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Research Article

Factors Associated with Measles Occurrence among Children Aged 6 Months to 10 Years in Ludimbi Health Zone, Lukula, Democratic Republic of the Congo, 2016–2022: A Case-Control Study.

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Abstract

Introduction: Measles remains a major cause of childhood morbidity and mortality in Africa. In the DRC, recurrent outbreaks reflect insufficient and uneven vaccine coverage, especially in rural areas. This study aimed to identify factors associated with measles resurgence among children aged 6 months to 10 years in Ludimbi Lukula Health Zone from 2016 to 2022.

Methods: A case-control study was conducted with 300 measles cases and 600 controls. Data were collected via KoboCollect from parents. Variables included vaccination status, nutritional condition, medical history, living conditions, and education level. Chi-square tests and logistic regression were used for analysis.

Results: Cases were concentrated in the Bemane (23.7%) and Luanga (19.7%) areas. Acute malnutrition was more prevalent among children with measles (54.3%) compared to those without (49.0%), with increased severity in boys and infants under one year old . Children from poor households were particularly vulnerable (35.0%). More than 90% of mothers were aware of measles, primarily through health workers, and considered vaccination the main form of prevention. Several factors were identified: health area, education, occupation, financial resources, age, and vaccination status, with the risk being four times higher among unvaccinated children.

Conclusion: Measles occurrence was associated with nutritional, socioeconomic, vaccination, and health-system-related factors. Integrated public health actions are needed to strengthen vaccine coverage, improve nutritional care, and include vulnerable populations in prevention strategies.

Keywords: Measles, associated factors, children, vaccination, Ludimbi Lukula

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I. Introduction

Measles is a highly contagious acute viral infection, primarily affecting children, with no specific cure. It manifests as a feverish rash accompanied by respiratory symptoms [1]. The introduction of an effective and inexpensive vaccine in the 1960s led to a significant reduction in global morbidity. However, the disease persists in countries with low vaccination coverage, particularly in Africa and Asia, where it causes large-scale outbreaks [1]. In 2019, the WHO reported a 300% increase in global measles cases in the first quarter compared to 2018, with a 700% increase in Africa. By that date, 170 countries had reported 112,163 cases, compared to 28,124 cases in 163 countries the previous year [2]. In Africa, nearly 17,500 cases were recorded between January and March 2022, an increase of 400% compared to the same period in 2021. Twenty countries reported outbreaks in the first quarter of 2022, compared to twelve in 2021 [3,4].

The Democratic Republic of Congo (DRC) experiences recurring measles outbreaks every two to three years, with peaks of 182,485 cases in 2005, 133,802 in 2011, and 88,381 in 2013. In 2018, 100 health zones were affected, with 124 more zones added in the first half of 2019, followed by 129 in the second half. In total, 353 out of 519 zones experienced a confirmed outbreak over two years [5]. Between 2019 and 2020, the DRC suffered the world's largest measles epidemic, with more than 380,000 cases and 7,000 deaths, primarily among children under five [6,7]. In 2023, Lomami province reported 20,791 cases, including 600 infant deaths, and the Ludimbi health zone Lukula recorded 1,142 cases [8,9]. Despite vaccination campaigns, 21 of the 26 provinces reported cases in 2023, revealing the persistence of the problem [7]. Obstacles include geographical inaccessibility, weak health infrastructure, malnutrition, and a lack of awareness about the importance of vaccination [10].

Ludimbi health zone In Lukula , several factors are implicated in the worsening situation: poor cold chain coverage, lack of training for vaccination providers, insufficient parental awareness, poverty, overcrowding, and malnutrition [11, 12, 13, 14]. The strategies implemented—improving cold chain equipment, providing EPI training, and increasing the number of outreach and mobile vaccination sessions—have had a limited impact [13]. Despite a reduction in cases in some areas, measles persists in Ludimbi. Lukula , due to unfavorable socio-economic conditions and inadequate dietary practices [10]. To effectively combat this preventable disease, it is essential to strengthen vaccination campaigns, improve access to care, and intensify community awareness. An integrated approach combining routine immunization, nutrition, and health infrastructure is indispensable. This study aims to identify the factors associated with the resurgence of measles cases in children aged 6 months to 10 years in the Ludimbi health zone. Lukula , in order to guide future interventions.

II. Methodology

Design

We conducted a case-control study with children aged 6 months to 10 years living in the Ludimbi health zone Lukula .

Study framework

Ludimbi health zone Lukula , located 100 km from Kabinda in Lomami province , covers 11,800 km² and has a low population density of nearly 200,000 inhabitants. It has a General Referral Hospital, 15 health centers, and 11 functional storage facilities. Despite a structured healthcare system, access to care remains difficult in remote areas such as Kitengie, Kiasame , and Kifuenkese . The population relies primarily on subsistence farming and small-scale livestock breeding, in a context of economic insecurity and limited access to essential services. These conditions exacerbate health vulnerabilities, particularly among children.

Sampling

a) Population

The sampling for this case-control study focuses on children aged 6 months to 10 years residing

in the Ludimbi health zone Lukula , Lomami Province . Participants were selected from health areas that had recorded cases of measles during the study period, and mothers or caregivers served as respondents to provide the necessary information. Cases included children diagnosed with measles, whether they tested positive or not, and who had attended a local health facility. Controls were children of the same age who had not contracted measles, living in the same villages as the cases and sharing similar environmental conditions. Excluded were children with measles who were unavailable at the time of the survey, as well as controls whose parents or caregivers refused to provide informed consent.

b) Size

The study focused on the six health areas that recorded the highest number of measles cases out of the fifteen in the Ludimbi health zone. Lukula . The calculation of the sample size was carried out using the StatCalc program of the Epi Info 7 software, based on the parameters of a study carried out in Mali by Diarra Moussa Modibo et al.[1], with a confidence level of 95%, a power of 80%, a proportion of exposed controls of 50% and an odds ratio of 2.55.

$$n \geq 2\times(Z\alpha+Z1-\beta)2\times p(1-p)/(po-p1)2n$$

After inserting the values into the formula:

$$n \geq 2\times(1.96+0.84)2\times 0.085\times(1-0.085)/(0.05-0.12)2n$$

This gives: $n \geq 272.5 \approx 273$ cases .

This calculation allowed us to estimate the number of cases needed at 273, corrected by a factor of 0.75 to obtain 410 controls. Thus, the calculated sample size was 615, comprising 273 cases and 410 controls. Due to organizational factors in the six selected health areas and to increase the study's statistical power, the number of cases was adjusted to 300 and the number of controls to 600, bringing the final sample size to 900.

c) Sampling technique

Cases were selected systematically from the line lists of children diagnosed with measles in the six most affected health areas. Each eligible case was assigned a sequential number from 1 to N. The sampling interval (k) was calculated by dividing the total number of eligible cases by the required sample size. A random starting point was selected between 1 and k, after which subsequent cases were selected at regular intervals. In the event of refusal to participate or failure to meet the eligibility criteria, a replacement was selected using the same systematic sampling procedure, where feasible.

Controls were selected using a non-probability sampling approach based on geographical proximity to the identified cases. Eligible children without a history of measles were approached in nearby households, starting with plots adjacent to those of the cases. If no eligible control was available in the immediate vicinity, the search was extended to other nearby plots within the same health area. No individual or frequency matching was performed on the basis of age or sex. This approach was adopted for operational feasibility; however, it does not guarantee that the controls are representative of the population from which the cases arose. The potential for selection bias was therefore acknowledged when interpreting the findings

Study variables

The variables studied in this research include a dependent variable—measles—defined as the presence of febrile maculopapular rash with or without rhinorrhea and conjunctivitis, or confirmed by laboratory testing, coded dichotomously (1: yes, 0: no). Independent variables include socioeconomic factors (income level and daily expenditure), demographic factors (child's sex and age, mother's marital status, head of household's occupation), educational factors (respondent's level of education), environmental factors (living environment, overcrowding), nutritional factors (nutritional status based on mid-upper arm circumference), and health factors (measles vaccination status). These variables were measured using nominal or ordinal scales, allowing for the exploration of their association with the occurrence of measles in children aged

6 months to 10 years in the Ludimbi health zone. Lukula .

Data collection

Data collection was carried out using structured interviews administered to the parents of children with measles and to the parents of control subjects, selected according to predefined criteria in neighboring villages. A detailed questionnaire, designed and deployed via the Kobocollect mobile platform, enabled secure, real-time digital data entry, reducing errors and facilitating data processing. Before the start of the study, a pre-test was conducted to validate the tools, and the interviewers, healthcare professionals fluent in the local language, were trained on the study objectives, interview techniques, ethics, confidentiality, and the use of Kobocollect. Field supervision ensured quality control through regular monitoring, immediate corrections, and debriefing meetings. Following approval from the ethics committee, contacts were established with academic and health authorities and local training managers to obtain the necessary authorizations and lists. Field visits were planned to cover the targeted health areas, with logistical support including transportation, equipment, and data management. This rigorous and structured process ensured the reliability and ethical compliance of the data collection.

Data Processing and Analysis

After data collection, the data were exported from Kobocollect and analyzed using SPSS version 25. Categorical variables were analyzed using absolute and relative frequencies, while quantitative variables were summarized using measures of central tendency and dispersion, according to their Kolmogorov-Smirnov distribution. In this study, nutritional status was assessed using mid-upper arm circumference (MUAC) and age to calculate MUAC-for-age Z-scores using WHO Anthro software for children under 5 years and WHO AnthroPlus for children aged 5 years and older. The use of these two software packages followed WHO recommendations according to the child's age group. Nutritional status was classified according to the applicable WHO reference standards. A Z-score below −2 was considered indicative of a value below the reference range(global acute malnutrition (GAM), whereas a Z-score of −2 or higher indicated a value within the reference range. Associations between variables were explored using the Chi-square test, and binary logistic regression was used to identify factors related to the occurrence of measles, with calculation of odds ratios and 95% confidence intervals.

Ethical considerations

The study protocol was reviewed and approved by the Ethics Committee of the Kinshasa School of Public Health (approval number: CE/ESP/178/2025) in 2025. The study involved a secondary analysis of data extracted from health facility records and case-identification forms concerning children registered in healthcare facilities between 2016 and 2022. Thus, the ethical approval obtained in 2025 related to the present analysis of previously collected data, whereas the data covered the period from 2016 to 2022. The confidentiality and anonymity of the information were maintained throughout data extraction, processing and analysis. Access to the records was restricted to the research team, and identifying information was handled in accordance with applicable ethical requirements. The study was conducted in accordance with the principles of respect for persons, confidentiality and responsible use of health data.

Results

Socio-demographic and socio-economic characteristics of households

Analysis of the table shows a varied geographical distribution of respondents according to health area. Cases are mainly concentrated in the Bemane (23.7%) and Luanga (19.7%) health areas. Sociodemographically, the majority of respondents are women, aged 15 to 49, and primarily mothers of the affected children. Primary and secondary education levels dominate, with 44.3% of cases and 42.7 % of controls having a secondary education. More than half of the households surveyed in

both groups have fewer than six members. Economically, 82.5% of controls live on less than 3,000 FC per day per person, compared to 66.3% of cases. Finally, 41% of cases have a low socioeconomic level, while 35.8% of controls have a middle socioeconomic level. (Table I)

Nutritional status of children aged 6 months to 10 years in surveyed households

The results in Table II show a higher proportion of acute malnutrition among children with measles (54.3%) compared to controls (49.0%). According to Table III, the analysis aimed to determine whether nutritional status was associated with age, sex, and household wealth level within each study group. No statistically significant association was observed with sex among cases (p = 0.87) or controls (p = 0.058), while age was significantly associated with nutritional status among controls (p = 0.006). Household wealth showed no statistically significant association, although children from poor households appeared more vulnerable, with 52.8% affected.

Knowledge and perceptions of women and childcare providers regarding vaccination and/or measles

The data reveal that the majority of respondents, both among cases (96.3%) and controls (91.7%), had heard of measles, primarily from healthcare workers. The most recognized symptoms were rash, fever, and cough. Over 80% of participants knew of at least one means of protection, with vaccination widely cited as the primary method (73.3% among cases, 71.3% among controls) (Table IV). The majority of respondents, both among cases (82.7%) and controls (79.7%), consider the vaccination to be effective against measles. A very positive perception of the vaccination is observed, with over 97% rating it as "good" among cases and 98.5% among controls. Finally, over 94.7% of cases, compared to 96.3% of controls, believe that the vaccine effectively protects the child (Table V).

Children's vaccination status

The majority of children, both cases and controls, had been vaccinated against measles (96.7% and 98.7%, respectively). However, a slightly higher proportion of affected children (3.3%) had not been vaccinated compared to controls (1.3%), which, although marginal, could contribute to the occurrence of cases in a context of incomplete vaccination coverage (Figure 1).

Factors associated with the occurrence of measles cases in children aged 6 months to 10 years

Bivariate analysis using the chi-square test showed several significant associations ($p < 0.05$) with the occurrence of measles. Cases varied according to the health area (p = 0.001) and were more frequent in children aged 6–11 months and ≥60 months (p = 0.001). The respondent's secondary education level (p = 0.043) and teaching occupation (p = 0.01) were associated with a higher incidence. Households with an expenditure ≥3000 FC/day had more cases (p = 0.001). Lack of information about measles (p = 0.009) and lack of vaccination, particularly against measles (p = 0.013), were also aggravating factors. (Table VI)

Bivariate and multivariate logistic regression analyses identified several factors significantly associated with measles occurrence. Children residing in the Bemane (adjusted odds ratio [aOR] = 9.42) and Kiasame (aOR = 4.96) health areas had higher odds of measles occurrence than those living in Bashimikie. Similarly, having a respondent with secondary education (aOR = 1.67) and having a teacher as the respondent (aOR = 2.01) were associated with higher odds of measles occurrence. Children from households with daily expenditures of ≥3,000 Congolese francs (FC) also had higher odds of measles occurrence (aOR = 2.18). Conversely, children whose respondents had never heard of measles had lower odds of measles occurrence (aOR = 0.45). Compared with children aged ≥60 months, those aged 12–23 months (aOR = 0.11) and 24–59 months (aOR = 0.63) had lower odds of measles occurrence. Finally, children who had not been vaccinated against measles had higher odds of measles occurrence (aOR = 4.23, 95% CI: 1.22–14.63), highlighting the importance of measles vaccination.

Table I: Distribution according to the sociodemographic and socioeconomic characteristics of respondents

Variables	Case		Control	
	n=300	%	n=600	%
Health area				
Bashimikie	51	17.0	102	17.0
Bemane	71	23.7	142	23.7
Kîasame	49	16.3	98	16.3
Luanga	59	19.7	118	19.7
Miombe ₂	12	4.0	24	4.0
Miombe muavi	58	19.3	116	19.3
Respondent's gender				
Female	188	62.7	406	67.7
Male	112	37.3	194	32.3
Respondent's age (in years)				
< 18	4	1.3	8	1.3
18-35	115	38.3	266	44.3
36-50	128	42.7	233	38.8
> 50	53	17.7	93	15.5
Relationship with the child				
Other relatives (brother, sister, aunt, uncle, grandparents)	16	5.3	44	7.3
Mother	184	61.3	389	64.8
Father	93	31.0	157	26.2
Tutor	7	2.3	10	1.7
Respondent's level of education				
No education	34	11.3	100	16.7
Primary	114	38.0	256	42.7
Secondary	149	49.6	237	39.5
Superior	3	1.0	7	1.2
Number of people in the household				
<6	167	55.7	308	51.3
>=6	133	44.3	292	48.7
Daily household expenses/day				
Less than 3000 FC/Day/person	199	66.3	495	82.5
Greater than or equal to 3000 FC/Day/person	101	33.7	105	17.5
Residence status in the plot				
Other (housed, family, etc.)	2	0.7	2	0.3
Tenant	53	17.7	82	13.7
Owner	245	81.7	516	86.0
Wealth index				
Low	123	41.0	211	35.2
Middle	85	28.3	215	35.8
High	92	30.7	174	29.0

Table II. Nutritional status of the child measured by mid-upper arm circumference according to age (Z-score for age)

Nutritional status	Case (n = 300)	Controls (n = 600)
Good (No acute malnutrition)	137 (45.7)	306 (51.0)
Bad / MAG	163 (54.3)	294 (49.0)
Total	300 (100,0)	600 (100,0)

$p(X^2)=0,131$

Table III: Distribution of children's nutritional status according to sex, age and level of wealth ownership

Features	Case			Control		
	Nutritional status			Nutritional status		
	Good n (%)	Bad/ MAG n (%)	p	Good n (%)	Bad /MAG n (%)	p
Sex of the child						
Female	66 (45.2)	80 (54.8)	0.87	141 (55.5)	113 (44.5)	0.058
Male	71 (46.1)	83 (53.9)		165 (47.7)	181 (52.3)	
Child's age						
6–11 months	6 (60.0)	4 (40.0)	0.81	10 (83.3)	2 (16.7)	0.006
12–23 months	1 (50.0)	1 (50.0)		26 (72.2)	10 (27.8)	
24–59 months	47 (46.1)	55 (53.9)		127 (49.0)	133 (51.0)	
≥60 months	83 (44.6)	103 (55.4)		143 (49.0)	149 (51.0)	
Wealth index						
Low	58 (47.2)	65 (52.8)	0.86	118 (55.9)	93 (44.1)	0.16
Middle	39 (45.9)	46 (54.1)		107 (49.8)	108 (50.2)	
High	40 (43.5)	52 (56.5)		81 (46.6)	93 (53.4)	

Table IV: Mothers'/Carers' Knowledge of Measles

Respondents' knowledge and perceptions about measles	Case		control	
	n=300	%	n=600	%
Have you ever heard of measles?				
No	11	3.7	50	8.3
Yes	289	96.3	550	91.7
Source of information				
Posters	4	1.3	38	6.3
Other (Social networks, internet):	10	3.3	17	2.8
Healthcare personnel	205	68.3	366	61.0
Radio	65	21.7	118	19.7
Neighbors/friends	16	5.3	61	10.2
Known signs of measles				
Fever	206	68.7	403	67.2
Cough	112	37.3	162	27
Rash	242	80.7	503	83.8
Runny nose	92	30.7	117	19.5
Bright red spots	91	30.3	115	19.2

Knowledge of means of protection (1/2)				
No	53	17.7	114	19.0
Yes	247	82.3	486	81.0
Knowledge of means of protection (2/2)				
Other (Isolation of cases, health education, surveillance)	1	0.3	4	0.7
Good nutrition	9	3.0	27	4.5
Timely medical care	17	5.7	26	4.3
Vaccination	220	73.3	428	71.3

Table V. Mothers'/Carers' Perceptions of Measles

Respondents' Perceptions	**Case**		**Control**	
	n=300	%	n=600	%
Do you think vaccination is effective against measles?				
Don't know	47	15.7	106	17.7
No	5	1.7	16	2.7
Yes	248	82.7	478	79.7
What are your thoughts on vaccination?				
Other (don't know, no choice)	4	1.3	4	0.7
Good	291	97	591	98.5
Bad .	5	1.7	5	0.8
Do you think the vaccine can protect the child?				
No	16	5.3	22	3.7
Yes	284	94.7	578	96.3

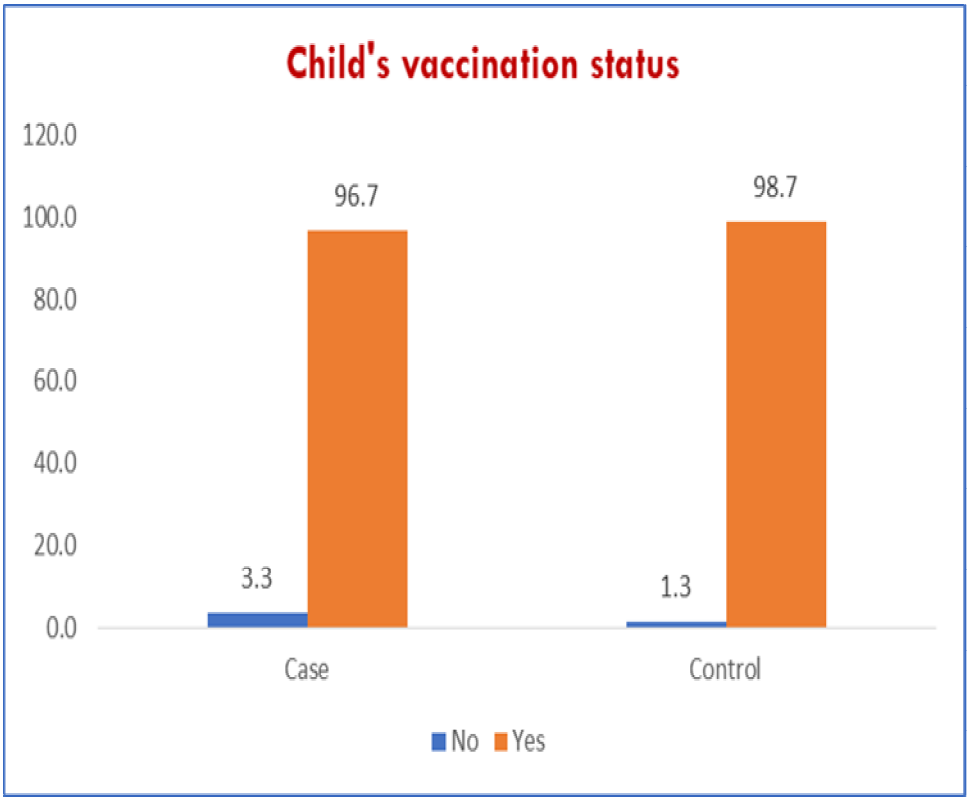

Figure 1: Child's vaccination status

Table VI: Factors associated with the occurrence of measles cases in children aged 6 months to 10 years in the Ludimbi Health Zone Lukula according to the Chi-square test

Variables	Case	Control	Total	p(X²)
Health area				0.001
Bashimikie	51 (17.0%)	102 (17.0%)	153 (17.0%)	
Bemane	71 (23.7%)	142 (23.7%)	213 (23.7%)	
Kîasame	49 (16.3%)	98 (16.3%)	147 (16.3%)	
Luanga	59 (19.7%)	118 (19.7%)	177 (19.7%)	
Miombe Etala	12 (4.0%)	24 (4.0%)	36 (4.0%)	
Miombe Muavi	58 (19.3%)	116 (19.3%)	174 (19.3%)	
Respondent's age (years)				0.072
< 18	4 (33.3%)	8 (66.7%)	12	
18–35	115 (30.2%)	266 (69.8%)	381	
36–50	128 (35.5%)	233 (64.5%)	361	
> 50	53 (36.3%)	93 (63.7%)	146	
Relationship with the child				0.29
Mother	184 (32.1%)	389 (67.9%)	573 (100%)	
Father	93 (37.2%)	157 (62.8%)	250 (100%)	
Tutor	7 (41.2%)	10 (58.8%)	17 (100%)	
Other	16 (26.7%)	44 (73.3%)	60 (100%)	
Respondent's level of education				0.043
Primary	114 (30.8%)	256 (69.2%)	370 (100%)	
Secondary	149 (38.6%)	237 (61.4%)	386 (100%)	
Superior	3 (30.0%)	7 (70.0%)	10 (100%)	
Other	16 (37.2%)	27 (62.8%)	43 (100%)	
Respondent's profession				0.01
Farmer/Livestock Breeder	230 (31.8%)	493 (68.2%)	723 (100%)	
Teacher	38 (51.4%)	36 (48.6%)	74 (100%)	
Shopkeeper	3 (25.0%)	9 (75.0%)	12 (100%)	
Other	29 (31.9%)	62 (68.1%)	91 (100%)	
Marital status of mother/guardian				0.6
Bride	287 (33.8%)	563 (66.2%)	850 (100%)	
Bachelor	3 (27.3%)	8 (72.7%)	11 (100%)	
Divorcee	8 (29.6%)	19 (70.4%)	27 (100%)	
Widow	2 (18.2%)	9 (81.8%)	11 (100%)	
Free union	0 (0.0%)	1 (100.0%)	1 (100%)	
Number of people in the household				0.22
<6 people	167 (35.2%)	308 (64.8%)	475 (100%)	
6 people or more	133 (31.3%)	292 (68.7%)	425 (100%)	
Daily household expenditure per day				0.001
<3000 FC	199 (28.7%)	495 (71.3%)	694 (100%)	
≥3000 FC	101 (49.0%)	105 (51.0%)	206 (100%)	
Wealth index				0.06
Low	123 (36.8%)	211 (63.2%)	334 (100%)	
Middle	85 (28.3%)	215 (71.7%)	300 (100%)	
High	92 (34.6%)	174 (65.4%)	266 (100%)	
Have you ever heard of measles?				0.009
Yes	289 (34.4%)	550 (65.6%)	839 (100%)	

No	11 (18.0%)	50 (82.0%)	61 (100%)	
Sex of the child				0.07
Female	146 (36.5%)	254 (63.5%)	400 (100%)	
Male	154 (30.8%)	346 (69.2%)	500 (100%)	
Child's age (in months)				0.001
6–11	10 (45.5%)	12 (54.5%)	22 (100%)	
12–23	2 (5.3%)	36 (94.7%)	38 (100%)	
24–59	102 (28.2%)	260 (71.8%)	362 (100%)	
≥60	186 (38.9%)	292 (61.1%)	478 (100%)	
Child's nutritional status (Z-score) Muac for age)				0.13
Good (No acute malnutrition)	137 (30.9)	306 (69.1)	443 (100)	
Bad (MAG)	163 (35.7)	294 (64.3)	457 (100)	
The child has already been vaccinated.				0.043
Yes	290 (32.9%)	592 (67.1%)	882 (100%)	
No	10 (55.6%)	8 (44.4%)	18 (100%)	
The child was vaccinated against measles.				
Yes	291 (32.8%)	596 (67.2%)	887 (100%)	0.013
No	9 (69.2%)	4 (30.8%)	13 (100%)	

Table VII: Factors associated with the occurrence of measles cases in children aged 6 months to 10 years in the Ludimbi Health Zone Lukula in bivariate and multivariate logistic regression

Variables	Case n=300	Control n=600	ORb (95% CI)	p	ORa (95% CI)	p
Health area						
Bashimikie	51 (34.0%)	99 (66.0%)	1		1	
Bemane	71 (48.0%)	77 (52.0%)	10.91 (5.65–21.07)	<0.001	9.42 (4.89–18.14)	<0.001
Kîasame	49 (32.9%)	100 (67.1%)	5.80 (2.94–11.45)	<0.001	4.96 (2.42–10.17)	<0.001
Luanga	59 (39.9%)	89 (60.1%)	7.84 (4.02–15.29)	<0.001	1.42 (0.63–3.17)	0.392
Miombe Etala	12 (7.8%)	142 (92.2%)	6.14 (3.11–12.12)	<0.001	1.10 (0.54–2.23)	0.45
Miombe Muavi	58 (38.4%)	93 (61.6%)	7.38 (3.78–14.41)	<0.001	1.41 (0.74–2.68)	0.8
Respondent's level of education						
None	34 (25.4%)	100 (74.6%)	1		1	
Primary	114 (30.8%)	256 (69.2%)	1.30 (0.82–2.07)	0.26	1.21 (0.74–1.98)	0.45
Secondary	149 (38.6%)	237 (61.4%)	1.80 (1.13–2.87)	0.014	1.67 (1.03–2.71)	0.038
Superior	3 (30.0%)	7 (70.0%)	1.26 (0.30–5.35)	0.75	0.74(0.39-1.45)	0.39
Respondent's profession						
Farmer/Livestock Breeder	230 (31.8%)	493 (68.2%)	1		1	
Teacher	38 (51.4%)	36 (48.6%)	2.23 (1.39–3.58)	0.001	2.01 (1.21–3.36)	0.007

Shopkeeper	3 (25.0%)	9 (75.0%)	0.71 (0.19–2.65)	0.61	2.02(0.85 – 4.79)	0.107
Other	29 (31.9%)	62 (68.1%)	1.01 (0.64–1.59)	0.96	1.24(0.69 – 2.22)	0.46
Daily household expenditure per day						
<3000 FC	199 (28.7%)	495 (71.3%)	1		1	
≥3000 FC	101 (49.0%)	105 (51.0%)	2.39 (1.73–3.29)	<0.001	2.18 (1.56–3.05)	<0.001
Wealth index						
Low	123 (36.8%)	211 (63.2%)	1		1	
Middle	85 (28.3%)	215 (71.7%)	0.68 (0.48–0.97)	0.033	0.74 (0.51–1.07)	0.11
High	92 (34.6%)	174 (65.4%)	0.89 (0.63–1.27)	0.52	0.94 (0.64–1.38)	0.76
Have you ever heard of measles?						
Yes	289 (34.4%)	550 (65.6%)	1		1	
No	11 (18.0%)	50 (82.0%)	0.42 (0.21–0.84)	0.014	0.45 (0.22–0.93)	0.032
Sex of the child						
Female	146 (36.5%)	254 (63.5%)	1		1	
Male	154 (30.8%)	346 (69.2%)	0.76 (0.56–1.03)	0.07	0.81 (0.59–1.12)	0.2
Child's age (in months)						
6–11	10 (46.7%)	12 (53.3%)	1.18 (0.52–2.66)	0.69	1.16 (0.49–2.75)	0.73
12–23	2 (5.3%)	36 (94.7%)	0.10 (0.02–0.43)	0.002	0.11 (0.03–0.47)	0.003
24–59	102 (28.2%)	260 (71.8%)	0.61 (0.45–0.84)	0.002	0.63 (0.46–0.88)	0.006
≥60	186 (38.9%)	292 (61.1%)	1		1	
The child has already been vaccinated.						
Yes	290 (32.9%)	592 (67.1%)	1		1	
No	10 (55.6%)	8 (44.4%)	2.55 (0.98–6.63)	0.053	2.31 (0.86–6.23)	0.097
The child was vaccinated against measles.						
Yes	291 (32.8%)	596 (67.2%)	1		1	
No	9 (69.2%)	4 (30.8%)	4.61 (1.39–15.27)	0.013	4.23 (1.22–14.63)	0.023

IV. Discussion

Key Results

Ludimbi Health Zone Lukula reveals a high concentration of measles cases among children aged 6 months to 10 years, particularly in the Bemane and Kiasame health areas . Analysis of mid-upper arm circumference shows a high prevalence of acute malnutrition among affected children (54.3%) compared to 49.0% among unaffected children, with increased severity in boys and infants under one year old. Children from households with low levels of wealth are also more vulnerable (35.0%). The majority of mothers or caregivers (over 90%) are familiar

with measles, primarily through health workers, and recognize its main clinical signs. Vaccination is perceived as the essential means of prevention, although some express doubts about its effectiveness. Vaccination coverage remains high in both groups (96.7% in cases and 98.7% in controls). Statistical analysis identifies several factors associated with the occurrence of measles: health area, respondent's education level and occupation, daily household expenses, child's age, and vaccination status. Unvaccinated children have a fourfold increased risk.

Knowledge of mothers and caregivers regarding measles and vaccination

In the Ludimbi Health Zone, Lukula, more than 90% of mothers and caregivers had heard of measles, primarily through healthcare workers. Respondents generally recognized the main clinical signs, including fever, cough and rash, and identified vaccination as the primary means of prevention. The importance of caregiver awareness, maternal education and access to vaccination services has also been documented in sub-Saharan Africa [15,16]. However, some respondents in Ludimbi expressed doubts about vaccine effectiveness, potentially reflecting personal experiences or concerns about breakthrough infections.

The prominent role of healthcare workers in providing information represents an opportunity to strengthen health education and address misconceptions. Nevertheless, adequate knowledge does not necessarily translate into complete vaccination. Practical barriers, including geographical distance, vaccine availability, indirect costs and missed opportunities during healthcare visits, may contribute to incomplete immunization. Evidence from the Democratic Republic of the Congo has highlighted disparities in measles vaccination coverage, supporting the need to combine health education with accessible and reliable vaccination services [17].

Factors associated with measles occurrence

The findings from Ludimbi reflect challenges reported in other African settings, where geographical inequalities and socioeconomic circumstances may be associated with differences in measles occurrence. Studies conducted in the DRC and systematic reviews from Africa have documented persistent challenges in vaccination coverage and measles control [18,19]. In the present study, children residing in Bemane (aOR = 9.42; 95% CI: 4.89–18.14) and Kîasame (aOR = 4.96; 95% CI: 2.42–10.17) had higher odds of measles occurrence than those living in Bashimikie. These substantial differences may reflect geographical inequalities in vaccination coverage, access to healthcare, vaccine availability, population mobility or outbreak detection. However, these mechanisms were not necessarily measured in the present study and should be considered possible explanations rather than established causes. Regional surveillance reports have documented persistent measles transmission and difficulties in achieving elimination targets in the WHO African Region [20]. Economic and occupational characteristics were also associated with measles occurrence in Ludimbi. Children from households reporting daily expenditure of at least 3,000 Congolese francs had higher odds of being cases (aOR = 2.18; 95% CI: 1.56–3.05). Similarly, having a respondent with secondary education (aOR = 1.67; 95% CI: 1.03–2.71) and having a teacher as the respondent (aOR = 2.01; 95% CI: 1.21–3.36) were associated with higher odds of case status. These findings should be interpreted cautiously because the observed associations may reflect differences in residence, mobility, household characteristics or other unmeasured factors. Socioeconomic inequalities in childhood vaccination have been documented in low- and middle-income countries, highlighting the importance of considering social and health-service contexts when interpreting these findings [21,22]. The present results do not establish that higher household expenditure, secondary education or teaching as an occupation directly increases measles susceptibility.

Nutritional vulnerability is another important consideration in measles prevention. Although nutritional status was not identified as a statistically significant factor in the present

analysis, this does not exclude its potential relevance to child health. Previous research has examined the epidemiology of measles outbreaks and the vulnerability of children in affected populations [18,19]. However, in Ludimbi, children aged 12–23 months (aOR = 0.11; 95% CI: 0.03–0.47) and 24–59 months (aOR = 0.63; 95% CI: 0.46–0.88) had lower odds of measles occurrence than children aged 60 months or older. This pattern differs from the commonly described vulnerability of younger children and warrants cautious interpretation, taking into account local vaccination patterns, exposure histories and the distribution of cases and controls across age groups.

From a behavioral perspective, concerns about vaccination and trust in health services may influence immunization uptake. The importance of supplementary immunization activities in reaching children missed by routine vaccination services has been documented in previous research [23]. In Ludimbi, respondents who had never heard of measles unexpectedly had lower odds of case status (aOR = 0.45; 95% CI: 0.22–0.93). This association should not be interpreted as a protective effect of limited awareness. The relatively small number of respondents in this category, potential selection or reporting bias, residual confounding, and possible measurement or coding problems may have influenced the result. Verification of the original data and variable coding is therefore advisable.

Finally, children who had not been vaccinated against measles had higher odds of measles occurrence (aOR = 4.23; 95% CI: 1.22–14.63). This association reinforces the importance of vaccination as a central component of measles prevention. National and regional immunization reports also emphasize the need to address vaccination gaps and strengthen strategies for reaching underserved populations [24]. Although the confidence interval indicates uncertainty regarding the magnitude of the association, the finding supports strengthening routine immunization, improving access to healthcare, addressing geographical disparities and implementing targeted community engagement. Because this was an observational case-control study, these results identify associations rather than establish causal relationships.

Strengths and limitations of the study

This study benefited from a case-control design involving 300 cases and 600 controls, systematic case selection, digital data collection using KoboCollect, and multivariable logistic regression. Nutritional status was assessed using MUAC-for-age Z-scores calculated with WHO Anthro for children under 5 years and AnthroPlus for those aged 5 years and older. Ethical approval was obtained from the relevant ethics committee. However, the final sample size differed from the initial calculation because of organizational considerations and the aim of improving statistical power. The non-probability selection of controls based on geographical proximity may have introduced selection bias and limits representativeness. The absence of documented vaccination histories may have caused recall bias, while social desirability may have influenced some responses. The study also did not adequately account for measles seasonality, and inaccessible areas may have limited generalizability. Finally, the observational design precludes causal conclusions, and the nutritional findings should be interpreted in relation to the specific anthropometric indicator used.

Conclusion

This case-control study conducted in the Ludimbi Health Zone, Lukula, identified several factors associated with measles occurrence among children, including socioeconomic characteristics, vaccination status, and other health-related factors. Despite reported awareness of measles, gaps in vaccination and concerns about vaccine efficacy may remain. These findings highlight the importance of an integrated public health approach that strengthens vaccination coverage, promotes nutritional well-being, and improves access to healthcare services. Although causal relationships cannot be established from this observational design, the results provide useful

evidence to inform locally adapted measles prevention and control strategies.

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- Nkongolo Bernard-Kennedy: contribution to the statistical analysis and critical review of the manuscript.
- Nelly Dikamba : Facilitation, methodological support, coordination and supervision of the writing, approval of the protocol and the manuscript

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