of the children ever skip meals because there wasn't enough food or money for food?*
E16	*If yes to E15, howoften did it happen?*
E17	*Were your children ever hungry but you just couldn't afford more food?*
E18.	*Did any of your children ever not eat for a whole day because there wasn't enough money for food?*

2. Methodology

Food insecurity analysis was done using the Rasch Model. The Rasch model is capable of simultaneously measuring individuals' ability to respond to a set of score items, while also assessing difficulty levels of the score items.It is the only IRT model in which total score across items characterizes a person totally. The sum of all these item scores gives each individual a total score (summary of all item responses) which is used for comparison. The person with a higher total score is said to possess more of the variable being assessed. The summing of item scores to get a single score implies that it is intended to measure a single/unidimentional variable. The Rasch model is named after George Raschwho made a case for models based on the principle of invariant comparison. The principle of invariant comparison states that, "The comparison between two stimuli should be independent of which particular individuals were instrumental for the comparison; and it should also be independent of which other stimuli within the considered class were or might also have been compared"(Rasch, 1961).Since formulation of the model by Rasch in 1960, various generalizations have been developed (Mair and Hatzinger, 2007). In food security assessment for example, two households assessed by two researchers should be independent of the researchers (http://www.rasch-analysis.com/rasch-model-specification.htm).

2.1 Model Testing

The Rasch model analysis generates 2 model fit sets of statistics, the infit and outfit. The weighted Infit and/or outfit statistics represent difference between item performance as expected by model under the model assumptions and observed household responses. They are used to assess extent to which items conform to the Rasch model specifications. They are based on the conventional sum of squared standardized residuals and is given as:

$$\frac{z^2}{N} \quad \ldots \quad (1)$$

Where: $z^2 = \frac{(X-E)^2}{\sigma^2}$ is the squared standardized residual

N is the number of observations summed

X is an observation

E is expected value based on Rasch parameter estimates

σ^2 is the modeled variance of X about its expectation.

The Infit/Outfit good range is 0.8 – 1.2 but values 0.7 – 1.3 are considered acceptable. When an item fits the model perfectly, the Infit/Outfit value equals one. Infit value above 1.0 indicates that the item discriminates less sharply than the average of all items in the scale while Outfit value above 1.0 indicates a weaker than average association of the items with the underlying conditions. The item Outfit is an outlier-sensitive fit statistic which like Infit compares the observed household responses with responses expected under the assumptions of the Rasch Model (Obayelu, 2012). Hackett et al (2008) in their gender respondent effects on Brazilian food security scale used weighted item infitvalues, arguing that infit values were most commonly used in food security scale assessment. They did not use the outfit statistics because they were heavily influenced by extreme responses. Obayelu (2012) in his comparative analysis of householdfood security status in Kwara and Kogi states in Nigeriahad both Outfit and Infitstatistics that were within the range of 0.8 and 1.2. According to him and other scholars, values higher than 1.2 indicate questions that are not consistently understood and should be removed or omitted. Values lower than 0.8 are more closely associated with the underlying condition and are undervalued in an equal weighted scale.Connel, Nord, Lofton and Yadrick (2004) in their Rasch model analysis to determine the food security status of older children in schools also reported Infit/Outfit statisticsof between 0.86 and 1.11 except one question whose outfit and infit statistics exceeded the range but they included it in their analysis. This study assessed both infit and outfit statistics and considered the range 0.7 to 1.3 as acceptable. Yong quoted Wang and Chen (2005) as recommending a plot of the mean squares on a graph, checking them visually to identify a misfit (Chong Ho Yu, 2010).This study also used a Rasch model graphical check.

2.2 Rasch Model Analysis using R Programming

The extended Rasch model in R statistical package was used to analyse the 18 items responded to by 577 households in Tororo and 598 households in Busia. The probability of a household's reaction to a stimulus was a function characterizing the household's food insecurity level as a latent trait. The log odds of a household i correctly responding to an item j was a function of ability (β_i) and the item's difficulty (δ_j). The location of a household on the Rasch scale was determined using the IRT indicator distribution I_{ij} with

$$\Pr(I_{ij} = 1 \mid \beta_i \delta_j) = \frac{\exp(\beta_i - \delta_j)}{1 + \exp(\beta_i - \delta_j)} \quad \ldots \quad (2)$$

Where I_{ij} is a dichotomous random variable representing response of household i to item j

i = 1, 2, ……., n are the households ($n_{Tororo} = 577, n_{Busia} = 598$)

j = 1, 2, ……., m (m=18) are the items

β_i = i^{th} household's ability parameter for i = 1, … n

This is also referred to as the severity of household food insecurity

δ_j = j^{th} item's difficulty parameter

Responses to the 18 Rasch Model questions were coded into binary codes. For the often/sometimes/never responses, "often" or "sometimes" were coded as affirmative (value = 1), and "never" was coded as negative (value = 0). For yes/no responses, "yes" was coded as 1 and "no" as 0. For "how often?" responses, "almost every month" and "some months" were coded as 1 and "only 1 or 2 months" and never were coded as 0. Thus, the data structure looked like Figure 1;

respondent	E1	E2	E3	E4	E5	E6	E7	E8	E9	E10	.	.	.
1	1	1	1	1	1	1	0	0	1	1			
2	1	1	1	0	1	1	0	0	1	1			
3	1	1	0	0	0	0	0	0	0	0			
4	1	0	1	1	1	0	1	0	1	0			
5	0	1	0	1	1	0	0	0	0	0			
6	1	1	1	1	1	1	1	0	1	1			
7	1	1	1	1	1	1	1	0	1	1			
8	1	1	1	1	1	1	1	0	1	1			
9	1	1	0	1	0	0	0	0	1	1			
10	1	1	1	1	1	1	0	0	1	1			
.	1	0	1	1	1	1	1	1	1	1			
.	0	0	0	0	0	0	0	0	0	0			
.	1	1	1	1	1	1	1	0	1	1			

Figure 1: Modified Data Structure

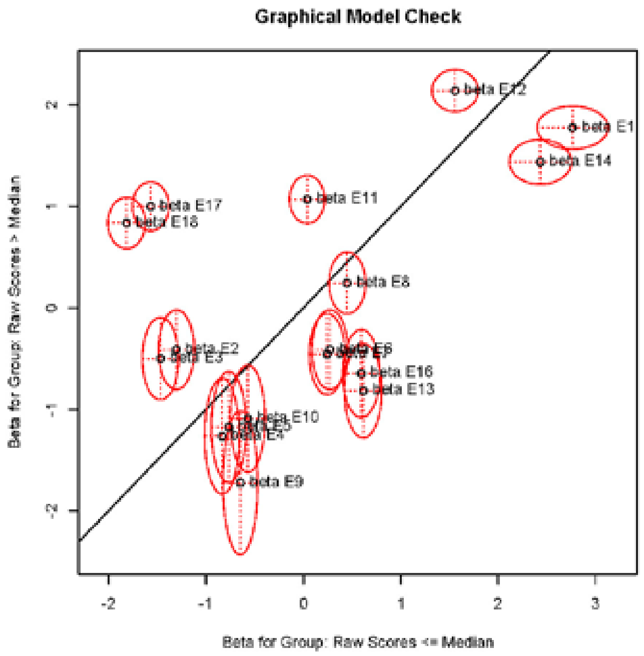
An algorithm for the Rasch model was developed and run using the R-programming software which also generated the Infit/Outfit statistics, Beta coefficients and probabilities for Busia and Tororo datasets.

The households were then classified using thresholds:Food Insecure (0.00-0.49); Moderately Food Insecure (0.50-0.79); Food Secure (0.80-1.00).

3. Results and Discussion

The graphical model check in Figure 2shows E9 and E13 to E18 to be outliers/misfits.Table 2 shows their outfit MSQs to be outside the acceptable range. However, their infit MSQ statistics except for E17 (infit MSQ 2.007) and E18 (infit MSQ 1.995) are within or close to acceptable range of 0.7 to 1.3.Therefore, given the infit statistics of E2 to E16 being within acceptable range, for the Rasch analysis we consider the 16 items E1 to E16. For Infit statistics for E17 and E18 (Table 2) are above 1.0 implying the item discriminate less sharply than the average of all items in the scale. Outfit statistics forE2, E3, E17 and E18 are above 1.0 indicating their weaker than average association with the underlying conditions.

Figure 2a - Graphical Rasch Model Check for all 18 Items



Generally, values higher than 1.2 indicate questions that are not consistently understood and should be removed or omitted. These include E2, E3, E17 and E18 that were earlier identified with outfit MSQ greater than 1. Values lower than 0.8 are more closely associated with the underlying condition and are undervalued in an equal weighted scale. These include E4 to E7, E9, E13 to E16 (see outfit MSQ, Table 2).

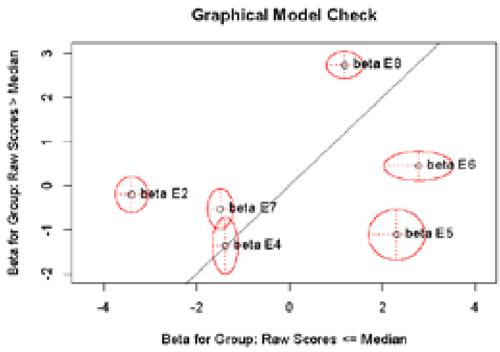
Considering the proposed interpretation of the infit/outfit ranges for parameter level mean square fit statistics by the website http://www.rasch-analysis.com/rasch-model-specification.htm, we have the following: Table 2showsvariables E17 and E18 with outfit MSQ↑2.0 implying theywould distort the measurements. Variable E3 has value between 1.5 and 2.0 and is therefore unproductive for construction of measurement. Most of the variables E2, E4 to E12, E15 and E16 have values between **0.5 and 1.5** and are therefore **good for productive measurement**. Variables E13 and E14 have values below 0.5 and are considered less productive for measurement, but not degrading and may produce misleadingly good reliabilities and separations. When we consider the infit MSQ, the variables all fit within the range 0.5 and 1.5 with the exception of E17 and E18. They can therefore be used for productive measurement.

Table 2 - Infit/Outfit Test Results for the 18 Items

	Chisq	df	p-value	Outfit MSQ	Infit MSQ	Outfit t	Infit t
E2	1286.13	1008	0	1.275	0.893	2.04	-2.32
E3	1530.81	1008	0	1.517	0.989	3.3	-0.21
E4	641.791	1008	1	0.636	0.726	-3.82	-6.63
E5	693.454	1008	1	0.687	0.824	-3.31	-4.11
E6	756.669	1008	1	0.75	0.754	-3.65	-6.36
E7	646.423	1008	1	0.641	0.833	-5.49	-4.17
E8	816.519	1008	1	0.809	0.924	-2.8	-1.86
E9	585.344	1008	1	0.58	0.689	-4.84	-7.75
E10	770.023	1008	1	0.763	0.78	-2.63	-5.32
E11	1265.53	1008	0	1.254	1.212	3.28	4.77
E12	1217.26	1008	0	1.206	1.187	1.67	4.37
E13	486.701	1008	1	0.482	0.618	-8.88	-10.59
E14	501.747	1008	1	0.497	0.685	-5.67	-8.87
E15	504.175	1008	1	0.5	0.71	-4.91	-7.92
E16	564.924	1008	1	0.56	0.67	-7.24	-8.94
E17	3125.6	1008	0	3.098	1.995	12.37	16.91
E18	3399.51	1008	0	3.369	2.007	11.72	16.53

Figure 2b shows that only two variables E4 (outfit MSQ 0.6, infit MSQ 0.7); and E7 (outfit MSQ 0.7, infit MSQ 0.7) were close to the line of model fit and would be considered to be within acceptable range as confirmed by their outfit MSQ/infit MSQ given in Table 3.

Figure 2b - Graphical Rasch Model Check for Children Items



Their values are within the productive measurement range of 0.5 to 1.5 when one considered both infit and outfit MSQs. Variable E6 infit MSQ of 0.5 also puts it within the productive measurement range. The other variables are misfits. Therefore, considering only the children factors for the Rasch analysis, variables E4, E6 and E7 can be used for food security analysis for household with children.

Table 3 - Outfit Infit Analysis for Households with children

Question	Chisq	df	p-value	Outfit MSQ	Infit MSQ	Outfit t	Infit t
E5	2501.445	614	0.000	4.067	1.178	5.49	2.42
E14	**339.406**	**614**	**1.000**	**0.552**	**0.659**	**-3.45**	**-6.9**
E15	191.457	614	1.000	0.311	0.41	-8.57	-12.18
E16	**247.383**	**614**	**1.000**	**0.402**	**0.531**	**-5.69**	**-8.94**
E17	**451.067**	**614**	**1.000**	**0.733**	**0.725**	**-1.87**	**-5.41**
E18	2161.368	614	0.000	3.514	1.142	5.25	2.46

3.1 Household Food Classification Using the Rasch Model

The probability of a household being food secure was derived from the Rasch Model with household food security status computed based on the following food security classification; Food Insecure (0.00-0.49); Moderately Food Insecure (0.50-0.79); Food Secure (0.80-1.00).

Table 5 - Household food insecurity status and the effect of number of household members by age category (<5 years; 5 to <18 years and 18 years and above)

Food Security Status/Characteristics	Insecure	Moderate	Secure	Total
Food Insecurity Distribution (%)	33.45	46.64	19.91	**1175**
HH average number of children <5 years old	1.61	1.64	1.74	**1.65**
HH average number of children 5 to <18 years old	2.7	2.47	2.45	**2.54**
HH average number with adults >18 years old	2.73	2.44	2.46	**2.54**

Table 5 shows that the largest percentage (46.6%) of households was moderately food insecure while one third (33.5%) were food insecure and only one fifth (19.9%) were classified as food secure. According to the analysis, food insecurity is more prevalent to households with more children aged 5 to 17 years, as it is with households having more adults compared to those with few children (5-17 years) and adult (18 years and above) household members. Children aged 5 through 17 years are classified as the most active whose bodies undergo various biological and physiological changes besides the intellectual growth (Kaiser et al., 2003). All these processes they undergo require a lot of energy as they form what type of adults they intend to be. Although, some of them may contribute to the household food production, their contribution is far less than their consumption since at most times, they are at school or involved in other activities that do not necessary contribute to the household food basket(Jyoti, Frongillo, & Jones, 2005).

Table 6 - Effect of Number of Children (less than 5 years and Less than 18 years) on Food Security Status in Uganda

Food Security Classification	Households with <5 year-old Children Status				Households with 5 to <18 year-old children status				Total
	With less than 5 year olds		Without less than 5 year-olds		With 5 to less than 18 year-olds		Without 5 to less than 18 year-olds		
	Frequency	Percentage	Frequency	Percentage	Frequency	Percentage	Frequency	Percentage	
Food Insecure	102	25.95	291	74.05	59	15.01	334	84.99	393
Moderate	137	25.00	411	75.00	119	21.72	429	78.28	548
Food Secure	57	24.36	177	75.64	47	20.09	187	79.91	234
Overall Total	**296**	**25.19**	**879**	**74.81**	**225**	**19.15**	**950**	**80.85**	**1,175**
	Pearson chi2 (2) = 0.2180 p= 0.897				Pearson chi2 (2) = 6.8066 p = 0.033				

When analyzed by age category of the children (Table 10), there is no significant difference in food security status for households with children under 5 years of age compared with those without this category of children (ˊ 0.2180 2 Pearson s , p 0.897). However, a significant difference in food security status was found between households with children aged 5 to ↓18 years and households without this category of children (ˊ 6.8066 2 Pearson s , p 0.033). It is possible that mothers tend to pay special attention to their very young children, providing for them required meals. When children grow older, they are expected to fend for themselves and may at times not be present for all the meals at home.When food is scarce, priority may be given to the younger children.

4.0 Conclusion

The effect of number of children in a household was studied(Owino, Wesonga, & Nabugoomu, 2014). Two main categories of children were thus hypothesized, those below five years and the 5 to 17 year olds with average household composition of 1.61 and 2.7 respectively for the sample of 1175 mainly rural-based households in the Eastern region of Uganda. Children 5 years to less than 18 years have a significant influence on the food insecurity status of a household. Attention needs to be given to understanding the food security situation of households with this category of children in order to plan for interventions.

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