Feeding Practices and Nutritional Status of Infants and Young Children Aged 6-23 Months in the South Kivu Region: A Cross-Sectional Study

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Abstract: *Background*: The increasing prevalence of stunting in the Democratic Republic of the Congo (DRC) represents a major public health concern. Adequate complementary feeding is crucial for preventing and reducing chronic malnutrition in early childhood in the long term.

Objective: This study aimed to assess the baseline complementary feeding practices and nutritional status of children aged 6–23 months in South Kivu Province, with a focus on commonly consumed complementary foods.

Methods: A cross-sectional analytical study was conducted among 515 children in the Kadutu and Miti-Murhesa health zones of South Kivu. Participants were selected through a systematic random sampling method. Dietary intakes and infant feeding practices were assessed using dietary recall questionnaires and a 7-day food frequency questionnaire. The nutritional status was measured by anthropometry.

Results: The mean age of children was 13.3 ± 5 months. Results showed that 59% of the children had a low dietary diversity score. Only 23% received an appropriate complementary feeding according to the minimum acceptable diet. Most of the children (88.5%) consumed porridge made exclusively of cereals, roots, or tubers and water. Animal-source foods, fruits, and vegetables were rarely consumed. Acute malnutrition and stunting affected 4.9% and 36.6% of children, respectively.

Conclusion: Stunting remains prevalent in both rural and urban areas of South Kivu. Furthermore, infant diets are nutritionally inadequate, as evidenced by their lack of diversity. Enriching widely consumed staple foods (maize, sorghum, and soy) with locally available animal-source products could improve micronutrient intake and constitute a promising strategy for preventing child malnutrition.

Keywords: Infant and young feeding practices, dietary intakes, complementary food, nutritional status, South Kivu.

1. INTRODUCTION

Malnutrition is a major global public health problem. Despite progress in recent decades, it is estimated that more than 148 million children under the age of five are stunted and that 45 million are wasted worldwide [1]. The situation is particularly alarming in sub-Saharan Africa, where the prevalence of undernutrition has increased slightly but steadily in almost all sub-regions since 2015 [2]. The Democratic Republic of the Congo (DRC) is one of the few countries in sub-Saharan Africa where the prevalence of chronic malnutrition has increased in recent years. National Multiple Indicators Cluster Survey (MICS) reports on children showed that the country has experienced a difficult socioeconomic situation for decades, characterized by high rates of child malnutrition. DRC has made some progress towards the stunting target, but 41.8% of children under five are still stunted, which is higher than the African regional average (30.7%) and one of the highest in the world. Some improvements have also been made towards the target of wasting, but 6.4% of children under five are still affected, which is higher than the African region (6.0%) [3]. Although there has been a downward trend in recent decades, DRC is not on track to meet the World Health Assembly's 2025 global nutrition targets, particularly for child stunting and wasting [3]. If the current trend continues, the country will not meet target 2.2 of the Sustainable Development Goals by 2030.

In recent decades, the nutritional status of children under five in the eastern provinces of the DRC, particularly in South Kivu, has been alarming. The MICS-Palu 2018 revealed a 48% prevalence of stunting and a 3% prevalence of wasting [4]. South Kivu was once a major food producer for the DRC due to its agricultural potential, which is attributed to its favorable rainfall. However, this food production has

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been affected by crop looting and general insecurity [5]. The impact of persistent insecurity on agricultural and pastoral practices has led to widespread food insecurity [6]. A growing body of research also suggests that suboptimal complementary feeding practices for infants and young children may be an essential risk factor for chronic malnutrition in this part of the country [7, 8]. The first 1000 days of life are a critical window for child development; adequate nutrient intake is essential for rapid physical and brain development [9]. Failure to provide sufficient nutrition for young children can lead to growth disorders and adverse effects on cognitive development [9-11]. A varied diet enables children to obtain all the essential nutrients their bodies need. Therefore, during this period from 6 to 23 months, the foods given to a child in addition to breast milk must provide not only sufficient quantity but also sufficient quality nutrients. In developing countries, inadequate complementary feeding is common, with diets consisting mainly of plant foods (cereals, roots, or tubers) and little to no animal food [8, 12-14]. Social factors have also been found to be associated with nutritional status in developing countries, and relationships between these social determinants and nutritional status have been shown to change over time [15]. Children's food choices and consumption patterns are influenced by several factors, including the child's gender, socioeconomic household factors, level of education, caregivers' nutritional knowledge, and social and cultural factors [16, 17]. Demographic and socioeconomic factors such as household wealth, mother's education, mother's age, pregnancy history, and time spent preparing food and feeding the child influence optimal child care practices [18], which in turn affect the child's nutritional status. In the present study, we investigated the food consumption patterns of children aged 6-23 months in households in two health zones (urban and rural) in South Kivu, in the DRC, and their impact on nutritional status. The research questions addressed were (1) whether sociodemographic factors influence the food consumption habits of children in urban and rural households; (2) whether there is a diversification of foods commonly used as complementary foods for children; and (3) whether there are associations between food intake and nutritional status in children aged 6–23 months.

2. MATERIALS AND METHODS

2.1. Study Area

This research was implemented in two health zones: the Kadutu zone in the city of Bukavu (capital of South Kivu) and the Miti-Murhesa zone, 33 km north of Bukavu. Kadutu is the most disadvantaged urban area of Bukavu. Its rapid and disproportionate expansion has gradually transformed it into a shanty town. Commercial activity is the mainstay of the population. The Miti-Murhesa area is a rural zone that has been relatively spared from the ongoing armed conflicts in eastern DRC, where subsistence agriculture is the main activity of the population.

2.2. Study Design and Population

The study employed a cross-sectional design and targeted children aged 6–23 months residing in households within the study areas. This study focused particularly on the complementary feeding period for the target age group, which is from six to 23 months [9].

2.3. Sample Size Determination

The sample size was calculated using the following formula:

$$N = \frac{Z_{1-\alpha/2} 2 * P * (1-p)}{d^2} \quad [19]$$

N is the minimum required sample size,

Z is the z-score for the desired level of confidence (assumed to be 95% or α =0.05),

p is the population of interest, estimated to be 48%, the prevalence of chronic malnutrition (stunted growth) among children in South Kivu [4]

d is the margin of error (assumed to be 4.5%).

The calculated sample size was further adjusted according to the design effect and the predicted no-response rate (10%), to obtain an optimal sample size of at least 520 mother-child pairs.

2.4. Sampling Procedure

A multistage sampling design was used. First, two health zones (Kadutu, Miti-Murhesa) were purposively selected. Specifically, data were collected from 13 health areas in Kadutu and 7 in Miti-Murhesa. Second, in both zones, health areas (HA) were randomly selected from the complete list of all HA. To be chosen, HA had to be sufficiently accessible for data collection. Households were allocated according to the population of the health zone (the demographic weight of each health zone). Households were selected using a 'random walk' method as a list of households was not available [20]. Starting from the identified central geographical location (the health centre), one team went to the left, and the other to the right. Enumerators followed a fixed direction, turning right at each junction. As the households were sufficiently far apart, the first household that met the inclusion criteria (i.e., had a mother-child pair aged 6-23 months) was the first household to be visited. The second household selected was the one whose front door was closest to that of the first household. The third household was the one whose front door was closest to that of the previous household (excluding households already visited). The exact process was repeated to select another household until the required number of children per health area was reached. In households with two or more eligible children, only one child was selected through simple random sampling.

2.5. Inclusion and Non-Inclusion Criteria of Mother-Child Pairs

The study included caregivers and their 6-23-month-old children who had resided in the study areas for more than 6 months before the survey and had given consent to participate in the study. Mothers and caregivers who did not consent to participate were omitted. In addition, the study did not include respondents (mothers/caregivers of children aged 6-23 months) and children who were mentally impaired or had physically deformed or chronically ill conditions according to medical records or child health card, as these conditions would affect their anthropometric measurements and would require special attention to feeding.

2.6. Data Collection

2.6.1. Sociodemographic Characteristics

A pre-tested, semi-structured questionnaire was used in face-to-face interviews to collect information on the mothers' sociodemographic characteristics, including residential area, age, marital status, level of education, occupation, income level, and the sex of the child. Ten trained enumerators facilitated data collection. The child's age was determined based on the date of birth (obtained from either the birth certificate or the child's health record) and the date of the interview. The structured questionnaire was uploaded to the KoboToolbox platform, and enumerators used smartphones during the data collection process. To ensure the quality of the data, the supervisor and investigator closely monitored the data collection technique daily, checked the completed questionnaires for completeness, and returned any incomplete questionnaires to the data collectors for correction.

2.6.2. Dietary Assessment and Feeding Practices

The children's dietary habits (breastfeeding and complementary feeding practices) were reported using a food frequency questionnaire (FFQ) and a 24-h dietary recall. Specifically, data were collected on the ingredients used in children's porridge. The FFQ contains a list of specific foods or food groups, along with their frequency of consumption. The food groups included in the questionnaire are: cereals, tubers, legumes, oilseeds and nuts, vitamin A rich vegetables, green leafy vegetables, other vegetables, yellow and red fruits, vitamin C rich fruits, other fruits, fruit juices, dairy products, meat, liver and organ meats, fish and fishery products, oils and fats, eggs, tea, and condiments. The percentage of children who consumed each type of food or drink frequently (once a day or two or more times a week), or rarely (at least once in the previous 7 days), and the percentage of children who did not consume at least one food or drink in each group in the last 7 days were calculated.

A 24-hour dietary recall was conducted for all respondents to collect information on the children's food and drink intake during the 24 hours preceding the interview. The interviews included a detailed description of the foods eaten and the cooking method. The amount consumed by the children was estimated by the respondent and expressed in terms of cups, tablespoons, and other common household measures. Standard methodology [21] was used to calculate the minimum meal frequency (MMF) and dietary diversity score (DDS), which ranged from 0 to 8 based on eight food groups: Breast milk; grains, roots and tubers; legumes, nuts and seeds; dairy products; flesh foods, eggs; vitamin A-rich fruits and vegetables and other fruits and vegetables [21]. Each group consumed within the previous 24 hours was scored as 1; otherwise, it was scored as 0 (no food group consumed). Minimum dietary diversity (MDD) was defined as the proportion of children who received foods from ≥5 food groups in the past 24 h, and minimum acceptable diet (MAD) was defined as the proportion of children who met the MMF and MDD in the previous 24 h.

2.7. Anthropometry

Anthropometric parameters were measured according to standardized procedures. Weight (kg) was measured unclothed using a calibrated electronic scale (Seca, Germany) with an accuracy of 0.1 kg. Weight was derived by subtracting the weight of the mother/caregiver from the combined weight of the mother/caregiver and child. The length (cm) of the child was measured without footwear using a precision length board and recorded to the nearest millimeter (Seca, Germany). To increase reliability, all measurements were taken twice, and the average of these values was recorded. Instruments were carefully calibrated at least twice a day to minimize systematic errors.

The child's age, sex, weight, and length were used to calculate the following growth indicators: length-for-age (stunting), weight-for-age (underweight), and weight-for-length (wasting) according to the WHO 2006 child growth reference [22].

2.8. Statistical Analysis

RStudio and R version 4.1.0 software were used to generate descriptive statistics, such as mean, standard deviation (SD), median (Interquartile range), frequencies, and percentages. Z-scores for anthropometric indices were generated using WHO Anthro version 3.2.2, and the values were entered into RStudio for further analysis, utilizing age-specific cut-off points. Wilcoxon rank sum and Pearson's Chi-squared test were used for bivariate analysis. A multivariate logistic regression analysis was performed in RStudio to analyze the association between MAD and child stunting and independent variables such as socioeconomic, demographic characteristics, and dietary intake. A p-value of less than 0.05 was considered statistically significant.

3. RESULTS

3.1. Socioeconomic and Demographic Characteristics of the Study Population

Overall, data from 515 pairs of mothers and children were analyzed. The socioeconomic and demographic-related characteristics of the study population are presented in Table **1**. Most of the children enrolled in the study lived in the Kadutu Health Zone (56.7%). The mean age of the children was 13.3 ±5 months, and approximately 51.5% were male. More than half of the mothers were between 20 - 30 years old (58.8%), among whom 42.5% were unemployed, and the majority were married (88.2%).

More than a third of the households earned less than USD 50-100 per month (32.2%), while almost a quarter of the mothers reported not knowing their monthly earnings (27%). Slightly more than two-thirds had between two and three children under the age of five. In terms of education, the highest level of education attained by most mothers was secondary education (53.4%).

3.2. Infant and Young Child Feeding Practices

About 97.1% of the children were breastfed, and approximately 85% of them started breastfeeding within the first hour after birth. Additionally, the majority (61.7%) of the children were exclusively breastfed under 6 months, and still breastfed at 12–13 months (62.4%).

Regarding water consumption, mothers reported introducing liquid beverages to their children at a median age of 4 months (range, 3-5 months). According to the mothers' responses, in addition to breastfeeding, 80%, 12%, 15.2%, and 10% of the children received water, sugar water, tea with soy, and tea with milk, respectively, on the day before the survey (n = 388) (Table **2**). Children were introduced to semi-solid foods (porridge) at a median age of 6 months (4–6 months). At the time of the survey, most children (94.2%) were already taking it (n = 485). Mothers reported using different types of flour to prepare their children's porridge. These flours were used separately or mixed. In general, the most commonly used flours were sorghum (70%), soybean (53%), and maize (44%). The remaining mothers used plantain flour (49%), wheat (36%), and millet (23%). Milk consumption by children was low, with only 12% of mothers reporting that they added milk to their children's porridge. The results of the questionnaires showed that the choice of flours was mainly motivated by their nutritional value (44%) and their traditional use (31%). Regarding solid food consumption, the median age at which children were introduced to family meals was 8 months (range, 7–10 months), and approximately 80.4% of the children in our study consumed family meals (Table **2**).

3.3. Dietary Diversity and Food Frequency Consumption

The consumption of foods from different food groups in the previous 24 hours was recorded for children (6–23 months). Foods from the starchy staples (cereals, grains, roots, and tubers) were consumed by almost all children. The second most consumed foods were pulses, legumes, and nuts, followed by flesh foods (meat, poultry, organ meat, and fish). In addition, almost half of all children consumed other fruits and

Table 1: Socioeconomic and Demographic-Related Characteristics of the Study Population (N=515)

Characteristic	Mean ± SD	N (%)
Residential area		
Kadutu		292 (56.7)
Miti-Murhesa		223 (43.3)
Age of the child (Months)		
6 – 11	13.3 ± 5	199 (38.6)
12 – 17		195 (37.9)
18 – 23		121 (23.5)
Sex of Child		
Girls		250 (48.5)
Boys		265 (51.5)
Mother's age (years)		
16 - 20	28.3 ± 5.8	24 (4.7)
21 - 30		303 (58.8)
31 - 40		161 (31.3)
41 - 50		27 (5.2)
Employment status		
Unemployed		219 (42.5)
Self-employed		50 (9.7)
Farmer		104 (20.2)
Business/Trader		127 (24.7)
Employed		15 (2.9)
Marital status		
Single/Divorced/widowed		61 (11.8)
Married		454 (88.2)
Household monthly income		
< USD 50		147 (28.5)
USD 50 – USD 99		166 (32.2)
> USD 100		61 (11.8)
Unknow		141 (27.4)
Number of under-5 children		
1 child		155 (30.1)
2–3 children		351 (68.2)
4 children		9 (1.7)
Mother's highest educational level completed.		
None		95 (18.4)
Primary		120 (23.3)
Secondary		275 (53.4)
University		25 (4.9)

Results were presented as N= number (percentage) and mean ± standard deviation (M±SD).

Table 2: Infant and Young Child Feeding Practices (N=515)

Characteristic	Median (IQR)	N (%)
Breastfed		
Ever breastfed		500 (97.1)
Early initiation of breastfeeding		438 (85)
Exclusive breastfeeding under 6 months		318 (61.7)
Continued breastfeeding 12 - 23 months		199 (62.4)
Liquid beverages		
Introduction age, months	4 (3 - 5)	
Water		352 (79.6)
Sugar water		53 (12)
Tea + soya		44 (10)
Tea + milk		67 (15.2)
Semi-solid food (porridges)		
Introduction age, months	6 (4 - 6)	
Maize porridge		209 (43.5)
Sorghum porridge		335 (69.9)
Soybean porridge		254 (52.9)
Wheat porridge		173 (36.1)
Millet porridge		110 (23)
Plantain porridge		236 (49.2)
Milk added to porridge		50 (11.9)
Infant formula porridge		15 (3.1)
Motivates flour choice		
Flour price		99 (20.4)
Amount of flour		22 (4.5)
Flour availability		65 (13.4)
Nutritional value of flour		213 (43.9)
Traditions		149 (30.7)
Other reasons		30 (6.2)

Results were presented as N = number (percentage) and median (IQR: Interquartile range).

vegetables such as avocado, orange, cucumber, aubergine, cabbage, and vitamin A-rich fruits and vegetables (yellow and red). The least consumed foods by children were dairy products and eggs (Figure **1**). The dietary diversity score (DDS) for children aged 6–23 months was determined (as described above). A child aged 6–23 months met the criterion for minimum dietary diversity if they had received food from five or more food groups [21]. The mean individual DDS of the children was 4.06 ± 1.78, and 59.2% had a low DDS (<5 groups). Out of the 515 children, 40.8 % (21.4 % in boys and 19.4 % in girls, $p > 0.05$) met the minimum dietary diversity (Table **3**).

The food groups most commonly consumed by children during the week (at least once a week) were: cereals, oils/fats, tubers and roots, green leafy vegetables, legumes, and oilseeds/nuts. This diet consisted of little to no food of animal origin. Mothers reported that they rarely gave their children fish/fish products, dairy products, and meat. In addition, 89% and 79% of mothers reported never giving liver/other organ meat and eggs, respectively. Few fruits were given to children, with only 38% frequently giving vitamin A-rich vegetables, 74% rarely giving vitamin C-rich fruits, and 83% never giving yellow/red fruits. Mothers also reported never giving their children the following foods: seasoning, tea, and fruit juices (Table **3**).

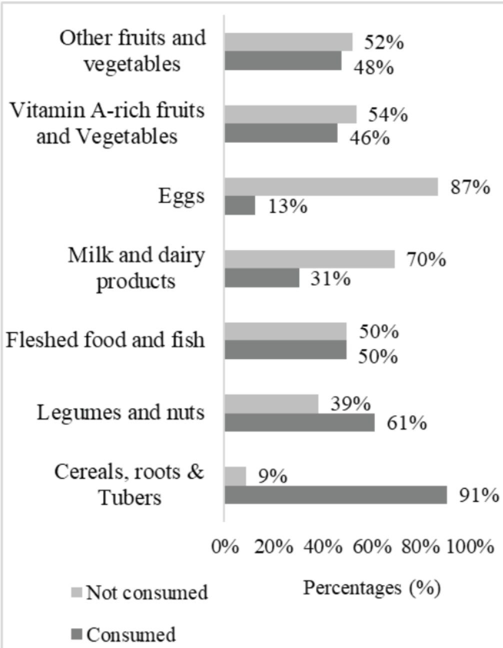

Figure 1: Food groups consumed by children in the previous 24 hours (N=515).

3.3.1. Minimum Meal Frequency and Minimum Acceptable Diet of the Children

Among children aged 6-8 months who were still breastfed, 61% had reached the minimum meal frequency (MMF) (≥ 2 meals per day) the previous day. In the 9-23-month age group, the proportion of children who had reached the MMF (≥ 3 meals per day) was 57.5%. Only 18% of non-breastfed children aged 6-23 months met the MMF (≥4 meals per day) (Figure **2**). Our results also showed that 23% of children have achieved the minimum acceptable diet (MAD), with a significant difference observed between breastfed and non-breastfed children ($p < 0.001$). In addition, MAD achievement was significantly higher among children living in urban areas (28.4%) compared to those living in rural areas (16.6%) ($p = 0.002$) (Figure **3**).

3.4. Nutritional Status of Children

Table **4** summarizes the nutritional status of the study children. The mean (± SD) weight-for-length z-score (WLZ), weight-for-age z-score (WAZ), and length-for-age z-score (LAZ) were 0.27 ± 1.37, -0.56 ± 1.27, and -1.46 ± 1.56, respectively. Statistically

Table 3: Dietary Diversity and Food Frequency Consumption of the Children (N=515)

Dietary Diversity	All (n=515)	Girls (n=250)	Boys (n=265)
Mean score ± SD	4.06 ± 1.78	4.12 ± 1.76	4.00 ± 1.81
MDD*, % (n)	40.8 (210)	19.4 (100)	21.4 (110)
Non-MDD, % (n)	59.2 (305)	29.1 (150)	30.1 (155)
Food Frequency Consumption,%	**All (n=515)**	**Girls (n=250)**	**Boys (n=265)**
Cereals	90.7	44.1	46.6
Oils/fats	69.8	34	35.8
Tubers and roots	66.8	33.2	33.6
Green leafy vegetables	54.9	27.5	27.3
Legumes	48.8	23.7	25.1
Oilseeds/nuts	44.7	22.7	22.1
Fish/fish products	40.1	20.0	20
Others vegetables	34.8	16.6	18.2
Vitamin A-rich vegetables	33.8	16.2	17.6
Others fruits	30	15.2	14.8
Milk, dairy products	27.7	12.3	15.4
Meats	20.4	7.9	12.6
Tea	14.2	6.5	7.7
Vitamin C-rich fruits	12.8	6.7	6.1
Eggs	10.3	5.1	5.3
Yellow and red fruits	7.9	3.4	4.5
Liver/other organ meats	5.3	3.2	2
Fruit juices	5.1	2.2	2.8
Seasoning	2.2	1.4	0.8

Results were presented as a percentage (%) and mean ± standard deviation (M±SD).
*Minimum dietary diversity (MDD) - Children: consumption of at least five food groups of eight (8) defined.

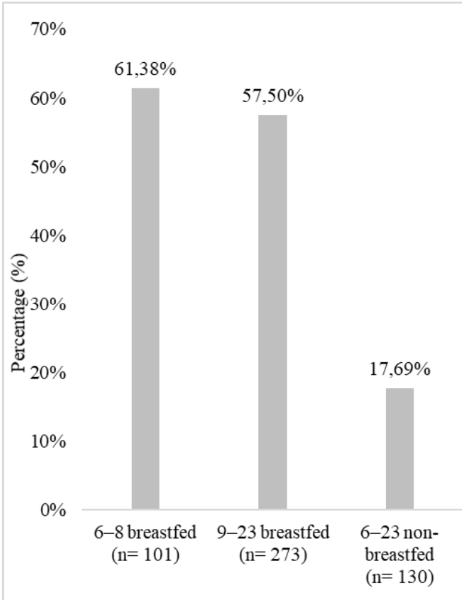

Figure 2: Minimum meal frequency among breastfed and non-breastfed children (N=515).

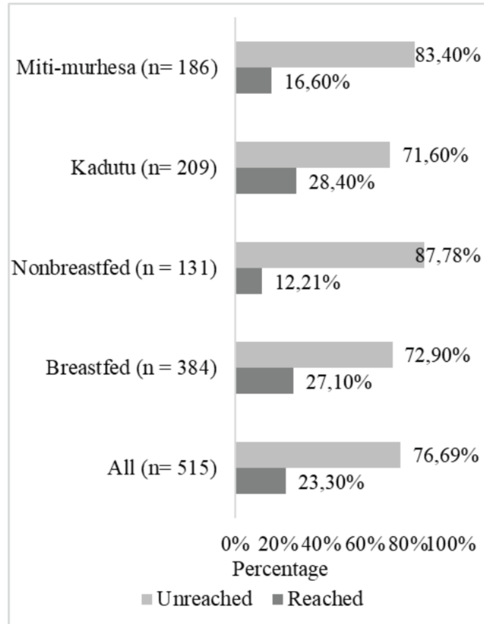

Figure 3: Minimum acceptable diet of children (N=515).

significant differences in WAZ and LAZ were detected between boys and girls. The overall prevalence of acute malnutrition (wasting) was 4.9%, with 1.6% for boys and 3.3% for girls. The prevalence of underweight was 12.8% (5.6% for boys and 7.2% for girls), and the prevalence of stunting was 36.7% (15.1% for boys and 21.6% for girls). The proportion of stunting differed statistically by sex (P < 0.05). Furthermore, caregivers of 56.7% of the children reported illness in the two weeks before the survey, and only 62% had received deworming treatment in the previous six months.

3.5. Factors Associated with Minimum Dietary Diversity among Children

The association between sociodemographic factors, frequency of food consumption, and minimum dietary diversity was assessed through a multivariable logistic regression analysis.

Minimum dietary diversity was particularly associated with maternal occupation, child age, frequent consumption of vitamin C-rich fruits, vitamin A-rich vegetables other than fruits, and fruit juice. Logistic regression analysis (Table **5**) revealed that maternal occupation was significantly associated with meeting the minimum dietary diversity requirements. Specifically, children of mothers employed as business/traders were 1.72 times more likely to meet the minimum nutritional diversity than those whose mothers were not employed (p = 0.050). The age of the child was also associated with the onset of MDD. Indeed, children aged 12–17 months were also more likely to achieve minimum dietary diversity than were

Table 4: Nutritional Status of the Children (N=515)

	All (515)	Girls (n = 250)	Boys (n = 265)	p-value^2
WLZ [Mean ± SD]	0.27 ± 1.37	0.38 ± 1.31	0.16 ± 1.41	0.13
WAZ [Mean ± SD]	-0.56 ± 1.27	-0.39 ±1.29	-0.73 ± 1.23	**0.003**
LAZ [Mean ± SD]	-1.46 ± 1.56	-1.26 ± 1.65	-1.65 ± 1.44	**0.003**
Wasting [WLZ < -2]	4.9 (25)	1.6 (8)	3.3 (17)	0.090
Underweight [WAZ < -2]	12.8 (66)	5.6 (29)	7.2 (37)	0.4
Stunting [LAZ < -2]	36.7 (189)	15.1 (78)	21.6 (111)	**0.012**
Child's history of illness in the past 2 weeks	27.6% (142)	29.1% (150)	56.7% (292)	>0.900
Deworming (within the last 6 months)	29.3% (151)	32.8% (169)	62.1% (320)	0.4

Results were expressed as percentage (%), mean ± standard deviation (M ± SD), number (n); WLZ: Weight-for-Length z-score; WAZ: Weight-for-Age z-score, LAZ: Length-for-Age z-score. ^{2}Wilcoxon rank sum test; Pearson's Chi-squared test.

Table 5: Factors Associated with Minimum Dietary Diversity among Children in South Kivu (N=515)

	Odds ratio	95% CI[1]	p-Value
Location			
Miti-Murhesa	1.00	Ref.	
Kadutu	1.34	0.77, 2.35	0.3
Mother's age (in years)			
16 - 20	1.00	Ref.	
21 - 30	0.87	0.32, 2.42	0.8
31 - 40	0.61	0.21, 1.75	0.3
41 - 50	0.33	0.08, 1.35	0.13
Employment status			
Unemployed	1.00	Ref.	
Self-employed	1.29	0.59, 2.82	0.5
Farmer	1.49	0.73, 3.03	0.3
Business/Trader	1.72	1.00, 2.99	0.050
Employed	2.97	0.72, 13.7	0.14
Age of the child (Months)			
6 – 11	1.00	Ref.	
12 – 17	1.82	1.07, 3.10	0.028
18 – 23	1.22	0.67, 2.23	0.5
Consumption of solid food			
Yes	8.99	3.85, 24.1	<0.001
Vitamin A-rich vegetables			
Never	1.00	Ref.	
Rarely	1.00	0.41, 2.40	>0.9
Frequently	2.13	1.28, 3.56	0.004
Vitamin C-rich fruit			
Never	1.00	Ref.	
Rarely	1.29	0.68, 2.43	0.4
Frequently	3.27	1.55, 7.17	0.002
Other fruit			
Never	1.00	Ref.	
Rarely	1.93	1.07, 3.49	0.028
Frequently	1.33	0.76, 2.31	0.3
Fruits juice			
Never	1.00	Ref.	
Rarely	1.18	0.39, 3.68	0.8
Frequently	0.28	0.10, 0.79	0.018
Wasting			
No	1.00	Ref.	
Yes	0.38	0.12, 1.06	0.078

[1]CI = confidence interval.
Food consumption frequency: Frequent (at least 1 time a day); Rare (2 - 6 time a week); Never (never consumed in the week).

children aged 6–11 months (OR = 1.82, p = 0.028). Logistic regression analysis of dietary patterns revealed that solid food consumption was a strong positive predictor of MDD (OR = 8.98, p < 0.001).

In addition, frequent consumption of vitamin A-rich foods (OR = 2.13, p = 0.004) and vitamin C-rich foods (OR = 3.27, p = 0.002) significantly increased the likelihood of MDD. Rare or no consumption of other fruits was also associated with better MDD (OR = 1.93,

Table 6: Factors Associated with Stunting among Children in South Kivu (N=515)

	Odds Ratio	95% CI[1]	p-Value
Sex of Child			
Girls	1.00	Ref.	
Boys	1.64	1.12, 2.41	0.011
Age of the child (Months)			
6 – 11	1.00	Ref.	
12 – 17	1.42	0.89, 2.25	0.14
18 – 23	2.49	1.47, 4.25	<0.001
Food consumption frequency[3]			
Other vegetables			
Never	1.00	Ref.	
Rarely	0.99	0.52, 1.87	>0.9
Frequently	0.56	0.35, 0.89	0.015
Other fruits			0.064
Never	1.00	Ref.	
Rarely	0.55	0.32, 0.92	0.025
Frequently	0.93	0.59, 1.46	0.7
Oils/fats			
Never	1.00	Ref.	
Rarely	0.99	0.29, 2.97	>0.9
Frequently	1.98	1.20, 3.31	0.008

[1]CI = confidence interval.
Food consumption frequency: Frequent (at least 1 time a day); Rare (2 - 6 times a week); Never (never consumed in the week).

p = 0.028). In contrast, frequent consumption of fruit juice was negatively associated with MDD (OR = 0.28, p = 0.018).

3.6. Factors Associated with Stunting among Children in South Kivu

The association between socio-demographics, food frequency, and stunting was assessed using multivariable logistic regression analysis. Stunting was significantly associated with the sex (male) and age (18–23 months) of the child, as well as the frequent consumption of oil/fat and other vegetables, and the never consumption of different vegetables. Logistic regression analysis (Table **6**) showed that boys were 1.64 times more likely to be stunted than girls (p = 0.011). In addition, children aged 18-23 months were 2.49 times more likely to be stunted than children aged 6-11 months (p < 0.001). Regression from dietary patterns showed that frequent consumption of other vegetables reduced the risk of stunting by 0.56 (p = 0.015), as did occasional consumption of different fruits (OR = 0.55, p = 0.025). Conversely, frequent consumption of oils was associated with an increased risk of stunting (OR = 1.98, p = 0.008).

4. DISCUSSION

The study was conducted to collect baseline data on the feeding practices of children aged 6-23 months in South Kivu, as part of a project aimed at improving the bioavailability of micronutrients in complementary foods consumed by these children. The results highlight suboptimal complementary feeding practices that may compromise infants' nutritional status.

The WHO recommends exclusive breastfeeding until 6 months of age [23]. However, in this study, only 62% of the children under 6 months were exclusively breastfed. First, the liquid and solid foods were introduced early. The problem with introducing solid foods early is that they are more likely to replace breast milk [24], thereby reducing the intake of valuable nutrients and bioactive compounds. This consumption of solid foods exposes infants to additional pathogens, while solid foods do not provide the immunological benefits of breast milk [25].

Second, the porridges introduced at six months of age were primarily composed of cereals and legumes, including sorghum, soybeans, plantains, and maize, in addition to continued breastfeeding. Although this limited dietary diversity was initially thought to be due to economic or supply constraints, interviews revealed that maternal selection of these ingredients was influenced primarily by their perceived nutritional value. These perceptions, although well-intentioned, may not align with the actual nutrient requirements of infants, particularly regarding critical micronutrients such as iron, zinc, and calcium, which are often deficient in plant-based diets unless they are adequately diversified or fortified.

The WHO recommends that complementary feeding should include a varied diet with adequate amounts of animal products (meat, poultry, fish, and eggs), as well as vitamin A-rich fruits and vegetables, for infants over 6 months of age [23]. Indeed, nutritional deficiencies are common during the complementary feeding period, partly because children's energy and micronutrient requirements are much higher than those provided by their usual diet [26]. These findings underscore the need for targeted nutrition education to improve maternal knowledge and promote the inclusion of more nutritious or fortified complementary foods in South Kivu.

In this study, only 41% of the children achieved a minimum level of dietary diversity. Our results are similar to those reported by Kambale in South Kivu [27]. It has been suggested that average or low levels of dietary diversity significantly contribute to inadequate nutrient intake [28].

Although the percentage of children receiving a minimum acceptable meal is generally low, we observed that children in the urban area (Kadutu) received more meals than did those in the rural area (Miti-Murhesa). This inadequate intake suggests that children in rural areas may be at a higher risk of nutritional deficiencies than their urban counterparts. This observation is consistent with the South Kivu Child Nutrition Survey, which found that malnutrition was more prevalent in rural than in urban areas [27].

Examining dietary diversity alone, without considering the frequency of consumption of different food groups, may not provide a clear picture of dietary adequacy. Increasing the frequency of consumption of food groups may have multiple effects. It may be associated with balanced nutrient intake, malnutrition, or overeating [29]. The results of the food frequency questionnaire confirmed those of the 24-hour recall test, on which we based our calculations of dietary diversity. We found that the food groups most commonly consumed by children were cereals, tubers, and legumes. The predominance of starchy food groups in the diets of children in South Kivu is not surprising, as these products are widely grown in the region. Cereals, which are rich in starch, are easy to preserve in dry form and can be stored for long periods. This may explain why these food groups dominate the diet of the inhabitants of South Kivu. Given that starchy foods are high in energy and low in essential micronutrients, it is plausible that their predominance prevents children from obtaining the necessary amount of vital nutrients, including micronutrients. Indeed, there is ample evidence that the predominance of starchy foods in the diet is an indicator of nutritional insufficiency and, by extrapolation, a factor in undernutrition [30-32].

Animal products, especially meat, eggs, fish, and milk, are a significant source of high-quality protein and bioavailable micronutrients, and are largely free from antinutritional factors. Despite their importance, our results indicate that only 50% of children consumed these foods, a proportion higher than that of 33.1% reported by Marinda *et al.* in Zambian children aged 6-23 months [12]. Among the animal food groups, fish were the most commonly consumed. The children consumed mainly whole small ndagaa fish (*Stolothrissa tanganicae*). Small fish species found in developing countries have been shown to contain high levels of micronutrients such as vitamin A, iron, and zinc [33], which are critical for children's growth and development. Fish are also a rich source of vitamin B12, which is found only in animal-based foods and is essential for many functions, including growth, brain function, and maintenance of the nervous system [34].

This limited consumption of animal products suggests that cereals, legumes, and nuts serve as alternative protein sources in South Kivu. However, these plant-based foods may not provide sufficient nutrients due to antinutritional factors (e.g., phytic acid, tannins) that hinder the digestibility and absorption of proteins and essential micronutrients [35]. This monotonous diet of cereals, tubers, and legumes, with little or no animal foods, restricts nutrient intake and raises the risk of malnutrition and micronutrient deficiencies. The prevalence of wasting among children in this study (5%) was nearly twice the provincial rate (2.6%, MICS 2018). However, it was still higher than the national average in DRC (6.5%, MICS 2018). Conversely, the stunting rate in our study (36%) is slightly lower than the DRC national average (41.8%, MICS 2018) but remains above the African regional average (30.7%, [36, 37]).

The key factors linked to childhood stunting in this study were female gender and the child's age. Unlike many studies in sub-Saharan Africa, our findings show that girls are more susceptible to stunting than boys. [37, 38] Similar results have been reported in Kenya by Ndiku and Jaceldo-Siegl [39], as well as by Hoffman [15]. These studies suggest that girls are at a higher risk of stunting, being underweight, and wasting. Combined across all sexes, children aged 18–23 months were significantly more likely to be stunted than other groups. This aligns with previous research in sub-Saharan Africa, which found that stunting generally increases with the child's age [37, 40]

Given this prevalence, mothers must adopt healthy, well-diversified eating habits as early as possible. Although children's eating habits may change over time, researchers have shown that healthy eating habits established early in life provide a foundation that can last for many years [41]. Other factors may also come into play. A lack of access to clean drinking water and poor hygiene practices during food preparation can expose children to infections. Diarrhea diseases, which are common in these conditions, contribute to chronic malnutrition [37].

This study has certain limitations. Its cross-sectional design prevents the establishment of causal links because exposure and outcomes were assessed simultaneously. Being based on recall and self-reporting, recall bias could have influenced the accuracy of data on minimum dietary diversity and consumption frequency. Despite this, the study offers the first insights into MDD and related factors among children aged 6 to 23 months in the Kadutu and Miti-Murhesa health zones. Future longitudinal research is needed to determine the causal relationships between variables.

5. CONCLUSION

This study revealed inappropriate feeding practices among infants and young children, in particular the early introduction of solid foods, the lack of dietary diversification, and the low consumption of foods of animal origin. In both rural and urban areas of South Kivu, complementary feeding is predominantly based on maize, sorghum, and soybeans, which are consumed as individual porridges or mixed. Enriching these staple foods with locally available animal-source products might be a good strategy to improve food consumption, dietary diversity, and the nutrient intake of micronutrients such as iron and zinc. Our results highlighted the persistence of undernutrition (wasting and stunting) among children in the region. It's also worth noting that a few percent of children had met the minimum acceptable diet. Linear modeling could thus be used to optimize the formulation of complementary food by incorporating micronutrient-rich animal-derived ingredients, thereby contributing to the prevention of child malnutrition and micronutrient deficiencies.

Given the results found in this study, it is advisable to recommend the followings: (i) Strengthening nutrition education at a community level by targeting caregivers and focusing on improving complementary feeding practices using locally available nutrient-rich foods ; (ii) Integrating locally adapted complementary foods into existing food aid and maternal and child health programmes to improve their availability and acceptability.

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LIST OF ABBREVIATIONS

CI	=	Confidence Interval
DRC	=	The Democratic Republic of the Congo
FAO	=	Food and Agriculture Organization
HA	=	health areas
IQR	=	Interquartile range
IYFC	=	Indicators for assessing infant and young child feeding practices
MDD	=	Minimum Dietary Diversity
MAD	=	Minimum acceptable diet
USD	=	United States Dollar

OR = Odds ratio

SD = Standard Deviation

UNICEF = United Nations Children's Fund

WHO = World Health Organization

ETHICAL APPROVAL AND CONSENT TO PARTICIPATE

The research protocol was approved by the Ethics Committee of the Université Catholique de Bukavu (UCB/CIE/02-07/2020) and the Division provinciale de la santé (N°015/CD/DPS-SK/2021) of South Kivu. The study was conducted by the ethical principles outlined in the Declaration of Helsinki. Local and health authorities were informed, and oral consent was obtained from heads of households and mothers or caregivers of children. The study participants were informed about the objectives, expected results, and benefits or risks, and all measures were taken to ensure the confidentiality of the information collected.

CONFLICTS OF INTEREST

The authors declare that they have no conflict of interest.

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