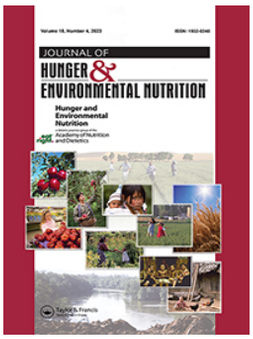

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ARTICLE

Food security variation among Indigenous communities in South-western Uganda

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ABSTRACT

We assess whether the household is an apt scale of analysis to examine food insecurity of Indigenous Batwa of Kanungu District, Uganda. Our objectives were: 1) estimate the prevalence and range of food insecurity, 2) estimate the variation in food insecurity associated with household and community factors. The survey was administered 6 times at 3-month intervals (Jan 2013-April 2014). Multilevel modeling was used to determine household and community associations with food insecurity. The Batwa were highly food insecure (97%). Variation in food insecurity that is explained by household and community factors was low. Food insecurity analyses should be considered scale-dependent.

KEYWORDS

Food Security; Indigenous Peoples; social determinants of health; multi-level modeling; Uganda

Background

Rising food prices, constraints on agricultural land, the occurrence of severe droughts, land degradation, and population growth have contributed to increasing attention to global hunger and food security. Indeed, the eradication of extreme poverty and hunger are the first two Sustainable Development Goals (SDGs).[1–5] Concerns regarding climate change impacts on food production and security (SDG 13) have further highlighted the importance of understanding and untangling the complex combination of regional, community, and household-scale stressors that interact to cause food insecurity and undernutrition burden.[6–9] In sub-Saharan Africa, high dependence on agriculture makes the region especially vulnerable to biophysical, climatic, economic, and geopolitical perturbations. For marginalized populations already struggling

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with poverty and hunger, stressors on food security may exceed their ability to adapt.[10,11]

Indigenous populations are believed to be particularly vulnerable to food insecurity due to patterns of neglect by governments, colonialism, lack of access to resources, ethnic discrimination, low employment, extreme poverty, and dependence on subsistence livelihoods.[8,10–12,13] Approximately 250 million Indigenous Peoples reside in Africa. The African Commission on Human and Peoples' Rights (ACHPR) cautions not to use Aboriginality as a synonym for Indigeneity, rather that focus should be placed on *1) self-definition as Indigenous; 2) special attachment to and use of their traditional lands, 3) experiences of subjugation, marginalization, dispossession, exclusion or discrimination*.-[14] The Batwa a rural Indigenous peoples (both recognized and self-identified as Indigenous), living in Southwestern Uganda, are among the poorest populations within Africa. They experience a high burden of illness relative to other Ugandans — including their non-Indigenous neighbors — and face social barriers accessing health care and education.[10,15–18] Economically marginalized populations, subsistence-based food systems, and Indigenous peoples more generally are recognized as highly vulnerable to perturbations in the stressors of food security.[19,20] Despite this, there is limited place-based research on Indigenous health and food systems in general, and Indigenous peoples' food security in sub-Saharan Africa in particular.[10,15,21–23]

Food insecurity can be conceptualized at a range of scales, from the individual to household, or as aggregate measures for a community or nation. The household-level survey is the current gold standard used most frequently to identify populations at risk,[24–26] though individual-level food security estimates are also common.[27,28] Household-level surveys characterize the variation in food security across populations to identify the most vulnerable households and frequently also to estimate associations with food security or insecurity. This approach, however, is predicated on the assumption that households within a sampled population are heterogeneous, and that the household level reflects an appropriate scale at which to capture variation in food security potential-associated factors. As highlighted by Pearce[29] and Rose,[30] the most important determinants of health may vary little within a particular population, and sampling should necessarily seek to capture a scale at which health outcomes and exposures vary. While the household is undoubtedly a highly relevant unit of analysis at which many food production, access, and consumption decisions are made, a focus on household-level variation may neglect empirical interrogation of larger-scale population-based determinants — at which important policy-relevant variation may occur — and intervention entry points. The use of household-level surveys for food security has herein remained relatively unchallenged as a unit of analysis, and there has been limited application of multilevel modeling within food security research.[31–34] What scale then is appropriate for measurement of

food security, in what contexts, and how can this be determined for a particular population? To what extent does the selection of sampling unit affect the range of potential intervention options inferred from epidemiologic analysis?

We herein seek to identify and characterize variation in food security across multiple scales for a Ugandan Batwa population. Objectives include: 1) estimate the prevalence and range of food insecurity for Indigenous Batwa in south-western Uganda, and 2) estimate the variation in food insecurity that is associated with household and community factors.

Methods

Study Population

The Batwa are an Indigenous People dispersed throughout Central Africa, and within Uganda live within three districts with a combined population of approximately 6,700.[35] Peer-reviewed and gray literature consistently cite poor health status and heightened risk among Batwa compared to their non-Indigenous counterparts.[22,36–38] Previous research has reported that poor nutrition and low food security status are high among the Batwa.[15,21,22,28]

Previously nomadic forest hunter-gatherers, the Batwa of Uganda were evicted from their ancestral homes, with no or negligible compensation, due to the establishment of Bwindi Impenetrable National Park (BINP) in 1991.[23] This displacement forced the Batwa to adopt an agricultural and sedentary lifestyle.[15] Main food sources for the Batwa since leaving the forest include subsistence agriculture (crop cultivation & small livestock rearing) and food in exchange for manual labor.[10,21] In Kanungu District, the Batwa live in settlements, and share agricultural land purchased and owned by non-governmental organizations (NGOs) and private donors.

Socioeconomically, the Batwa are highly impoverished compared to the Ugandan average and their neighbors. Uganda's national per capital income is significantly higher (550$) compared to the Batwa (97$),[10,39] and adult literacy (<10%) is significantly lower than the mean for Uganda's south western province (neighboring non-Indigenous population) (>73%).[10,40] Maternal health, child mortality, infant mortality, and life expectancy are all poorer among the Batwa than among neighboring peoples or the Ugandan average, and the Batwa have been highlighted as one of the world's most impoverished and marginalized populations.[15,41] Despite a wealth of gray literature highlighting concerns related to Batwa food security, there is negligible peer-reviewed research on Batwa health and food systems. Indeed, most articles in the peer-reviewed literature citing Batwa focus on the impact of the Batwa on the health of primates in Bwindi Impenetrable National Park, with limited focus on the Batwa themselves.

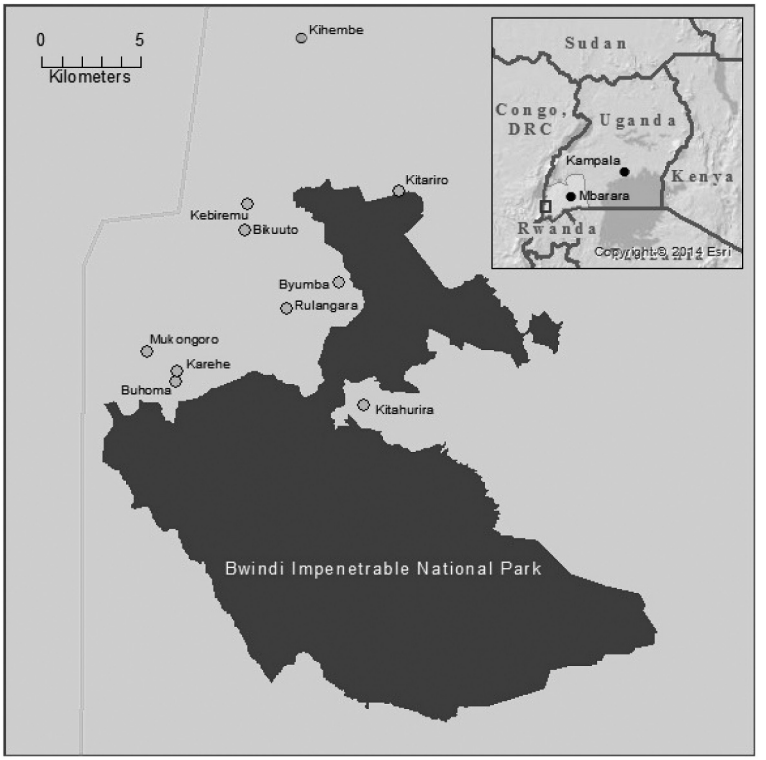

Figure 1. Map of Batwa communities in Kanungu District, Uganda.

This research took place in Kanungu District, South-western Uganda. As of 2013, there were approximately 750 Batwa living in Kanungu District, scattered throughout 10 communities in 130 households (Fig. 1). These communities are partners with the Indigenous Health and Adaptation to Climate Change Research Team. In 2011, the Batwa communities identified food insecurity as a key climate-sensitive health priority; a series of six longitudinal open-cohort census surveys was identified as the best way to assess food insecurity within these communities.[10] Surveys were administered in 3-month intervals; January 2013, April 2013, July 2013, November 2013, January 2014 and April 2014. Due to the relatively small Batwa population, each round of survey implementation aimed to capture a full census of Batwa households. 767 household and food security surveys were collected with an average of 127 households participating in each survey administration.

Analytical Framework

Defining food security is difficult and as of yet there is no universally accepted definition. Food systems broadly refer to the production, processing,

distribution, preparation, and consumption of food.[20] Food systems can become stressed by a number of factors – including climatic (drought, flooding), economic (price or demand increases, food shortages), social (food sharing disruption), and conflict (supply routes destroyed, decreased safety) – which can lead to increased difficulty in securing food at various scales (e.g. regional, community, household, and individual).[42] These factors lead to increased difficulty in securing food for the household or self, leading to food insecurity. The FAO defines food security as "*all people, at all times, [having] physical and economic access to sufficient, safe and nutritious food to meet their dietary needs and food preferences for an active and healthy life*."[43] In other words, when a group is food insecure, their access to, quality of, or quantity of food resources may be lacking.[20] Food insecurity in itself is a negative outcome, but it can also indirectly lead to other negative health outcomes: under-nutrition or over-nutrition, stunting, wasting, mental illness, adverse pregnancy outcomes and chronic illness (e.g. type II diabetes).[44–48]

Numerous methods and indices exist to measure food security at a range of scales: global, continental, regional, community, household, and individual levels. Data collected for each scale range from global food supply to self-reported experiences, perceptions, and behaviors of food insecurity.[50] The U.S. Department of Agriculture's (USDA) Household Food Security Survey Module (HFSSM) is one of the most frequently used instruments for assessing and measuring food security and has been validated and used internationally in less developed countries, emergency situations, and among Indigenous populations.[50–52] In selecting the food security measures for this study, we considered a variety of options from the economic literature, health literature, and international development literature, among other options. Following our community-led approach to this research[53–55] our decisions on food security measures were made in collaboration with Ugandan and community partners. The HFSSM was selected for this research because of its adaptive nature, its focus on the experiences and behaviors that characterize ranges of food insecurity and hunger severity, and a recognition in the literature that it is appropriate for vulnerable or high-risk populations.[25,49] Data from the HFSSM were not available for regional or national estimates; however, Kanungu District (and all of Southwestern Uganda) was considered to experience none or minimal food insecurity (at least 80% of households are able to meet their food and non-food needs without relying on unsustainable measures) by the Integrated Food Insecurity Phase Classification project.[56]

Data Collection

Data were collected using three survey instruments: individual, household head, and food security (FS). The first was administered to all members of the Batwa community (n = 750). The second instrument was administered

to self-identified household heads (n = 130), or their spouse, and the third instrument (food security) was administered to the head of household food preparation (n = 130). Paper questionnaires were used to record responses with each question administered conducted orally in Rukiga (the local language). The individual and household head survey aimed to identify an individual's characteristics (health, education, employment), and a household's characteristics (size, composition, assets wealth and agricultural participation). The food security survey was based upon the HFSSM and aimed to establish the extent and occurrence of food insecurity within the Batwa community from October 2012 to April 2014. The version of the HFSSM used examined the conditions, experiences and behaviors that characterize ranges of food insecurity and hunger severity experienced over the previous 3 months.[57] We used a one week recall period to reflect the high level of food insecurity reported by communities, in response to the difficulty with long recall periods during pilot work in 2011, to respect Batwa worldview and conceptualizations of time, and to follow the recommendations and instructions from our partners. Questions ranged from concerns about food insecurity, experiences of being food insecure and the frequency at which they occurred (Table 1). Additional questions on number of meals and food diversity were collected. Because Batwa communities share access to agricultural land owned in trust by NGOs, key informants and partners were consulted to identify and collect data for community-level associations with food security, which included crop-raiding, land quality, landscape type, and market access.

Food Insecurity Score and the Adapted Vulnerable Populations Score (AVPS)

To reflect the high proportion of Batwa with high food insecurity, we adapted the HFSSM (hereafter referred to as the Adapted Vulnerable Populations Score or *AVPS*) to capture variation in food security along a continuous gradient, reflecting variation at more severe levels of food insecurity (See Table 1). The HFSSM module categorizes score from (0–18) into the following four categories; "high food security," "marginal food security," "low food security," or "very low food security."[57] Based on pilot work we found that 85% of Batwa households were categorized into the "very low food security" category. We used a 26-point score to reflect a wider continuum of food security. As the score increases so does the severity of food insecurity. Our HFSSM-based *AVPS* incorporates an additional 6 points for households without children and an additional 8 points for households with children for total maximum scores of 16 and 26, respectively (See Table 2 for comparison between AVPS and HFSSM score/categorization). The additional points allowed us to capture wider variation among the most severe households. Missing data were imputed following standard HFSSM guidelines.[57]

Table 1. Adapted vulnerable populations score (AVPS) 26-point scale design.

HFSSM #	Question	Negative responses (Code = 0)	Affirmative responses (Code = 1)	Affirmative severe response (Code = 2)	AVPS with kids	AVPS without kids
1	In the past week, did you ever worry whether the food for you and your family would run out before you could get more?	never	sometimes, often		1	1
2	In the past week, did it happen that the food you Bought/obtained didn't last enough time and you couldn't buy/obtain more?	never	sometimes, often		2	2
3	In the past week, did you have enough varied, healthy or balanced meals to eat?	never	sometimes, often		3	3
4	In the past week, were there times when you could only feed your children less expensive/ lower quality foods because food ran out at home and it was difficult to buy/obtain higher quality food?	never	sometimes, often		4	
5	In the past week, were there times when you did not have enough to feed your children with varied, balanced and healthy meals?	never	sometimes, often		5	
6	In the past week, where there times when your children were not eating enough because you just couldn't buy/obtain enough food?	never	sometimes, often		6	
Added	How many meals does your household typically eat in a day?	3 or 4	2		7	4
				1	8	5

(*Continued*)

Table 1. (Continued).

HFSSM #	Question	Negative responses (Code = 0)	Affirmative responses (Code = 1)	Affirmative severe response (Code = 2)	AVPS with kids	AVPS without kids
7	In the past week, did you or other adults in your household ever cut the size of your meals or skip meals because there wasn't enough food at home?	no	yes		9	6
8	How many days in the past week did adults skip or cut meals?	1	1+		10	7
Added	Adults skipped/cut meals weighted	0–2	3–4		11	8
				5+	12	9
9	In the past week, did you or other adults in your household ever eat less than you felt you should because there wasn't enough food at home?	no	yes		13	10
10	In the past week, were you or other adults in your household ever hungry but didn't eat because there wasn't enough food at home?	no	yes		14	11
11	In the past week, did you or other adults in your household lose weight because you couldn't buy/obtain enough food?	no	yes		15	12
12	In the past week, did you or other adults in your household ever not eat for a whole day because there wasn't enough food in the home?	no	yes		16	13
13	How many days in the past week did adults not eat for whole day?	1	1+		17	14
Added	Adults not eat for whole day weighted	0–2	3–4		18	15
				5+	19	16

(*Continued*)

Table 1. (Continued).

HFSSM #	Question	Negative responses (Code = 0)	Affirmative responses (Code = 1)	Affirmative severe response (Code = 2)	AVPS with kids	AVPS without kids
14	In the past week, did you have to reduce your children's food portions because there wasn't enough food at home?	no	yes		20	
15	In the past week, did any of your children have to skip meals because there was not enough food at home?	no	yes		21	
16	How many days in the past week did children skip meals?	1	1+		22	
Added	Children skip meals number weighted	0–2	3–4		23	
				4+	24	
17	In the past week, did any of your children ever go hungry because there was no food at home?	no	yes		25	
18	In the past week, did any of your children not eat for a whole day because there was no food at home?	no	yes		26	

Table 2. Adapted vulnerable populations score (AVPS) 26-point scale compared to Household Food Security Survey Module (HFSSM) standard categorizations.

USDA Categories	HFSSM	AVPS
High food security	0	0–2.32
Marginal food security	1	3–6
Low food security	2	6.96–10.44
Very low food security	3	11–26

Independent Variables

We selected variables that have been identified as important for food security at the individual, household and community level based on the literature. Table 3 presents the variables that were selected for univariate testing as associations with food insecurity, the type of variable (i.e. continuous, binary, or categorical) expected direction of influence, and the justification for inclusion in preliminary testing. Wealth variable selection was guided by case studies in Africa among poorer populations and local observations[58–60] Principal component analysis was employed to create an asset-based wealth variable; the results were then transformed into quartiles to include in the model "least poor," "poor," "very poor" and "poorest" (Table 4). A large proportion of Batwa houses were constructed by the Batwa Development Programme (BDP), a local NGO, thus type, size, and materials of the household were not a reflection of wealth. We controlled for seasonal variation;[21] using a mixed-methods approach, found that seasonality was a significant component of food security for this population. The Batwa had higher food insecurity in the dry season compared to the rainy season.

Analysis

Food security scores for each household were calculated as described above; the distribution of the food security variable approximated normal. To examine internal consistency of the *AVPS* we assessed Cronbach's alpha for the 26 items.[61] Univariate multilevel linear regression was used to identify candidate independent variables collected at the individual and household levels using a threshold of $p<0.20$.[62–64] Collinearity among candidate variables was assessed through the Spearman rank correlation analysis with a cutoff point of 0.70.[65] When variables were collinear, we proceeded with the variable that had the highest R2, the smallest confidence intervals, and/or the variable with higher causal plausibility based on similar studies in Africa. The multilevel model structure accounts for repeated measure at the household and community levels (n = 170 households, n = 10 communities). Three best-fit models were estimated: 1) household-level variables only (accounting for repeated

Table 3. Variables included in data analysis as potential associations with food security among the Batwa of Kanungu District, Uganda from November 2012-April 2014.

Description	Type	Expected Direction	Justification
Dependent Variable			
Food security	Categorical (1–4) (HFSSM) Continuous (1–26) (AVPS). As the score increase so does the severity of food insecurity.	N/A	We present both the USDA Household hold food security survey module (HFSSM) and the Adapted Vulnerable Populations Score (AVPS) Food security exists on a continuum rather than a specific scale. A larger range enhances the ability to differentiate households with more severe food insecurity.
Independent variables			
Household variables			
Sex of head of household	Binary outcome male = 1, female = 0	Increase score	Households with no male head have been found to have lower food security[30].
Highest level of adult female education	Categorical variable (No formal schooling = 3, Primary school incomplete = 2, Primary complete or above = 1	Decrease score	Higher levels of education have been associated with food security, particularly education of mothers.[66,67]
Number of adults employed full or part time within a household	Continuous Variable	Decrease score	Employment increases wealth and access to food in kind for labor, decreasing food insecurity.[66,68]
Any event of chronic illness in children or adults	Binary outcome yes = 1 no = 0	Increase score	Health and Chronic disease are major stressors on household wealth, resources and ability to work.[32,48,68] Food insecurity can also increase the likelihood of chronic illness.
Number of dependents under the age 18 within a household	Continuous Variable	Increase score	Households with children experience a higher food insecurity burden [32,67]
Number of people within a household divided by the number of rooms.	Continuous Variable	Increase score	Variable is used as a proxy for crowding within the communities.[69]
Wealth	Categorical variable, 4 quartiles	Decrease score	Principal component analysis (PCA) was used to calculate 4 categories of wealth based on an ownership score of the following assets: soap, fuel, land ownership, animal ownership, toilet type, phone, radio, remittances. [32,59,68,70–72]
Community level variable			
What type of landscape is most prevalent in the community	Categorical Variable Flat = 1, Mixed = 2, Hilly = 3	Increase score	Flat landscape is more ideal for growing crops. Hilly or steep inclines are vulnerable to erosion.[73]
Rank the community's access to small markets or shops	Categorical variable Good = 1, Fair = 2, Poor = 3	Increase score	Access to small markets to buy or trade goods is important for day to day access. [66,74]

(*Continued*)

Table 3. (Continued).

Description	Type	Expected Direction	Justification
Dependent Variable			
Rank the community's road access in terms of proximity and quality	Categorical variable Good = 1, Fair = 2, Poor = 3	Increase score	Road access is key determinant to transport goods to trade or items bought at markets and an indicator of infrastructure in the area.[75]
Rank the community's access to large trading centers/markets	Categorical variable Good = 1, Fair = 2, Poor = 3	Increase score	Larger centers and markets enable people to negotiate or barter in a competitive environment and often have lower prices than smaller centers. [66,74].
How often does the community have events of crop raiding	Categorical variable, often = 1, sometimes = 2, never = 3	Decrease score	Crop raiding increases the burden of food security as it reduces yields and lessens harvest.[76]
Rank the overall quality of land within the community	Categorical variable Good = 1, Fair = 2, Poor = 3	Increase score	Arable land is a key determinant of yields and harvest potential.[19,73]
Control variables			
Sex of person in charge of household food preparation	binary outcome male = 1, female = 0	N/A	Responses may differ by gender, women may report higher food insecurity than men.[77] However, women are typically responsible for food preparation and may be more aware of the household food situation .[67]

Table 4. Distribution of assets by principle component analysis category among Indigenous Batwa in Kanungu District, Uganda, October 2012-April 2014.

	Principle component analysis – Wealth Status			
Assets	*Poorest*	*Very Poor*	*Poor*	*Least Poor*
Soap	0%	100%	5.29%	41.80%
Land ownership	70.68%	76.83%	74.07%	83.07%
Pigs	0%	0%	10.58%	25.40%
Chickens	0%	0%	3.17%	47.62%
Cell phone ownership	0%	0%	8.99%	37.04%
Radio ownership	0%	0%	77.25%	75.13%
Receiving remittances	10.10%	13.41%	10.05%	6.88%

household measures), 2) community-level variables only (accounting for repeated household measures and clustering within communities), and 3) household and community-level variables combined in a multilevel model (accounting for repeated household measures and community-level clustering). A manual iterative stepwise approach was used in model building. Akaike Information Criterion (AIC) was utilized to assess the best-fit model.[78] We conducted sensitivity analyses for all excluded candidate variables by testing them in the final best-fit model. We conducted post-estimation assessments of the models, examining normality and homogeneity of variance for the best linear unbiased predictors and a graphical assessment of Pearson's residuals. Variation accounted for by the model and random affects was recorded to calculate the intraclass correlation (ICC) or variance partitioning coefficient (VPC). These were used to analyze the amount of variation accounted by each level included in the model. Finally, we assessed how well the models were able to predict true food insecurity levels of households in the sample. All analyses were conducted in Stata version 13 (StataCorp13).

Results

Batwa Demographics

A full census of the Batwa residing in Kanungu district was attempted; the response rates ranged between 93% and 99% for individuals, and each administration had 99% participation from households. The demographic structure of Batwa households was relatively homogenous within and across communities, with an average of 4.7 people (2.6 dependents). A typical Batwa household lives in a 2-room mud house with iron sheet roofs. Sixty-five percent of households ranked in the two lowest categories of wealth. The majority of households (77%) reported owning land; the BDP and Kellerman foundation hold these land titles in trust. No households owned bicycles or motorbikes, and none had electricity. Eleven percent owned phones and 40% owned a radio. Few

Table 5. Food security results (HFSSM and AVPS) for Batwa households in Kanungu District, Uganda, October 2012-April 2014.

Food Security level		Households without children (%)	Households with children (%)	Total (%)
HFSSM		86	681	767
Food secure	High food security	7 (8)	9 (1)	16 (2)
	Marginal food security	0 (0)	10 (1)	10 (1)
Food insecure	Low food security	15 (17)	81 (12)	96 (13)
	Very low food security	64 (74)	581 (85.31)	645 (84)
AVPS 26-point scale				
Minimum, maximum (Standard deviation)		0–18.57 (4.70)	0–26	0–26 (5.72)
Mean		9.92	14.92	14.37
Median		10.44	16	15

households (10%) had external monetary support or remittances. Sixty-one percent of households had no adult females with formal schooling, 32% had some primary school and 7% of households had an adult female who had completed primary school. More than ninety-five percent of households participated in tending crops and manual labor. Only 10% reported tending animals and less than 5% reported participating in hunting activities. Due to this low variation among and between households and communities, further analysis of these agricultural variables was precluded. Most households did not own any animals (73%); those that did owned chickens (13%), pigs (9%) and goats (13%).

Communities ranged in size from 3 to 21 households. Landscape in communities ranged from flat to hilly, with most being mixed. No communities had *good* quality road access, 50% had *fair* and 50% had *poor* access. Access to large trading centers was fair or poor; small markets were more accessible. Land quality was generally good (40%) or poor (40%). Crop raiding occurred in communities located near the national park, 50% did not experience any crop raiding.

Prevalence of Food Security among Batwa Households

The Batwa of Kanungu are severely food insecure (Table 5). According to the HFSSM standard categorization, 97% of households were food insecure, with 13% of households reporting low food security and 84% experiencing very low food security. The AVPS was better able to distinguish variation between households, particularly in the most severe category. Cronbach's alpha for the *AVPS* was 0.8931, indicating high internal reliability. Among the Batwa the mean food insecurity score was 14.37 (out of 26) and the median was 15. Comparing these results to the HFSSM categorization, both the median and mean of the adapted score fall within the most severe HFSSM category of food

Figure 2. Word cloud of food consumption in batwa households, Kanungu District, Uganda (2013–14). The more frequently a word is mentioned by households, the larger and darker its presentation in the image.

insecurity. Experiences of food insecurity did not vary significantly by community.

Ninety percent of households responded that they were worried they would run out of food, that food would not last and that they could not afford balanced meals (Fig. 2). Households with children fed children lesser quality foods, unbalanced meals, and felt they were unable to feed their children enough food. Sixty-eight percent of households reported eating two meals or fewer per day. Seventy one percent of adults reported skipping meals with 31% skipping more than 3 meals in the past week. The majority of adults also reported eating less than they felt they should (81%), feeling hungry (66%), losing weight (68%), and not eating for whole days in the past week (50%). Households reported cutting the size of their children's meals (89%), skipping meals (57%), children feeling hungry (59%) and children being unable to eat for a whole day (41%) in the past week.

Variables Associated with Batwa Food Insecurity

Based on unconditional linear regression at the household level, we retained the following household-level variables in the mixed-effect multivariable models: adult female education, presence of a household member with a chronic disease, the total number of household members and dependents, number of people sleeping per room, and household wealth. At the community level, we tested the role of landscape type, road access, access to trading centers, and

Table 6. Final multivariable mixed effects linear regression model using random intercepts to control for repeated household measurements and community-level clustering for associations with food insecurity among the Batwa of Kanungu District, Uganda, October 2012-April 2014.

Model name (description)	Null model	Model 1 (Household associations only)	Model 2 (Community associations only)	Model 3 (Household and community associations)
Intercept/Constant	14.36		14.23	12.03
Total variation (%)	32.63 (100)	25.75 (100)	32.59 (100)	25.90 (100)
Explained by household (%)	-	4.27 (25.58)	5.39 (16.53)	3.14 (12.12)
Explained by community (%)	-	-	0.48 (1.47)	0.08 (0.00)
Random effects/Unexplained (%)	32.63 (100)	21.43 (83.22)	26.72 (81.98)	22.68 (87.56)
Intra-class correlation/ Variance partitioning coefficient				
Household level	0.18	0.14	0.16	0.11
Community level	0.01	-	0.00	0.002
Independent variables				
Highest Adult female education	-		-	
Primary complete or Above		ref.		ref.
Primary incomplete		0.21		0.17
No formal Schooling		0.99		0.90
Presence of chronic disease	-		-	
No		ref.		ref.
Yes		0.71		0.66
Number of dependents	-	0.37***	-	0.41***
Wealth quartiles	-		-	
Least poor		ref.		ref.
Poor		1.70**		1.67**
Very poor		−0.03		−0.19
Poorest		1.62**		1.59**
Crop raiding	-	-		
Never			ref.	ref.
Sometimes			0.34	.80
Often			0.93*	1.28*
Access to markets	-	-		
Good			ref.	ref.
Fair			−1.59*	−1.57*
Poor			−0.17	−0.41
AIC of model	4816.425	4803.353	4815.815	4777.72

crop raiding. Based on unconditional univariate analysis of these variables, we retained market access and experiences with crop raiding as community-level variables in the mixed-effects multivariable models.

All multivariable models accounted for repeated measures of households over multiple surveys (Table 6). In the null model, intra-class correlations at the household level (0.18) exceeded the community level (0.01), both indicating low levels of between-group variation. A higher household-level ICC reflects the repeated nature of the data, with households similar across multiple measurements. In the household-only mixed-effects model, households in the poorest quartiles had significantly higher food insecurity than households in the least poor quartile (4^{th}), 1.62 ($p < .01$) (1^{st} quartile) and 1.70 ($p < .01$) (3^{rd} quartile). For each dependent a household had, food insecurity increased by

0.37 points ($p < .01$). Female education and the presence of chronic disease in the household were not significant in this model but contributed to model fit. The data indicated that the presence of educated females may be protective, and that the presence of chronic disease may increase food insecurity. The ICC for the household level (0.14) decreased modestly compared to the null model.

In the mixed-effects multivariable community-level model, communities subject to regular crop raiding showed higher levels of food insecurity (0.93-point increase compared to those with no crop raiding). Access to markets was also associated with higher food insecurity. Households in communities with fair access to markets had a food insecurity score 1.59 points ($p < .05$), *lower* (i.e. more food secure) compared to households in communities with good access. The explanatory power of the community-level model was poorer (higher AIC) compared to both the null and household-level models. Further, community-level clustering accounted for less than 2% of the variation, with variation from household and random effects >98%. These results indicate that food insecurity was highly homogenous among communities, and that community differences did not contribute to explaining variation among households in food insecurity.

The final best-fit multilevel model incorporating both household and community-level variables and accounting for repeated household measures and community-level clustering retained four household level and two community-level associations (identical to those retained by the household-only and community-only models). Coefficients of the variables varied only marginally between the models; both direction and strength of associations for all variables were stable across the three models. Wealth – measured via PCA – had the largest protective impact on the food security score, though even in the case of wealth, the magnitude of impact was relatively low: a difference of only 1.59–1.67 points on a scale of 26 for food insecurity between the poorest and least poor quartiles. Community-level variation, similar to the Model 2 was <1%, while variation explained by the household level decreased to 12.12%. Post-estimation diagnostics were normal, and the model was a good fit for the data.

Despite the retention of significant independent variables at both the household and community levels in the best-fit models, all models had the poor capacity to explain variation in food security among households and communities. Notably, the magnitude of all the regression coefficients was low, even for categorical independent variables with high theoretical predictive capacity (e.g. education, wealth).

Discussion

This study found that the prevalence of food insecurity among the Batwa was among one of the highest in the published literature, with more than 97% of

households being classified as food insecure over six surveys between January 2013 and April 2014. A new scale, AVPS, was developed to capture variation of food security occurring within the HFSSM's worst category. The model found that wealth, experiences with crop raiding and proximity to markets were significant associated with food security for the Batwa. However, due to the homogenous nature of severe poverty among Batwa households, the significantly associations with food insecurity found in our models explained little of the variation in food security.

The scale at which food security should be measured is debated in the literature, with no clear agreement.[79,80] Policymakers and governments favor the household-level measure as it is cost-effective yet focused enough to deal with context-specific issues. Some argue that the current household-level scale of food security analysis is overly broad and suggest that the individual-level would be more appropriate.[79,80] However, there has been negligible empirical research attempting to integrate broader scale associations with food insecurity into quantitative food security research, despite advances in multilevel modeling.[66] Review of the drivers of food insecurity in southern Africa re-iterates the role of external factors on household associations with food security. Misselhorn found that food insecurity resulted from "the interaction between environmental stressors, and socio-economic conditions over various time scales".[66] Developments in public health research highlight growing recognition of "neighbourhood" (or higher level) effects, and multilevel modeling techniques are increasing applied to understand the relative contribution of determinants of health outcomes across scales.[81–88]

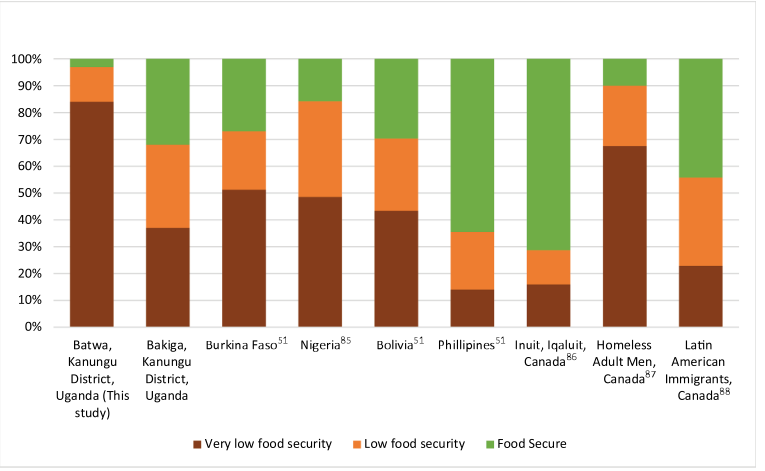

Figure 3. Global comparison of household food security survey module (HFSSM) status. High and marginal food security have been collapsed into one category.

Our findings represent among the highest levels of food insecurity recorded in the peer-reviewed literature (Fig. 3). Ninety seven percent of Batwa households in Kanungu were found to be food insecure. Levels of food insecurity among Batwa exceed reported prevalence among the surrounding neighbouring Bakiga population and other Indigenous or low-income populations globally, confirming findings of high impoverishment and anecdotal and gray literature reports of severe food insecurity.[10,17,18,21,23,38] Other studies have found similar disparities in the experiences of infant death, acute gastrointestinal illness, malaria, malnutrition between the Batwa and their neighboring populations.[38,41,89–91] The Batwa have been systemically marginalized and discriminated against based on their physical appearance, their identities as hunter-gatherers, and lack of literacy (read, write and speak in English).[92,93] Finally, in Uganda the recognition of Indigenous peoples includes all ethnic groups; therefore, policy instruments meant to protect the rights of Indigenous peoples are of little use to the Batwa.[23,92]

We considered both community and household-level food security variables to explain variation in food insecurity among the Batwa. Community variables, though retained in the best-fit model, provided negligible power to explain variations in food security. Several household-level variables provided weak but significant explanatory power. The number of dependents increased household experiences of food insecurity. This finding is similar to other case studies of highly food insecure populations.[94–97] Larger households have more numbers to feed, and the Batwa lacked sufficient wealth and assets to ensure adequate food for each member. Reduction in food intake occurred at a higher prevalence for adults than children. This finding was consistent with similar findings elsewhere and supports the theory that households may be protecting children from hunger: adults take on a higher burden and buffer children's exposure to food insecurity.[98,99] Adults within communities' work for food in-kind or for money, which is then shared with household members unable to work (including children or elderly). Additionally, education and health costs of dependents increased the burden on household wealth.[95,96] Adult female education was predictive of food security. Among the Batwa, adult literacy was very low compared to the Ugandan average and women tended to be less educated. Formal educational opportunities – within the Ugandan national schooling system – were largely absent for Batwa until their eviction from the forest in 1991, and many were unable to afford the school fees until the Batwa Development Programme established a scholarship program for all Batwa children to attend school for free in 2006. Older Batwa (>45 yrs.) typically have no formal education, while education of younger adult Batwa remained limited. Young Batwa (<20 yrs.) had the highest levels of education (increasingly frequent attendance at secondary school and a small number of post-secondary students) and reflect an emerging generational shift in education levels of future adults and household heads.

In lower income countries, the wealth acquisition of rural populations is typically from agriculture or manual labor and/or remittances. Wealth assets usually center around owning animals, radios, cell phones, and modes of transportation.[100–102] National associations with food insecurity in Uganda include poverty, living in rural areas compared to urban, having a female-headed household, subsistence farming, owning land and distance to access the land.[103] Eighty percent of Uganda's population depends on agriculture. Among the Batwa, however, owning land was not found to be significant in affecting food security, likely since most land has been purchased through an NGO and is held in trust; indeed, Batwa reported poor land fertility and low yields.[104,105] This is further exacerbated by experiences with crop raiding by wildlife; communities within close proximity of the BNIP borders reported higher frequency of raiding events.[76,106,107] Owning animals, and having employed members of the household theorized as indicators of wealth within the Batwa population and as potentially associated with increased food security. Owning animals was not significantly associated with increased food security, likely due to low ownership within these communities. Household employment was analyzed through number of members working, number working full-time jobs, number of women employed, and presence of a salaried job. None of these were significantly associated with food security.

Lack of variance in both food security outcomes and measured independent variables constrained analysis and identification of the associations with food insecurity among the Batwa. For example, the importance of agriculture often varies greatly from one household to one another, and from one community to one other. However, in our study, we found little variation between and among households and communities, which precluded further analysis of the agriculture variables captured by the questionnaire. Further research should include more sensitive and specific questions in attempts to capture more heterogeneity in responses among participants. For instance, at the household level, time to access to cultivated plots, land size, agriculture yields, type of crops grown, crop diversity, access market information through cell-phones, among other factors are often important. At the community level, existence of agricultural extension services, time to access the nearest market, among other factors are often important.

Social networks and sharing networks may explain some of the absence of variation in food security outcomes, and the low impact of wealth.[108] Data on social networks were not available for this research, but informal discussions and observations indicated regular movement of households and members between communities. Social and reciprocal relationships are often found in Indigenous Peoples globally and may help explain how households are able to acquire food if not through typical sources of wealth, i.e., owning animals or having a wage employment.[109–111] However, exposure to adverse realities did not vary among the Batwa: all Batwa reported difficulty accessing sufficient

food. Homogenously extreme impoverishment, as in this case, may preclude development of effective social and reciprocal networks.

Rose [30] highlights the shortcomings of seeking within a homogenous population to identify outliers and defining normal as the average within a local population: as a result, "real" determinants – those outside the scale of study – may remain undiscovered. Even exposure variables that are associated with 100% of poor outcomes will explain 0% of variation in that outcome if that variable is invariant in a population.[29] In the case of food insecurity among the Batwa, our results suggest that the most significant associations with food insecurity may explain little of the variation in food insecurity – not because they are not important causes of food insecurity, but because they vary little when households are used as the scale of analysis. Interpretation of significant independent variables based on these results could indicate interventions targeted at educating women, eliminating chronic disease presence, reducing family size and increasing wealth may increase food security. However, while interventions targeting education and wealth are likely to be appropriate within this population, the Batwa likely face larger social mediating effects that are invariant at the household scale or even community scale, including exposure to inequality, and lack of social capital and access. In this case-study, even multi-level modeling to include the community level was insufficient. Rose[30] provides further insights and suggests that policy-relevant variance may be observable only between populations rather than within them, particularly if an exposure is unvarying at the scale of analysis. Herein, multilevel models that include regional comparisons (Batwa versus neighboring populations) would be required to fully – and appropriately – identify the distinctive causes of Batwa food insecurity.

Limitations

There are a few limitations that should be addressed. First, measuring food security is difficult and the measure used here was based on self-reporting and perceptions. this can be subjective and potentially impacted by recall bias.[112] However, we shortened the recall period to better respond to community preferences (1 week, rather than 3 months), and we worked with community members to ensure the translations and meaning of the questions were clear through pilot work (four pilot surveys were conducted in 2011–2012). Second, alternative tools to measure food insecurity are available and widely used, and may have resulted in more variance for analysis. We brought several options to the community for feedback and the choice to use the USDA HFSSM and the AVPS to categorize food security was finalized by our community partners. Third, comparative analysis would likely illustrate and underscore the assumptions made here, that food insecurity is worse than neighboring populations and may have illuminated other inequities in social determinants of

health. Again, during the study design Batwa communities preferred focusing on Batwa-only sampling. In the future, in partnership with Batwa communities, a comparative study may be supported to illustrate and analyze the inequities between communities. Fourth, the positionality of the researchers may have impacted answers.[113–116] Some studies have found that the level of food insecurity may be over-emphasized to receive potential aid, or that participants respond with answers they believe the researchers want to hear.[112] Extensive pilot work was conducted in an effort to integrate communities into the research process and prevent this. The research team acknowledged their positionality and attempted to reduce the asymmetry in power between the researchers and participants. However, given the inequity this community experiences, the power imbalance may still have impacted responses by community members.

Conclusion

Our results suggest that variation in food insecurity may be poorly reflected in household-level, or even community-level analyses and that variation and key predictors of food security – and therein appropriate intervention entry points – are likely occurring at the regional scale. Food insecurity analyses should be considered scale-dependent, with increased use of multilevel modeling approaches to identify methodologically appropriate and policy-relevant scales of analysis. The AVPS may be appropriate for analyses where a large proportion of the population are food insecure. The scale dependence of food insecurity among the Batwa, may indicate the scale dependence of other burdens of disease. A comparative study between the Batwa and the Bakiga may provide valuable insight into the determinants of health outcomes in the District. While the Batwa do have extremely high burdens of food insecurity, they have an extensive history of adaptation and resilience. Moving forward, the Batwa will need external support to negate historical injustices and partnerships strengthening their capacity.

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