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Predictors of stunting with particular focus on complementary feeding practices: A cross-sectional study in the northern province of Rwanda

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ABSTRACT

Objectives: The aim of this study was to review the factors associated with stunting in the northern province of Rwanda by assessing anthropometric status, dietary intake, and overall complementary feeding practices.
Methods: This was a cross-sectional study with 138 children 5 to 30 mo of age. A structured questionnaire was used to collect information on sociodemographic characteristics of each mother and child and breastfeeding and complementary feeding practices. Anthropometric status was assessed using height-for-age z-scores for children and body mass index for caregivers. Dietary intakes were estimated using a 24-h recall. Multiple linear and logistic regression models were performed to study the predictors of height-for-age *z* scores and stunting.
Results: There was a 42% stunting prevalence. Prevalence of continued breastfeeding and exclusive breastfeeding were 92% and 50%, respectively. Most children (62%) fell into the low dietary diversity score group. The nutrient intake from complementary foods was below recommendations. The odds of stunting were higher in children >12 mo of age (odds ratio [OR], 1.18; 95% confidence interval [CI], 1.08–1.29). Exclusive breastfeeding (OR, 0.22; 95% CI, 0.10–0.48) and deworming tablet use in the previous 6 mo (OR, 0.25; 95% CI, 0.07–0.80) decreased significantly the odds of stunting in children. Also, the body mass index of the caretaker ($\beta = 0.08$ kg/m^2; 95% CI, 0.00–0.17) and dietary zinc intake ($\beta = 1.89$ mg/d; 95% CI, 0.29–3.49) were positively associated with the height-for-age *z* scores.
Conclusion: Interventions focusing on optimal nutrition during the complementary feeding stage, exclusive breastfeeding, and the use of deworming tablets have the potential to substantially reduce stunting in children in the northern province of Rwanda.

Introduction

Stunting, also termed *linear growth retardation*, occurs when a child is not growing in length or height in accordance with his or her potential [1]. Globally, ~22.9% of children <5 y of age are stunted [2]. Africa and Asia have the highest numbers of stunted children estimated at 59 million and 87 million, respectively [3]. Nationally, 38% of children <5 y of age in Rwanda are stunted [4]. The World Health Organization (WHO) considers stunting to be a public health problem when the prevalence of stunting among children <5 y of age is >20% [5]. Growth retardation begins during pregnancy and continues until 2 y of age [6]. Almost half of the growth retardation happens during the complementary feeding period [7].

The WHO framework provides an overview of the causes of stunting and classifies them into four main proximal factors: household and family factors, inadequate complementary feeding practices, inadequate breastfeeding practices, and infection [1]. In practice, multicausality is usually present, which makes stunting one of the most difficult health challenges to address. For example, the problem of infection and its effects on child health is worsened when zinc deficiency is present. Zinc deficiency has been associated with stunted growth, impaired immunity, and poor weight gain in children [8–10]. Inadequate dietary zinc intake in its bioavailable forms is the most likely cause of zinc deficiency [11].

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Rwanda has successfully managed to reduce to 2% the prevalence of wasting or acute malnutrition in children [4]. However, the reduction in stunting is limited despite the efforts to reduce its prevalence [12]. Thus, there is a need for scientific research to assess the locally relevant predictors of stunting. Previous studies in Rwanda have focused more on the sociodemographic factors, child health care, and parasite infection in children and their influence on undernutrition or stunting prevalence [13–15]. To our knowledge, this is the first study to combine complementary feeding practices and nutrient intake assessed through the 24-h recall, to study the predictors of stunting in Rwanda and Musanze District particularly.

Methods

Study overview

A cross-sectional study was conducted in May 2015 in Musanze District, which has a high stunting prevalence of 38% [4]. Most of the population in the district live in the rural area. The study population consisted of children 5 to 30 mo of age and their caregivers. A required sample size of 145 children was estimated, taking into account the estimation of mean dietary zinc intake based on previous studies [16–18], considering a power of 80%, a significance level of 0.05, and a non-response rate of 10%. Cluster-random sampling was applied using villages in Musanze District as the sampling frame and households as the basic sampling units. Five of 38 villages were randomly selected, and a random walk method [19] was used to visit the households in each sector. All households with a child 5 to 30 mo of age had an equal chance of being asked to participate in the survey. No caregiver refused to participate in the study.

Ethical approval

Ethical approval was obtained from the Institutional Review Board of the College of Medicine and Health Sciences in Rwanda. Permission to collect data in Musanze was obtained from local authorities. Participants signed an informed consent form after the research aim and objectives were explained to them.

Interactive 24-h recall

An interactive and multipass 24-h recall questionnaire, adapted and validated for use in developing countries, was used [20]. The questionnaire applied a multipass method in which the first pass consisted of gathering a list of foods consumed the previous day. The second pass consisted of probing for more information about the food consumed, such as time of the day, food specification, and the cooking method used. The third pass consisted of estimating the portion sizes using local household utensils, units or monetary values, and recording the ingredients of the homemade mixed dishes consumed by the child. The fourth and final pass consisted of reviewing the recall information to ensure the accuracy of the data gathered. For the administration of the questionnaire, graduated food models were assembled and calibrated; five qualified interviewers were trained, and a pilot test was done. The food intake data was assessed through a single 24-h recall with the caregiver of each child as the respondent, and at study population level, each day of the week was included. The 24-h recall questionnaire also included a yes or no question to know if the food the child ate the previous day was similar to his or her usual food intake.

Data processing of the food intake data was done in Excel 2010. The estimation of energy and nutrient intake from the 24-h recall was done by compiling a local food composition database using nutrient composition from published sources [21–24]. Food matching was performed following the guidelines published by the Food and Agriculture Organization's International Network of Food Data Systems (FAO/INFOODS) [25] and Greenfield and Southgate [26]. The Murphy model to estimate the intake of available zinc was applied where the zinc availability factor was set to 0.10 if the phytates-to-zinc ratio was >30; 0.15 for ratios between 15 and 30; and 0.30 for ratios <15 [20]. To assess the quality of the complementary diets of children, a dietary diversity score (DDS) was calculated for which each of the seven food groups consumed received a score of 1. A DDS of ≥4 was classified as high dietary diversity, whereas a DDS <4 was classified as low dietary diversity [27].

Household questionnaire and anthropometric measurement

The household questionnaire was adapted from the validated Rwanda Demographic and Health Survey household questionnaire [4]. It comprised questions on the sociodemographic characteristics of mother and child, household characteristics, breastfeeding and complementary feeding practices, and child's current and past illness. Sociodemographic characteristics included age, sex, marital status, education, and employment. Household characteristics included household size, wealth category, drinking water source, water treatment before use, and access to agricultural land. Breastfeeding and complementary feeding practices included exclusive breastfeeding in the first 6 mo, continued breastfeeding, vitamin A supplementation in the previous 6 mo, deworming tablets use in the previous 6 mo, and micronutrient powder use. Child illness included the presence of diarrhea, cough, malaria, and flu in the previous 4 wk and presence of illness the day before the interview.

Anthropometric measures of children and their respective caregivers were recorded. Birth weight and child age were obtained from parental recall or the child's birth certificate. The height of children was measured in recumbent position using a height board designed by UNICEF and was recorded to the nearest 0.1 cm. The height of caregivers was measured in the standing position without shoes to the nearest 0.1 cm using a portable stadiometer. The weight of both caregiver and child was measured in duplicate to the nearest 0.1 kg using an electronic scale (SECA Model 803, Hanover, MD, USA) [28]. The WHO Anthro software version 3.2.2 [29] was used to calculate height-for-age *z* scores (HAZ), weight-for-age *z* scores (WAZ), and weight-for-height *z* scores (WHZ). According to WHO criteria, a *z* score of less than −2 for HAZ indicates stunting; for WAZ, undernutrition; and for WHZ, wasting. For descriptive purposes, further classifications of height-for-age as adequate (HAZ: <−2 to +2), moderately stunted (HAZ <−3 to <−2) and severely stunted (HAZ<−3) were used [30]. Extreme values for HAZ, WAZ, and WHZ were (−6, +6), (−6, +5) and (−5, +5) respectively; these were automatically flagged in Anthro software, and in subsequent data analysis, they were considered as outliers. For caregivers, BMI was classified as mild undernutrition (≤16 to <18.5 kg/m^2), normal (<18.5 to ≤24.9 kg/m^2), overweight (<25 to ≤29.9 kg/m^2), and obese (≥30 kg/m^2) [30]. For comparison between age groups, the age of children was split into four groups: 5 to 11 mo, 12 to 17 mo, 18 to 23 mo, and 24 to 30 mo.

Statistical analysis

Continuous variables were checked for normality and log transformation was conducted if needed. Frequencies and percentages were reported for categorical variables, and means (SD) or medians (interquartile range) were reported for continuous variables. Spearman's rank-order correlation was used to study the bivariate association between variables. For group means or percentage comparison between stunted and non-stunted children, independent sample *t* test or χ^2 test were used. Multiple linear regression was used to study the association between HAZ and the explanatory variables. The explanatory variables were from the socioeconomic characteristics of mothers and children, household characteristics, breastfeeding and complementary feeding practices, and child illness status. A backward linear regression model was conducted on all predictors, and the predictors in the last model were fitted in a linear regression model together with energy and zinc intake variables. Interaction factors of age groups and energy intake also were tested as the energy intake can differ within age groups of children. The adjusted R^2 was reported for model cross-validation. Similarly, a logistic regression model was fitted to the data with the binary indicator of stunting as the dependent variable to obtain odds ratios (OR) and 95% confidence intervals (CIs). The model Nagelkerke R^2 was reported. Multicollinearity was checked using Pearson pairwise correlation coefficient and variance inflation factor statistic, with $r > 0.7$ and the variance inflation factor > 0.5 as cutoff values for the indication of multicollinearity in the regression model [31]. Consequently, the energy intake and the interaction factor of age group 18 to 23 mo and energy intake that introduced multicollinearity were not considered in the model. A model sensitivity analysis with the linear regression model was tested by including only children whose intake on the previous day was similar to their usual food intake. For all the analyses, $P < 0.05$ indicated statistical significance. All statistical analyses were performed using the SPSS version 24 (IBM, Armonk, NY, USA).

Results

Study participants

The present study included 145 infants and their caregivers. Of the 145 infants, 67 (46%) were boys and 78 (54%) were girls. There were missing HAZ values for 7 children, thus their data were excluded for the present analyses. Characteristics of the children, caregivers, and households are shown in Table 1. Most of the caregivers were mothers (95%) of the children. The majority of caregivers (67%) had a primary education; whereas 22% were illiterate. The mean age of caregivers were 28 ± 8 y. Of the caregivers, 73% had a normal BMI; whereas 3% were mildly undernourished, 20% were overweight, and 4% were obese. The mean household size was 4.7 ± 1.8 persons. Of the households, 34% and 58% were in the

Table 1
Child, caregiver, and household characteristics by stunting status of children between 5 and 30 mo of age (N = 138) in Musanze District, Rwanda

Characteristic	Non-stunted (n = 77) N (%) or mean ± SD	Stunted (n = 61)	Total (N = 138)	P-value*
Sex child				
Girls	44 (57)	28 (46)	72 (52)	0.189
Boys	33 (43)	33 (54)	66 (48)	
Children age groups (mo)				
5–11	34 (44)	14 (23)	48 (35)	0.021
12–17	25 (32)	19 (31)	44 (32)	
18–23	13 (17)	19 (31)	32 (23)	
24–30	5 (7)	9 (15)	14 (10)	
Relationship to child				N/A
Mother	71 (93)	59 (97)	130 (95)	
Other	5 (7)	2 (3)	7 (5)	
Caregiver education				0.152
Illiterate	13 (17)	17 (28)	30 (22)	
Primary level	52 (68)	40 (66)	92 (67)	
Secondary & tertiary level	11 (15)	4 (6)	15 (11)	
Caregiver marital status				N/A
Married (monogamy)	66 (87)	53 (87)	119 (87)	
Married (polygamy)	3 (4)	4 (7)	7 (5)	
Unmarried	7 (9)	4 (6)	11 (8)	
Caregiver age (y)	28.3 ±7.5	28.3 ± 9.1	28.4 ± 8.2	0.992†
Caregiver height (cm)	159 ± 5.8	159 ± 5.4	159 ± 5.7	0.777†
BMI of caregiver				N/A
Mild undernutrition	2 (3)	2 (3)	4 (3)	
Normal	51 (68)	48 (79)	99 (73)	
Overweight	19 (25)	9 (15)	28 (20)	
Obese	3 (4)	2 (3)	5 (4)	
Household size	4.8 ± 1.8	5 ± 1.9	4.7 ± 1.8	0.507†
Wealth category of household				0.770
First (lowest) category	27 (35)	20 (33)	47 (34)	
Second category	44 (58)	35 (57)	79 (58)	
Third category	5 (7)	6 (10)	11 (8)	
Kitchen garden–yes	30 (40)	16 (26)	46 (34)	0.103†
Access to agricultural land–yes	56 (74)	44 (72)	100 (73)	0.839
Livestock ownership–yes	32 (42)	20 (33)	52 (38)	0.264

BMI, body mass index; N/A, n was too low for statistical testing.
**P*-value: Two-sided, obtained through Pearson χ^2.
†Independent sample *t* test was performed.

first (lowest) and second wealth category, respectively. One-third of households (34%) had a kitchen garden, 73% had access to agricultural land, and 38% had livestock.

Anthropometric results

Figure 1 shows the growth curve of the study population compared with the WHO standard growth curve. The overall mean (SD) was −1.58 (1.77), −0.86 (1.31), and 0.22 (1.32) for HAZ, WAZ, and WHZ, respectively. In all, 44% of children were stunted, among which 62% were moderately stunted and 38% were severely stunted. Also, among stunted children, 54% were boys and 46% were girls. Undernutrition prevalence was 16%, of which 22% were severely undernourished. Wasting prevalence was 7%, of which 39% were severely wasted [32].

Child feeding practices

Child feeding practices are shown in Table 2. Among the non-stunted children, exclusive breastfeeding in the first 6 mo of life was 66% compared with 31% in the stunted children ($P < 0.001$). Although not significant, differences between preweaning age groups for stunted and non-stunted; age groups at first introduction of complementary foods; and the presence of diarrhea, cough, and flu in the 4 wk before the study were observed. The majority of all children were still breastfeeding (92%) and most of the children (65%) who received preweaning foods were in the range of 4 to 5 mo of age. The reason for feeding children before they turn 6 mo of age was mainly that the child wanted to eat (34%), was sick (26%), or had colic disease (18%). Traditional herbal mixture (29%), fruit juice (24%), plain water (18%), and porridge (16%) were the most commonly used preweaning foods. For weaned children (8%), 55% were in the 13 to 24 mo age group and 36% were in the 7 to 12 mo age group [32]. The majority of the children were introduced to complementary meals around 6 to 9 mo of age (72%). The use of vitamin A supplements in the previous 6 mo was 93%; whereas the use of micronutrient powder in children's diet in the previous 4 wk was 38%. Of all the children, 73% had received deworming tablets in the previous 6 mo and 37% of children had been ill the previous day. The presence of diarrhea (34%), vomiting (14%), malaria (9%), and flu (33%) in the previous 4 wk was low compared with coughing (72%).

The main staple foods consumed in Musanze were sorghum, maize, potatoes, beans, and green leafy vegetables. Consequently, the most consumed food groups on the recall day were grain, roots, and tubers (96%), legumes and nuts (79%), and vitamin A-rich fruits and vegetables (75%) (Table 2). Animal source foods were the least consumed by both non-stunted and stunted children; with dairy products, flesh foods, and eggs consumed by 2%, 8%, and 2% of children, respectively. The mean ± SD DDS among the study population was 3.1 ± 1.1. The majority of children (62%) had consumed food from fewer than four food groups and thus were in the low dietary diversity group. There was no significant difference between DDS and stunting status (Table 2), and the consumption of specific food groups by children was similar across all age groups [32].

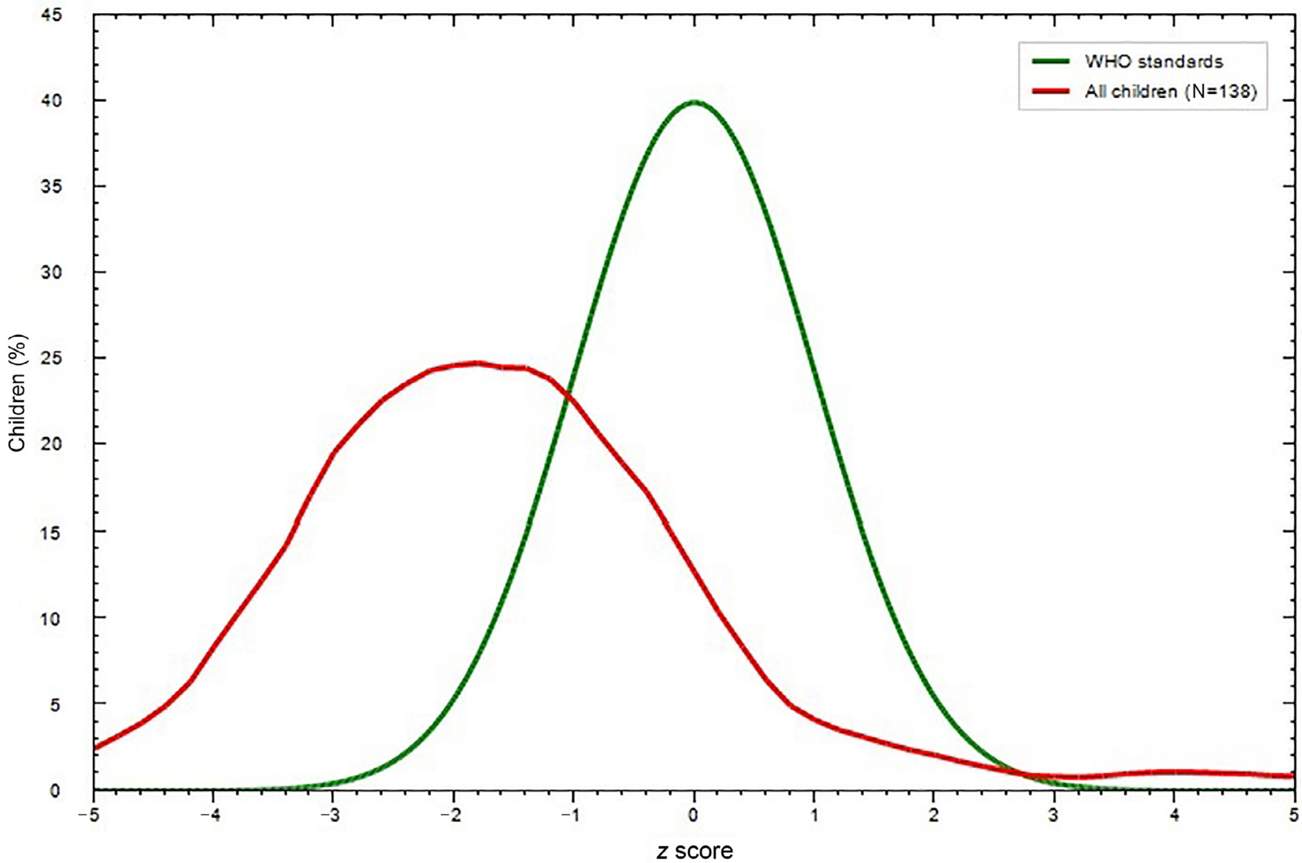

Fig. 1. Height-for-age *z* score distribution of children 5 to 30 mo of age (N = 138) in Musanze District compared with the standard curve from the World Health Organization.

Quantification of nutrient intake

Intakes of energy and nutrients from complementary foods are shown in Table 3 [33–37]. Considering average breast-milk intake per age group, the median energy intake was low compared with the energy required from complementary foods. The same was observed for macronutrients such as protein, fat, and carbohydrates. However, it should be noted that these requirements were set for total intake including breastfeeding. Assuming low bioavailability, zinc intakes also were low compared with requirements across age groups. Intake of zinc, iron, vitamin A, and vitamin C included intake from micronutrient powder, but only one caregiver had included it in the meal of her child the day before the interview.

The main food groups that contributed to energy and nutrient intake for all children were cereals, vegetables, and fats and oils.

HAZ and stunting predictors

From the multiple linear regression analysis, age groups, exclusive breastfeeding, use of deworming tablets, caregiver BMI, and dietary zinc intake were predictors of HAZ (Table 4).

The model adjusted R^2 was 0.27. By comparing age groups, children who were in the older age groups were more likely to be stunted than children in the 5 to 11 mo age group. Also, exclusive breastfeeding together with the use of deworming tablets, a higher caregiver BMI and a greater dietary zinc intake positively predicted height-for-age in children. There was no significant association between energy intake and stunting; however, when age was taken into account, energy intake inversely predicted height-for-age in children 12 to 17 mo of age (β = -0.002; 95% CI, −0.004 to 0.000) and 24 to 30 mo (β = −0.003; 95% CI, −0.005 to 0.000). From the model sensitivity analysis limited to 116 children for which intake on the recalled day was similar to their usual intake, all the variables significantly predicted height-for-age except the 12 to 17 mo of age group (β = −0.92; 95% CI, −7.55 to −3.10), dietary zinc intake (β = 1.13; 95% CI, −0.52 to 2.79), and interaction factors [32].

For the estimation of risk for stunting in children using logistic regression analysis (Table 5), as the child grew older by 1 mo, the odds of stunting increased by 20% (OR, 1.18; 95% CI, 1.08–1.29). On the other hand, the odds of being stunted were significantly lower if a child had been exclusively breastfed (OR, 0.22; 95% CI, 0.10–0.48) and had received deworming tablets in the previous 6 mo (OR, 0.25; 95% CI, 0.07–0.80). The model Nagelkerke R^2 was 0.29.

Discussion

Stunting prevalence (44%) in the study population was higher than the general prevalence (38%) reported for the District of Musanze. We examined the predictors of HAZ and stunting in the study population. Children 12 to 17 mo, 18 to 24 mo, and 24 to 30 mo of age were more likely to be affected by stunting than those 5 to 11 mo of age. This confirms the increase in stunting observed during the complementary feeding period. As observed by Dewey and Huffman [7], a combination of factors such as low birth length, lack of exclusive breastfeeding in the first 6 mo of life, suboptimal complementary feeding, and presence of infection exposes older children to stunting. In the present study, the lower exclusive

Table 2
Description of breastfeeding, complementary feeding practices, presence of illness (presence of infection), and food group consumption per non-stunted and stunted children (5–30 mo of age) in Musanze District, Rwanda

		Non-stunted N (%)	Stunted *P*-value*	Total	
Breastfeeding practices					
Exclusive breastfeeding	Yes	50 (66)	19 (31)	69 (50)	<0.001
Current breastfeeding	Yes	68 (91)	57 (93)	125 (92)	N/A
Breastfeeding frequency					
2–3 times/d		6 (9)	4 (7)	10 (8)	N/A
>3 times/d		60 (91)	50 (93)	110 (92)	
Complementary feeding practices					
Preweaning age groups					
1–3 mo		10 (38)	14 (33)	24 (35)	0.86
4–5 mo		16 (62)	28 (67)	44 (65)	
Age groups at first introduction of complementary foods					
1–5 mo		17 (23)	21 (35)	38 (28)	0.17
6–9 mo		57 (77)	39 (65)	96 (72)	
Vitamin A supplements in the previous 6 mo	Yes	71 (93)	57 (93)	128 (93)	N/A
Micronutrient powder use in the in previous 4 wk	Yes	30 (40)	22 (36)	52 (38)	0.81
Illness (or presence of infection)					
Deworming tablets use in previous 6 mo	Yes	55 (72)	44 (73)	99 (73)	1
Diarrhea in previous 4 wk	Yes	23 (30)	23 (38)	46 (34)	0.46
Vomiting in previous 4 wk	Yes	9 (12)	10 (16)	19 (14)	0.6
Malaria in previous 4 wk	Yes	7 (9)	5 (8)	12 (9)	1
Cough in previous 4 wk ks	Yes	57 (75)	41 (67)	98 (72)	0.41
Flu in previous 4 wk	Yes	28 (37)	17 (28)	45 (33)	0.35
Previous day illness	Yes	27 (36)	23 (38)	50 (37)	0.93
Food groups consumption					
Grain, roots, & tubers	Yes	73 (95)	60 (98)	133 (96)	N/A
Legumes & nuts	Yes	59 (77)	50 (82)	109 (79)	0.54
Dairy products (milk, yogurt, cheese)	Yes	3 (4)	0 (0)	3 (2)	N/A
Flesh foods (meat, fish, poultry & liver/organ meats)	Yes	7 (9)	4 (7)	11 (8)	N/A
Eggs	Yes	1 (1)	2 (3)	3 (2)	N/A
Vitamin A-rich fruits & vegetables	Yes	61 (79)	43 (71)	104 (75)	0.32
Other fruits & vegetables	Yes	40 (52)	25 (41)	65 (47)	0.26
DDS					
Average score, mean (SD)		3.2 (1.1)	3 (1.1)	3.1 (1.1)	0.41†
Low DDS (<4 food groups)		47 (61)	38 (62)	85 (62)	1.00

DDS, dietary diversity score; N/A, If n was too low for statistical testing in the group for non-breastfed children, for children, who did not receive vitamin A, and for those that did not consume the specific food group.
**P*-value: Two-sided, obtained by Pearson χ^2.
†Independent sample *t* test was performed.

breastfeeding rate and the low quality of complementary foods could play a role. In rural Rwanda, similar results were found where being >12 mo of age was a risk factor for stunting [38]. Both exclusive breastfeeding and the use of deworming tablets in the previous 6 mo were independently associated with less risk for stunting in children. Exclusive breastfeeding is known to provide all essential nutrients for growth and immunity of a child within the first 6 mo of life, thus offering a protective effect against stunting [39]. Although we did not find a significant association between continued breastfeeding and height-for-age, the former has been shown to improve linear growth in mostly deprived children [40]. Infection that translates into persistent diarrhea negatively affects a child's development and growth, whereas malnutrition predisposes a child to infection [41]. In the present study, the use of deworming tablets was associated with significantly lower odds of stunting in children, although we did not find an association with infections. In southern Rwanda, Heimer et al. [42] found that infection with *Giardia duodenalis* is a possible cause of stunting in children. The use of deworming tablets in children is a practice that should be encouraged, especially in rural settings where children might be more prone to infections owing to less hygienic environments and low levels of caregiver education [43]. Caregiver BMI was a predictor of HAZ in the present study population, and this links to previous observations that mothers with a low BMI tend to have smaller babies [44]. Adequate nutrition during the preconception stage for future mothers is vital and could prevent intrauterine growth retardation [45]. Dietary zinc intake positively predicted HAZ, after taking into account the interaction term between energy and age. Although both variables were significant, their significance was not robust because they were not found to be significant in the sensitivity analysis nor were they predictors for stunting. Thus, we cannot draw a conclusion about the significance of the interaction terms.

Most children were being breastfed; only half had been exclusively breastfed during the first 6 mo of life. Continued breastfeeding is a common practice in developing countries. Alvarado et al. [46] and Roche et al. [47] reported similar levels of continued breastfeeding in Afro-Colombian children 15 mo of age and Ecuadorian children 12 to 16 mo of age. Exclusive breastfeeding until 6 mo of age is not practiced at the same level as continued breastfeeding. In the present study, caregivers acknowledged that they stopped exclusively breastfeeding their children because the child wanted to eat, was sick, or had colic. This demonstrated that there is a need for a continued effort in educating caregivers about the importance and benefits of exclusive breastfeeding during the first 6 mo of life.

The number of children who received vitamin A doses in the previous 6 mo was high (93%), whereas a small percentage (38%) of caregivers had used micronutrient powders in the previous 4 wk. Micronutrient powders are known to improve micronutrient status

Table 3
Dietary intake of energy and nutrients from complementary foods per age groups in children between 5 and 30 mo in Musanze District, in comparison to requirements (based on 24-h recall method)

Nutrient	Age groups, mo									
	5–11 (n = 49)			12–17 (n = 46)		18–23 (n = 35)		24–30 (n = 14)		
	Median	25th, 75th	EAR (RNI)	Median	25th, 75th	Median	25th, 75th	Median	25th, 75th	EAR (RNI)
Energy (kcal/d)*	107	65, 332	417	202	91, 345	282	141, 415	247	84, 426	772
Protein (g/d)	3	1, 9	(11)	6	3, 9	8	4, 13	7	2, 14	(13)
Fat (g/d)	2	1, 5	30†	2	1, 6	4	1, 6	2	0, 4	30 to 40‡
Carbohydrate (g/d)	19	10, 49	95†	35	18, 62	52	29, 76	51	18, 87	100
Iron (mg/d)§	0.9	0.5, 1.4	(18.6)	1.3	0.7, 2.1	2.2	1.1, 2.9	2	0.5, 4.1	11.6
Calcium (mg/d)	19	7, 42	(400)	23	11, 49	42	24, 65	30	5, 45	417
Magnesium (mg/d)	29	17, 58	(54)	42	25 75	74	40, 103	76	21, 133	(60)
Vitamin A (μg/d)	6	2, 27	286	14	1, 41	32	2, 95	1	0, 36	286
Vitamin C (mg/d)	6	2, 13	(25)	6	3, 15	10	6, 16	8	2, 13	25
Zinc (mg/d)‖	0	0.0, 0.1	4	0.1	0.0, 0.1	0.1	0.1, 0.2	0.1	0.0, 0.2	2

AI, adequate intake; AMDR, acceptable macronutrient distribution range; EAR, estimated average requirement; RNI, recommended nutrient intake. 25th, 75th, interquartile range.
Unless otherwise indicated, RNI values were taken from WHO/FAO [33], EAR values are from Allen, Benoist [34], and RDA values for protein from IOM [35].
*Energy required from complementary foods assuming average breast-milk energy intake [36]. (For the age group 5–11 mo, energy required was estimated as an average between requirements for age groups 6–8 mo [356 kcal/d] and 9–11 mo [479 kcal/d]).
†Adequate intake [37].
‡AMDR is the range of intake for a particular energy source that is associated with reduced risk for chronic disease while providing intakes of essential nutrients [35].
§Iron: Assuming a 5% bioavailability [34].
‖Zinc: Assuming low bioavailability from unrefined, cereal-based diet [5].

Table 4
Predictors of height-for-age *z* scores in 135 children ages 5 to 30 mo in Musanze District, Rwanda (adjusted $R^2 = 0.27$)[1]

Variables	β	*P*-value	95% CI for β	
			Lower bound	Upper bound
Age (mo)				
12–17 vs 5–11	−1.08	0.034	−2.08	−0.08
18–23 vs 5–11	−2.27	<0.001	−3.19	−1.35
24–30 vs 5–11	−2.14	0.002	−3.49	−0.79
Exclusive breastfeeding (yes)	0.76	0.006	0.22	1.29
Deworming tablets use in previous 6 mo (yes)	1.99	<0.001	1.16	2.83
Caregiver BMI (kg/m^2)	0.08	0.049	0.00	0.17
Dietary zinc intake (mg)	1.89	0.021	0.29	3.49
Interaction terms between age groups (mo) and energy intake				
12–17 × energy intake	−0.002	0.049	−0.004	0.000
24–30 × energy intake	−0.003	0.040	−0.005	0.000

BMI, body mass index.

Table 5
Predictors of risk for stunting in children between 5 and 30 mo (n = 136) in Musanze District, Rwanda

Variables	OR	*P*-value	95% CI for OR	
			Lower bound	Upper bound
Age (mo)	1.18	<0.001	1.08	1.29
Exclusive breastfeeding (yes)	0.22	<0.001	0.10	0.48
Deworming tablets use in previous 6 mo (yes)	0.25	0.02	0.07	0.80

$R^2 = 0.29$ (Nagelkerke).

in children [48], but low compliance has been identified as a challenge in using them [49].

Although Musanze district is a highly fertile region and is considered to be the food basket of Rwanda, we observed that the diet for most children was not diversified. There was no apparent difference between stunted and non-stunted children regarding food group intake, probably because most of the children were having a non-diversified diet. This could be explained by the low wealth status of the participants and the higher price of animal source foods. However, a lack of knowledge on the part of caregivers about providing a balanced diet for children is also likely to play a role [50].

Nutrient intake from complementary foods was compared with the nutrient intake requirements for children. Overall, the nutrient intake of children was below the recommended levels. Considering absorbable zinc, dietary zinc intake was deficient across age groups because the children's diet was mostly plant-based. Not only was the diet poor in zinc but we also observed poor availability owing to the high phytate content of the diet. Flesh foods were consumed mostly in the form of small dried fish known as *indagara*. Dietary diversification focusing on increasing the consumption of locally available nutrient-rich foods, such as the small fish, could help to increase children's intake of zinc.

Study strength and limitations

This study was conducted as a first necessary step in the process of scaling up on a national level the research on stunting in Rwanda. The strength of this study lies in the use of a multipass interviewing technique to minimize the recall bias and ensure correctness of the data collected. For the interpretation of the findings, however, some limitations should be considered. First, the size of the sample was small and might not have allowed us to capture extensively the predictors of stunting in Musanze District. Second, because of the cross-sectional nature of this study, we were unable to establish causal relationships. Third, because a single 24-h recall was used, usual intake at the individual level could not be estimated. However, for comparing mean group-level dietary intake, a single recall is acceptable [20]. Last, calculations for the nutrient content of foods relied mainly on the use of yield, density, and nutrient retention factors from published sources.

Conclusions

Results from the present study demonstrated the multifactorial nature of the stunting problem in the northern province of

Rwanda. Age, exclusive breastfeeding, and use of deworming tablets in the previous 6 mo were predictors of stunting in children with >12 mo of age, exposing them to stunting; whereas exclusive breastfeeding and use of deworming tablets were protective. Although not robust, the predictive effect of caregiver BMI, dietary zinc intake, and the interaction terms between age groups and energy intake on HAZ was observed. Although most of the children were still breastfed, their complementary diet often was low in essential nutrients for growth and development because of a predominantly plant-based diet. Public health messages focusing on the importance of the optimal nutritional status of women during the preconception period and exclusive breastfeeding within the first 6 mo of life need to be reinforced and sustained. Also, the use of deworming tablets needs to be encouraged because it can contribute to reducing the burden that infections impose on a child's growth. A dietary diversification strategy that includes locally available and affordable animal-source foods in the diet of children is recommended.

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