

Evolution of Factors Associated With Zero-Dose Status in Children Aged 12–23 Months in Mai-Ndombe Province, Democratic Republic Of Congo, 2021–2023: A Secondary Analysis of Vaccination Coverage Surveys

Mumpubi Christian^{1*}, Nkongolo Bernard-Kennedy²,

Lievin Tshimanga² and Nkamba Dalau³

¹MD, Student at the School of Public Health, University of Kinshasa, Democratic Republic of Congo.

²MD, MPH, School of Public Health, University of Kinshasa, Democratic Republic of Congo.

³MD, MPH, PhD, School of Public Health, University of Kinshasa, Democratic Republic of Congo.

Article Info:

***Corresponding author:**
Mumpubi Christian,
MD, Student at the School of Public Health, University of Kinshasa, Democratic Republic of Congo.
drchristianmumpubi@gmail.com

DOI: [10.68819/anslhs.2026.0004](https://doi.org/10.68819/anslhs.2026.0004)

[Received 19-08-2026,
Accepted 18-10-2026,
Published 22-10-2026]

Publishers Note: Natural Science Association stays neutral with regard to jurisdictional claims in published maps and institutional affiliations.

Copyright: ©2026 by the author(s). This is an Open Access article distributed under the terms of the Creative Commons Attribution 4.0 license (unless stated otherwise) permits unrestricted use, distribution, and reproduction in any medium, provided the original work is properly cited.

<https://creativecommons.org/licenses/by/4.0/>

I. Introduction

A “zero-dose” child is defined by the WHO as who had received no dose of the pentavalent vaccine, as determined from the vaccination card or caregiver recall (1). These children often live in precarious circumstances such as conflict

Abstract

Background: A “zero-dose” child is defined by the World Health Organization (WHO) as a child who had received no dose of the pentavalent vaccine, as determined from the vaccination card or caregiver recall. This study aimed to identify factors associated with zero-dose status among children aged 12–23 months in Mai-Ndombe Province between 2021 and 2023.

Methods: This was a secondary analysis of data from vaccination coverage surveys conducted in 2021, 2022, and 2023 by the Kinshasa School of Public Health. Household characteristics were analyzed using frequencies and percentages for categorical variables and means and standard deviations for continuous variables. A multivariate logistic regression model was used to identify factors associated with zero-dose status, reporting adjusted odds ratios (AORs) with 95% confidence intervals.

Results: The prevalence of zero-dose children dropped from 56.2% in 2021 to 22.4% in 2022, before rising again to 29.0% in 2023—still below 2021 levels. In 2021, the highest prevalence was observed among children from very poor households and mothers with no education, with religion also playing a role. In 2022, socioeconomic status, maternal age, and marital status were statistically significant. By 2023, maternal age, occupation, and marital status remained influential, although household wealth was no longer significant. Multivariate analysis confirmed these patterns.

Conclusion: Sociodemographic and economic factors particularly maternal characteristics play a key role in zero-dose prevalence. Tailored, community-sensitive strategies are needed to improve vaccination coverage.

Keywords: Zero-dose, Children 12–23 Months, Associated Factors, Mai-Ndombe, Vaccination Coverage, DRC.

zones, marginalized communities, or migration settings, and are frequently deprived of other essential health services (1). The WHO and UNICEF emphasize that immunization is not only a protective measure against disease but also a gateway to broader services including

nutrition and child development (2,3). Between 2019 and 2021, an estimated 67 million children missed some vaccinations, of whom 48 million received none at all (3). The COVID-19 pandemic further exacerbated this trend, although inequities in access predated the crisis (3). In 2023, 14.5 million children worldwide remained unvaccinated (4).

To address these challenges, the Seventy-Third World Health Assembly endorsed the 2030 Agenda for Immunization (WHA73) in 2020, integrating immunization into the foundation of primary health care and universal health coverage (5). In the Democratic Republic of Congo (DRC), the proportion of children aged 12 to 23 months who had not received any vaccine increased from 9.2% in 2020 to 12.7% in 2021 (6), and further to 18.8% in 2022 (7). In Mai-Ndombe province, fluctuations were particularly striking: 41.8% of children were zero-dose in 2021, compared to 22.1% in 2022, despite overall immunization coverage ranging only between 23% and 37.1% from 2021 to 2023 (6–8). These figures highlight unstable and insufficient coverage. The pandemic intensified disruptions to immunization services, especially in rural and conflict-affected provinces where health facilities are difficult to access (6–8). In response, the DRC implemented several strategies, including targeted micro-planning, catch-up campaigns, National Immunization Days (NIDs), community-based education and awareness activities, and capacity building for health workers (2,3). Despite these efforts, coverage remains well below the global target of 90% (9). It is therefore imperative to identify the factors driving the rise in zero-dose status among children aged 12 to 23 months in Mai-Ndombe province, in order to guide interventions more effectively and align with the 2030 immunization targets.

II. Methods

1. Study framework

This study was conducted in the province of Mai-Ndombe, in the Democratic Republic of Congo (DRC), using vaccination coverage surveys carried out between 2021 and 2023.

This province was selected because of its geographical and socio-demographic diversity, as well as persistent obstacles related to access to vaccination.

2. Type of study

This is a secondary analysis based on data collected during vaccination coverage surveys (ECV) carried out in 2021, 2022 and 2023 by the School of Public Health of Kinshasa in the province of Mai-Ndombe.

3. Sampling Method

ECV used a three-stage cluster probability sampling method covering all 26 provinces and health zones (HS) of the DRC. Within each HS of Mai-Ndombe, five health areas (HAs) were selected by simple random sampling. Then, 30% of the avenues or villages within each HA were randomly selected. Finally, systematic sampling was applied to select households with at least one child aged 6 to 23 months.

- In 2021: 1,380 children aged 12 to 23 months from 2,434 households
- In 2022: 1,699 children from 2,478 households
- In 2023: 1,380 children from 2,478 households

This rigorous method made it possible to collect data representative of living conditions, access to vaccination, and contextual factors in the province.

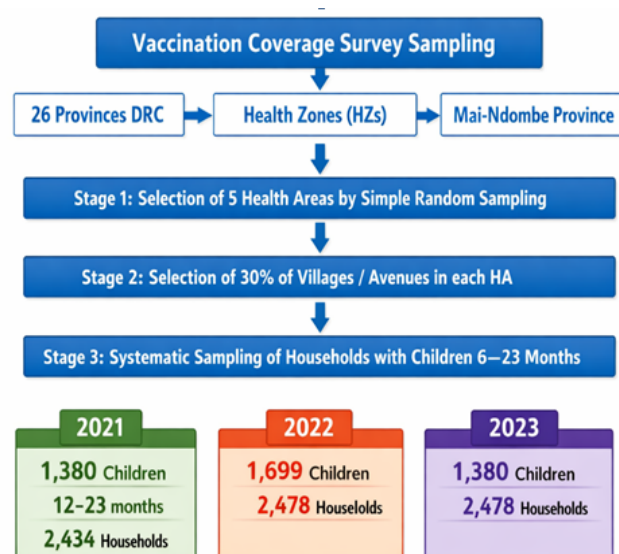


Figure 1. Vaccination Coverage Survey Sampling Flow Diagram in Mai-Ndombe Province, DRC.

4. Data Collection

Data were collected using structured questionnaires administered through the Survey CTO application on Android tablets. Information was obtained on sociodemographic characteristics, children's vaccination history, and socioeconomic and geographic factors. Interviews were conducted with household heads, mothers or guardians of children aged 6 to 23 months, as well as health center staff. To strengthen data reliability, interviews were complemented by direct observations and document reviews, including immunization cards and health center registers.

All data entries were verified in the field before being securely transmitted to a central server, with GPS coordinates included to ensure geographic precision. Vaccination status was established following a hierarchical order of evidence: first from vaccination cards, then from health center registers, and finally from caregiver recall when documentation was unavailable. This layered approach enhanced the accuracy of classification and minimized potential reporting bias.

5. Study Variables

The dependent variable was zero-dose status, defined according to the World Health Organization (WHO) as having received no dose of the pentavalent vaccine, as determined from the child's vaccination card or caregiver recall. This variable was dichotomized into two categories: zero-dose, for children who had received no dose of the pentavalent vaccine, and non-zero-dose, for children who had received at least one dose. Independent variables included the sociodemographic and economic characteristics of the mother or caregiver.

Respondent age was recorded in completed years and initially categorized as 15–19, 20–24, 25–29, 30–34, 35–39, 40–44, 45–49, and ≥ 50 years. For multivariable analysis, age was regrouped into two categories: under 30 years and 30 years or older. Marital status was classified as single, married, divorced, separated, in a de facto union, or widowed, and subsequently dichotomized as in a union

(married or in a de facto union) and not in a union (single, divorced, separated, or widowed). Educational attainment was categorized as no schooling, primary, secondary, or higher education, then grouped into no formal education and any formal education. The relationship to the child distinguished biological mothers from other guardians, including grandparents and other relatives, and was coded as biological mother versus other guardian.

Occupation was classified as farmer/livestock breeder, merchant, pupil/student, teacher, official, worker, fisherman, unemployed, or other. For multivariable analysis, it was grouped into employed and unemployed, according to the study's coding criteria. Religious affiliation included Catholic, Protestant, Revival/Independent Church, Kimbanguist, Muslim, other religion, no religion, and unknown. It was recoded as Christian and non-Christian, based on the predefined classification used in the analysis. Socioeconomic status was measured using a household asset-based wealth index divided into five categories: very low, low, average, high, and very high. These categories could be retained or collapsed into broader groups, depending on the final analytical coding. Finally, the number of dependent children was measured as a continuous variable, representing the total number of children living in the household under the respondent's care.

The recategorization of selected independent variables was intended to facilitate multivariable binary logistic regression, reduce the number of parameters estimated, and improve the interpretability of associations. The same coding approach was applied consistently across the study years.

6. Data Processing and Analysis

This study was a secondary analysis of existing ECV survey data collected in 2021, 2022, and 2023. Data were analyzed using SPSS version 25.0. Categorical variables were summarized as frequencies and percentages, while continuous variables were described using medians and

interquartile ranges (IQRs) because of their non-normal distribution.

Bivariate associations between independent variables and zero-dose status were assessed using the chi-square test. Multivariable binary logistic regression was performed separately for each study year. Variables with p-values below 0.20 in bivariate analyses were considered for inclusion, alongside variables supported by previous studies or theoretical considerations. Results were expressed as adjusted odds ratios (AORs) with 95% confidence intervals (CIs). Statistical significance was set at $p < 0.05$, and reference categories were defined consistently across study years.

As a secondary analysis, data collection procedures and field-level quality-control activities were not repeated. Information on missing data and the original sampling design was considered only where available in the dataset and survey documentation. Adjustments for complex sampling and model diagnostics were reported only if performed. Findings were interpreted as associations rather than causal relationships.

7. Ethical Aspects

Prior to the start of the study, the 2021-2023 vaccination coverage surveys received approval from the ethics committee of the Kinshasa School of Public Health, as well as authorization

from the provincial health authorities. This secondary study was also validated by the same committee. Written informed consent was obtained from participants after an explanation of the objectives, risks, benefits, and confidentiality guarantees. Participation was voluntary and without consequence. Data anonymization ensured the protection of personal information.

III. RESULTS

1. Sociodemographic characteristics of mothers/caregivers of children aged 12-23 months in the Mai-Ndombe province

The evolution of the socio-economic and demographic characteristics of households in Mai-Ndombe between 2021 and 2023 highlights notable trends: a rise in the standard of living, a younger age of mothers (20–24 years), and an increase in single-person households. The profile of respondents is changing, with more caregivers than mothers in 2023. There is a decline in the level of secondary education, but a rise in the primary level. Occupationally, the number of farmers is decreasing, while the number of students is increasing. These changes illustrate a significant social transformation influencing access to vaccination (Table I).

Table I. Sociodemographic characteristics of mothers/caregivers of Zero dose children in Mai Ndombe province during the year 2021-2023.

Features	% (95% CI) ECV 2021	% (95% CI) ECV 2022	% (95% CI) ECV 2023
Socioeconomic level of the household			
Very low	48.3(45.7-50.9)	13.9(12.2-15.6)	24.4(22.1-26.6)
Low	48.1(45.5-50.7)	12.5(10.9-14.1)	13.8(11.9-15.6)
Middle	3.5(2.5-4.5)	11.1(9.7-12.5)	19.8(17.7-21.9)
High	0.1(0.0-0.3)	28.3(26.1-30.5)	21.4(19.2-23.5)
Very high	0(0-0)	34.1(31.8-36.4)	20.7(18.5-22.8)
Age of mother/caregiver			
15-19 years old	5.8(4.6-7)	12.7(11.1-14.3)	9.8(8.1-11.4)
20-24 years old	23.7(21.4-26)	35.8(33.5-38.1)	37.3(34.8-39.7)
25-29 years old	20.2(18.0-22.4)	26.6(24.5-28.7)	23.6(21.4-25.7)
30-34 years old	24.8(22.4-27.2)	14.7(13.0- 16.4)	14.5(12.6-16.4)

Features	% (95% CI) ECV 2021	% (95% CI) ECV 2022	% (95% CI) ECV 2023
35-39 years old	16.8(14.8-18.8)	8(6.7-9.3)	9.0(7.4-10.5)
40-44 years old	7.0(5.7-8.3)	1.9(1.3- 2.5)	5.1(3.9-6.3)
45-49 years old	1.2(0.6-1.8)	0.3(0.0-0.6)	0.4(0.0-0.7)
>=50 years	0.5(0.1-0.9)	0.1(0.0-0.3)	0.3(0.0-0.5)
Relationship between respondent and child			
Guardian	2.0(1.3-2.7)	0.4(0.1-0.7)	3.1(2.1- 4.0)
Mother of the child	98.0(97.0-98.7)	99.6(99.3- 99.9)	96.9(96.0-97.8)
Current marital status of the mother/child's guardian			
Single	4.5(3.4-5.6)	1.2(0.7-1.7)	89.9(88.1-91.6)
Divorced	3.0(2.1-3.9)	0.6(0.2-1.0)	7.2(5.8-8.5)
Married	83.6(81.7-85.5)	89.6(88.0-91.2)	0.9(0.4-1.3)
Separated	3.1(2.2-4.0)	0.6(0.2-1.0)	1.4(0.7-2.0)
Cohabiting / de facto union	4.9(3.7-6.1)	7.5(6.3-8.7)	0.4(0.0-0.7)
Widowed	1.0(0.4-1.6)	0.4(0.1- 0.7)	0.2(0-0.4)
Highest level of education attained by the child's mother/caregiver			
Never went to school	8.9(7.4-10.4)	3.4(2.5-4.3)	8.9(7.3-10.4)
Don't know	34.2(31.7-36.7)	0.2(0.0-0.4)	32.3(29.8-34.7)
Primary	46.8(44.2-49.4)	27.9(25.8-30.0)	57.9(55.2-60.5)
Secondary	1.2(0.6-1.8)	67.2(64.9-69.5)	0.9(0.4-1.4)
Superior	8.9(7.4-10.4)	1.3(0.8- 1.8)	0(0-0)
Mother's/child's caregiver's occupation			
Farmer/livestock breeder	70.6(68.2-73.0)	50.9(48.5-53.3)	16.3(14.2-18.3)
Others	1.1(0.5-1.7)	0.6(0.2-1.0)	6.5(5.2-7.7)
Merchant	1.8(1.1-2.5)	4.2(3.2- 5.2)	2.4(1.5-3.2)
Student	2.1(1.3-2.9)	4.3(3.3-5.3)	64.9(62.4-67.3)
Teacher	4.6(3.5-5.7)	10.8(9.3-12.3)	0.7(0.2-1.1)
Official	0.9(0.4-1.4)	2.9(2.1-3.7)	3.1(2.1-4.0)
Worker	0.6(0.2-1.0)	1.6(1.0-2.2)	1.7(1.0-2.3)
Fisherman	0.5(0.1-0.9)	0.1(0.0-0.3)	0.4(0.0-0.7)
Unemployed	17.8(15.7-19.9)	24.6(22.6-26.6)	4.0(2.9-5.0)
Religion of the mother/child's guardian			
Other religion	0.6(0.2-1.0)	1.1(0.6-1.6)	3.4(2.4-4.3)
Catholic	33.5(31.0-36)	36.2(33.9-38.5)	37.1(34.6-39.5)
Revival/Independent Church	23.1(20.9-25.3)	21.7(19.8-23.6)	30.0(27.6-32.3)
Kimbanguist	5.8(4.6-7.0)	7.6(6.4-8.8)	4.3(3.2-5.3)
Muslim woman	0.6(0.2-1.0)	1.9(1.3-2.5)	1.5(0.8-2.1)
Don't know	0.1(0.0-0.3)	0.1(0.0-0.3)	21.4(19.2-23.5)
No religion	6.4(5.1-7.7)	3.0(2.2- 3.8)	2.1(1.3-2.8)
No response	30.0(27.6-32.4)	1.5(0.9-2.1)	0.1(0.0-0.2)
Protestant	0.6(0.2-1.0)	27.0(24.9-29.1)	3.4(2.4-4.3)

2. BESD Indicators of mothers/childcare providers with zero doses in Mai Ndombe province during the year 2021-2023

Table II. BESD indicators of mothers/childcare providers zero_dose in Mai Ndombe province during the year 2021-2023.

BESD Indicators	%(95% CI) ECV 2021	%(95% CI) ECV 2022	%(95% CI) ECV 2023
Vaccine availability			
Yes	68.3(65.4-71.2)	32.4(28.4-36.4)	87.1(85.2-88.9)
No	5.9(4.5-7.3)	0.4(0.0-0.9)	12.9(11.0-14.7)
Distance from the vaccination site			
No	63.3(60.4-66.2)	32.5(28.5-36.5)	69.3(66.8-71.7)
Yes	10.9(9.0-12.8)	0.2(0.0-0.5)	30.7(28.2-33.1)
Belief in vaccination by the mother/child's caregiver			
No	58.8(55.8-61.8)	26.8(23.1-30.5)	10.1(8.4-11.7)
Yes	15.4(13.3-17.5)	6.0(4.0-8.0)	89.9(88.1-91.6)
Ignorance of the need for vaccination			
No	67.8(64.9-70.7)	29.3(25.5-33.1)	37.2(34.7-39.6)
Yes	6.4(4.9-7.9)	3.5(2.0-5.0)	62.8(60.3-65.2)
Knowledge of the vaccination schedule			
No	70.5(67.7-73.3)	32.5(28.5-36.5)	91.5(90.0-92.9)
Yes	3.7(2.6-4.8)	0.2(0.0-0.5)	8.5(7.0-9.9)

Table II shows variations in BESD indicators among caregivers of zero-dose children in Mai-Ndombe Province between 2021 and 2023. Reported vaccine availability increased from 68.3% in 2021 to 87.1% in 2023, while distance-related barriers rose from 10.9% to 30.7%. Belief in vaccination increased to 89.9% in 2023. However, the proportion of caregivers reportedly lacking knowledge of the vaccination schedule increased from 70.5% in 2021 to 91.5% in 2023, suggesting major gaps in awareness-raising activities. Furthermore, 62.8% were classified as unaware of the need for vaccination in 2023. Overall, these findings highlight important gaps in mothers' and caregivers' knowledge of vaccination (Table II).

3. Evolution of the prevalence of zero-dose children from 2021-2023

In 2021, 56.2% of children in this age group received zero doses. In 2022, this prevalence decreased drastically to 22.4%, a reduction of more than 30%. In 2023, the prevalence increased again to 29.0%, but it remains significantly lower than the level observed in 2021 (Figure 2).

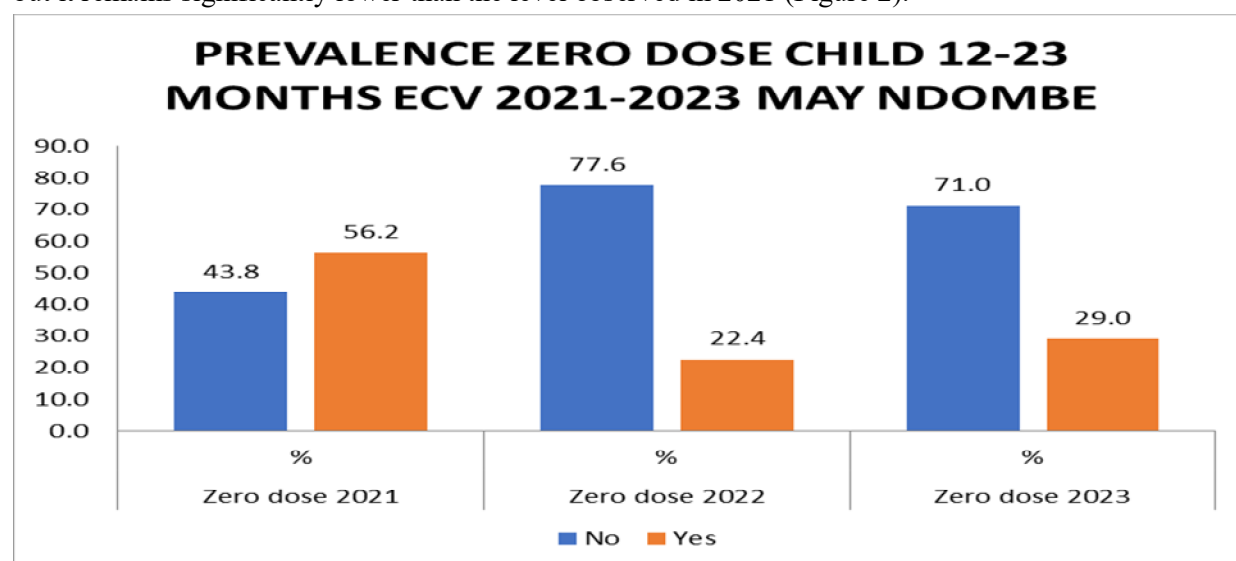


Figure 2. Prevalence of zero-dose children aged 12–23 months in Mai-Ndombe Province, 2021–2023 (“Yes” indicates zero-dose status).

4. Factors associated with zero-dose status in children aged 12-23 months from 2021-2023

Table III shows that the factors associated with zero-dose status varied across the three ECV periods. In 2021, being non-Christian increased the odds of having a zero-dose child by a factor of 1.28 (AOR = 1.28; 95% CI: 1.05–1.57). In 2022, low and medium socioeconomic status were associated with lower odds of zero-dose status, with AOR values of 0.07 and 0.20, respectively, whereas having no occupation increased the odds by a factor of 2.63 (AOR = 2.63; 95% CI: 2.04–3.39). Being non-Christian was associated with lower odds in 2022 and 2023, with AOR values of 0.49 and 0.72, respectively. In 2023, having a mother or caregiver younger than 30 years was associated with lower odds of zero-dose status (AOR = 0.57; 95% CI: 0.46–0.70). (Table III).

Table III. Factors associated with zero-dose status among children aged 12–23 months in Mai-Ndombe Province, 2021–2023 (adjusted odds ratios)

Variables and categories	aOR (95% CI), 2021	aOR (95% CI), 2022	aOR (95% CI), 2023
Household socioeconomic status			
Low	1.68 (0.62–4.57)	0.07 (0.06–0.09)*	1.06 (0.86–1.31)
Medium	2.38 (0.78–7.23)	0.20 (0.15–0.28)*	1.03 (0.81–1.30)
High	1	1	1
Mother's/caregiver's age			
< 30 years	0.93 (0.76–1.15)	1.08 (0.84–1.39)	0.57 (0.46–0.70)*
≥ 30 years	1	1	1
Relationship to the child			
Guardian/other respondent	1.51 (0.86–2.65)	0.15 (0.02–1.09)	0.77 (0.50–1.18)
Biological mother	1	1	1
Marital status			
Not in a union	1.40 (1.00–1.95)	0.18 (0.08–0.41)*	0.77 (0.41–1.45)
In a union	1	1	1
Educational level			
No formal education	1.06 (0.67–1.67)	0.84 (0.67–1.06)	0.90 (0.27–2.99)
Formal education	1	1	1
Occupation			
No occupation	0.87 (0.67–1.14)	2.63 (2.04–3.39)*	0.65 (0.38–1.10)
Employed	1	1	1
Religion			
Non-Christian	1.28 (1.05–1.57)*	0.49 (0.37–0.64)*	0.72 (0.58–0.89)*
Christian	1	1	1

Abbreviations: aOR, adjusted odds ratio; 95% CI, 95% confidence interval; * : Sig

IV. Discussion

1. Key Results

This study examined the sociodemographic and economic factors associated with zero-dose status among children aged 12–23 months in Mai-Ndombe Province, Democratic Republic of the Congo (DRC), between 2021 and 2023. The prevalence of zero-dose status fluctuated considerably, declining from 56.2% in 2021 to 22.4% in 2022 before increasing to 29.0% in 2023. Despite this subsequent increase, the

prevalence remained substantially below the level observed in 2021. These variations highlight persistent inequalities in vaccination coverage and the need for context-specific immunization strategies (10–12).

Multivariate analyses revealed temporal variations in the factors associated with zero-dose status. In 2021, being non-Christian was associated with 1.28 times higher odds of having a zero-dose child (aOR = 1.28; 95% CI: 1.05–1.57). In 2022, low and medium socioeconomic

status were associated with lower odds of zero-dose status (aOR = 0.07 and 0.20, respectively), whereas having no occupation was associated with 2.63 times higher odds (aOR = 2.63; 95% CI: 2.04–3.39). Being non-Christian was associated with lower odds in 2022 and 2023 (aOR = 0.49 and 0.72, respectively). In 2023, having a mother or caregiver younger than 30 years was associated with lower odds of zero-dose status (aOR = 0.57; 95% CI: 0.46–0.70). These findings underscore the importance of adapting vaccination interventions to changing local circumstances (13–15).

2. Evolution of Zero-Dose Prevalence Among Children Aged 12–23 Months in Mai-Ndombe Province (2021–2023)

The evolution of zero-dose prevalence among children aged 12–23 months in Mai-Ndombe Province between 2021 and 2023 showed substantial fluctuations. In 2021, 56.2% of children were classified as zero-dose, a proportion that declined markedly to 22.4% in 2022 before increasing to 29.0% in 2023. Despite this rebound, the prevalence remained considerably below the 2021 level. Similar patterns were reported by Elmi A, et al. in Ethiopia (15), who highlighted the vulnerability of vaccination programmes during crises, and by Ibrahim UM et al. in Nigeria (16), who documented disruptions associated with conflict and weak health infrastructure.

When compared to the results of the Democratic Republic of Congo's national immunization surveys conducted between 2021 and 2023 (6–8), the trends observed in Mai-Ndombe province show notable differences. While national surveys indicated an increase in zero-dose prevalence from 9.2% in 2020 to 12.7% in 2021, and reaching 18.8% in 2022 among children aged 6 to 23 months, our study—focused specifically on children aged 12 to 23 months—revealed a prevalence of 41.8% in 2021, decreasing to 22.1% in 2022, before rising again in 2023. These discrepancies are likely explained by differences in the age groups analyzed, as national surveys included younger infants. This methodological distinction underscores the importance of targeting analyses

to specific age groups in order to better inform immunization policies (12–14).

3. Factors Associated with Zero-Dose Status Among Children Aged 12–23 Months in Mai-Ndombe Province (2021–2023)

The multivariable analysis showed that factors associated with zero-dose status varied between 2021 and 2023, suggesting that immunization inequalities may reflect different social and contextual circumstances over time. In 2021, non-Christian religious affiliation was associated with higher odds of zero-dose status. In Mai-Ndombe Province, geographical dispersion, differences in community engagement and potential barriers to accessing health facilities may complicate the delivery of routine immunization. Although these contextual factors were not directly assessed in the present analysis, they provide relevant avenues for interpreting the findings. Similarly, Elmi et al. (15), in urban areas of Ethiopia's Somali region, identified maternal and household-related factors, including absence of antenatal care, home delivery and restrictions on decision-making regarding vaccination, as factors associated with zero-dose status. Their findings also highlighted the concentration of zero-dose children in underserved urban areas where vaccination strategies relied heavily on health facilities. These results emphasize that immunization gaps may reflect both household circumstances and the organization and accessibility of health services.

In 2022, the associations observed in Mai-Ndombe changed. Lower household socioeconomic status and being outside a marital union were associated with lower odds of zero-dose status, whereas having no occupation was associated with higher odds. Non-Christian religious affiliation was also associated with lower odds, contrasting with the association observed in 2021. These unexpected variations should be interpreted cautiously because the available data do not establish the mechanisms underlying them. Evidence from northeastern Nigeria further illustrates the importance of context. Ibrahim et al. (16), studying nomadic and non-nomadic Fulani communities in Yobe

State, found substantial differences in zero-dose status between the two populations. The absence of a vaccination card was significantly associated with zero-dose status in both groups, while parental vaccine hesitancy was associated with markedly higher odds of non-vaccination. Although these findings cannot be directly extrapolated to Mai-Ndombe, they underline the relevance of caregiver attitudes, vaccination documentation and population-specific barriers when interpreting immunization inequalities.

In 2023, maternal or caregiver age below 30 years and non-Christian religious affiliation were associated with lower odds of zero-dose status in Mai-Ndombe. The changing direction or statistical significance of associations across the three years indicates that the factors identified were not consistent over time. Differences between the Congolese, Ethiopian and Nigerian findings may reflect variations in population characteristics, mobility, social organization and healthcare accessibility, as well as differences in study design and measurement. Consequently, findings from other countries should inform comparison rather than serve as direct explanations for the local results. In Mai-Ndombe, locally adapted vaccination outreach, improved identification and follow-up of children, caregiver engagement and collaboration with community and religious leaders may help address immunization gaps. Further qualitative and longitudinal research is needed to clarify the observed temporal variations and investigate barriers that were not captured in the secondary dataset.

4. Strengths and Weaknesses of the Study

The study on factors associated with zero-dose status among children aged 12 to 23 months in Mai-Ndombe province (2021–2023) presents several methodological and analytical strengths. Covering a three-year period, it enables the monitoring of trends in vaccination coverage over time. The use of rigorous multivariate analysis, preceded by chi-square testing, provides a nuanced understanding of the interactions between sociodemographic and economic variables. By focusing on a specific province, the study generates targeted evidence

that can guide local interventions, while also allowing for contextualization through international comparisons with similar research conducted in Ethiopia and Nigeria. Its identification of the most vulnerable groups further enhances its relevance for shaping health policies and prioritizing resources.

Nonetheless, certain limitations should be acknowledged. The age range studied (12–23 months) differs from that used in national immunization surveys (6–23 months), which may complicate direct comparisons. Reliance on self-reported data introduces potential recall bias and social desirability bias. Moreover, the restriction to a single province limits the generalizability of findings to the national level. Finally, important contextual factors—such as access to health infrastructure, awareness campaigns, and cultural practices—were not explored, which may reduce the explanatory power of the analysis.

Conclusion

Analysis This secondary analysis of zero-dose status among children aged 12 to 23 months in Mai-Ndombe (2021–2023) reveals marked fluctuations, with a decline in 2022 followed by increase in 2023. Sociodemographic factors such as maternal education, occupation, and household economic status remain key determinants of vaccination coverage. Although limited to one province, the findings provide valuable evidence for designing targeted, context-specific interventions. To strengthen explanatory power, future research should expand secondary analyses across multiple provinces and incorporate additional variables such as infrastructure access, cultural practices, and awareness initiatives. Ultimately, a longitudinal study will be necessary to identify the true causal pathways behind these variations and to guide sustainable, equity-focused immunization strategies at both provincial and national levels.

Acknowledgements

We are grateful to the Ethics Committee of the Kinshasa School of Public Health for approving

the study protocol. We also thank the local facilitator for their ongoing involvement throughout the data collection process.

Disclaimer

The views expressed in this article are those of the authors and do not necessarily reflect the official position of the Kinshasa School of Public Health.

Ethics Statement

Ethics approval was obtained from the Ethics Committee of the Kinshasa School of Public Health and written informed consent was obtained from all participants involved in the study.

Data Availability

The data supporting the findings of this study are available from the corresponding author upon reasonable request.

Funding

This study received no specific external funding. It was carried out using internal resources mobilized by the researchers, with methodological support from the Kinshasa School of Public Health.

Authorship Contributions

- **Mumpubi Christian:** Principal investigator; study design, drafting of the initial manuscript protocol.
- **Nkongolo Bernard-Kennedy:** Statistical analyses and interpretation of results; critical review of scientific content.
- **Nkamba Dalau:** Lead promoter and facilitator; support for planning, stakeholder mobilization, and administrative support.

Disclosure of Interest

The authors completed the ICMJE Disclosure of Interest Form (available upon request from the corresponding author) and declare no relevant interests.

Declaration of Generative AI and AI-Assisted Technologies:

Generative AI and AI-assisted

tools were used to assist with language editing, grammar correction, and improvement of the clarity and readability of the manuscript. The authors reviewed and revised the AI-assisted content and take full responsibility for the accuracy, originality, integrity, and final content of the article. AI tools were not considered authors and were not assigned authorship.

References

1. World Health Organization. (2005). Global immunization vision and strategy 2006–2015. World Health Organization. <https://www.who.int/publications/i/item/WHO-IVB-05.05>
2. Gavi, the Vaccine Alliance. (2020). Reaching zero-dose children. <https://www.gavi.org/our-alliance/strategy-2016-2020/zero-dose-children>
3. UNICEF. (2023). The State of the World's Children 2023: For every child, vaccination. UNICEF Innocenti – Global Office of Research and Foresight. <https://www.unicef.org/reports/state-worlds-children-2023>
4. World Health Organization. (2023). Immunization coverage. <https://www.who.int/news-room/fact-sheets/detail/immunization-coverage>
5. World Health Organization. (2021). Immunization Agenda 2030: A global strategy to leave no one behind. World Health Organization. <https://www.who.int/teams/immunization-vaccines-and-biologicals/strategies/ia2030>
6. Kinshasa School of Public Health. (2021). Vaccination coverage survey among children aged 6–23 months in the Democratic Republic of the Congo. Kinshasa School of Public Health.
7. Kinshasa School of Public Health. (2022). Vaccination coverage survey among children aged 6–23 months in the Democratic Republic of the Congo. Kinshasa School of Public Health.
8. Kinshasa School of Public Health. (2023). Vaccination coverage survey among children aged 6–23 months in the Democratic

- Republic of the Congo. Kinshasa School of Public Health.
9. Ministry of Public Health, Democratic Republic of the Congo. (2018). Emergency plan for the resumption of routine immunization (MASHAKO Plan). Expanded Program on Immunization.
 10. Ntambue Malu, E., Magazani, A. N., Kasonga, J. B., Mudipanu, A., Kabamba Nzaji, M., Ishoso, D. K., & Nkamba, D. M. (2024). Correlates of zero-dose status among children aged 12–23 months in the Luambo Health District, Democratic Republic of Congo: A matched case-control study. *Vaccines*, 12(7), Article 700. <https://doi.org/10.3390/vaccines12070700>
 11. Acharya, P., Kismul, H., Mapatano, M. A., & Hatl, A. (2020). Determinants of child immunization in the United States: A multilevel analysis. *BMC Public Health*, 20, Article 86.
 12. Nchinjoh, S. C., Saidu, Y., Muteh, N. J., Njoh, A. A., Ndoula, S. T., Nsah, B., Edwige, N. N., Roberman, S., & Zamir, C. S. (2022). Factors associated with zero-dose childhood vaccination status in a remote fishing community in Cameroon: A cross-sectional analytical study. *Vaccines*, 10(12), Article 2052. <https://doi.org/10.3390/vaccines10122052>
 13. World Health Organization. (2022). Routine immunization and catch-up for zero-dose children. World Health Organization.
 14. Gavi, the Vaccine Alliance. (2023, July 28). New funding boosts efforts to vaccinate “zero-dose” children in the Democratic Republic of the Congo. <https://www.gavi.org/news/media-room/new-funding-boosts-efforts-vaccinate-zero-dose-children-democratic-republic-congo>
 15. Elmi, A., Ibrahim, M., Farah, A., Tahir, A., Muktar, A., & Abdilahi, A. M. (2026). Prevalence of zero-dose vaccination and associated factors in urban areas of the Somali region, Ethiopia: A mixed-methods approach. *BMJ Public Health*, 4(3). <https://doi.org/10.1136/bmjph-2025-003980>
 16. Ibrahim, U. M., Abdulhamid, D., Kofi, B., Wade, M. M., Danzomo, A. A., Audu, S., Muhammad, N., Namadi, F. A., Shehu, U. L., Jalo, R. I., Tsiga-Ahmed, F. I., Lisanework, S., Jibril, M., Gajida, A. U., & Jibo, A. M. (2024). Prevalence and factors associated with zero-dose children amongst nomadic and non-nomadic Fulani in Yobe State, North-East Nigeria. *Nigerian Medical Journal*, 65(5), 775–791. <https://doi.org/10.60787/nmj.v65i5.545>