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RESEARCH ARTICLE

Understanding the factors associated with child malnutrition in rural Burundi: experiences from the Muyinga and Ngozi provinces

Willy Désiré Emera[a,c], Marijke D'Haese[a*], Wannes Slosse[a] and Carl Lachat[b]

[a]*Department of Agricultural Economics, Ghent University, Ghent, Belgium*
[b]*Department of Food Technology, Safety and Health, Ghent University, Ghent, Belgium*
[c]*Institut des Sciences Agronomiques du Burundi, Bujumbura, Burundi*
**Correspondence: marijke.dhaese@ugent.be*

Background: Childhood stunting, wasting, and underweight are markers of poor nutrition and socioeconomic deprivation in low-income countries. It remains unclear which factors are associated with child malnutrition in rural Burundi, in particular in a context of subsistence farming as found in rural Burundi.
Aim: This study investigates child undernutrition in rural Burundi and identifies household-level risk factors in subsistence farm households.
Method: A sample of 242 children participated in a cross-sectional survey conducted in Muyinga and Ngozi provinces. Height-for-age z-scores (HAZ), weight-for-age z-scores (WAZ) and weight-for-height z-scores (WHZ) were calculated using the WHO Anthro Survey Analyser. Descriptive and regression analyses were used to identify factors associated with a child's risk of stunting (children with a HAZ < −2 standard deviation [SD]), underweight (children with a WAZ < −2SD) and wasting (children with a WHZ < −2SD).
Results: A high prevalence of stunting was found (in 53.1% of children under 5 years of age) in our sample. About a quarter of the children in the sample (25.1%) were underweight and 8.9% were wasted. The presence of off-farm income in the household of the children was associated with a lower prevalence of underweight and wasting. Households whose earnings were more than US$238 in the season prior to the survey were less likely to have a child who was underweight (OR = 0.05; CI: 0.00–0.32; $p = 0.009$) than households whose earnings were less than US$96 in that season, but children were equally likely to suffer from stunting. No evidence was found that children from households that were able to sell more of their produce were less malnourished.
Conclusion: In the context of subsistence farming, self-consumption of agricultural produce is insufficient to support optimal growth of children under the age of 5. Diversifying household income sources could contribute to improve the children's nutritional status in the short run.

Keywords: stunting, wasting, underweight, malnutrition, farm households, Burundi

Introduction

Child malnutrition, particularly stunting, remains a critical concern in rural areas, where children under the age of 5 are most vulnerable. Globally, over 149.2 million children suffer from stunting (height-for-age z-score [HAZ] < −2 standard deviation [SD]), and 45.4 million experience wasting (weight-for-height z-score [WHZ]< −2SD).[1] Numerous studies have examined household-level factors associated with child malnutrition. These studies have pointed to various risk factors and behavioural characteristics, such as food consumption choices, education levels, food insecurity, household size, age of the household head and the mother, and breastfeeding frequency.[2–7] The household environment is an important driver of poor nutrition and includes the households' access to healthcare, hygiene, and clean drinking water.[8] Malnutrition is inherently linked to the income levels and, hence, livelihoods of the households. It is well known that smallholder households and especially subsistence farmers are particularly vulnerable to food insecurity.[9] This may seem paradoxical, as they are the source of food. However, the difficult economic situation in which subsistence farmers find themselves often restricts their access to inputs needed to secure food produced on the farm for their families and/or to money that would enable them to buy food that complements agricultural produce.

Burundi faces high rates of chronic malnutrition.[10] According to estimates on the national nutritional situation and food security survey,[11] 54.2% of children under 5 in Burundi were stunted in 2020, with notably high rates in the northern provinces of Muyinga (58.1%) and Ngozi (63.1%). Gaiser et al.[10] report similarly high prevalence rates of stunting. The prevalence of underweight children is estimated at 27.2% nationwide[11]. Despite these alarmingly high numbers - particularly of stunting, which is a marker of chronic malnutrition and has long-term effects on children's continued development - there is remarkably limited attention for the region in literature. Exceptions include Gaiser et al.,[10] who examined factors associated with stunting in Burundian children and demonstrated the importance of maternal literacy and knowledge. Leroy et al.[12] examined the impact of a nutrition intervention on children's stunting levels. This study showed that over 60% of the children suffered from stunting, which the authors link to material deprivation and child and household conditions. Gaiser et al.[10] also found a higher prevalence of stunting in rural compared with urban areas. Generally, households in rural areas are prone to poverty, thus, undernutrition and their low ability to buy food contribute to the risk of stunting.[10] The nutritional vulnerability of households is also due to a dietary inadequacy not adequately compensated for by the food produced on their farms.[13] Indeed, according to World Bank data, agriculture still

represents 85% of employment in Burundi.[14] Many households depend on subsistence agriculture for their livelihoods. The alarming levels of stunting are therefore striking as one would expect the farm output to be at least sufficient to feed the children.

The dire nutritional status of children in subsistence farming households is still insufficiently studied. Here, we analyse data collected from farming households in Muyinga and Ngozi, two northern provinces of Burundi. The study identifies the prevalence of malnutrition among children under 5 years of age in the Muyinga and Ngozi provinces of Burundi. We identify household-level risk factors associated with high malnutrition among these young children. More than others before us, we sought to understand whether children's malnutrition is related to the agricultural livelihoods of their mainly subsistence-oriented households. We also relate the malnutrition status of the children to the food security status of the households.

Multiple individual, household, and environmental factors are known to influence the nutritional status of children. Child's age and gender, and the mother's age, are potentially important individual factors. At the household level, we consider the education level of the head of the household, the farm type, and the family's level of off-farm income. By including the farm type, we assess whether children on subsistence farms tend to be more prone to malnutrition than children on farms with some sales. We are also interested in how the farm household's revenue from sources outside of the farm that each household member engages in associates with the risks of child malnutrition.

Methods

Data

Study setting

We conducted a cross-sectional study in the Muyinga and Ngozi provinces of Burundi. The sample considered six of the seven communes in Muyinga and all nine communes in Ngozi. We discarded the data of one commune in Muyinga as it was where the survey was pretested.

Sampling plan

The sampling frame is based on earlier research. As explained in Niragira,[15] 10 villages were chosen at random from the villages' list of each commune, and 4 households from each village were also chosen at random. While the sample consisted of 640 households (which consists of four households of 60 communes in Muyinga and 70 communes in Ngozi), the data of 583 households could be used for future research after data cleaning. This study considers a subset of this sample, namely that of 264 households with children aged under 5 who were willing to participate in anthropometric measures. During data collection, surveyed households were asked whether they had children under 5 years of age. For the analysis, a filtering condition 'if-else' was applied to extract a subset of households with children aged under 5 from the overall sample. Surveyed households were required to provide consent for anthropometric measurements of their youngest child, aged 6–59 months. The data collection was carried out by interviewers trained in the various techniques of data collection, and especially in the techniques of taking anthropometric measurements on children under 5 years of age.

Questionnaire

The questionnaire used for data collection was divided into several sections to capture a wide range of socioeconomic, demographic, and food security characteristics of the household and the diet diversity and anthropometric information of the children. The subsistence level of the farms is determined by the level of farm produce that is sold outside the farm gates. We consider 5% and 10% as cut-off thresholds to identify three groups of farms (i.e. subsistence farms, quasi-subsistence farms, and farms with some sales).

We define off-farm income as income that the household gains from activities the household engages in outside the farm gate. We follow Van den Broeck and Kilic,[16] who define off-farm employment as all economic activities that take place outside the agricultural household, hence excluding on-farm self-employment activities but including off-farm salaried and casual wage employment, and off-farm self-employment.

In addition to the socioeconomic and demographic questions, the level of household food security was assessed using the questions of the Household Food Insecurity Access Scale (HFIAS) proposed by the USAID.[17] The HFIAS is composed of nine questions on food access in the household, for which the respondent is asked to (dis)affirm the occurrence of the access problems over the last four weeks prior to the interview and, if the occurrence is affirmed, how frequently the issue presented itself on a three-point scale from 'rarely' to 'often'.[17]

Food access in the household and for children was also measured by their dietary diversity. The guidelines of UNICEF and the WHO[18] were used to draft a list of seven food groups presented to the mother or caregiver of the children asking them to recall the food the child consumed over the last 24 hours. The seven food groups are (1) grains, roots and tubers, (2) legumes and nuts, (3) dairy products (milk, yogurt, cheese), (4) flesh foods (meat, fish, poultry, and liver/organ meats), (5) eggs, (6) vitamin-A rich fruits and vegetables, and (7) other fruits and vegetables.[18] Following the UNICEF and WHO guidelines,[18] a child is considered to reach minimum dietary diversity when the child consumes four of the seven food groups. The food groups were translated into local language and examples of the food considered were given by the enumerators.

Anthropometric measurements

A specialist from the Ministry of Health in the National Nutrition Program (PRONIANUT) trained the interviewers for all the necessary anthropometric measurements. Only households with children aged under 5 were considered for the subsample of this study. Where a household had more than 1 child under 5 years of age, the youngest child between 6 and 59 months was selected for the anthropometric measurements.

The anthropometric data were obtained as per WHO standards.[19, 20] The child's age was verified by consulting the child's vaccination card. The weight of the children was measured using the fully battery-operated Seca 874 U scales (Seca GmbH, Hamburg, Germany), with a 10-gram precision. Before a child was placed on the scale, the mother or caregiver was instructed to remove all heavy clothing from the child to increase the accuracy of the weight measurement. For older children, all clothing was removed except for essential items such as pants. For children under the age of 2, a 2-in-1 method was used: First, the mother or caregiver was weighed,

then mother and child were weighed together, and the child's net weight was calculated by subtracting the mother's weight from the combined total.

To measure the children's height/length, the Infant/Child/Adult ShorrBoard tailored by UNICEF was used as advised by the WHO anthropometry manual.[20] The height measurements were always carried out by two people: a measurer and an assistant. For children under 2 years of age, the length was measured using the ShorrBoard, which was placed on a flat, stable surface. The assistant knelt behind the base of the board while the measurer positioned himself on the right side of the child to hold the foot section with his right hand. The assistant supported the back of the child's head with his hands and gently lowered the child onto the board.

For children over the age of 2, the ShorrBoard was fixed to a wall to ensure stability while the child stood on it. The assistant knelt next to the child, with both knees on the floor on the child's right side, while the measurer knelt on his right knee to maintain mobility. After making sure the child's torso was adequately supported, the measuring officer carefully pushed the board up to the child's head and then announced the measurements out loud.

Malnutrition indicators

Malnutrition indicators were calculated using the weight, height, sex, and age of children under 5 in the WHO Anthro Survey Analyser. The following indicators were calculated: (i) the prevalence of chronic malnutrition (stunting) using the HAZ based on the 2006 WHO standards;[21] (ii) the prevalence of underweight using the weight-for-age (WAZ) of the child; and (iii) the prevalence of wasting using the weight-for-height (WHZ) z-score of the child.[22] The HAZ, WAZ, and WHZ were determined using the WHO Anthro survey analyser software[23] and integrated with the survey data set for descriptive and econometric analysis in R (R Foundation for Statistical Computing, Vienna, Austria).

The software flags up data points that are biologically implausible. The flags generated by the software are defined as follows: height-for-age z-score (HAZ): < -6 or $> +6$; weight-for-length/height z-score (WHZ): < -5 or $> +5$, and weight-for-age z-score (WAZ): < -6 or $> +5$.[23] The flagged data points were discarded from further analysis. To exclude flagged cases, we applied the filter function of the dplyr package in R script tailored to select cases that meet WHO thresholds for the malnutrition indicators analysis.[24]

Data analysis

Binary logistic regression was used to explore the statistical relationship between the nutritional status of children aged under 5 (stunting, wasting, and being underweight) and several child, mother, and household characteristics. Table 1 gives an overview of the variables of interest (stunting, underweight, and wasting) and explains how we proxied the characteristics we considered as independent variables in our analysis. To assess the association between dependent and independent variables, odds ratios (ORs), 95% confidence intervals (CI), and *p*-values were calculated. Two model specifications are presented in order to check the robustness of the results. Before validating our regression analyses, collinearity between independent variables was investigated.

Table 1: Summary of the variables included in the study

Variable name	Measurement	Coding/Cut-offs
Dependent variables		
Stunting	Based on the height-for-age z-score (HAZ) calculated by the Anthro survey analyser	We considered a child with a HAZ lower than −2 standard deviation as suffering from stunting
Underweight	Based on the weight-for-age z-score (WAZ) calculated by the Anthro survey analyser	We considered a child with a WAZ lower than −2 standard deviation as being underweight
Wasting	Based on the weight-for-height z-score (WHZ) calculated by the Anthro survey analyser	We considered a child with a WHZ lower than −2 standard deviation as wasted.
Independent variables: child, mother, and household characteristics		
Child's age	Age in months (survey)	Different age groups are considered: 6–11 months, 12–23 months, 24–35 months, 36–47 months and 48–60 months
Child's gender	Female/Male (survey)	Coded as female = 0; male = 1
Household size	Number of household members (survey)	Less than 6 persons = 0 More than 6 persons = 1
Child's dietary diversity	Number of food groups consumed by the child (1–7 excluding breastfeeding) (survey)	A child with diversified diet consumes at least 4 out of 7 food groups; a child whose diet is not diversified consumes less than 4 out of 7 food groups excluding breastfeeding
Mother's age	Current age of the mother (survey)	Mother is less than 36 years old = 0 Mother is more than 36 years old = 1
Education of the household head	Self-reported level of education (survey)	Educated (primary and secondary schooling) = 0 Illiterate (illiterate and enjoyed some informal schooling) = 1
Farm characteristic	Farms were categorised based on their level of subsistence (survey)	Farms that sold less than 5% of their produce = 1 Farms that sold between 5% and 10% of their produce = 2 Farms that sold more than 10% of their produce = 3
Off-farm income	Income earned by the farm household outside the sales of farm produce in the season prior to the survey measured in FBU (survey) exchanged to US$	Less than the 96 US$ per season = 1 Between 96 and 238.1 US$ per season = 2 More than 238.1 US$ per season = 3
Food security status	Categories measured following the responses in the survey to the nine HFIAS questions	Food secure = 1 Mildly food insecure = 2 Moderately food insecure = 3 Food insecure = 4

Ethical procedure

The protocol of the study, including the questionnaire, was ethically approved by the Statistical Service of Burundi (N/réf: 540/95/4066/2019) and by the UZGent, Belgium (EC2019-1951-BC06872) before the start of the study. Parents were informed about the concept, objectives, and procedure of the study. Parental consent was obtained for all children participating in the study. Participants were free to stop the survey at any time.

Chat GPT and Instatext were used to improve the English writing and the readability of this paper.

Results

Prevalence of stunting, underweight, and wasting

In total, 228 children were included for the analysis of stunting, 235 for the analysis of underweight, and 234 for the analysis of wasting. None of the children showed signs of oedema.

The red curve in panel (a) of Figure 1 shows the distribution of the HAZ in our sample, which suggests that 53% of children are suffering from stunting, while the green curve shows the distribution of HAZ in the reference population. The results underscore the high frequency of severely stunted children (with more than 29% of the children having a HAZ < −3SD) in our sample. The distribution of the z-scores for the WAZ in the children in our sample is shown by the red curve in Figure 1 (b). An estimated 25% of the children included in the study suffer from underweight, which is high compared with the WHO reference. Figure 1 (c) plots WHZ and shows that 8.9% of the children in the study were wasted.

Characteristics of children with malnutrition

More than 50% of the children in the sample were found to be stunted (Table 2). The prevalence of stunting was the lowest amongst children in the youngest cohort. We found a relative higher prevalence of being underweight and suffering from wasting amongst the youngest age group in our sample (40.5% and 28.6% of the children between 6 and 11 months old had WAZ and WHZ scores below −2SD, respectively). The sample comprised 54% boys and 46% girls and a larger prevalence of stunting was found in the group of boys compared with girls.

A majority of the households in the sample suffered from moderate to severe food insecurity as measured by their HFIAS (83.7% of the sample). Only just under 12% of the households could be considered food secure. Stunting and underweight of children below age 5 was found across all food security groups with no discernible difference between groups.

Overall income levels of the households in the sample were low and households' dependence on agricultural production is clear from the high levels of subsistence production and the low levels of income from outside agriculture. For 67.7% of the households in the sample, off-farm income was below USD$96 per season. A majority (78.4%) of the farm households sold less than 10% of their produce. The data did not show a statistically significant correlation between the subsistence nature of farming and the prevalence of stunting and being underweight. The prevalence of being underweight was slightly higher for children in households with low levels of off-farm income compared with the other off-farm income groups.

In Tables 3 and 4, the factors associated with the occurrence of stunting and underweight are evaluated using logistic regression. The model results of Table 3 include the relationship between child malnutrition and food security indicators (HFIAS prevalence and dietary diversity). The latter factors were not included in the model; these results are presented in Table 4. We show the results of both models as a robustness check: Supplementary Figures S1 to S3 plot the relationships between the probabilities of children suffering from stunting, underweight, wasting, and various factors analysed, and Supplementary Tables S1 and S2 give the coefficients of the logistic regressions that were calculated.

The regression results show that stunting is related to the child's age and gender. Compared with children aged 6–11 months, children aged 12–23 months (OR = 2.22; CI: 0.88–5.90; p = 0.098), 24–35 months (OR = 4.07; CI: 1.54–11.37; p = 0.006) and 48–60 months (OR = 3.11; CI: 1.17–8.70; p = 0.026) were more likely to be stunted. Boys were more likely to be stunted compared with girls (OR = 2.06; CI: 1.13–3.78; p = 0.018). We found no evidence that off-farm income and subsistence level of farm households were significantly associated with higher prevalence of stunting in the household.

The second two columns in Table 3 test the factors associated with malnutrition in terms of low weight-for-age (WAZ). The odds of being affected by low WAZ were lower for children aged 12–23 months than for children aged 6–11 months (OR = 0.27; CI: 0.09–0.78; p = 0.017) and for children aged 36–47 months (OR = 0.18; CI: 0.02–0.84; p = 0.047) than for children aged 6–11 months. Children from households with off-farm income of US$96–238.1 per season (OR = 0.18; CI: 0.05–0.50; p = 0.002) and children from households with off-farm income of more than US$238.1 per season (OR = 0.05; CI: 0.00–0.32; p = 0.009) than children from households earning less than US $96 per season.

The last columns of Table 3 show the results of the models assessing the factors associated with wasting in children in our sample. Older children in our sample were less likely to suffer from wasting compared with children aged 6–11 months. In particular, children aged 12–23 months (OR = 0.06; CI: 0.01–0.30; p = 0.002), between 24 and 34 months (OR = 0.17; CI: 0.03–0.79; p = 0.030), and between 48 and 60 months (OR = 0.06; CI: 0.01–0.33; p = 0.004) were less likely to be affected by wasting compared with children aged between 6 and 11 months. Children with mothers older than 36 years were more likely to be wasted than children with younger mothers (OR = 4.17; CI: 1.12–18.74; p = 0.044). Children from families in which the head of the household had enjoyed some form of education were less likely to be wasted (OR = 0.25; CI: 0.07–0.82; p = 0.028). Children from households with off-farm income between US$96 and US$238.1 were less likely be wasted (OR = 0.05; CI: 0.00–0.38; p = 0.017) compared with children from households with less than US$96 earned from off-farm activities.

We find little evidence that the subsistence level of the farms affects the child's nutrition status. Across all three indicators of undernutrition—stunting, wasting, and underweight—no statistically significant associations were observed among children from the three subsistence farming household groups.

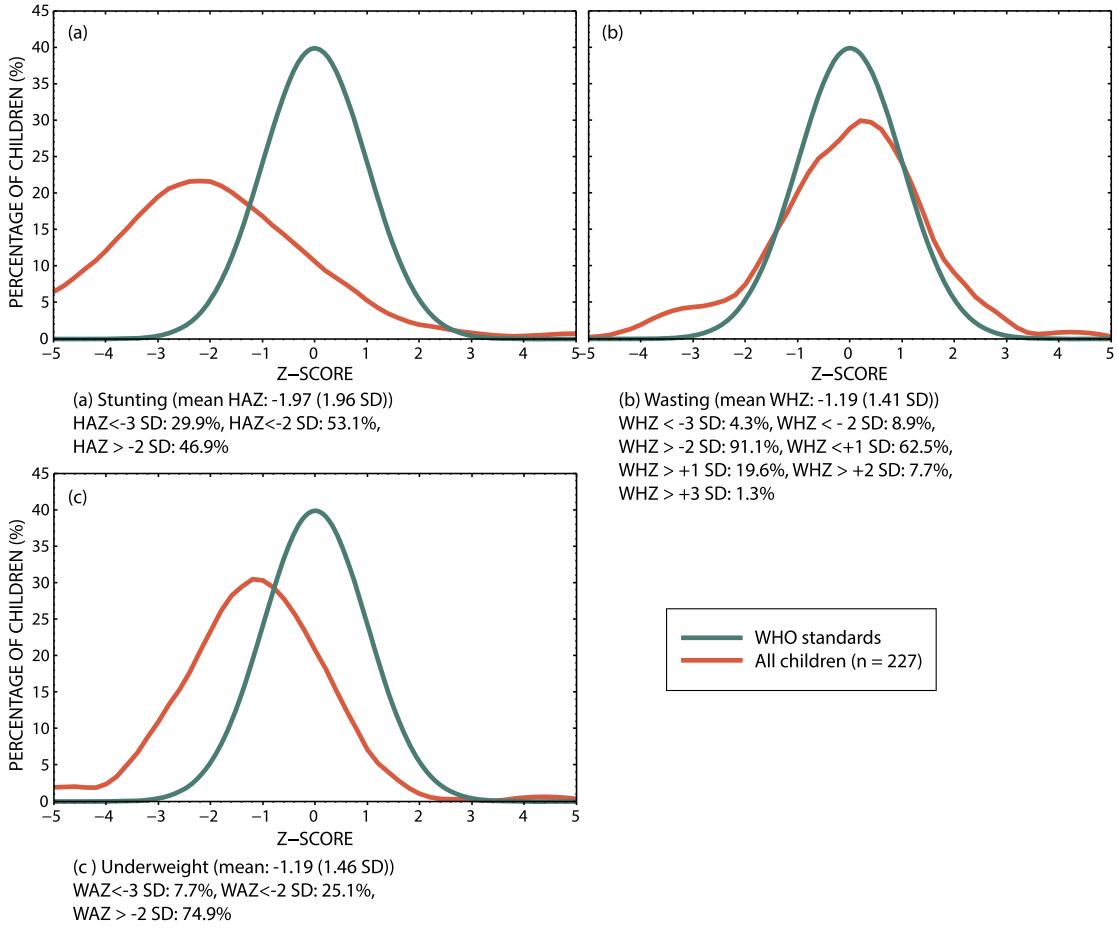

Figure 1: Distribution of the (a) HAZ, (b) WHZ, and (c) WAZ over the sample of children in Muyinga and Ngozi compared to the WHO reference.
Note: %<−2SD includes %<−3SD; %>+2SD includes %>+3SD; %>+1SD includes %>+2SD and %>+3SD.

Discussion

The prevalence rates of 53% of children aged under 5 suffering from stunting that we determined are in good agreement with the prevalence rates reported by others.[25] Nkurunziza et al.[25] found in their study that 53% of Burundian children aged 6–23 months were stunted. Gaiser et al.[10] report that 56.9% of children under 5 years of age who participated in the DHS survey in Burundi were stunted.

A large group of children in our sample suffered from underweight. Based on the WAZ and WHZ indicators, we found that 25.1% and 8.9% of the children in the sample are underweight and suffering from wasting respectively. These figures are in line with the estimates from the statistical service.[11] Wasting and underweight signal acute malnutrition with stunting further affecting the already weak children due to wasting and underweight.

Like other studies, we show that the risk of stunting increased with the age of the child and the child being a boy.[10] The literature explains that high levels of stunting result from a prolonged period of malnutrition or chronic illness in the child's life before or after birth.[26] In contrast to other studies,[27] we find no clear association between the risk of stunting and household socioeconomic status. We find a higher prevalence of underweight and wasting amongst the youngest children in our sample and stunting amongst the older children, which may suggest the multiple occurrence of malnutrition problems results in poor growth in children.[28]

The finding that off-farm income was associated with a lower risk of child underweight and wasting signals the importance of secure livelihoods, which smallholder farming was not providing in a large group of households in the sample. Hence, the high levels of child malnutrition and household food insecurity in this study highlight the need for drastic changes and interventions in the study area. The households included in our survey seem to have been unable to produce enough food to feed their family members over the years, as also reported by Niragira et al.[15] Households suffered from episodes of cash shortages that put their children at risk of malnutrition. Even households that sold part of their production seemed unable to significantly decrease the risk of their children being malnourished. We find no evidence that the subsistence level of the households influenced the risk of malnutrition nor did we find evidence that this risk was reduced by the child having a more diversified diet. Most of the children in our sample consumed food from at least four food groups. However, these four food groups were mainly plant-based products. The proportion of the children in the sample consuming animal-based food groups was particularly low: eggs, dairy products, and flesh foods were given to 2.2%, 3.6%, and 23.2% of the children, respectively. Hence, there was not enough diversity in the diet to show an association.

Table 2: Distribution of the sample and prevalence of undernutrition among children aged 6–59 months relelative to socioeconomic factors

Factor	Level	Pooled data	Stunting			Underweight			Wasting		
		n (% of total sample)	No HAZ>−2 SD	Yes HAZ<−2 SD	*p*-value	No WAZ > −2 SD	Yes WAZ < −2 SD	*p*-value	No WHZ > 2 SD	Yes WHZ<−2 SD	*p*-value
			n (% of stunted children)			*n* (% of underweight children)			*n* (% of wasting children)		
	n (% across stunting, underweight, wasting)		107 (46.9)	121 (53.1)		176 (74.9)	59 (25.1)		214 (91.1)	21 (8.9)	
Child's characteristics											
Child's age	6–11 months	40 (16.3)	23 (62.2)	14 (37.8)	0.153	22 (59.5)	15 (40.5)	0.122	25 (71.4)	10 (28.6)	< 0.001
	12–23 months	72 (29.3)	32 (47.8)	35 (52.2)		56 (81.2)	13 (18.8)		64 (95.5)	3(4.5)	
	24–35 months	61 (24.8)	19 (38.0)	31 (62.0)		39 (73.6)	14 (26.4)		47 (92.2)	4 (7.8)	
	36–47 months	20 (8.1)	10 (50.0)	10 (50.0)		17 (85.0)	3 (15.0)		19 (95.0)	1 (5.0)	
	48–60 months	53 (21.5)	19 (38.0)	31 (62.0)		37 (72.5)	14 (27.5)		49 (96.1)	2 (3.9)	
Child's gender	Female	122 (46.2)	60 (57.7)	44 (42.3)	0.004	84 (77.8)	24(22.2)	0.429	90 (44.1)	13 (12.6)	0.120
	Male	142 (53.8)	47 (37.9)	77 (62.6)		92 (72.4)	35 (27.6)		114 (94.2)	7 (5.8)	
Child's dietary diversity	Diversified diet	234 (89.7)	92 (46.2)	107 (53.8)	0.481	151 (72.6)	57 (27.4)	0.062	177 (89.8)	20 (10.2)	0.293
	Not diversified diet	27 (10.3)	15 (55.6)	12 (44.4)		23 (92.0)	2(8.0)		20 (80.0)	5 (20.0)	
Household characteristics											
Mother's age	Less than 36 years	131 (49.6)	53 (46.5)	61 (53.5)	0.999	87 (75.0)	29 (25.0)	0.998	108 (94.7)	6 (5.3)	0.085
	More than 36 years	133 (50.4)	54 (47.4)	60 (52.6)		89 (74.8)	30 (25.2)		96 (87.3)	14 (12.7)	
Household size	Less than 6 persons	137 (51.9)	58 (54.2)	59 (48.8)	0.491	95 (77.2)	28 (22.8)	0.473	105 (90.5)	11 (9.5)	0.293
	More than 6 persons	127 (48.1)	49 (45.8)	62 (51.2)		81 (72.3)	31 (27.7)		99 (91.7)	9 (8.3)	
Household education level	Illiterate (1)	110 (41.7)	42 (43.8)	54 (56.2)	0.493	69 (71.1)	28 (28.9)	0.336	82 (87.2)	12 (12.8)	0.293
	Educated (0)	154 (58.3)	65 (49.2)	67 (50.8)		107 (77.5)	31 (22.5)		122 (93.8)	8 (6.2)	
Farm characteristic	Share farm produce sold less than 5%	106 (44.2)	44 (44.0)	56 (56.0)	0.677	74 (70.5)	31 (29.5)	0.340	86 (89.6)	10 (10.4)	0.305
	Share farm produce sold between 5% and 10%	82 (34.2)	40 (50.6)	39 (49.4)		63 (78.7)	17 (21.2)		75 (94.9)	4 (5.1)	
	Share farm produce sold more than 10%	52 (21.7)	23 (46.9)	26 (53.1)		39 (78.0)	11 (22.0)		43 (87.8)	6 (12.2)	
Off-farm income	Less than US$96 per season	168 (67.7)	68 (47.2)	76 (52.8)	0.678	103 (69.1)	46 (30.9)	0.002	126 (88.7)	16 (11.3)	0.112
	Between US$96 and US$238.1 per season	53 (21.4)	26 (54.2)	22 (45.8)		43 (87.8)	6 (12.2)		47 (97.9)	1 (2.1)	
	More than US$238.1 per season	27 (10.9)	11 (45.8)	13 (54.2)		23 (95.8)	1 (4.2)		21 (95.5)	1 (4.5)	
HFIAS prevalence	Food secure	31 (11.7)	10 (38.5)	16 (61.5)	0.086	21 (84.0)	4 (16.0)	0.334	21 (95.5)	1 (4.5)	0.901
	Mildly food-insecure access	12 (4.5)	5 (50.0)	5 (50.0)		9 (81.8)	2 (18.2)		9 (90.0)	1 (1.0)	
	Moderately food-insecure access	75 (28.4)	40 (59.7)	27 (403)		53 (79.1)	14 (20.9)		58 (90.6)	6 (9.4)	
	Severely food-insecure access	146 (55.3)	52 (41.6)	73 (58.4)		93 (70.5)	39 (29.5)		116 (90.6)	12 (9.4)	
Province	Muyinga	123 (46.6)	57 (53.8)	49 (46.2)	0.072	79 (73.1)	29 (26.9)	0.676	87 (87.0)	13 (13.0)	0.092
	Ngozi	141 (53.4)	50 (41.0)	72 (59.0)		97 (76.4)	30 (23.6)		117 (94.4)	7 (5.6)	

Table 3: Results of a logistic regression showing determinants of stunting, underweight WAZ, and underweight BAZ in children under 5 years of age

	Stunting			Underweight			Wasting		
Predictors	**Odds ratios**	**CI**	***p*-value**	**Odds ratios**	**CI**	***p*-value**	**Odds ratios**	**CI**	***p*-value**
(Intercept)	0.81	0.18–3.66	0.788	0.93	0.14–5.77	0.942	0.79	0.02–17.27	0.886
Child aged from 6 to 11 months reference									
Child aged from 12 to 23 months	2.22	0.88–5.90	**0.098**	0.27	0.09–0.78	**0.017**	0.06	0.01–0.30	**0.002**
Child aged from 24 to 35 months	4.07	1.54–11.37	**0.006**	0.75	0.26–2.16	0.594	0.17	0.03–0.79	**0.030**
Child aged from 36 to 47 months	1.72	0.49–6.07	0.394	0.18	0.02–0.84	**0.047**	0.1	0.00–0.88	0.07
Child aged from 48 to 60 months	3.11	1.17–8.70	**0.026**	0.52	0.18–1.53	0.237	0.06	0.01–0.33	**0.004**
Child gender (Male = 1)	2.06	1.13–3.78	**0.018**	1.59	0.79–3.25	0.198	0.63	0.18–2.00	0.434
Household size (household larger than 6 persons = 1)	1.33	0.69–2.61	0.396	1.86	0.87–4.10	0.115	1.93	0.50–7.90	0.344
Mother's age (more than 36 years = 1)	1.01	0.52–1.94	0.986	1.17	0.55–2.49	0.685	4.17	1.12–18.74	**0.044**
Household education level (illiterate = 1)	0.8	0.44–1.45	0.472	0.76	0.38–1.53	0.442	0.25	0.07–0.82	**0.028**
Subsistence level: sales less than 5% reference									
Subsistence level: sales from 5.01 to 10%	0.72	0.37–1.42	0.348	0.63	0.28–1.37	0.245	0.36	0.06–1.56	0.193
Subsistence level: sales more than 10%	0.74	0.34–1.61	0.454	0.53	0.21–1.29	0.171	1.83	0.48–7.11	0.371
Off-farm income: less than US$96 reference									
Off-farm income: from US$96 to US$238.1	0.75	0.35–1.59	0.456	0.18	0.05–0.50	**0.002**	0.05	0.00–0.38	**0.017**
Off-farm income: more than US$238.1	0.8	0.27–2.35	0.681	0.05	0.00–0.32	**0.009**	0.11	0.00–2.94	0.246
Food insecure reference									
Mildly food insecure access	0.66	0.13–3.45	0.623	3.18	0.31–28.66	0.298	10.23	0.22–678.84	0.218
Moderately food insecure access	0.35	0.11–1.02	**0.059**	0.7	0.17–3.23	0.625	0.87	0.06–24.64	0.921
Severely food insecure access	0.61	0.20–1.76	0.371	1.04	0.27–4.55	0.96	0.81	0.07–21.73	0.876
Dietary diversity (not diversified = 1)	0.72	0.37–1.39	0.329	0.94	0.42–2.07	0.884	1.3	0.27–5.61	0.731
N		210			215			210	
R^2 Tjur		0.112			0.147			0.227	

Note: A p-value of less than 0.10 was considered significant and highlighted in bold in the table.

Given that the target group are farming households, nutrition could be improved by increasing subsistence food production and agricultural sales. Yet our results show that potential is limited under the current circumstances. If farmers primarily produce food for survival that at least meets the needs of their children, the results of our study show that they are currently not able to do so. An increase in production can be envisaged only if structural changes such as access to land, infrastructure, and credit are improved. Even an increase in agricultural sales is unlikely to help alleviate malnutrition under the current circumstances. Our results show that the level of household sales is too low to make a difference. It is, therefore, crucial for households to diversify their sources of income, especially through off-farm activities. However, this strategy too requires structural changes.

Conclusion

In this study, anthropometric data were used to assess malnutrition in children under 5 years of age born in rural households in Ngozi and Muyinga provinces. The results confirm the high levels of stunting and underweight reported elsewhere. The study found a significant association between off-farm income and wasting and underweight. We found no association between a child's risk of stunting and the household's off-farm income or the child's age and sex. The risk of a child being underweight and wasting was high among the youngest children in our sample and the household's available off-farm income. Children of mothers older than 36 years also had a higher risk of being underweight. The study points to the high risk of children in subsistence households becoming stunted and underweight. It shows how vulnerable subsistence farmers are to malnutrition and calls for structural changes that create a favourable environment for households to diversify their income.

Our study is characterised by its focus on agricultural subsistence households in poor rural areas. Burundi has a high level of malnutrition, although the population is heavily involved in agriculture. The farming households in our study suffered from structural production constraints, difficult access to land and markets, and limited income opportunities. The extent to which each of these problems affects child malnutrition separately and over a longer time span could not be clarified due to a lack of epidemiological data. Instead, our study is exploratory and cross-sectional in nature. We observed the results of the difficult living conditions of the farm households, but lacked the longitudinal data to map the long-term pathways. We also lacked indicators of health care and medical history of the children and their mothers. Moreover, due to the relatively small sample, we had to limit the number of explanatory variables. This opens up numerous areas for future research. Epidemiological studies are needed to confirm the underlying factors of child malnutrition. Of particular interest is further research into the underlying agricultural constraints associated with food insecurity and child malnutrition.

Table 4: Model 2 results of a logistic regression showing determinants of stunting, underweight WAZ, and underweight BAZ in children under 5 years of age without HFIAS and dietary diversity

	Stunting			Underweight			Wasting		
Predictors	**Odds ratios**	**CI**	***p*-value**	**Odds ratios**	**CI**	***p*-value**	**Odds ratios**	**CI**	***p*-value**
(Intercept)	0.37	0.12–1.07	0.071	0.77	0.23–2.47	0.655	0.61	0.11–3.41	0.574
Child aged from 6 to 11 months reference									
Child aged from 12 to 23 months	2.04	0.82–5.29	0.132	0.29	0.10–0.81	**0.02**	0.07	0.01–0.32	**0.002**
Child aged from 24 to 35 months	3.95	1.52–10.85	**0.006**	0.74	0.26–2.09	0.569	0.19	0.04–0.83	**0.034**
Child aged from 36 to 47 months	1.72	0.50–5.93	0.387	0.2	0.03–0.94	0.063	0.12	0.01–1.02	0.092
Child aged from 48 to 60 months	3.4	1.31–9.34	**0.014**	0.59	0.21–1.69	0.325	0.07	0.01–0.38	**0.005**
Child gender (male = 1)	2.12	1.19–3.83	**0.011**	1.49	0.75–3.02	0.259	0.57	0.17–1.73	0.328
Household size (household larger than 6 persons = 1)	1.46	0.77–2.80	0.251	2.06	0.97–4.51	0.063	2.16	0.59–8.44	0.25
Mother's age (more than 36 years = 1)	1.08	0.57–2.05	0.821	1.17	0.55–2.48	0.683	4.36	1.19–19.05	**0.035**
Household education level (illiterate = 1)	0.79	0.44–1.42	0.438	0.81	0.41–1.60	0.536	0.27	0.07–0.84	**0.031**
Subsistence level: sales less than 5% reference									
Subsistence level: sales from 5.01 to 10%	0.74	0.38–1.41	0.359	0.59	0.27–1.27	0.182	0.35	0.07–1.50	0.178
Subsistence level: sales more than 10%	0.76	0.35–1.63	0.485	0.52	0.20–1.24	0.148	1.59	0.43–5.82	0.476
Off-farm income: less than US $96 reference									
Off-farm income: from US$96 to US$238.1	0.72	0.35–1.48	0.375	0.24	0.08–0.59	**0.004**	0.07	0.00–0.47	**0.022**
Off-farm income: more than US $238.1	0.86	0.33–2.30	0.762	0.07	0.00–0.36	**0.011**	0.45	0.02–3.11	0.494
N		212			217			212	
R^2 Tjur		0.092			0.139			0.214	

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ORCID

Willy Désiré Emera http://orcid.org/0000-0002-5023-8987
Marijke D'Haese http://orcid.org/0000-0002-0544-3420
Wannes Slosse http://orcid.org/0000-0001-6095-6416
Carl Lachat http://orcid.org/0000-0002-1389-8855

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