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Prevalence of undernutrition and environmental factors estimated using the composite index of anthropometric failure among children aged 24-59 months in the Democratic Republic of Congo: a secondary data analysis of the National Nutrition Survey 2023

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Abstract

Introduction: Child undernutrition remains a major public health problem in the Democratic Republic of Congo (DRC). While interventions target the first 1,000 days, the 24–59-month age group, a period of continued vulnerability, is often neglected. The study aimed to identify the social and environmental factors associated with undernutrition, in children aged 24 to 59 months in the DRC.

Method: This study was a secondary analysis of data from the 2023 National Nutrition Survey in the Democratic Republic of the Congo. We analysed data of 10512 children aged 24-59 months. Undernutrition was assessed based on the Composite Index Anthropometry Failure as calculated from weight, height, and age. Statistical analyses, including Chi-square tests ($p<0.2$), multivariate logistic regression, stepwise multivariate regression ($p<0.05$) and marginals effect were performed on STATA 17.0, after weighting the data. For controlling multicollinearity, a variance inflation factor (1.3) was assessed.

Results: The prevalence of undernutrition was 56.7% (95%CI: 54.7%; 58.8%), with a significant disparity ($p < 0.001$) between rural (63.7%, 95%CI: 61.5%-65.9%) and urban environments (44.9%, 95%CI [41.4%-48.5%). Stepwise analysis identified several protective factors: urban residency (Aor= 0.65: 95%CI 0.59; 0.71), maternal education like secondary (Aor= 0.75, 95%CI 0.68;0.83) and university (Aor= 0.26, 95%CI 0.16;0.41) level and measles vaccination (Aor= 0.81, 95%CI 0.72;0.91). conversely, the factors associated with undernutrition were boys (Aor= 1.34 95%CI 1.24;1.46), child age above 36months (Aor= 1.20, 95%CI 1.11;1.31), households with >2 children (Aor= 1.24 95%CI 1.14;1.35) and recent diarrhea (Aor = 1.25, 95%CI 1.11;1.40). Predictive margins confirmed a systematic geographic gap (rural areas remaining consistently more vulnerable). However, a crucial intersection point emerged: a mother's university education reduced rural undernutrition prevalence to approximately 33% (95%CI 22 ;42%), crossing and outperforming the urban setting where children of uneducated mothers displayed a prevalence of 54%.

Conclusion: Interventions must be extended beyond 24 months and must incorporate hygiene promotion (WASH) and, in the long term, education for girls to ensure a lasting impact.

I. INTRODUCTION

Undernutrition remains a major public health problem, and includes stunting, wasting, and underweight [1]. Globally, an estimated 23.2%, 5.5% and 13.4% of children under five were stunted, wasted and underweight, respectively. Sub-Saharan Africa (SSA) is the second most affected World Health Organization (WHO) region by undernutrition in the world, with more than three out of ten children under five being undernourished [2]. This trend is particularly worrying when one considers the importance of effective care for children's development [3], [4].

Nutritional interventions are mainly focused on the critical window of the first 1,000 days [5]. However, children aged 24-59 months are also in a distinct period of vulnerability and frequently overlooked. Studies have shown that as children get older, they are more vulnerable to malnutrition due to their increased nutritional needs. They are exposed to morbidity (measles, malaria, diarrhoea, etc.), poor nutrition, limited access to quality healthcare services, unsanitary environments and food insecurity in their households [6], [7]. Regular monitoring of growth in health programmes and households tends to decline, as the front is perceived to have passed the critical period. It is therefore a period when nutritional deficiencies can develop or worsen, affecting the child's long-term physical and cognitive development [8]–[10].

Studies carried out in Bangladesh, India, Ethiopia and Tanzania have consistently revealed that undernutrition remains a major public health threat in both rural and urban areas, with rural regions being the most severely affected. [11]–[14]. In rural contexts, the high prevalence of anthropometric failure is heavily exacerbated by geographic isolation, structural household poverty, and limited access to parental education[11], [14]. Conversely, in urban environments, nutritional disparities are primarily driven by intra-urban socioeconomic inequalities, where a lack of dietary diversity and inadequate feeding practices penalize children living in disadvantaged neighbourhoods [12], [13], [15].

In the Democratic Republic of Congo (DRC), the results of the 2023 National Nutrition Survey (ENN) and the 2024 Demographic and Health Surveys (DHS) show an alarming increase in the prevalence of undernutrition. The ENN reveals that the prevalence of stunting, wasting, and underweight is *47.7*%, 9% and 25%, respectively. The 2023-2024 [16]. DHS reports that 45%, 8% and 24%respespectively stunting, wasting, and underweight [17]. These data highlight the urgent need to strengthen nutritional interventions and adopt multisectoral strategies to improve food intervention and sustainably reduce child malnutrition rates in the DRC.

Traditional single indicators can mask the severity of the problem among children suffering from multiple forms of undernutrition, thereby underestimating the true prevalence and misguiding nutritional programming. An increasing body of evidence reveals that Composite Index

Anthropometry Failure (CIAF) is essential for identifying children affected by at least one form of undernutrition. Consequently, the CAFI provides a more comprehensive and sensitive measure of overall nutritional vulnerability [11], [12], [18], [19].

To effectively address the heavy burden of undernutrition in the DRC, researchers and policymakers must also focus on the critical but neglected 24–59-month cohort. By employing a comprehensive metric like the CIAF to prevent undercounting malnourished children, we can more accurately identify the current determinants driving anthropometric failure. This study therefore aimed to identify the rural and urban factors associated with undernutrition among children aged 24-59months in the DRC, using data from the 2023 National Nutrition Survey.

II. METHODOLOGY

2.1 Study design

This study was a secondary analysis of the 2023 National Nutrition Survey (ENN) data. This survey was a nationally representative cross-sectional survey. The methodology adopted was based on the guidelines of the Standardized Expanded Nutrition Survey (SENS, Version 1.3, March 2012), ensuring a rigorous and structured approach.

2.2 Study setting

The study took place in all 26 provinces of the DRC that were considered like a degree of the cluster[16].

2.3 Study population

The basic survey data were collected in the households with children aged 0-59 months. In this secondary analysis, we only extracted the data of children aged 24-59 months. The inclusion criteria were children with complete data on anthropometric index variables. Children were excluded if they were overweight or obese, or if they had resided in the household for less than four months. Consequently, the final sample comprised only children classified as either adequately nourished or undernourished.

2.4 Sampling

2.4.1 Sample size

In the basic survey, the size required for each stratum was calculated from the estimated prevalence from the 2017-2018 Multiple Indicator Cluster Survey (MICS)-PALU survey by province.

$$n = \frac{\mathrm{Z^2 x\ P(1-P)}}{\mathrm{d^2}} \mathrm{xEGx(1+NRR)}$$

n is the sample size in number of individuals, Z is the 95% confidence level (1.96), P is the estimated prevalence of malnutrition (MICS-PALU survey 2017-2018), d is the desired precision at 0.05, EG is the cluster effect, and *NRR* is the non-response rate. A total of 18,252 households were surveyed, which resulted in 20,176 children[16].

In the secondary study, the final sample size was determined based on children aged 24-59 months (presented in the flowchart fig.1).

2.4.2 Sampling technique

In the basic survey, a three -stage cluster random sampling was used, 26 strata corresponding to the 26 provinces were defined. In each province, 60 clusters (including 6 reserve clusters) were selected according to the number of stages of sampling. The primary units were selected on the basis of geographical location. In urban areas, the districts of communes were selected; in rural areas, sectors or chiefdoms were selected. The secondary units were selected on the basis of topography or sociocultural context. The third stage of sampling involved the exhaustive list of households enumerated in each selected unit. Instead, this sampling was conducted during the

investigators' visits to each cluster, with 13 randomly selected households surveyed per cluster, for a total of 18,252 households and 21,017 children under five years of age [16].

In this study, data from children aged 24-59months were extracted based on the defined inclusion and exclusion criteria. Finaly, we extracted 10512 data of children.

2.5 Data collection

The Ethics Committee of the Kinshasa School of Public Health ((ref. ESP/CE/71/2025) has approved the research protocol, and the National Nutrition Program has authorized use of the 2023 ENN data. Data was obtained based on a questionnaire. Household sociodemographic data, infant and young child feeding practices, and prevalence and intervention data were obtained.

2.6 Variables

2.6.1 The dependent variables

It was undernutrition based on the CIAF, which derived from stunting (height-for-age), wasting (weight-for-height) and underweight (weight-for-age). Each anthropometric index was calculated by creating two categories z-score <-2 (children with overall undernutrition) and z-score ≥-2 to ≤ 1 (children without undernutrition). The CIAF categories were classified in Table I. Undernutrition based on the CIAF was defined as any child with at least one form of undernutrition, compared to children without undernutrition[13], [20]–[22].

Table I category of undernutrition from the CIAF.

Band	Description	Wasting	Stunting	Underweight
A	No failure (*without undernutrition)*	No	No	No
B	Wasting only	Yes	No	No
C	Wasting and underweight	Yes	No	Yes
D	Wasting, stunting and underweight.	Yes	Yes	Yes
E	Stunting and underweight	No	Yes	Yes
F	Stunting only	No	Yes	No
Y	Underweight only	No	No	Yes

2.6.2 The Independent Variables

The sociodemographic factors were considered in relation to household characteristics. These were residential environment (urban and rural), mother's education level, marital status, household size and the number of the children who died in the last six months before the survey (yes or no if the invent was arrived) . In addition, data pertaining to water, hygiene and sanitation were extracted. WASH indicators were dichotomized into improved and unimproved categories per WHO/UNICEF Joint Monitoring Programme guidelines. Improved drinking water included protected systems such as piped networks and boreholes. Unimproved water sources involved unprotected wells, springs, and surface water. Improved sanitation required facilities that hygienically isolate excreta, like flush toilets and slab latrines. Unimproved sanitation encompassed open pits, bucket latrines, and open defecation practices. Hand hygiene was classified as improved only when designated facilities possessed both water and soap upon observation. Improved waste management was defined by regulated municipal collection or controlled on-site disposal. Conversely, practices like open burning or indiscriminate dumping constituted unimproved waste management[23].

Data concerning the characteristics of children was extracted, including the age of the child (categorized to 24-35months and 36-59moths), child's sex, number of children of 24-59 months (categorized to one or last child, first child and second or above), child's measles vaccination status, child's vitamin A supplementation and the presence of fever or diarrhoea in the child over the two previous weeks. The final set of variables was subjected to a categorization system comprising the responses of 'don't know', 'no' and 'yes'.

Potential bias: Non-response bias like a risk of selection bias related to individuals who didn't respond to the initial survey. Bias related to cluster representativeness: data collected didn't initially reflect the demographic weight of each cluster. Mitigating bias: data weighting to minimize variations due to probability of individual selection. Selection bias limited by excluding children with abnormal anthropometric data. Study base: the 2023 ENN, a nationwide cross-sectional survey using two-stage random cluster sampling.

2.7 Data processing

The initial data were processed on Microsoft Excel 2019 and imported into Stata version 17.0 software for a second cleaning and analyses. Data extracted by strata did not initially respect the demographic weight of each region. Thus, we weighted the results to minimize variations due to the probability of selection of individuals at the time of the survey. This was performed according to the clusters for the sample weight and the provinces for its demographics. Weighting was performed in STATA by the PRONANUT using the svy command.

Data were stratified by area (rural and Urban area), thus enabling the identification of factors in relation to each area group. Categorical variables were presented as percentage and the central tendency analyses (mean and standard deviation) were presented for the subset of the data that are weighted. These analyses were expressed as percentages in STATA 17.

To calculate anthropometric indices (weight-for-age, weight-for-height and height-for-age), we used the WHO Anthroplus 2006 . CIAF identifies multiple forms of undernutrition in children, grouping six categories of nutritional deficits and one normal (no deficit). This was recoded into two modalities: undernutritious (Yes: B to Y and No: A, expressing no failure) (see Table I above).

2.8 Data analysis

The factors associated with undernutrition for each area group were investigated. First, we performed bivariate analyses with the X^2 of independence for independent samples (because all the variables collected were categorized into two or more modalities), the Ficher exact test for data with less than 5 frequencies in category (representing 25% of the data). The significance threshold (p-value <0.20 for the bivariate test) was used to choose variables to be introduced into the multivariate model. First, logistic regression was used to identify factors associated with undernutrition (Model 1). In the second step, stepwise multivariate regression was performed to select the most parsimonious set of predictors, retaining only variables with a statistically significant association ($p < 0.05$) in the final model. Subsequently, for predictive analysis, we computed adjusted predictive margins (marginal effects) to compare how independent variables influence undernutrition according to the place of residence (rural vs. urban). Finally, to check whether the regression model was suitable, the Goodness -of-fit test and the variance inflation factor (VIF) (to verify the absence of multicollinearity) were used in the model. The mean vif was 1.3 and the GFT p-value was 0.47, confirming that our models were suitable.

2.9 Ethical considerations

This study used secondary data from the 2023 ENN. We obtained the authorization from PRONANUT to use the database. The study received approval from the ethics committee of the Kinshasa School of Public Health (ref. ESP/CE/71/2025). Data were anonymized and stored in accordance with current ethical standards. We respected the copyright and intellectual property rights of the PRONANUT.

III. RESULTS

3.1 Socio-demographic characteristics of children and household.

A total of 10512 children aged between 24 and 59 months were extracted from the ENN 2023 database. The data characteristics of households and children are presented in Table II, which compares the prevalence of undernutrition according to each variable, depending on the environment and the sample as a whole. The significance level for the bivariate test is p<0.20.

Table II. Socio-demographic variables relating to parents/households and their bivariate chi-square independence analyses

Variables	Urban			Rural			All		
	Undernutrition			Undernutrition			Undernutrition		
	N	No(Yes)%	p	N	No(Yes)%	p	N	No(Yes)%	p
Socio-demographic variables relating to parents/households									
Marital status			0.142			0.140			0.004
Bachelor	227	58.7(41.3)		462	34.2(65.8)		68.9	46.2(53.8)	
Divorced	48	65.4(34.6)		122	38.7(61.3)		17.0	48.5(51.5)	
married	1413	569(43.1)		4083	38.5(61.5)		5496	45.5(54.5)	
Union of effect	671	49.0(51.0)		2490	34.2(65.8)		3161	38.8(61.2)	
Widow	54	47.0(53.0)		167	31.8(68.2)		221	37.0(63.0)	
Total	2413	54.7(45.3)		7324	36.5(63.5)		9737	43.2(56.8)	
Study Level			<0.001			0.001			<0.001
None	277	41.9(58.1)		1765	32.6(67.4)		2042	34.7(65.3)	
Literate	220	41.4(58.6)		977	36.8(63.2)		1197	38.1(61.9)	
Primary Level	913	50.1(49.9)		3026	35.8(64.2)		3939	40.4(59.6)	
Secondary Level	925	61.0(39.0)		1527	41.8(58.2)		2452	51.7(48.3)	
Upper Level	78	86.4(13.6)		29	71.2(28.8)		107	85.0(15)	
Total	2413	54.7(45.3)		7324	36.5(63.5)		9737	43.2(56.8)	
Deceased children			0.495			0.034			0.234
No	2448	55.0(45.0)		7403	36.7(63.3)		9851	43.5(56.5)	
Yes	140	58.7(41.3)		372	29.2(70.8)		512	39.7(60.3)	
Total	2588	55.1(44.9)		7775	36.4(63.6)		10363	43.3(56.7)	
Salt			0.310			0.475			<0.001
Iodized salt	1804	56.1(43.9)		5152	36.7(63.3)		6956	44.1(55.9)	
Non-iodized salt	821	52.7(47.3)		2735	35.4(64.6)		3556	41.5(58.5)	
Total	2625	55.1(44.9)		7885	36.3(63.7)		10512	43.2(56.8)	
Hand hygiene			0.043			0.037			<0.001
Improved	608	60.8(39.2)		1122	40.6(59.4)		1730	50.5(49.5)	
unimproved	2017	52.7(47.3)		6765	35.3(64.7)		8782	41.1(58.9)	
Total	2625	55.1(44.9)		7887	36.3(63.7)		10512	43.2(56.8)	
Waste management			0.586			0.132			0.134
Improved	676	56.8(43.2)		2351	34.2(65.8)		3027	41.0(59.0)	
unimproved	1912	54.7(45.3)		5424	37.4(62.6)		7336	44.3(55.7)	
Total	2588	55.1(44.9)		7775	36.4(63.6)		10363	43.3(56.7)	
Water source			0.875			0.366			0.827
Improved	838	55.5(44.5)		2552	37.6(62.4)		3390	43.6(56.4)	
unimproved	1750	55.0(45)		5223	35.7(64.3)		6973	43.2(56.8)	
Total	2588	55.1(44.9)		7775	36.4(63.6)		10363	43.3(56.7)	
Toilette			0.549			0.231			0.100

Variables	Urban			Rural			All		
	Undernutrition			Undernutrition			Undernutrition		
	N	No(Yes)%	p	N	No(Yes)%	p	**N**	No(Yes)%	p
Improved	188	58.1(41.9)		961	33.1(66.9)		1149	38.9(61.1)	
unimproved	2400	54.9(45.1)		6814	37.0(63)		9214	43.9(56.1)	
Total	2588	55.1(44.9)		7775	36.4(63.6)		10363	43.3(56.7)	

The data indicates that girls constituted 51% of the households, and 75% of the households were located in rural areas. The sociodemographic analysis shows that marital status is significantly associated with undernutrition in the general sample (p=0.004). The highest prevalence of undernutrition is among children of widowed mothers (63%). The prevalence of undernutrition is higher among mothers with no education (65% overall), it was lower among mothers with a university degree (15%). Child mortality within rural households is significantly associated with undernutrition.

Environmental factors such as hand hygiene are associated with undernutrition in all areas (p<0.001 for total). It was more frequent in the case of unimproved hygiene. Waste management, water sources and toilets did not show significant associations. However, used iodised salt was significantly associated with undernutrition in the total sample (p<0.001).

In relation to the characteristics of the children, Table III presents their data according to place of residence.

Table III children characteristic and their bivariate chi-square independence analysis

Variables	Urban			Rural			All		
	Undernutrition			Undernutrition			Undernutrition		
	N	No (Yes)%	p	N	No (Yes)%	p	N	No (Yes)%	p
Sex of child			0.315			<0.001			<0.001
Girls	1317	56,6(43.4)		4059	40,1(59.9)		5376	46,1(53.9)	
Boys	1308	53.6(46.4)		3828	32.3(67.7)		5136	40.2(59.8)	
Total	2625	55.1(44.9)		7887	36.3(63.7)		10512	43.2(56.8)	
Childs size			0.001			0.001			<0.001
≤2 Childs	1578	59.4(40.6)		4713	38.6(61.4)		6291	46.6(53.4)	
>2 Childs	1047	47.8(52.2)		3174	32.8(67.2)		4221	38.0(62)	
Total	2625	55.1(44.9)		7887	36.3(63.7)		10512	43.2(56.8)	
Age group			0.634			0.001			0.026
≤35 months	885	56.1(43.9)		2654	39.8(60.2)		3539	45.6(54.4)	
>35 months	1740	54.6(45.4)		5233	34.5(65.5)		6973	42.1(57.9)	
Total	2625	55.1(44.9)		7887	36.3(63.7)		10512	43.2(56.8)	
Child position			0.179			0.013			0.003
Last or own Childs	1335	58(42)		3835	38.7(61.3)		5170	46.2(53.8)	
First Childs	980	52.3(47.7)		3170	34.3(65.7)		4150	40.6(59.4)	
Other position	310	50.4(49.6)		882	32.9(67.1)		1192	39.4(60.6)	
Total	2625	55.1(44.9)		7887	36.3(63.7)		10512	43.2(56.8)	
dewormed			0.026			0.727			0.579
Don't know	52	31.1(68.9)		96	42.4(57.6)		148	37.3(62.7)	
No	752	55.1(44.9)		2572	36.5(63.5)		3324	43(57)	
Yes	1602	55.2(44.8)		4655	36.5(63.5)		6262	43.4(56.6)	
Total	2411	54.7(45.3)		7323	36.6(63.4)		9734	43.2(56.8)	
Measles vaccine			0.013			0.605			0.066
Don't know	27	17.5(82.5)		80	35.1(64.9)		107	28.6(71.4)	
No	365	51.7(48.3)		1188	34.6(65.4)		1553	40.6(59.4)	
Yes	2019	55.6(44.4)		6055	36.9(63.1)		8074	43.8(56.2)	
Total	2441	54.7(45.3)		7323	36.6(63.4)		9734	43.2(56.8)	
Diarrheic			0.001			0.094			<0.001
Don't know	5	91.1(8.9)		14	70.7(29.3)		19	77.6(22.4)	
No	2037	56.7(43.3)		6094	36.8(63.2)		8131	44.2(55.8)	
Yes	371	41(59)		1216	34.7(65.3)		1587	36.7(63.3)	
Total	2413	54.7(45.3)		7324	36.5(63.5)		9737	43.2(56.8)	
Fever			0.107			0.458			0.078
Don't know	5	72.5(27.5)		9	50.4(49.6)		14	57.1(42.9)	
No	1268	57.0(43)		3509	36.3(63.7)		4777	44.4(55.6)	
Yes	1140	51.0(49)		3806	36.8(63.2)		4946	41.4(58.6)	

Variables	Urban			Rural			All		
	Undernutrition			Undernutrition			Undernutrition		
	N	No (Yes)%	p	N	No (Yes)%	p	**N**	No (Yes)%	p
Total	2413	54.7(45.3)		7324	36.5(63.5)		9737	43.2(56.8)	

P= p-value,

With regard to child characteristics, the prevalence of undernutrition is higher in boys (59.8%) than in girls (53.9%) and is significantly associated with all residence place (p<0.001). The same is true for sibling size (p<0.001), where undernutrition is associated in households with more than two children under the age of five (62%). Children over 35 months of age had a higher prevalence of undernutrition (59.9%) than children under 35 months (54.4%), showing a significant association (p=0.026). Similarly, diarrhoea was associated with undernutrition (p<0.001), with a prevalence of 63.3%.

3.2 Prevalence of undernutrition based on the CIAF and other traditional indices

Table IV shows the prevalence of undernutrition according to the CIAF and traditional indices.

Table IV. Prevalence of undernutrition according to the CIAF and traditional indices

Undernutrition based of the CIAF		N %	IC95%	Urban%	Rural%
A	No failure	43.3	[41.2;45.3]	55.1(51.5;58.6)	36.3(34.1;38.5)
B	Wasting only	0.7	[0.5 ;0.9]	1.1(0.6;1.9)	0.4(0.2;0.6)
C	Wasting and underweight	1.8	[1.5 ;2.3]	1.7(1.1;2.8)	1.9(1.5;2.5)
D	Wasting, Stunting et Underweight.	3.4	[2.8 ;4.2]	2.2(1.5;3.2)	4.2(3.3;5.3)
E	Stunting et Underweight	20.7	[19.2 ;22.3]	15.9(12.8;19.6)	23.5(22.1;25.0)
F	Stunting only	29.4	[27.8 ;31.1]	23.6(21.0;26.4)	32.8(30.9;34.8)
Y	Underweight only	0.7	[0.5 ;1.0]	0.5(0.3;0.9)	0.8(0.6;1.2)
Total		100.0		100.0	100.0

Only 43% (IC95% [41.2 ;45.3]) of children have no form of undernutrition (Table IV). The most frequent form is the combined stunting and underweight (20.7% IC95% : 27.8;31.1). Compared with traditional indices, stunting is 53.5% (95% CI [51.4 ;55.6]), wasting 6% (95% CI [5.1 ;6.9]) and underweight 26.7% (95% CI [25.0 :28.5]).

The figure 2 shows a prevalence of undernutrition of 56.7%. this prevalence is higher in rural areas (63.7% 95% CI [61.5%; 65.9%]) than in urban areas (44.9% CI95% [41.4%, 48.5%]).

By province, only Kinshasa has a prevalence of 25.0% (CI95% [18.9%,.32.9%]). The most provinces affected by undernutrition are Kwango (72.9%), North Kivu (70.9%), Haut-Lomami (69.8%), South Kivu (65.6%) and South Ubangi (64.3%) (see Figure 3).

3.3 Factors associated with undernutrition after logistic regression (model 1)

The multivariate analysis highlights several factors associated with undernutrition, with notable variations according to the place of residence

Table V. Multivariate analysis of undernutrition in children aged 24 to 59 months

Undernutrition	Urbain			Rural			All Area		
	AOR	P>|t|	[95%CI]	AOR	P>|t|	[95%CI]	AOR	P>|t|	[95%CI]
Area									
Rural							1		
Urban							0.65	**<0.001*** **	0.59;0.72
Study level									
No one	1			1			1		
Alphabetised	1.03	0.910	0.59;1.81	0.84	0.216	0.64;1.11	0.81	**0.008** **	0.7;0.9
Primary	0.78	0.177	0.55;1.12	0.88	0.225	0.75;1.08	0.91	0.104	0.81;1.01
Secondary level	0.51	**<0.001*** **	0.35;0.74	0.71	**0.004** **	0.56;0.89	0.71	**<0.001*** **	0.62;0.8
University level	0.13	**<0.001*** **	0.06;0.34	0.19	**0.004** **	0.06;0.58	0.25	**<0.001*** **	0.15;0.39
Marital Status									
Married	1			1			1		
Single	1.1	0.776	0.67;1.70	1.25	0.099	0.95;1.63	1.26	**0.007** **	1.1;1.49
Divorced	0.6	0.183	0.29;1.27	1.13	0.630	0.69;1.86	1.31	0.101	0.95;1.82
Union of effect	1.12	0.526	0.79;1.58	1.08	0.439	0.88;1.33	1.13	**0.011***	1.03;1.24
Widow	1.22	0.639	0.53;2.85	1.31	0.193	0.87;1.98	1.35	**0.039***	1.02;1.81
People's Death									
No				1					
Yes				1.47	**0.019***	1.07;2.04			
Hand hygiene									
Improved	1			1			1		
Unimproved	1.06	0.692	0.78;1.46	1.36	**0.032***	1.03;1.80	1.2	**0.020***	1.03;1.36
Waste management									
Improved				1			1		
Unimproved				0.87	0.173	0.72;1.06	0.92	0.081	0.84;1.01
Toilet									
Improved							1		
Unimproved							1.1	0.409	0.92;1.21
Salt									
Iodine Salt				0.99	0.939	0.84;1.17	0.99	0.088	0.91;1.08
No Iodine Salt				1			1		
Childs size									
≤2 Childs	1			1			1		
>2 Childs	1.63	**0.004** **	1.17;2.27	1.16	0.151	0.99;1.41	1.2	**0.001** **	1.1;1.32
Sex of children									
Female				1			1		
Male				1.4	**<0.001*** **	1.23;1.58	1.34	**<0.001*** **	1.24;1.46
Child position									

Undernutrition	Urbain			Rural			All Area		
	AOR	P>|t|	[95%CI]	AOR	P>|t|	[95%CI]	AOR	P>|t|	[95%CI]
Last or own child	1			1			1		
First child	1.0	0.998	0.77;1.29	1.2	0.071	0.99;1.36	1.15	**0.006****	1.04;1.26
Other position	102	0.916	0.69;1.49	1.14	0.411	0.84;1.55	1.12	0.188	0.95;1.32
Age group									
≤35 months				1			1		
>36 months				1.27	**<0.001*****	1.11;1.46	1.21	**<0.001*****	1.11;1.33
dewormed									
No	1								
Yes	1.20	0.121	0.95;1.52						
Don't know	2.05	**0.046***	1.10;4.14						
Measles vaccine									
No	1						1		
Yes	0.85	0.345	0.62;1.18				0.83	**0.002***	074;0.93
Don't know	6.9	**0.001****	2.32;10.46				1.41	0.126	0.91;2.21
Diarrhea									
No	1			1			1		
Yes	1.70	**0.012***	1.11;2.49	1.08	0.489	0.87;1.34	1.23	**0.001***	1.10;1.38
Don't know	0.03	0.087	0.01;1.66	0.21	**0.011***	0.06;0.70	0.43	0.119	0.15;1.14
Fever									
No	1						1		
Yes	1.28	0.081	0.97;1.70				1.00	0.913	0.92;1.09
Don't know	0.59	0.671	0.05;6.9				1.1	0.911	0.32;3.54

***<0.05, **<0.01, ***<0.001 CPS,**

Across the entire study area, urban residency shows an inverse association with undernutrition (AOR 0.65; 95% CI [0.59–0.72]), suggesting a lower prevalence compared to rural settings. Maternal education level demonstrates a strong and graded protective association: the prevalence of undernutrition is lower among children of literate mothers (AOR 0.81; 95% CI [0.7–0.9]), and this association becomes more pronounced for secondary (AOR 0.71; 95% CI [0.62–0.8]) and university levels (AOR 0.25; 95% CI [0.15–0.39]).

Conversely, certain sociodemographic characteristics are positively associated with undernutrition, notably male sex (AOR 1.34; 95% CI [1.24–1.46]), the age group over 36 months (AOR 1.21; 95% CI [1.11–1.33]), and first-born status (AOR 1.15; 95% CI [1.04–1.26]). Regarding the family environment, undernutrition is associated with having a single mother (AOR 1.26; 95% CI [1.1–1.49]) or a widowed mother (AOR 1.35; 95% CI [1.02–1.81]), as well as a sibling group size exceeding two children (AOR 1.2; 95% CI [1.1–1.32]). On the health front, unimproved hand hygiene (AOR 1.2; 95% CI [1.03–1.36]) and a history of diarrhea (AOR 1.23; 95% CI [1.10–1.38]) are also associated with a higher prevalence.

In rural areas, the association with male sex is more marked than urban areas (AOR 1.4; 95% CI [1.23–1.58]). A significant association is also observed between undernutrition and the occurrence of a death within the household (AOR 1.47; 95% CI [1.07–2.04]), as well as unimproved hand hygiene (AOR 1.36; 95% CI [1.03–1.80]).

In urban zones, undernutrition is strongly associated with a sibling group size of more than two children (+-AOR 1.63; 95% CI [1.17–2.27]). Important links also emerge with specific health factors: the prevalence of undernutrition is higher when the mother is unaware if the child has been dewormed (AOR 2.05; 95% CI [1.10–4.14]) or in the event of a diarrheal episode (AOR 1.70; 95% CI [1.11–2.49]). Finally, the

mother's university education level remains the factor most strongly associated with a reduction in prevalence in this environment (AOR 0.13; 95% CI [0.06–0.34]).

3.4 Factors associated with undernutrition after stepwise analysis (Model 2)

The stepwise analysis presented in table 6 highlights interactive factors associated with Undernutrition.

Table VI Multivariate stepwise analysis of undernutrition in children aged 24 to 59 months

Undernutrition	Urbain			Rural			All Area		
	AOR	P>|t|	[95%CI]	AOR	P>|t|	[95%CI]	AOR	P>|t|	[95%CI]
Area									
Rural									
Urban							0.65	**<0.001*** **	0.59;0.71
Study level									
No one									
Alphabetised				0.82	0.007	0.71;0.94	0.86	**0.023***	0.75;0.97
Primary									
Secondary level	0.62	**<0.001**	0.53;0.74	0.81	**0.001**	0.72;0.91	0.75	**<0.001*** **	0.68;0.83
University level	0.021	**<0.001**	0.12;0.37	0.31	0.003	0.14;0.68	0.26	**<0.001*** **	0.16;0.41
Marital Status									
Married									
Single							1.25	**0.009**	1.10;1.48
Divorced				1.6	0.024	1.11;2.38			
Union of effect							1.13	**0.010**	1.03;1.24
Widow							1.36	**0.035**	1.12;1.82
People's Death									
No									
Yes				1.26	**0.049**	1.01;1.59			
Hand hygiene									
Improved									
Unimproved				1.23	**0.026**	1.03;1.46	1.20	**0.013**	1.04;1.38
Childs size									
≤2 Childs									
>2 Childs	1.40	**<0.001**	1.20;1.65	1.19	0.001	1.08;1.32	1.24	**<0.001*** **	1.14;1.35
Sex of children									
Female									
Male				1.33	**<**0.001	1.21;1.46	1.34	**<0.001*** **	1.24;1.46
Child position									
Last or own child									
First child				1.13	0.017	1.02;1.25	1.12	**0.014**	1.02;1.22
Second or above									
Age group									
≤35 months									
>36 months				1.20	0.001	1.10;1.32	1.20	**<0.001*** **	1.11;1.31
Dewormed									
No									
Yes									

Undernutrition	Urbain			Rural			All Area		
	AOR	P>|t|	[95%CI]	AOR	P>|t|	[95%CI]	AOR	P>|t|	[95%CI]
Don't know	2.45	**0.005**	1.31;4.57						
Measles vaccine									
No									
Yes	0.78	0.031	0.62;0.98				0.81	**<0.001*** **	0.72;0.91
Don't know									
Diarrhea									
No									
Yes	1.81	**<0.001**	1.44;2.29				1.25	**<0.001*** **	1.11;1.40
Don't know									

***<0.05, **<0.01, ***<0.001 CPS,**

In the table 6, the stepwise analysis presented in this study is provided that residing in an urban environment is associated with undernutrition at 35% in the global model, with an AOR of 0.65 [95% CI: 0.59-0.71]. Simultaneously, the educational level of parents presents a strong and graded protective association. Compared to the reference group, basic literacy is associated with a decrease in prevalence (AOR 0.86 [95% CI: 0.75-0.97]), while the secondary level (AOR 0.75 [95% CI: 0.68-0.83]) and the university level (AOR 0.26 [95% CI: 0.16-0.41]) show even more marked protective associations. In urban areas specifically, the university level displays the most powerful association with an AOR of 0.21 [95% CI: 0.12-0.37].

Regarding household and family characteristics, a sibling group size of more than two children is associated with undernutrition, with a probability of 24% at the global level (AOR 1.24 [95% CI: 1.14-1.35]) and 40% in urban areas (AOR 1.40 [95% CI: 1.20-1.65]). Marital status also reveals associations, particularly for children of single mothers (AOR 1.25 [95% CI: 1.10-1.48]) or widows (AOR 1.36 [95% CI: 1.12-1.82]). In rural areas, divorce is associated with an increase in prevalence with an AOR of 1.6 [95% CI: 1.11-2.38], as is the death of a relative within the household (AOR 1.26 [95% CI: 1.01-1.59]).

Male sex is associated with undernutrition with a global AOR of 1.34 [95% CI: 1.24-1.46]. Birth order shows that being the first child is associated with undernutrition at 1.12 [95% CI: 1.02-1.22], and the age group of over 36 months presents a similar association (AOR 1.20 [95% CI: 1.11-1.31]). Regarding health interventions, not knowing if the child has been dewormed in urban areas is associated with undernutrition (AOR 2.45 [95% CI: 1.31-4.57]), while measles vaccination shows a protective association (global AOR 0.81 [95% CI: 0.72-0.91]).

Unimproved hand hygiene is associated with undernutrition (global AOR 1.20 [95% CI: 1.04-1.38]). Furthermore, the occurrence of a diarrheal episode presents a positive association with undernutrition, particularly marked in urban areas where the AOR rises to 1.81 [95% CI: 1.44-2.29], compared to 1.25 [95% CI: 1.11-1.40] for the entire study area.

3.5 Predictive margins effect

This section presents the predictive margins to illustrate how undernutrition varies across different factors following stepwise regression analysis.

This graph (fig.4) highlights an association between family size and the prevalence of undernutrition, with a marked increase in households with more than two children. It is observed that rural areas show a significantly higher vulnerability, reaching a prevalence of approximately 65% compared to 55% in urban areas for large families.

This graph (fig.5) demonstrates that higher education is a powerful lever for reducing undernutrition, with a dramatic drop in prevalence among university graduates. A stagnation is observed between the none and primary levels, suggesting that only reaching the secondary level initiates a real change. Rural areas remain systematically more affected, with a prevalence exceeding 60% for low education levels, compared to approximately 55% in urban areas.

This graph (fig.6) reveals that measles vaccination is associated with a significant reduction in the prevalence of undernutrition in both areas of residence. A similar risk plateau is observed for the Don't know and No categories, followed by a notable drop as soon as the child is vaccinated. The rural environment shows a much more marked vulnerability, with prevalence dropping from 65.5% to approximately 61%, compared to a decrease from 55.5% to about 50.5% in urban areas.

This graph (fig. 7) reveals that boys exhibit a significantly higher vulnerability to undernutrition than girls, regardless of the place of residence. In rural areas, the prevalence reaches a peak of approximately 65% for boys compared to 58% for girls, confirming a significant gap. In urban areas, although the rates are overall lower, the trend remains identical, with a prevalence of 55% among boys versus 48% among girls. The lack of overlap in the confidence intervals highlights the statistical robustness of this gender difference.

This graph (fig. 8) demonstrates that poor hand hygiene is associated with an increased prevalence of undernutrition in both settings. In rural areas, the risk rises from 58% to approximately 62% when hygiene facilities are inadequate, highlighting a persistent environmental vulnerability. In urban areas, although the rates are overall lower, a similar increase is observed, rising from 47.5% to approximately 52%.

IV. DISCUSSION

This study highlights a high prevalence of undernutrition among children aged 24 to 59 months in the DRC. This specific age group has historically been neglected by public health interventions, which predominantly target the critical window of the first 1,000 days[24]. By utilizing the CIAF, this research reveals that **56.7%** of children aged 24-59 months suffer from at least one form of undernutrition.

This finding demonstrates the superior diagnostic sensitivity of the CIAF compared to traditional indicators when analysed in isolation[6]. While standard indices report stunting at 53.5%, wasting at 5.9%, and underweight at 26.7%, they mask critical overlaps. Specifically, 20.7% of the children simultaneously exhibit both stunting and underweight. Conventional single-index approaches therefore significantly underestimate the true magnitude of nutritional vulnerability and multiple anthropometric deficits, which have been robustly linked to an increased risk of child mortality [25]. Furthermore, our results indicate a noticeable deterioration in nutritional status compared to the study of Djomo using 2018 MICS data, which reported a lower undernutrition prevalence of 47% for the same age bracket [26]. This upward trend underscores the urgent need to extend growth-monitoring and nutritional programs well beyond the 24-month threshold.

4.1 Place of residence influence and others factors

The overall prevalence of child undernutrition is significantly higher in rural areas (**63.7%**) than in urban environments (**44.9%**). Multivariate logistic regression models confirm that urban residency exerts a strong protective association against undernutrition (AOR = 0.65; 95% CI: 0.59–0.71). This deep structural divide is deeply rooted in long-standing challenges characteristic of the Congolese hinterland, including poorer access to primary healthcare services, inadequate drinking water infrastructures, and chronic household food insecurity. In the context of the DRC, ongoing armed conflicts and structural instability in several rural provinces further strip communities of their agricultural livelihoods and aggravate household vulnerability[27].

This reality is mirrored in the striking variations observed across provinces. Only the capital city of Kinshasa exhibits a prevalence of undernutrition below the 40% threshold (25%; 95% CI: 18.9%–32.9%). Conversely, the provinces most severely ravaged by undernutrition include Kwango (72.9%), North Kivu (70.9%), Haut-Lomami (69.8%), South Kivu (65.6%), and South Ubangi (64.3%). These localized crises perfectly align with areas suffering from intense geopolitical conflicts, displaced populations, and severe economic precarity[24].

The multivariate regression and stepwise analyses unreservedly identify maternal education as the most robust protective factor against child undernutrition, demonstrating a clear, graded social continuum. Compared to children whose mothers have no formal education, simple basic literacy yields a statistically significant risk reduction (AOR = 0.86; 95% CI: 0.75–0.97). This protective association strengthens noticeably for children of mothers with a secondary education (AOR = 0.75; 95% CI: 0.68–0.83) and peaks dramatically at the university level (AOR = 0.26; 95% CI: 0.16–0.41). This trend is even more pronounced within urban areas, where maternal higher education displays the most powerful inverse association with anthropometric failure (AOR = 0.21; 95% CI: 0.12–0.37). This result is consistent with a vast body of literature showing that maternal education improves care practices, hygiene, dietary diversification and the use of health services [28] [29]. It is extremely important to educate women in a country where the literacy rate among women at secondary and university level remains low [30].

Single mothers and widows were more likely to have undernourished children than married women. The mother's marital status is therefore a social determinant reflecting the increased economic vulnerability of single-parent households[31]. Support and assistance initiatives,

particularly for widowed women, must be designed to safeguard the physical and mental health of children. This is underscored by findings from Tanzania, where childhood undernutrition was significantly associated with single-mother households[14].

Family size and household composition emerge as critical determinants of a child's nutritional path. Children belonging to households with more than two children under the age of five face a substantially higher probability of undernutrition (AOR = 1.24; 95% CI: 1.14–1.35). As visualised in the predictive margins (Figure 4), large family size drastically exacerbates vulnerability, driving rural prevalence up to approximately 65%. Interestingly, this particularly is severe in urban zones (AOR = 1.40; 95% CI: 1.20–1.65), pointing to an intense competition for limited food resources and maternal care within low-income urban households. This finding is consistent with the conclusions of other studies, which have demonstrated that household members residing in urban areas expend financial resources to access adequate resources.[32]. This suggests competition for food resources and maternal care in urban households where resources may be limited or costly, resulting in inadequate care for the youngest children [7], [33]–[35]. Measles vaccination (0.83) was found to be a protective factor. This highlights the importance of basic public health interventions, such as vaccination, in preventing diseases that increase the risk of undernutrition.[36].

On a biological level, a striking and consistent finding across both residential settings is that boy exhibit a significantly higher vulnerability to undernutrition than girls (global AOR = 1.34; 95% CI: 1.24–1.46). This biological gender gap is clearly substantiated by the predictive margins (Figure 7), showing a stark lack of overlap in confidence intervals. In rural areas, this male vulnerability reaches its peak (AOR = 1.40; 95% CI: 1.23–1.58). This pattern aligns closely with broader epidemiological literature across Sub-Saharan Africa, which frequently links male children to a heightened immuno-biological frailty against early childhood infections and environmental stress [5], [14], [21], [22]. Additionally, child age presents a distinct positive correlation with undernutrition, with the risk rising significantly for children older than 36 months (AOR = 1.20; 95% CI: 1.11–1.31). This finding strongly suggests that a routine growth monitoring in health programs and maternal attention systematically decline [37]. Nutritional deficits accumulate silently over time, leaving older preschool children structurally neglected [7].

Our results heavily underscore the critical intersection between environmental sanitation, hygiene, and childhood illness. Unimproved or inadequate hand hygiene facilities display a significant positive association with undernutrition globally (AOR = 1.20; 95% CI: 1.04–1.38). This environmental hazard feeds directly into the classic, destructive synergy between infection and undernutrition[38]–[40]. The presence of a recent diarrheal episode is a potent accelerator of nutritional failure, which is exceptionally pronounced in urban settings where the risk nearly doubles (AOR = 1.81; 95% CI: 1.44–2.29). Poor hygiene promotes frequent diarrheal and enteric infections; [18], [41], [42] these infections, in turn, severely deteriorate nutritional status by causing malabsorption, intestinal inflammation, systemic nutrient loss, and acute appetite suppression [43].

Children aged 24 to 59 months are therefore vulnerable to undernutrition if neglected in any way. This affects early childhood development. [8], and physical growth. The behaviour of mothers towards children in this age group is strongly linked to the number of children in the household, the distance and environment of residence, and other factors that make these children vulnerable.[9], [44]. Raising awareness among mothers about how to properly care for these children will prevent neglect and save lives.

Our models strongly validate the protective power of basic, systematic public health interventions. Measles vaccination acts as a vital protective factor against undernutrition (global AOR = 0.81; 95% CI: 0.72–0.91). This is visually captured by the significant drop in undernutrition prevalence among vaccinated children in both environments (Figure 6), demonstrating how preventing severe vaccine-preventable childhood infections protects physical growth curves[45]. On the other hand, maternal ignorance regarding routine health measures, such as a child's deworming status in urban areas, serves as a strong indicator of fragile medical follow-up, poor preventative care awareness, or a broader breakdown in routine paediatric health delivery[2].

4.2 Significance and Implications for public health policies

These findings dictate an immediate shift in strategic planning. National nutritional guidelines and surveillance frameworks must expand beyond the exclusive focus on the first 1,000 days (0–23 months). Active community-based nutritional screening, care, and growth monitoring must be systematically extended to include preschool children aged 24 to 59 months. The Public health programs should transition to adopting the CIAF as a standard tool for national mapping and geographic targeting. Using individual anthropometric indices in isolation masks the true multi-deficit burden, leading to skewed resource allocation in areas requiring multifaceted emergency responses. Given the strong correlation between unimproved hygiene, diarrhoea, and undernutrition, nutrition-specific food distribution or supplementation projects must be systematically paired with nutrition-sensitive WASH infrastructure interventions. Ultimately, investing heavily in the long-term, compulsory education of girls and mass literacy programs for women stands out as the single most sustainable structural intervention to definitively break the intergenerational cycle of malnutrition in the DRC.

4.3 Study Strengths

To the best of our knowledge, this study possesses several distinct methodological and epidemiological strengths that enhance the validity of its findings. First, utilizing secondary data extracted from the 2023 DRC ENN 2023, this study benefits from a highly robust and large sample size (n = 10,512 children) derived from a rigorous two-stage stratified cluster sampling design covering all 26 provinces. Next, the systematic application of sample weights calculated based on cluster design and regional provincial demographics successfully minimized selection bias and corrected variations in demographic weights across strata. And by operationalizing the CIAF, this paper successfully bridges a major analytical gap in Congolese health literature, capturing multi-deficit nutritional statuses that traditional WHO indices systematically overlook.

4.4 Study limitation

While these findings provide critical insights for public health programming, certain limitations warrant careful consideration. First, the cross-sectional nature of the underlying national survey prevents this study from establishing definite, temporal causal relationships; it can only identify statistically significant associations between the evaluated socio-environmental factors and undernutrition. Next, data concerning short-term childhood morbidities (e.g., diarrhoea and fever episodes within the preceding two weeks) or preventive health measures (such as deworming history) rely heavily on maternal memory and self-reporting, introducing potential recall or social desirability biases. And because this research relied strictly on secondary data analysis, the investigation was confined only to the pre-existing variables within the ENN 2023 database. Consequently, several vital, unmeasured proximal determinants—such as the quantitative and qualitative household food consumption (dietary diversity scores), exact household income, and objective laboratory testing of drinking water quality at the household level—could not be integrated into the multivariate models.

CONCLUSION

This study shows that nutritional vulnerability persists well beyond the first 1,000 days. Children aged 24-59 months, particularly boys and those in rural areas, constitute a neglected group that accumulates nutritional deficits. The strong association with hand hygiene and diarrhoea confirms the vicious cycle between infections and malnutrition.

As a recommendation, integrated multisectoral approaches are required, combining food security, access to drinking water, and the strengthening of primary health services in neglected rural areas. But also, programs to promote hygiene (WASH), linking them explicitly to the prevention of malnutrition and diarrhoea. Promoting girls' education is one of the most powerful and sustainable ways to break the intergenerational cycle of malnutrition.

Abbreviations

- **AOR** : *Adjusted Odds Ratio* (Rapport des cotes ajusté)
- **CI / IC** : *Confidence Interval* (Intervalle de confiance, généralement à 95%)
- **EG** : *Effect of the Group / Cluster Effect* (Effet de grappe - utilisé dans la formule d'échantillonnage)
- **NRR** : *Non-Response Rate* (Taux de non-réponse)
- p **/** $p\text{-value}$: Valeur de significativité statistique
- **VIF** : *Variance Inflation Factor* (Facteur d'inflation de la variance, pour tester la colinéarité)
- **DHS / EDS** : *Demographic and Health Surveys*
- **ENN** : Enquête Nationale de Nutrition (RDC)
- **MICS** : *Multiple Indicator Cluster Survey*
- **PRONANUT** : Programme National de Nutrition (RDC)
- **SENS** : *Standardized Expanded Nutrition Survey*
- **CIAF** : *Composite Index of Anthropometric Failure*
- **WASH :***Water, Sanitation and Hygiene*
- **DRC / RDC** : *Democratic Republic of Congo*
- **ESPK / KSPH** : École de Santé Publique de Kinshasa (*Kinshasa School of Public Health*)
- **SSA** : *Sub-Saharan Africa*

- **UNICEF** : *United Nations International Children's Emergency Fund*
- **WHO / OMS** : *World Health Organization*
- **MD** : *Medical Doctor* (Docteur en médecine)
- **MPH** : *Master of Public Health*
- **PhD** : *Doctor of Philosophy*

Declarations

Author contribution : Conceptualization, Richard Makaba ; methodology, Richard Makaba and Berthold Bondo, Marcel Mubelo, Emerite Disuemi ; software, Richard Makaba, Yannick Jobalo, Emerite Disuemi, Marcel Mubelo ; validation, Muyer Muel, Mapatano Ali, Richard Makaba, Yannick Jobalo, Emerite Disuemi, Marcel Mubelo; data curation, Richard Makaba, Berthold Bondo, Marcel Mubelo,Yannick Jobalo, Nahimana Damien ; writing—original draft preparation, Richard Makaba and Marcel Mubelo; writing—review and editing, Richard Makaba, Yannick Jobalo, Emerite Disuemi, Berthold Bondo, Nahimana Damien ; visualization, Richard Makaba and, Muyer Muel ; supervision, Muyer Muel; project administration Muyer Muel ; All authors have read and agreed to the published version of the manuscript."

Data Availability Statement: The Kinshasa Public Health School has all the data it needs. We promise to give them all the basic data and all the data analysis that we used to do this work.

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Conflicts of interest: The authors declare no conflict of interest.

Ethics approval: The protocol was approved by the Ethics Committee of the Kinshasa School of Public Health (Ethics committee KSPH, Approval Number: (ref. ESP/CE/71/2025) in accordance with ethical standards as defined in the 1964 Declaration of Helsinki and its subsequent amendments before data collection began.

Clinical trial number: not applicable

Consent to Participate: The requirement for informed consent to participate was waived by the Ethics Committee of the Kinshasa School of Public Health (Approval Number: ESP/CE/71/2025) owing to the secondary nature of the study, which utilized fully anonymized data from the 2023 National Nutrition Survey (ENN 2023).

Consent to Publish declaration: not applicable

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Use of Artificial Intelligence

For this paper, Gemini 3 (Canva, Pro Version 3.1) was used for translation and grammatical improvement; however, the authors retain full responsibility for the content.

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Figures

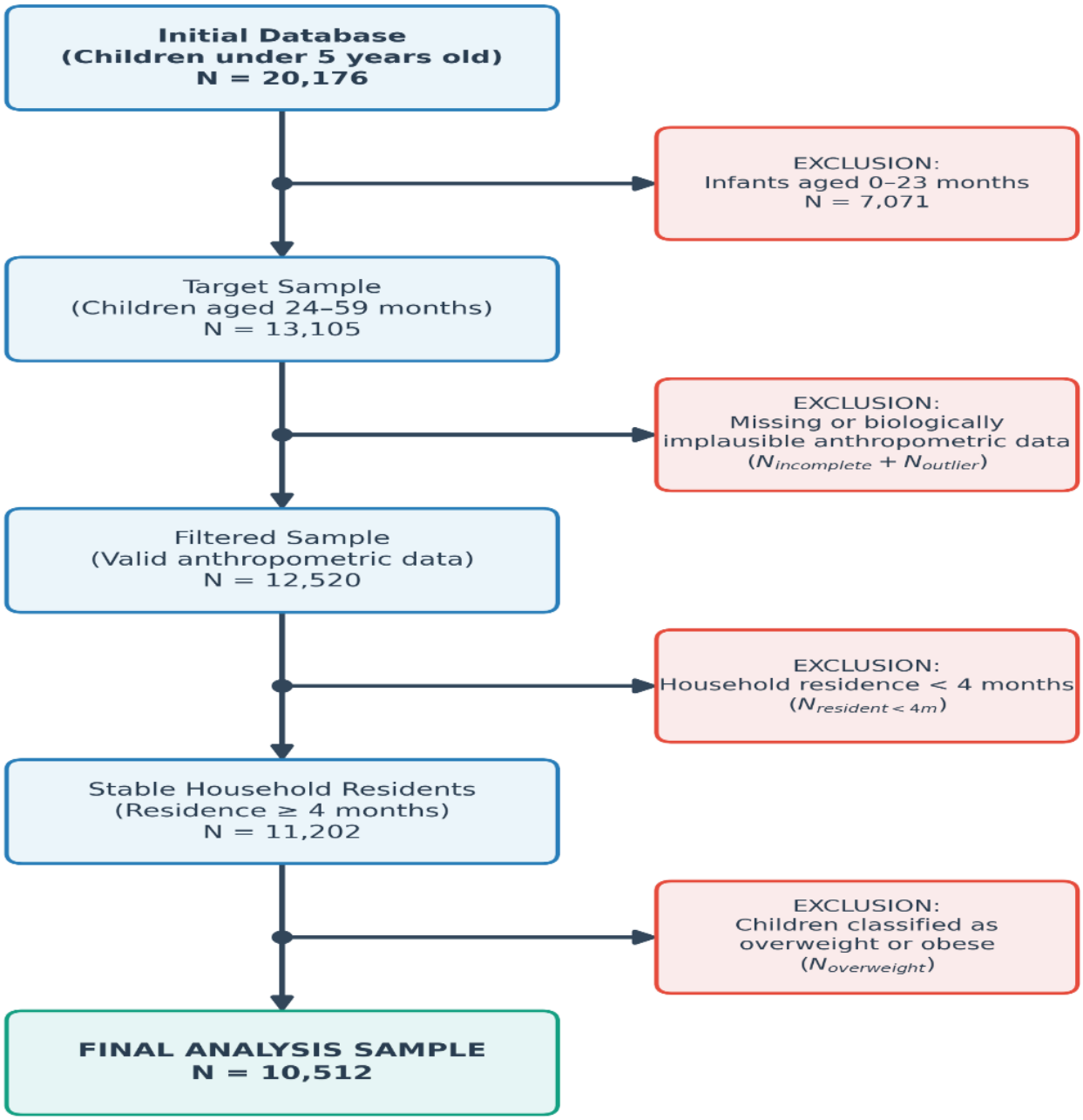


Figure 1

Data selection flowchart for children aged 24-59 months

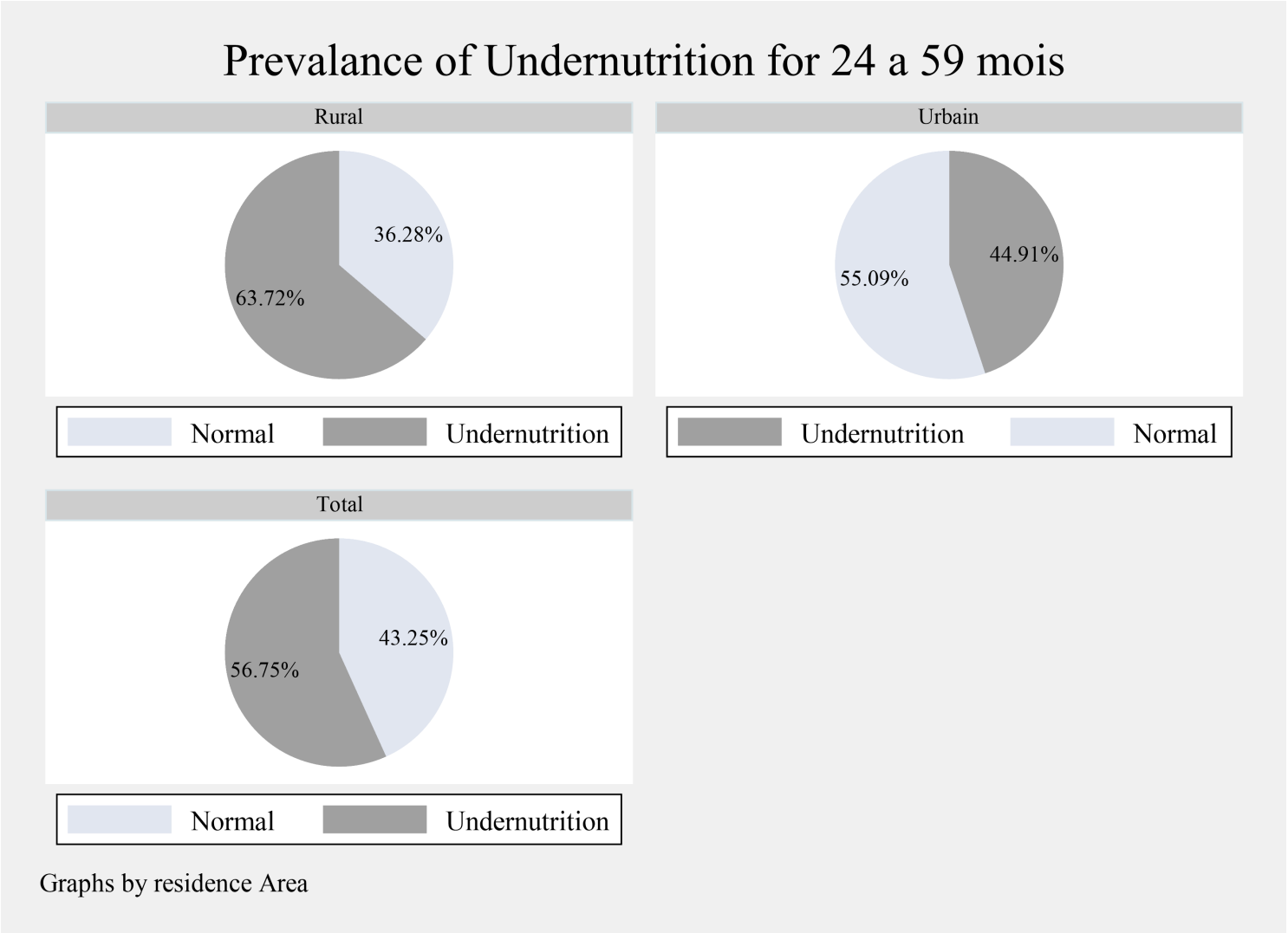


Figure 2

Prevalence of undernutrition.

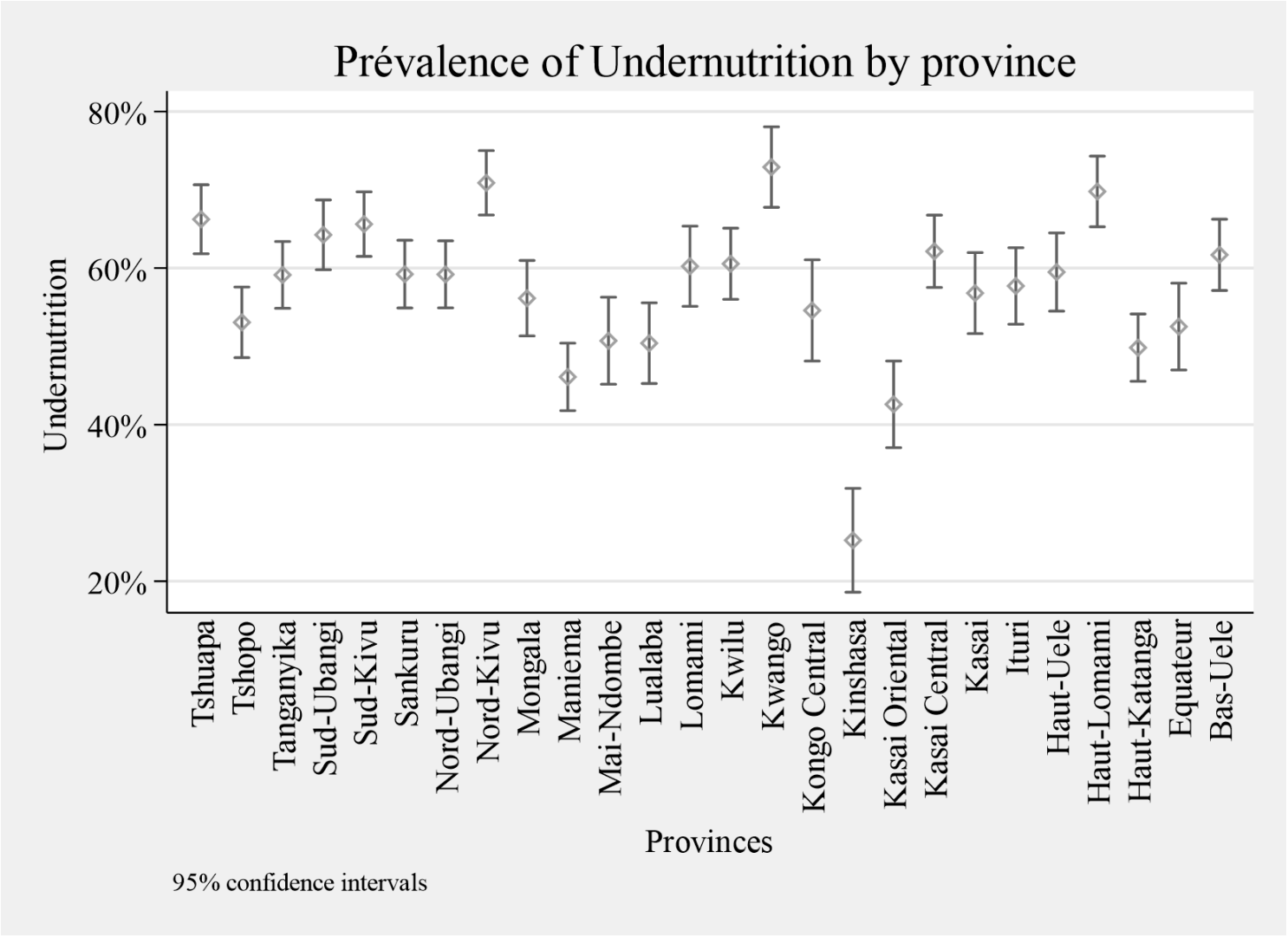


Figure 3

Prevalence of undernutrition by province

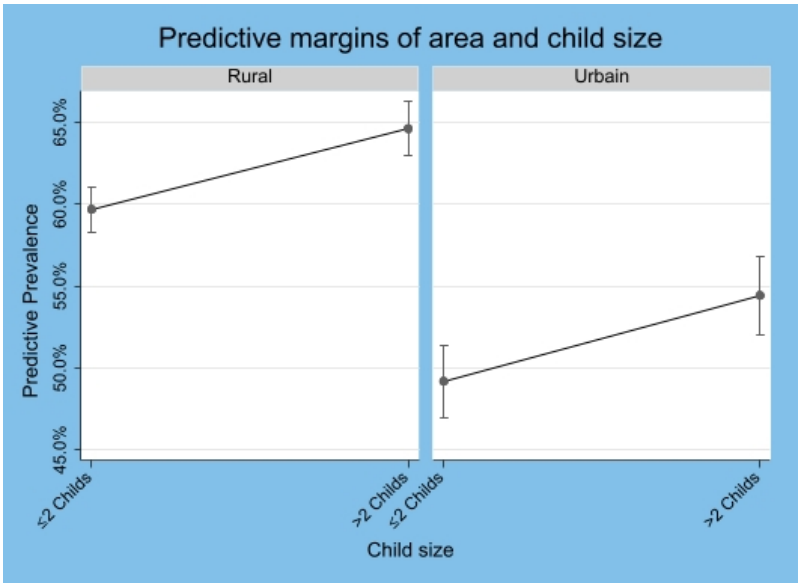


Figure 4

Margins effect of Undernutrition between place of residence and child size

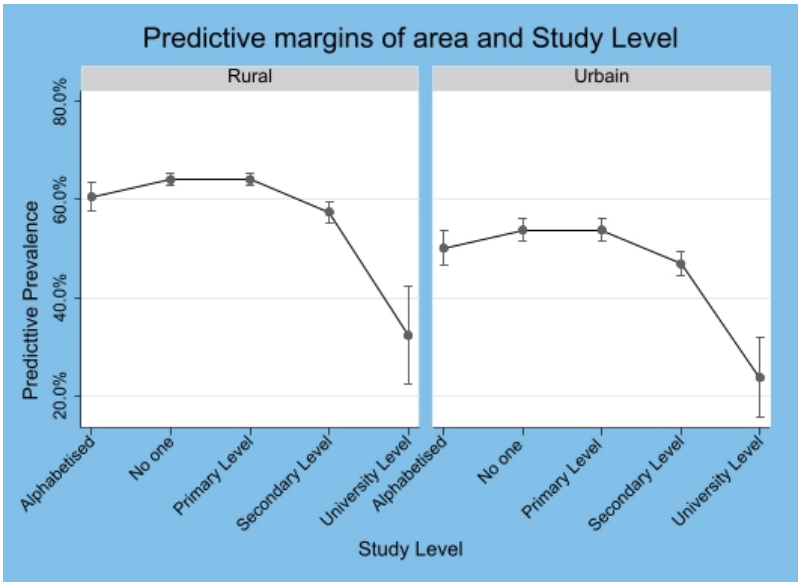


Figure 5

Margins effect of Undernutrition between place of residence and Study level

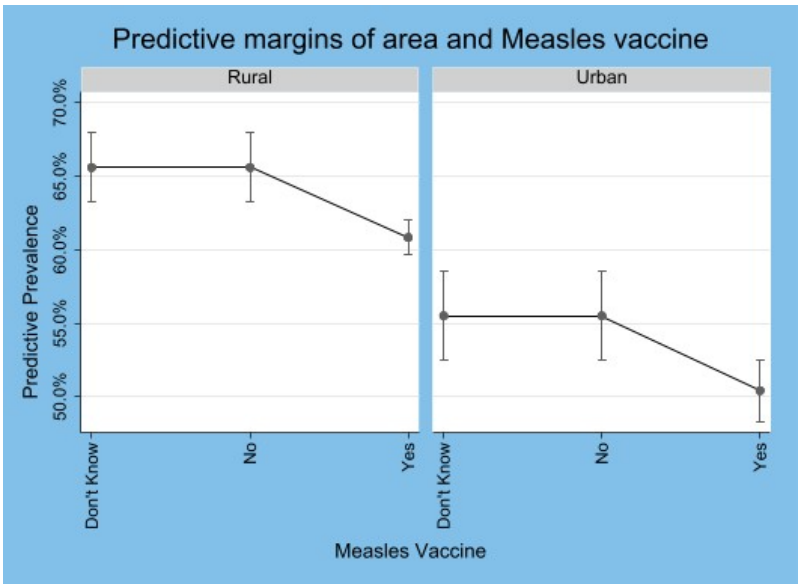


Figure 6

Margins effect of Undernutrition between place of residence and Measles vaccine

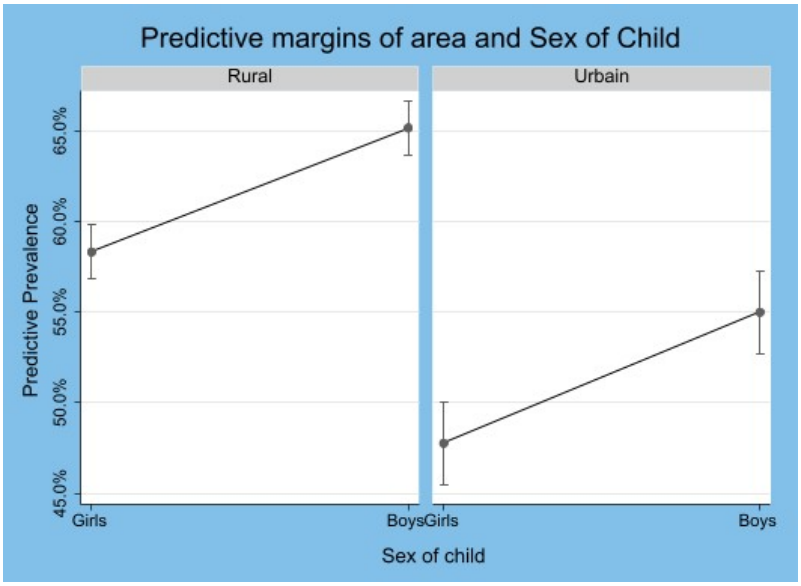


Figure 7

Margins effect of Undernutrition between place of residence and Sex of child

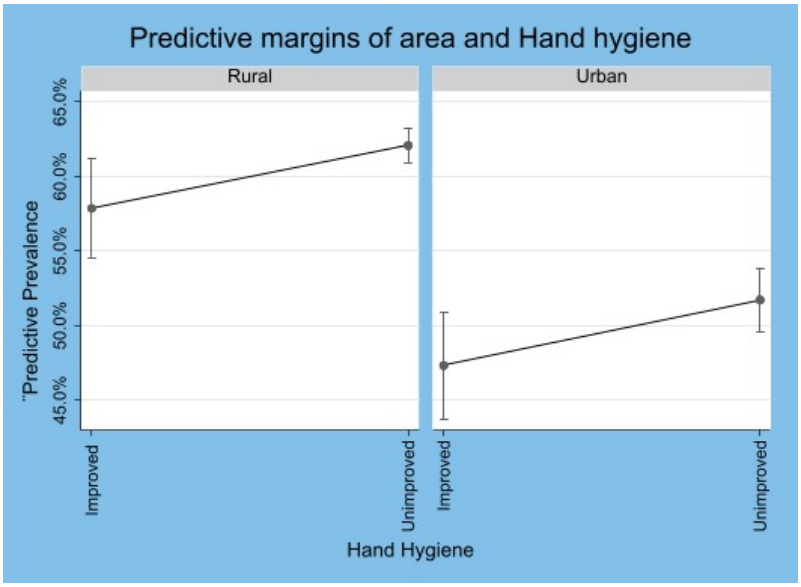


Figure 8

margins effect of Undernutrition between place of residence and Hand hygiene