

Adequate dietary diversity among lactating women in conflict-affected and severely food-insecure rural settings in the western part of the Democratic Republic of the Congo

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Abstract

Background

Lactating women have heightened nutritional needs to sustain optimal maternal health and adequate breast milk production. Little is known about their diet in low-income and conflict-affected settings and the role of household income sources on maternal diet quality. This study investigated the determinants of dietary diversity and role-playing by household income and nutritional status among lactating women in a food-insecure and conflict-affected area.

Methods

Between July and September 2024, a community-based cross-sectional study was conducted among 662 lactating women (15–49 years) in Popokabaka Health Zone, Kwango Province, DRC. Dietary diversity was assessed using the Minimum Dietary Diversity for Women (MDD-W). BMI and MUAC were used to measure maternal nutritional status, while household food insecurity was assessed using the Household Food Insecurity Access Scale (HFIAS). Household income sources were categorized as agriculture-only or mixed/non-agricultural. Multivariable logistic regression models coupled to propensity score matching (PSM) and mediation analysis were applied to examine determinants of adequate dietary diversity ($MDD-W \geq 5$).

Results

A total of 662 lactating women were surveyed, with a mean age of 32.8 years. Only 34.8% achieved $MDD-W \geq 5$. Multivariable analysis showed that income diversification increased the odds of adequate dietary diversity (AOR: 1.65; 95% CI: 1.09–2.48), while maternal BMI was strongly associated: women with normal BMI (AOR: 1.87; 95% CI: 1.19–2.94) and overweight/obese women (AOR: 6.44; 95% CI: 2.36–17.52) were more likely to meet MDD-W compared to underweight women. After applying PSM, women relying on mixed income sources had significantly higher dietary diversity compared to those relying solely on agriculture (ATET = 0.19, $p = 0.001$). In addition, mediation analysis suggested that maternal underweight modestly mediated the relationship between income diversification and dietary diversity.

Conclusions and recommendations

Dietary diversity can be reached by lactating women in conflict-affected rural areas. Household income diversification and maternal nutritional status were the strongest predictors of MDD-W. Understanding adaptive behaviors applied by the lactating to achieve MDD-W should provide an opportunity for improving maternal diets and prioritizing livelihood diversification and targeted nutrition support for undernourished women, alongside broader strategies addressing food insecurity in fragile rural settings.

Background

Lactation is a nutritionally demanding period in a woman's life, characterized by increased energy and micronutrient requirements to sustain optimal breastmilk production and ensure maternal well-being. Adequate dietary diversity during this period is therefore essential to meet the elevated nutritional needs of both mother and child, supporting recovery from childbirth, maintaining maternal health, and promoting infant growth and development (1–5). Evidence consistently demonstrates that lactating women who fail to achieve minimum dietary diversity are at increased risk of micronutrient deficiencies, undernutrition, and poor health outcomes for themselves and their infants, including impaired immunity, delayed child growth, and heightened morbidity (1–6). These vulnerabilities are particularly acute in low- and middle-income countries (LMICs) (2, 7–12), where diets often rely heavily on starchy staples and lack sufficient animal-source foods, fruits, and vegetables (5, 6, 13).

Globally, suboptimal diets are a leading risk factor for maternal and child morbidity and mortality, and lactating women represent a uniquely vulnerable group within this context (14). In sub-Saharan Africa, studies report that less than half of women of reproductive age achieve minimum dietary diversity for women (MDD-W), with even lower rates observed in rural and fragile settings (8–10). In the Democratic Republic of Congo (DRC), national survey data indicate that only 17% of women of reproductive age consume diets considered adequately diverse (11). Such findings underscore the structural challenges faced by Congolese women in meeting their nutritional requirements during lactation. These challenges include persistent poverty, seasonal food insecurity, limited access to markets, and recurrent shocks that disrupt agricultural production and food systems (12–14).

The Popokabaka Health Zone, situated in Kwango Province in western DRC, illustrates these challenges vividly. It is characterized by pervasive food insecurity, low agricultural productivity, and poor market integration, these conditions recently exacerbated by the “Mobondo” intercommunity conflict that displaced households, disrupted agricultural livelihoods, and further constrained access to food (15, 16). Indeed, armed conflicts can affect nutrition during the lactation period through several pathways, including population displacement, loss of productive assets, insecurity-related mobility restrictions, and erosion of social support systems. For lactating women, these disruptions are related to increased physiological demands, gendered caregiving responsibilities, and limited decision-making power, amplifying nutritional vulnerability (17, 18). However, little is known about how lactating women could adapt their dietary practices in rural conflict settings.

Among the key determinants of dietary diversity, household socioeconomic conditions and food security play central roles (19). Education, household wealth, and access to safe water and health services have all been positively associated with more diverse diets among women of reproductive age (19, 20). However, in fragile rural settings where livelihoods are predominantly agricultural, household income sources may also shape dietary opportunities, and some women may be able to provide themselves and their children with a diverse diet (21). Dependence on subsistence farming or fishing exposes households to seasonal shortages and conflict-related disruptions. In contrast, diversified or non-agricultural income sources, such as wage labor, petty trade, or remittances, may buffer against these shocks and improve access to nutrient-rich foods (20–22). Yet despite the theoretical importance of

livelihood diversification, few studies in conflict-affected LMIC settings have explicitly examined how household income sources interact with food insecurity and maternal nutritional status to influence dietary diversity among lactating women (22–25).

Furthermore, nutritional status itself may act as an intermediate factor linking household livelihoods to maternal diets. For instance, undernutrition can limit women's physical capacity to procure or prepare diverse meals, while overweight or obesity may reflect greater access to varied diets but also pose risks of diet-related chronic disease (22–25). To date, empirical studies have rarely modeled maternal anthropometric status as a potential mediator between income sources and dietary diversity in fragile settings (23). Such an approach may provide deeper insights into the pathways through which structural vulnerabilities affect maternal diets during lactation.

The present study aimed to examine how dietary diversity among lactating women is shaped by livelihood strategies and maternal nutritional status in a conflict-affected, food-insecure rural setting of Popokabaka Health Zone of DRC. Specifically, the study showed [1] whether women in this setting can achieve dietary diversity despite having a low income and food insecurity, [2] whether household income sources were associated with dietary diversity among lactating women after accounting for food insecurity and socioeconomic characteristics, and [3] whether maternal body mass index (BMI) mediated the association between income sources and dietary diversity. By addressing these questions, this study seeks to generate context-specific evidence on the nutritional vulnerabilities of lactating women in fragile rural environments and to identify potential entry points for nutrition-sensitive interventions that address both household livelihoods and maternal nutrition. Figure 1 illustrates the preliminary conceptual model that guides this study, based on the literature review.

Methods

Study Design and Setting

A community-based cross-sectional study was carried out between July and October 2024 in the Popokabaka Health Zone (HZ), Kwango Province, DRC (Fig. 2). The setting is one of the 516 health zones of the DRC, with a total population of approximately 232,994. The region is predominantly rural, characterized by subsistence farming, fishing, and small-scale livestock keeping as the main livelihood activities. Agricultural productivity is generally low due to poor soil fertility, limited access to agricultural inputs, and underdeveloped markets. Recently, Popokabaka has been experiencing “Mobondo” intercommunity conflict (2021–2023), which aggravated the vulnerability to food insecurity by causing displacement, livelihood destruction, and nutritional conditions (17, 18). These dynamics provided a critical backdrop for examining dietary diversity, as they directly affected food availability, income sources, and women's capacity to secure a diverse diet.

Study population, sample size determination, and sampling procedure

The study was conducted among lactating women aged 15–49 years. The eligibility criteria were to have a breastfeeding child younger than 24 months and to be a resident in the study area for at least six months preceding this study. The sample size was estimated using the single population proportion formula $[N \geq (Z^2 \cdot 1 - \alpha / 2 \times P (1 - P) / d^2) \cdot deff]$, assuming that 40% of lactating women would achieve adequate dietary diversity (26), with a 95% confidence level, 5% margin of error, and a design effect of 1.5 to account for the clustered nature of the data. The minimum required sample size was 610 participants. Anticipating an 8% non-response rate, we targeted 670 participants. The study participants were selected by using a three-stage cluster sampling technique. First, 20 health areas (HA) were built up from a sample frame of 25 HA, which allowed to list 72 villages as clusters. In the first stage, sixty clusters were randomly selected through a probability-proportion-to-size technique. In the second stage, 11 lactating women were randomly selected from each cluster using the household list from community workers 1 (Fig. 3).

PSU. Primary Statistic Units: PPS. Probability proportion size

Figure 3. Sampling procedure

Data collection procedures

Data collection was completed by trained research assistants. A structured questionnaire was used to collect data on socio-demographic characteristics, maternal and child feeding practices, household hygiene conditions, and household food security with a digital tool (Open Data Kit). The information on food groups used to assess dietary diversity in this study was collected using the Women's Dietary Diversity (27, 28). Women were asked to report all the foods consumed during the 24 hours preceding interview.

Food insecurity was measured using the Household Food Insecurity Access Scale (HFIAS), developed by USAID's Food and Nutrition Technical Assistance (28). The tool consists of nine "frequency-of-occurrence" questions that measure the severity of food insecurity in the last four weeks using four Likert scale responses, including never, rarely (once or twice), sometimes (three to ten times, and often (more than ten times). Each Likert scale corresponds to a unique score, including 0 for never, 1 for rarely (once or twice), 2 for sometimes (three to ten times), and 3 for often (more than ten times). The severity of food insecurity is scored by adding up these scores, resulting in a cumulative score ranging between 0 and 27. The higher HFIAS score indicated greater food insecurity experienced by the household.

Anthropometric indices measured were weight and height, and Mid-Upper Arm Circumference (MUAC) measurements were conducted on all participants. The weight of the lactating women was measured to the nearest 0.1 kg on a battery-powered digital scale (SECA type). Whereas, the height was measured to the nearest 0.1 cm using a wooden height-measuring board with a sliding head bar, following standard anthropometric techniques (29). To ensure the quality of the collected data, the functionality of digital weight scales was checked every morning before data collection began. In addition, the investigator and

supervisors monitored and checked the collected data for completeness, accuracy, and consistency each day. Field supervisors cross-checked the filled questionnaire on-site, and any discrepancies and/or missing data were re-inquired.

Dependent variable

Minimum dietary diversity for women (MDD-W). The foods reported in the dietary diversity questionnaire were categorized into 10 food groups: (1) *Grains, white roots and tubers, and plantains*, (2) *Pulses (beans, peas, and lentils)*, (3) *Nuts and seeds* (4) *Dairy*, (5) *Meat, poultry, and fish*, (6) *Eggs*, (7) *Dark green leafy vegetables*, (8) *Other vitamin A-rich fruits and vegetables*, (9) *Other vegetables* and (10) *Other fruits*. One point was awarded for the consumption of each food group, with a total possible score being 10 if all foods were consumed in the previous 24 hours. Adequate MDD-W was achieved if a lactating woman consumed foods from five or more food groups during the last 24 hours. The cumulative MDD-W was categorized for building a dichotomized outcome variable: acceptable dietary diversity (consuming five or more food groups) and poor dietary diversity (consuming less than five food groups) (8).

Covariables

Food insecurity. The cumulative HFIAS scores were categorized into the original four levels of household food security status, including: food secure, mild, moderate, and severe food insecurity, following HFIAS guidelines (27). However, for the analytical purpose, these three (mild, moderate, and severe) levels of food insecurity were re-categorized into two categories (food secure and food insecure).

Household socioeconomic status (SES). The information from the socio-demographic questionnaire was used to assess the wealth index status of the Household. Households were assigned scores of '0' for No and '1' for Yes, based on the number and type of consumer assets they own, ranging from televisions to bicycles, as well as on housing characteristics such as drinking water supply, sanitation facilities, and flooring. The SES was used to generate a wealth index based on household asset ownership using Principal Component Analysis. Tertiles were generated by dividing the household population into three groups (lowest, middle, and highest). A household was affected by its score (30).

Anthropometric indicators. Maternal nutritional status was assessed using two anthropometric indices: Body Mass Index (BMI) and Mid-Upper Arm Circumference (MUAC). BMI was calculated as weight (kg) divided by height squared (m^2) and used to classify women as underweight ($BMI < 18.5 \text{ kg}/m^2$) or overweight/obese ($BMI \geq 25 \text{ kg}/m^2$). MUAC was used as a secondary indicator to identify acute forms of wasting, with values below 215 mm indicating moderate or severe undernutrition. Both measures were analyzed to cross-validate nutritional status and ensure robustness of classification among lactating women (31).

Household income source. This was derived from the questionnaire, which captured whether households generated income from agriculture, fishing, wage labor, petty trade, remittances, or other

activities. For analysis, income sources were categorized into two groups: (1) agriculture only, and (2) mixed or non-agricultural income (including wage labor, petty trade, remittances, or a combination).

All the data were merged and analyzed using STATA 17 (StataCorp, College Station, TX, USA). Socio-demographic characteristics were summarized descriptively. The median and interquartile range (IQR) were reported for continuous variables that were not normally distributed, while the mean (SD) was used for continuous variables that were normally distributed. Frequency and percentages were used to describe categorical data, and confidence intervals (CIs) for prevalence. Moreover, a Pearson chi-squared test was used to test the association with MDD-W as the outcome variable sociodemographic, anthropometric and food security characteristics. A logistic regression model was applied to examine factors associated with adequate dietary diversity. Variables included maternal age, education, household food insecurity, wealth index, household size, income source, and BMI categories. The model was checked for interaction terms and multicollinearity. Multicollinearity was examined using variance inflation factors (VIF).

Sensitivity analysis

To evaluate the robustness of the findings, several sensitivity analyses were conducted. First, a propensity score matching (PSM) analysis was applied. Propensity scores were estimated using logistic regression by including all covariates in the model. The exposed participants were matched to controls using 1:1 nearest-neighbor matching with a caliper of $0.2 \times \text{SD}(\text{logit}[\text{PS}])$. Covariate balance before and after matching was assessed using standardized mean differences (SMDs), with SMDs below 0.1 considered acceptable. To investigate potential pathways, we performed a causal mediation analysis to examine whether women's nutritional status mediated part of the total effect. Average causal mediation effects (ACME), average direct effects (ADE), total effects, and the proportion mediated were estimated from 2,000 Monte Carlo simulations (seed = 12345) and are reported on the probability scale. We report mediator and outcome model coefficients, ACME/ADE/total effect estimates with 95% CIs, and the proportion of the total effect mediated. The significance level was set at $p < 0.05$.

Results

3.1. Participants' Characteristics

A total of 662 lactating women completed the survey, with a response rate of 98.8%. The largest proportion of lactating women (39.4%) was aged 35–49 years. Regarding education, only 43.4% of women had completed secondary or tertiary education, while almost one-third had no formal schooling. Most households had fewer than six members (59.8%). Income source was predominantly derived from agriculture (46.8%), and 84.9% of households were food insecure. In terms of nutritional status, more than one-quarter of women (26.1%) were underweight (BMI < 18.5) (Table 1).

Table 1
Sociodemographic Characteristics of Household
and Lactating Women Profile (N = 662)

Characteristics	n	%
Age, mean $\pm$ SD	32.8 $\pm$ 9.8	
Age		
18–24	168	25.4
25–34	233	35.2
35–49	261	39.4
Education		
None	186	28.1
primary	189	28.5
Secondary/University	287	43.4
Household size		
Less than 6	396	59.8
6 and more	266	40.2
Source of income		
None	99	15.0
Sale of agricultural products/food	310	46.8
Fishing	20	3.0
Sale of other products	28	4.2
Traders and services	43	6.5
Salaries	154	23.3
Wealth index		
Lowest tertile	417	62.9
Middle tertile	235	35.5
Highest tertile	10	1.51
Food security level		
Food secure	37	5.6
Middle	15	2.2

Characteristics	n	%
Moderated	48	7.3
Severe	562	84.9
Nutritional status using BMI		
Underweight	173	26.1
Normal	462	69.8
Overweight/obesity	27	4.1

3.2. Food consumption patterns, dietary diversity frequency, and food security conditions

Food consumption varied in the study population. Nuts and seeds were the most consumed food group (83.3%), followed by grains, roots, tubers, and plantains (65.9%), and dark green leafy vegetables (65.9%); while dairy products (6.0%) and eggs (12.1%) were the least represented. The mean women's dietary diversity score (MDD-W) was 4.04 (± 1.88), with only 34.8% of households meeting the threshold for adequate nutritional diversity (Table 2).

Table 2
Food Items, dietary diversity, and household food condition

Food Items and Dietary Diversity	Total	
	n	%
Dietary diversity frequency		
Inadequate diversity	432	65.2
Adequate diversity	230	34.8
MDD_W (Mean $\pm$ SD)	4.04 $\pm$ 1.88	
Food items used in DDS		
Grains, white roots and tubers, and plantains	371	65.9
Pulses (beans, peas, and lentils)	189	33.6
Nuts and seeds	469	83.3
Dairy	34	6.0
Meat, poultry, and fish	315	56.0
Eggs	68	12.1
Dark green leafy vegetables	371	65.9
Other Vitamin A-rich fruits and vegetables	169	30.0
Other vegetables	219	38.9
Other fruits	69	12.3

Throughout Table 3, dietary diversity was more prevalent among lactating mothers with higher education. Additionally, households classified as food secure have a higher mean dietary diversity frequency compared to food-insecure households. There is a gradient in dietary diversity across wealth tertiles, with the highest SES group showing the greatest diversity. The difference between the lowest and highest SES groups was both substantial and statistically meaningful. Furthermore, smaller households (< 6 members) show slightly higher dietary diversity compared to larger households (≥ 6 members), though the magnitude of difference is modest. Regarding the source of income, mixed-income households have notably higher dietary diversity than households that rely solely on agriculture. Finally, overweight/obese individuals have markedly higher dietary diversity frequency compared to underweight and normal-weight groups.

Table 3
Distribution of dietary diversity following lactating mothers' characteristics (N = 662)

Characteristics	Overall n (%)	Dietary Diversity		p-value
		MDD-W ≥ 5 n(%)	MDD-W < 5 n(%)	
Age, mean $\pm$ SD	32.8 $\pm$ 9.8	33.6 $\pm$ 10.1	32.5 $\pm$ 9.6	0.144
Age				0.416
18–24	168 (25.4)	53 (22.5)	115 (27)	
25–34	233 (35.2)	88 (37.3)	145 (34.0)	
35–49	261 (39.4)	95 (40.2)	166 (38.9)	
Education				0.689
None	186 (28.1)	62 (26.3)	124 (29.1)	
primary	189 (28.5)	71 (30.1)	118 (27.7)	
Secondary/University	287 (43.4)	103 (43.6)	184 (43.2)	
Household size				0.563
Less than 6	396 (59.8)	91 (38.6)	175 (41.1)	
6 and more	266 (40.2)	145 (61.4)	251 (58.9)	
Source of income				< 0.01
Agriculture only	409 (61.7)	108 (55.1)	301 (64.6)	
Mixed source	253 (38.3)	88 (44.9)	165 (35.4)	
Wealth index				0.741
Lowest tertile	417 (62.9)	153 (64.8)	264 (62.0)	
Middle tertile	235 (35.6)	80 (33.9)	155 (36.4)	
Highest tertile	10 (1.5)	3 (1.27)	7 (1.6)	
Food security level				0.321
Food secure	37 (5.6)	16 (6.8)	21 (4.9)	
Insevere	562 (94.4)	220 (93.2)	405 (95.1)	
Nutritional status using BMI				< 0.01
Underweight	173 (26.1)	47 (19.9)	126 (29.6)	
Normal	462 (69.8)	171 (72.5)	291 (68.3)	

Characteristics	Overall n (%)	Dietary Diversity		p-value
		MDD-W ≥ 5	MDD-W < 5	
		n(%)	n(%)	
Overweight/obesity	27 (4.1)	18 (7.6)	9 (2.1)	

Over 70% of studied households reported experiencing food insecurity, with 73.4% worried about food availability and a lack of preferred foods (75.0%) (Table 4). Severe coping strategies were also frequently employed, with nearly 80% of households reducing meal size or frequency, and 64.3% reporting going without food for an entire day and night. HFIAS showed that 84.9% of households experienced severe food insecurity, while only 5.6% were food secure.

Table 4
Food security conditions

Food Security Conditions	Total	
	n	%
Food insecurity access-related condition at any time during the recall period (%)		
Worry that her household would not have enough food	413	73.4
Unable to eat the kinds of foods you preferred because of a lack of resources	422	75.0
Eat a limited variety of foods due to a lack of resources	56	10.9
Eat some foods that you did not want to eat because of a lack of resources	446	79.2
Eat a smaller meal than she felt she needed because there was not enough food	449	79.8
Eat fewer meals in a day because there is not enough food	449	79.8
No food to eat of any kind in the household	403	71.6
Went to sleep at night hungry because there was not enough food	349	62.0
Went a whole day and night without eating anything because there was not enough food	362	64.3

3.3. Factors associated with dietary diversity

The results in Table 5 show that households with mixed income sources had 59% higher odds of achieving dietary diversity relative to the reference income source (AOR: 1.59, 95% CI 1.08–2.34; $p = 0.017$) and lactating women nutritional status showed a graded relationship with dietary diversity: normal BMI was associated with increased odds of dietary diversity (AOR 1.57, 95% CI 1.05–2.35; $p = 0.025$), and overweight/obesity was associated with markedly higher odds (AOR 5.11, 95% CI 2.10–12.41; $p < 0.001$). There was no association between maternal age, education, food security category, socioeconomic status, household size, and MDD-W.

Table 5
Factors associated with dietary diversity using logistic regression

Factors	COR	CI95%	AOR	CI _{95%}
Age of mothers	1.01	[0.99–1.02]	1.00	[0.98–1.02]
Mother Education				
None	1			
Primary	1.20	[0.78–1.83]	1.18	[0.76–1.84]
Secondary/University	1.12	[0.75–1.65]	0.87	[0.56–1.35]
HFIAS score				
Secure	1			
Insecure	0.71	[0.36–1.39]	0.82	[0.41–1.65]
Socioeconomic Status				
Lowest	1			
Middle	0.95	[0.64–1.41]	0.91	[0.61–1.38]
Highest	1.35	[0.91–1.98]	1.11	[0.72–1.71]
Household size				
Less than 6	1			
6 and more	1.11	[0.80–1.53]	1.12	[0.79–1.59]
Source of Income				
Agriculture only	1			
Mixed source	1.57	[1.11–2.20]	1.59	[1.08–2.34]*
Women BMI				
Underweighted	1			
Normal	1.57	[1.07–2.31]*	1.57	[1.05–2.35]**
Overweight/obese	5.36	[2.25–12.76]**	5.11	[2.10–12.41]**

COR: Crude Odds ratio; AOR: Adjusted odds ratio; CI: Confidence interval

3.4. Sensitivity analysis

In the adjusted logistic regression model, two predictors remained independently associated with dietary diversity after controlling for the mother's age, education, household food insecurity, wealth index, household size, and income source. After applying Propensity Score Matching (PSM), the Average Treatment Effect on the Treated (ATT) was statistically significant (ATT = 0.127, $p = 0.025$), indicating that women with more secure income sources had substantially higher dietary diversity scores compared to their matched counterparts (Supplementary materials, Appendix 1). The figure below (Fig. 4) illustrates the standardized mean differences for each covariate before and after PSM. Before matching, substantial imbalances were observed in two covariates, particularly the highest tertile and secondary education, which displayed standardized mean differences exceeding 60%. After matching, all covariates showed a substantial reduction in bias and improved comparability between groups.

Additionally, the mediation analyses provide complementary insights into the pathways linking household income sources, maternal nutritional status, and dietary diversity. For underweight women (Table 6a), household income source was significantly associated with reduced odds of undernutrition ($\beta = 0.549$; $p = 0.012$), while underweight status itself was inversely related to dietary diversity ($\beta = -0.518$; $p = 0.010$). Decomposition of effects indicated that maternal underweight mediated approximately 12–14% of the relationship between income source and dietary diversity. In contrast, when overweight was treated as a mediator (Table 6b), the findings indicated an opposite mechanism. Overweight status was positively associated with dietary diversity ($\beta = 1.291$; $p = 0.002$), and the mediation effect accounted for around 9–10% of the total effect.

Table 6
Summary of adjusted associations and mediation estimates: household income source, maternal BMI, and dietary diversity, Underweight vs other

	coefficient	Std. Err	Z	p	CI _{95%}	
Underweight						
Income Source	0.549	0.217	2.520	0.012	0.122	0.975
Women Age	-0.042	0.010	-4.080	0.000	-0.062	-0.022
Primary education	-0.006	0.232	-0.030	0.979	-0.462	0.449
Secondary/university	-0.681	0.243	-2.800	0.005	-1.157	-0.204
Household size	0.143	0.195	0.730	0.465	-0.240	0.526
Middle tertile	-0.048	0.215	-0.220	0.823	-0.469	0.373
Third tertile	-0.573	0.249	-2.300	0.021	-1.061	-0.086
_cons	0.496	0.383	1.300	0.194	-0.253	1.246
Dietary diversity						
Income Source	0.501	0.194	2.580	0.010	0.120	0.881
Underweight	-0.518	0.202	-2.560	0.010	-0.914	-0.122
Women Age	0.006	0.009	0.680	0.496	-0.011	0.023
Primary education	0.163	0.223	0.730	0.465	-0.274	0.599
Secondary/university	-0.132	0.223	-0.590	0.554	-0.570	0.305
Household size	0.136	0.177	0.770	0.442	-0.211	0.483
Middle tertile	-0.132	0.206	-0.640	0.521	-0.537	0.272
Third tirile	0.065	0.218	0.300	0.765	-0.362	0.492
_cons	-0.874	0.344	-2.540	0.011	-1.549	-0.200
Effect	Mean	CI _{95%}				
ACME1	-0.014	-0.038	-0.002			
ACME0	-0.012	-0.031	-0.002			
Direct Effect 1	0.112	0.027	0.206			
Direct Effect 0	0.114	0.027	0.210			
Total Effect	0.100	0.013	0.193			
% of Total via ACME1	-0.140	-0.836	-0.084			

	coefficient	Std. Err	Z	p	CI _{95%}
Underweight					
% of Total via ACME0	-0.123	-0.691	-0.069		
Average Mediation	-0.013	-0.035	-0.002		
Average Direct Effect	0.113	0.027	0.208		

Table 6

b. Summary of adjusted associations and mediation estimates: household income source, maternal BMI, and dietary diversity, Overweight vs other

	Coefficient	Std. Err	Z	p	IC95%	
Overweight						
Income Source	0.595	0.460	1.290	0.196	-0.307	1.497
Women Age	0.053	0.020	2.580	0.010	0.013	0.092
Primary education	-0.382	0.588	-0.650	0.516	-1.535	0.771
Secondary/university	-0.034	0.538	-0.060	0.949	-1.089	1.021
Household size	0.435	0.463	0.940	0.348	-0.472	1.342
Middle tertile	-1.143	0.554	-2.060	0.039	-2.229	-0.057
Third tirile	-0.864	0.528	-1.640	0.102	-1.899	0.170
_cons	-4.805	0.805	-5.970	0.000	-6.382	-3.228
Dietary diversity						
Income Source	0.427	0.193	2.210	0.027	0.049	0.806
Overweight	1.291	0.424	3.050	0.002	0.461	2.122
Women Age	0.007	0.009	0.780	0.438	-0.010	0.023
Primary education	0.175	0.223	0.790	0.432	-0.262	0.612
Secondary/university	-0.077	0.223	-0.340	0.730	-0.513	0.360
Household size	0.095	0.177	0.540	0.591	-0.252	0.443
Middle tirtile	-0.072	0.207	-0.350	0.729	-0.478	0.334
Third tirile	0.159	0.218	0.730	0.466	-0.269	0.587
_cons	-1.113	0.333	-3.340	0.001	-1.767	-0.460
Effect	Mean	IC95%				
ACME1	0.010	-0.006	0.031			
ACME0	0.010	-0.006	0.034			
Direct Effect 1	0.096	0.010	0.183			
Direct Effect 0	0.096	0.010	0.185			
Total Effect	0.106	0.017	0.197			
% of Total via ACME1	0.092	0.048	0.434			

	Coefficient	Std. Err	Z	p	IC95%
Overweight					
% of Total via ACME0	0.097	0.050	0.454		
Average Mediation	0.010	-0.006	0.032		
Average Direct Effect	0.096	0.010	0.184		

Discussion

This study investigated dietary diversity and its determinants among lactating women in a fragile and conflict-affected rural zone of the DRC, where food insecurity is compounded by disrupted livelihoods and weakened local food systems. The findings reveal that around three lactating women achieved the minimum dietary diversity despite a high level of severe food insecurity. Lactating women from households with mixed or non-agricultural income had significantly higher dietary diversity compared to those dependent solely on agriculture, even after adjusting for socioeconomic and demographic factors. Maternal nutritional status also emerged as a strong predictor. The low frequency of lactating women met the MDD-W confirms the critical nutritional situation of lactating women in rural areas of DRC, consistent with national survey data showing that only 17% of Congolese women of reproductive age consume adequately diverse diets (30), and with reports from other sub-Saharan African settings where maternal diets remain largely monotonous (26, 32–34) by limiting consumption of fruits and animal-source foods in rural households, and enhancing the likelihood of inadequate micronutrient intake among lactating mothers, as recommended by the FAO guidelines (35).

However, despite economic, social, and environmental constraints, the study provides insights to explore positive deviance. Despite this generalized deprivation, some lactating women achieved adequate dietary diversity. Indeed, the positive deviance phenomenon suggests the presence of enabling factors, such as innovative food preparation, prioritizing diverse foods for mothers, informal food exchange networks, and local knowledge of wild and seasonal foods, that allow some lactating women to overcome barriers common to their peers. Identifying and amplifying such community-driven adaptive practices could inform more sustainable nutrition-sensitive interventions that build on existing strengths rather than solely addressing deficits.

The findings showed that lactating women in households with mixed income sources were more likely to achieve adequate dietary diversity compared to those relying solely on agriculture. Although agricultural livelihoods remain the backbone of rural economies in DRC, dependence on subsistence farming exposes households to seasonal shortages, price volatility, and conflict-related disruptions (12–14). By contrast, diversified income streams, such as petty trade, wage labor, or remittances, may buffer households against these risks, improve purchasing power, and expand access to market-sourced foods. Additionally, dietary diversity likely increases household purchasing power and buffer capacity against

seasonal and conflict shocks, enabling greater access to a wider variety of foods such as pulses, dairy, eggs, and vitamin A-rich produce (36, 37). This is consistent with the observed higher consumption of animal-source and micronutrient-rich food groups among mixed-income households (38–42). The findings align with evidence from SSA, such as Ethiopia, Nigeria, and Uganda, where livelihood diversification has been associated with better maternal and child diets. (17, 43, 44). However, the variable capturing income source in this study was relatively coarse, categorizing households into “agriculture only” versus “mixed/non-agriculture,” which may have introduced misclassification bias. Nonetheless, the consistency of the associations and their biological plausibility strengthen the interpretation that income diversification plays a protective role in maternal diets. In the conflict-affected settings such as Popokabaka, income sources are poorly diversified, particularly because salaried jobs are scarce and the processing sector is underdeveloped. Households' dependence on the sale of agricultural and forestry products also impacts their self-consumption and makes them vulnerable to shocks. It highlights the need for innovative livelihood strategies that empower families to access a wider variety of nutritious foods.

The PSM analysis strengthens the validity of the association between household income source and dietary diversity. These results are consistent with prior studies conducted in similar settings, which have demonstrated that diversified income sources enhance dietary adequacy by improving household purchasing power and access to a wider range of food groups (45–48). Moreover, the households relying solely on subsistence agriculture are more vulnerable to seasonal shocks and food shortages, which directly compromise women's and children's nutrition (49–53). From a programmatic perspective, these results underscore the need for interventions to strengthen livelihood diversification and women's economic empowerment. For example, supporting small-scale agricultural households in conflict-affected areas to access off-farm income opportunities, microcredit schemes, or women-led cooperatives could mitigate the negative nutritional effects of protracted crises.

Additionally, maternal BMI was another strong determinant of dietary diversity. Underweight lactating women had the lowest dietary diversity, while overweight and obese women were much more likely to consume diverse diets. This pattern suggests that poor nutritional status may constrain women's capacity to access or consume a variety of foods. In contrast, those with higher BMI may reflect greater access to diversified diets, albeit with potential risks of overnutrition (54, 55). Because BMI integrates longer-term energy balance, its cross-sectional association with 24 h dietary diversity must be interpreted cautiously; BMI may reflect past diet, illness, or other socioeconomic factors rather than being an immediate nutritional consequence of the previous day's food group variety (56).

Although household food insecurity and socioeconomic status were not independently associated with dietary diversity in the adjusted models, these variables remain central contextual factors. Nearly 95% of households in this study were food insecure, with over four in five classified as severely food insecure. The high rates of food insecurity and undernutrition could be increased by the upsurge in conflicts observed in the region. The results correlated with evidence reported in Ethiopia during the war conditions (57). Similarly, the lack of association with the wealth index may reflect the relatively

homogeneous poverty of the study setting, where most households fall into lower wealth categories compared to urban populations. This contrasts with findings from other African contexts where maternal education, household wealth, and food security have consistently predicted better diets (17–19). The divergence highlights the importance of context: in settings of extreme poverty and food insecurity, structural vulnerabilities may overwhelm the protective influence of education or wealth index alone (58–60). Furthermore, a good score on the MDD-W exhibited by some lactating women could be attributed to underlying factors such as food coping strategies and accessibility. Future studies are needed to understand the mechanisms that allow women with food insecurity to achieve adequate dietary diversity. Thus, this finding reinforces the need for interventions that go beyond individual-level factors to address systemic drivers of dietary inadequacy.

Policy and Practice Implications

The findings of this study carry several implications. First, interventions aimed at improving the diets of lactating women in fragile settings should consider livelihood diversification as a potential entry point. Supporting lactating women and households in engaging in small-scale trade, wage labor, or other income-generating activities may enhance dietary diversity by reducing their dependence on subsistence farming. In addition, regarding food insecurity, targeted actions are required to enhance communities' food availability and mitigate the impact of economic shocks and poverty. By the way, protection of land and assets, conflict-sensitive cash-based assistance, and targeted support to severely food-insecure and underweight mothers should be prioritized.

Second, nutrition programs targeting lactating women should incorporate screening and management of maternal undernutrition, given its dual role as both a consequence and determinant of poor diets. Addressing underweight through targeted supplementation and community-based nutrition support may not only improve maternal health but also facilitate access to a diverse range of diets.

Third, the study underscores the limitations of focusing solely on food production in addressing maternal undernutrition in conflict-affected areas. Policies should integrate food security, livelihood, and nutrition-sensitive approaches that address both availability and access to nutrient-rich foods. For instance, social protection schemes, conditional cash transfers, or food vouchers targeting lactating women could buffer against livelihood shocks and improve dietary diversity.

Additional education support techniques could be beneficial for vulnerable households, especially those with small children and informal jobs, to protect lactating women and children (61). Finally, to address the vulnerability, it is crucial to establish robust mechanisms to monitor the food insecurity status of households, with a focus on vulnerable groups, such as older individuals and households relying on informal employment (62, 63). Monitoring of maternal and infant outcomes alongside livelihood programming is important; programs should integrate early screening and referral for undernutrition.

Strengths and limitations

The study employed a robust methodology and is the first to explore the dietary diversity of this vulnerable group in the DRC in a conflict context. It provides an understanding of the food habits of mothers during lactation in food-insecure settings affected by conflict. Factors identified could help to adjust nutritional counseling during the lactation period. Moreover, it provides complementary evidence from PSM analysis on the role of household income sources in shaping dietary diversity among lactating women.

Nevertheless, some limitations must be noted. First, although the study was conducted in a conflict-affected area, exposure to conflict was not measured at the individual or household level. This may have led to residual confounding, as the intensity and nature of conflict-related shocks likely varied across communities. The cross-sectional design precludes causal inference. The measure of income source was limited in detail and may have led to misclassification. Dietary diversity assessments are based on self-reported data, which may be subject to recall bias and could affect the reliability of the dietary diversity scores. The categorization of income sources may oversimplify the complexity of household economies. In addition, BMI reflects longer-term nutritional status but is an imperfect indicator in lactating women. Despite the strengths of the PSM approach, some residual imbalance remained for variables such as food security status and nutritional status (overweight/underweight), suggesting that unobserved or imperfectly balanced confounders may have influenced the estimates. Finally, food recalls, income reporting, and HFIAS responses rely on participant recall and may be affected by social desirability or recall error. The study was conducted in a specific geographic area (Popokabaka Health Zone), which may not be representative of other regions in the DRC or similar contexts. Differences in cultural practices, economic conditions, and access to resources could limit the applicability of the findings to broader populations.

Recommendations for future research

Longitudinal studies are needed to unpack causal pathways: whether income changes lead to sustained improvements in diet and how changes in income over time affect dietary diversity through maternal nutritional status. In addition, the use of quantitative dietary assessment (multiple 24-hour recalls, food frequency questionnaires, or biomarkers for key micronutrients) would improve estimates of nutrient intake and status beyond food group diversity. Furthermore, mixed-methods research could explore the intra-household allocation of food, decision-making processes, cultural practices, and the gendered control of income to better understand how household income sources translate into maternal dietary choices. Finally, evaluation studies testing cash, voucher, or market-based interventions in similar fragile contexts would provide actionable evidence for scaling up these interventions.

Conclusions and recommendations

This study highlights that lactating women can meet dietary diversity in conflict-affected settings. While income diversification and maternal nutritional status emerged as key determinants, the presence of positive deviance highlights opportunities for resilience-oriented, community-based interventions. Addressing maternal nutrition in fragile contexts requires integrated, conflict-sensitive approaches that

combine livelihood support, nutrition services, and protection of women's access to food and resources. From a policy perspective, interventions should extend beyond nutrition-specific approaches that target lactating women alone. Integrated strategies are required that simultaneously strengthen household livelihoods, improve women's access to diverse foods, and mitigate the constraints imposed by chronic food insecurity and conflict-related disruptions. In particular, livelihood diversification programs, support for women's economic participation, and community-based nutrition education could contribute to enhancing dietary diversity.

Ethic considerations

The study received ethical approval from the University of Kinshasa, DRC (ESP/CE/159/2023) and the Regional Ethics Committee, Norway (643416). Informed consent was obtained from all participants after explaining the study objectives. Participation was voluntary, and mothers signed a statement of informed consent before the interview. Lactating women aged 15–17 years were included with parental or spousal consent and individual assent. Datasets were accessible only to the research team. All study participants were treated equally. There was no direct profit for participants, and no compensation was given. However, any participants identified as undernourished were referred to a hospital.

Abbreviations

NORAD

Norwegian Agency of Development

DRC

Democratic Republic of Congo

GROWNUT

Growing Partnership for Higher Education and Research in Nutritional Epidemiology

MDD-W

Minimum Dietary Diversity Score for Women

LMIC

Low-middle-income countries

HZ

Health zone

IPC

Integrated Food Security Phase Classification

Declarations

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Authors' contributions

BMK initiated the study and wrote the proposal. BKM, CH, AH, TH, PMB, and PA contributed to the design of the study. BMM collected the data, and CH, AH, and PA supervised fieldwork. BKM and PAZ undertook data analysis with support from CH, AH, and PMB. BMK wrote the first version of the manuscript. All authors contributed to the drafting and revising of the manuscript. All authors approved the final version.

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Data availability

The datasets analyzed and supporting documents in this study are available from the corresponding author upon reasonable request by writing an email to the corresponding author.

Consent for publication

The authors consent to the publication of the submitted manuscript

Competing interests

The authors declare that they have no competing interests

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Figures

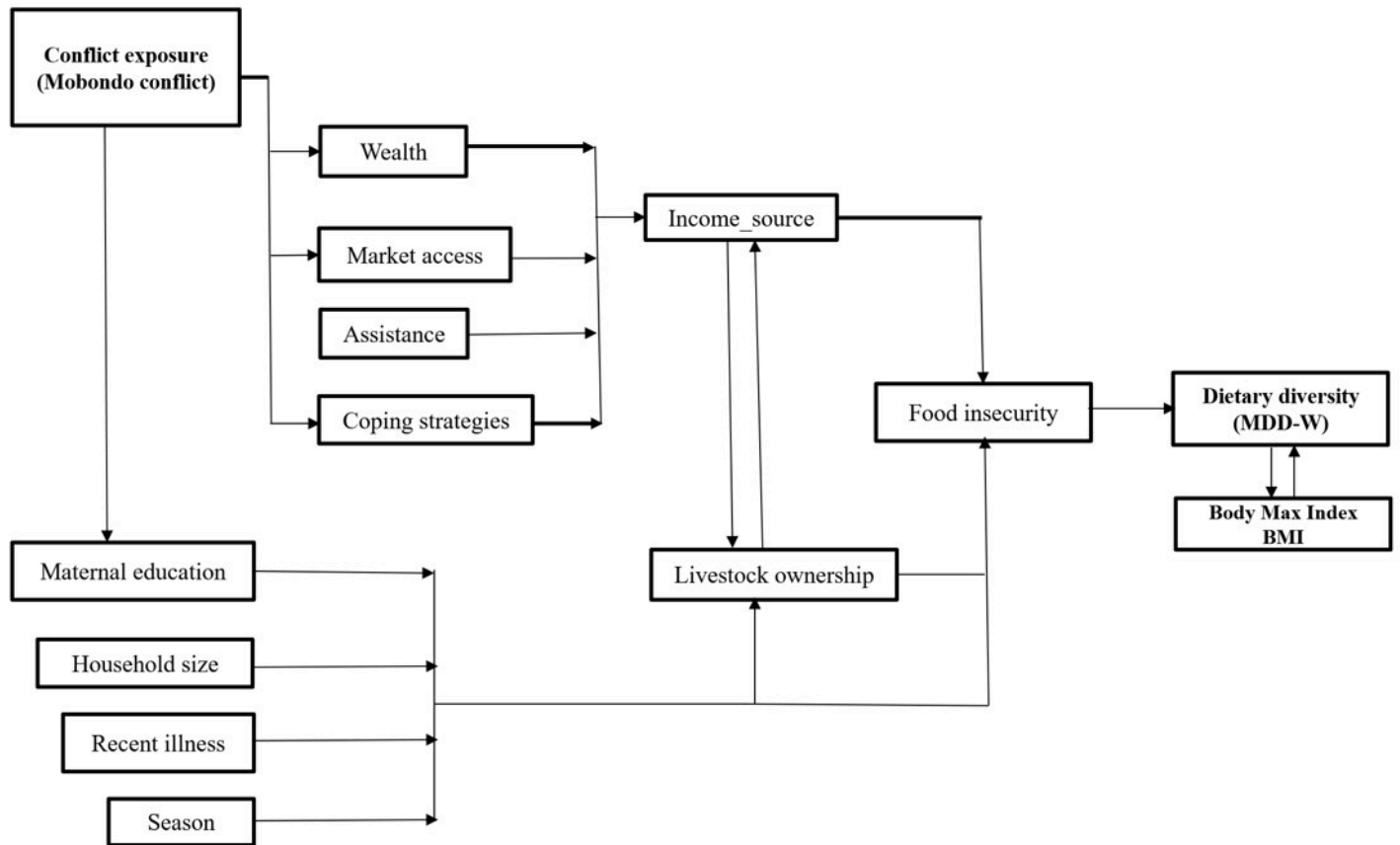


Figure 1

Preliminary conceptual model of Dietary Diversity in a fragile rural setting

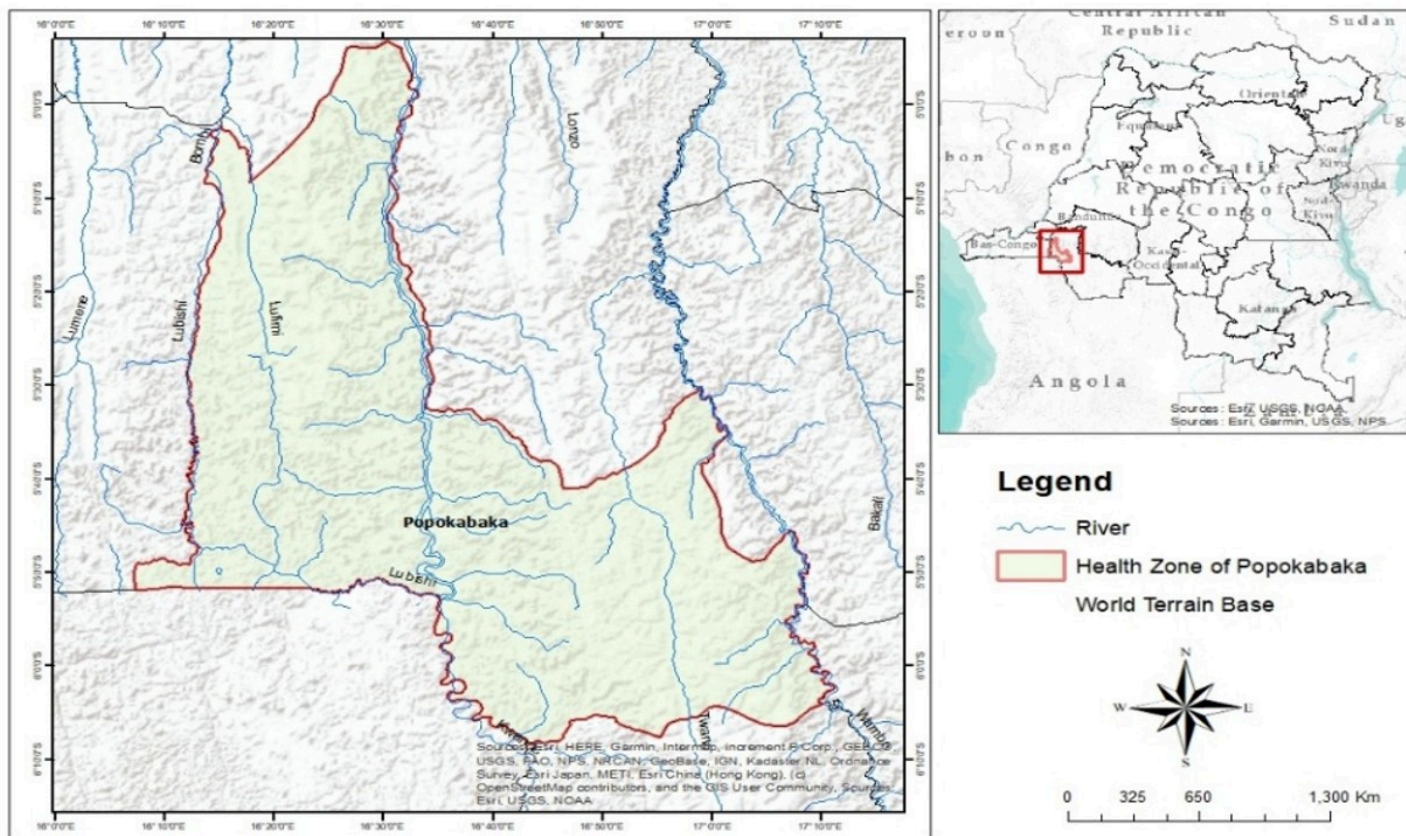
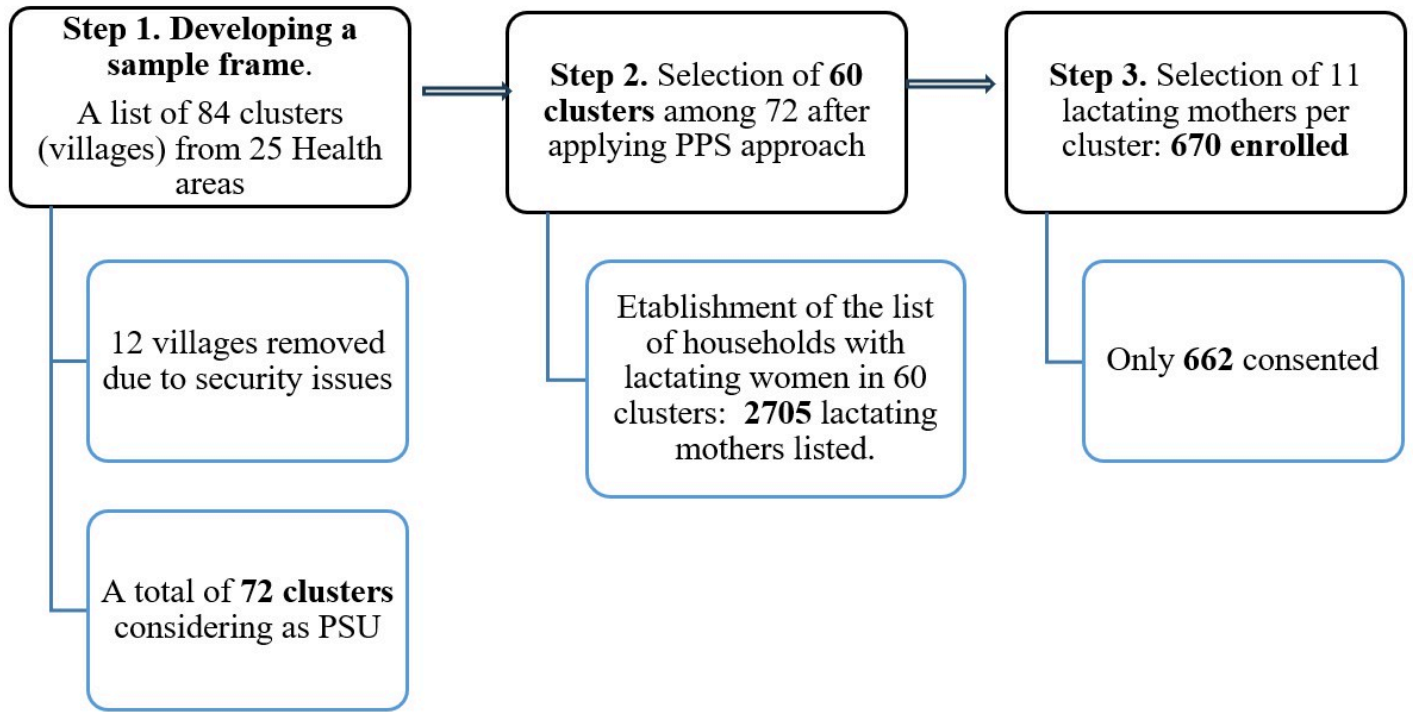


Figure 2

Map indicating the specific location of Popokabaka (from the National Institute of Statistics of DR Congo)



PSU. Primary Statistic Units; PPS. Probability proportion size

Figure 3

Sampling procedure

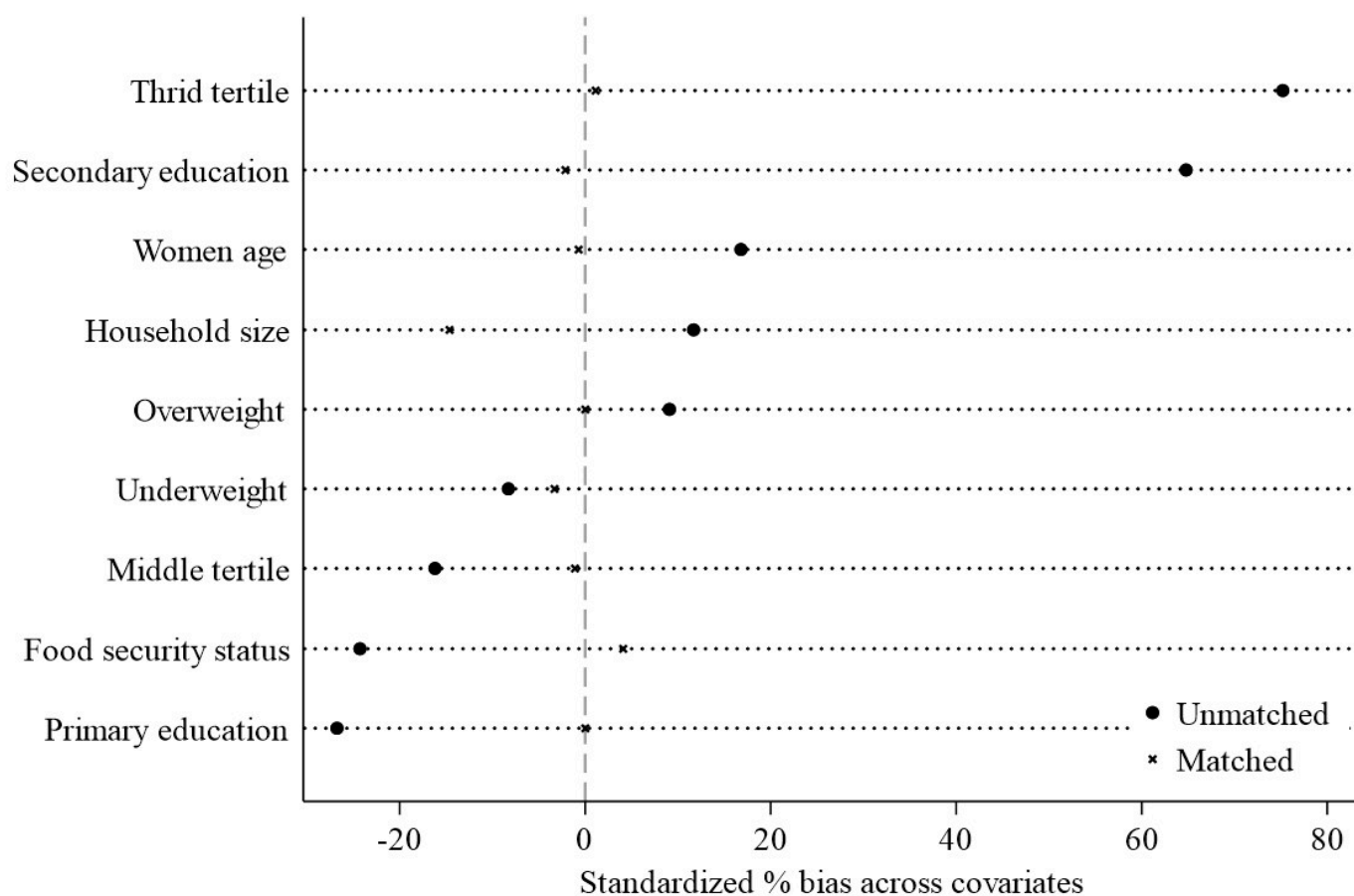


Figure 4

Standardized Bias Before and After Matching

Supplementary Files

This is a list of supplementary files associated with this preprint. Click to download.

- [Supplementaryresults.docx](#)