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Dropout from the pentavalent vaccine series among children aged 12–23 months in the Central African Republic: prevalence, associated factors, and caregiver-reported barriers

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ABSTRACT

Background: Routine childhood immunization in the Central African Republic (CAR) is inconsistent due to reasons including political instability and service disruptions. This study assessed dropout between the first and third pentavalent doses among children aged 12–23 months who had received Penta 1, identified associated risk factors, and explored caregiver-reported barriers. Additional dropout indicators within this cohort—specifically from Penta 1 to Penta2, from Penta2 to Penta 3, and from Penta 3 to measles—were also examined to support contextual interpretation.

Methods: We conducted a cross-sectional household survey from December 2023 to March 2024, based on a nationally representative sample covering all seven health regions and 35 districts of the CAR. This secondary analysis focused on dropout between key vaccine doses among children aged 12–23 months and was conducted using Stata 17. Data were collected through structured interviews with caregivers, with vaccination status primarily verified using home-based records; when unavailable, health facility data or caregiver recall were used. Survey-weighted logistic regression models were used to identify factors associated with vaccine dropout. Reasons for non-vaccination were analyzed thematically using the adapted WHO BeSD framework.

Results: Among 4121 children aged 12–23 months who had received Penta 1, the national prevalence of dropout between the first and third doses of the pentavalent vaccine was 34.5% (95% CI: 32.4–36.6). Additionally, among these children, we observed 17.0% dropout from Penta 1 to Penta2, 17.5% from Penta2 to Penta 3, and 15.8% from Penta 3 to the measles-containing vaccine. Higher odds of dropout between Penta 1 and Penta 3 were associated with households lacking television (aOR: 2.98; 95% CI:1.88–4.72), absence of birth registration (aOR:1.56; 95% CI:1.26–1.94) and caregivers engaged in agricultural activities (aOR:3.45; 95% CI:1.85–6.44). Primary reported reasons for non-vaccination included access barriers such as distance to the vaccination site

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(30.9%) and vaccine stockouts (14.0%), contextual and household challenges like caregiver time constraints (29.7%) and family-related problems (10.8%), information gaps including lack of knowledge about the vaccination schedule (27.3%), and motivational concerns such as fear of side effects (10.4%) and distrust in vaccines (2.9%).

Conclusion: In the CAR, 34.5% of children who receive the first pentavalent dose fail to complete the three dose vaccination series. Improving follow-up and adapting services to overcome local barriers is essential to increase rates of complete immunization.

1. Introduction

Vaccinating children early in life is still one of the most powerful ways to confer protection from infectious diseases and prevent avoidable deaths. Among the first vaccines administered, the diphtheria–tetanus–pertussis (DTP) series—usually given in three doses—offers essential protection against three dangerous illnesses [1]. In many low- and middle-income countries (LMIC), including those in sub-Saharan Africa, DTP is delivered as part of the pentavalent vaccine, which also covers hepatitis B and *Haemophilus influenzae* type b (Hib).

Even though progress has been made, many children, particularly in resource-limited areas, do not receive all the recommended doses of vaccines following their national routine immunization schedule [2]. While some remain entirely unvaccinated, many others start but do not finish the three dose pentavalent series, a scenario commonly referred to as dropout [3]. The Penta 1-Penta 3 dropout rate, which measures the gap between the first and third doses, serves as a key indicator of how well immunization programs can maintain follow-up and ensure completion [4].

Dropout can result from various challenges, including weaknesses in service delivery, difficulties faced by caregivers, and broader social or environmental barriers. Factors such as long travel distances, poverty, low levels of education, fear of vaccine side effects, and irregular access to health services have been linked to incomplete vaccination in several sub-Saharan African settings characterized by constrained resources, geographic barriers, and fragile health systems. [5–7].

In the Central African Republic (CAR), a country marked by recurrent crises and persistent health system fragility, immunization coverage remains among the lowest in the world. The national immunization program follows the WHO-recommended schedule, with three doses of the pentavalent vaccine administered at 6, 10, and 14 weeks of age, and a measles-containing vaccine (MCV1) given at 9 months. However, routine vaccination coverage remains low, with 2022 WHO/UNICEF estimates showing 65% coverage for the first pentavalent dose (Penta 1), 51% for Penta 3, and only 42% for MCV1 [8]. The country continues to report sporadic outbreaks of vaccine-preventable diseases, with rising incidence of diphtheria and persistent cases of pertussis and neonatal tetanus [9]. These immunization gaps highlight the need to better understand why some children fail to complete their vaccination schedule and to design strategies that improve follow-up and series completion.

Despite efforts by the government and international partners—including repeated supplemental immunization campaigns—the uptake of essential vaccines like pentavalent remains far below global targets [2,4]. In this context, tracking dropout across the primary vaccine series becomes critical for assessing program performance. The dropout between the first and third doses of the pentavalent vaccine (Penta 1–Penta 3) is widely used as a standardized indicator by WHO and national immunization programs to measure the ability of health systems to ensure continuity of care. It captures children who were initially reached by the system but failed to return, signaling missed opportunities for engagement.

Although zero-dose children have been at the center of many global strategies to address under-immunization, those who drop out after receiving at least one dose are often overlooked by public health interventions. Yet these children may represent a more actionable group: they have already been in contact with the system and might be more easily reached again. Understanding the reasons behind this incomplete vaccination, and the barriers caregivers face after initial contact, is essential to closing the immunization gap. Identifying and addressing dropout can help relink families to health services and support more resilient vaccination coverage.

This study sought to use nationally representative data from the 2023–2024 CAR Vaccine Coverage Survey (VCS) to: (i) estimate the prevalence of pentavalent dropout among children aged 12–23 months; (ii) examine factors associated with pentavalent dropout; and (iii) explore the reasons reported by caregivers for not completing the routine immunization schedule.

2. Materials and methods

2.1. Study design

This was a cross-sectional, population-based survey conducted from December 2023 to March 2024 using a revised WHO methodology adapted to the country's context [10], aiming to assess routine immunization coverage among children aged 6–23 months across all seven health regions (HR) and 35 health districts (HD) of the CAR. Here we present a secondary analysis of the survey data, focusing on children aged 12–23 months. In total, 6909 children aged 6–23 months were surveyed, of which 4138 were aged 12–23 months and retained for analysis.

The sampling followed a two-stage cluster design, stratified by region and district. In each district, 13 enumeration areas, considered as primary sampling units, were selected by simple random sampling. Within each enumeration area, 15 households with at least one child aged 6–23 months were systematically selected, yielding a total of 6825 households across 455 clusters. All eligible children within sampled households were included.

2.2. Data collection

Data were collected in both local languages and French using structured questionnaires administered via tablets through the SurveyCTO platform. Interviews were conducted with household members and health personnel. Vaccination information was collected from home-based records (HBRs), also called vaccination cards, kept by the caregiver. For children without records, data was retrieved from health facility registers when available, or via caregiver recall. GPS coordinate collection and daily data quality checks were integrated into the survey instruments.

The primary outcome was dropout from the pentavalent vaccine series, defined as having received the first dose of the pentavalent vaccine (Penta 1) but not the third dose (Penta 3). Beyond vaccination status, demographic variables, socioeconomic indicator variables, and healthcare knowledge, attitudes, and practice questions were collected.

For children who had missed at least one vaccine dose in the routine immunization schedule, caregivers were asked to report the main reason for non-vaccination. These responses were not collected using a standardized WHO BeSD instrument. Rather, in this secondary analysis, they were grouped a posteriori into four thematic categories conceptually informed by the WHO's Behavioral and Social Drivers (BeSD) framework (2022) [11], while reflecting the context-specific nature of the survey

data. The four domains included: motivation and beliefs (e.g., fear of side effects, reluctance), social influences (e.g., lack of family support), practical or service-related barriers (e.g., distance to health facility, vaccine stockouts), and information and awareness gaps (e.g., lack of knowledge about follow-up doses). This analytic grouping was used to facilitate interpretation of caregiver-reported reasons for dropout from the pentavalent vaccine series and to capture structural, behavioral, social, and informational dimensions of incomplete immunization, rather than to validate a new measurement tool.

2.3. Statistical analysis

All statistical analyses were conducted using Stata version 17, accounting for the complex sampling design. The svyset command was used to define the primary sampling units, stratification by HR, and individual sampling weights (Ponderation). A univariate description was performed for socio-demographic, economic, contextual, and behavioral variables. Weighted proportions were calculated for all variables, and 95% confidence intervals were reported only for the outcome: dropout between the first and third doses of the pentavalent vaccine, using the Taylor-linearized standard error method. In addition to the primary outcome (dropout between Penta 1 and Penta 3), we also calculated dropout rates between Penta 1 and Penta2, Penta2 and Penta 3, and between Penta 3 and MCV1 among children who had received Penta 1, to provide complementary descriptive insights.

Survey-weighted bivariate logistic regressions (svy: logistic) were used to examine associations between each predictor and the outcome. Global and individual Wald tests were applied for categorical variables. Variables with a p-value < 0.20 or with programmatic relevance were retained for multivariable modeling.

A full multivariable model was initially fitted, including relevant variables at the child, caregiver, household head, and household levels. The "household head's age group" was removed due to high multicollinearity (VIF > 60), with similar information captured by caregiver age. Access to television, radio, and internet—though part of the wealth index—were included separately to assess exposure to information; they showed no collinearity and were retained for their relevance. A backward elimination procedure was used to refine the model, and adjusted odds ratios (aORs) with 95% confidence intervals were reported ($p < 0.05$). Model fit was assessed using the Archer–Lemeshow test for complex surveys. To address data hierarchy, a multilevel logistic model with random intercepts for health regions was also tested. The intraclass correlation coefficient (ICC = 0.50) confirmed substantial clustering. Although some differences in significance arose, both models showed similar patterns. Main interpretations rely on the survey-weighted model due to its representativeness.

Additionally, descriptive analyses were conducted on the reasons for missed vaccination among children who dropped out between Penta 1 and Penta 3. For each binary response variable, weighted frequencies and proportions were estimated. To enhance interpretability, similar reasons were grouped thematically into four categories inspired by the WHO BeSD framework and adapted to the local context: access-related barriers, information-related gaps, motivation and belief factors, and contextual or household-level constraints. A summary figure was produced, ranking these reasons by frequency while preserving their thematic grouping.

2.4. Ethical considerations

The national vaccination coverage survey protocol obtained prior ethical approval from several ethics' committees, including the Comité d'Éthique de l'Université de Bangui (Ref. 47/UB/FACSS/IPB/CES/2023) and the Institutional Review Board of the University of California, Los Angeles (IRB#23-001839). The protocol and all data collection instruments were reviewed and approved by the national Vaccine Coverage Survey Steering Committee, the Ministry of Health and Population, the WHO country and Geneva offices, UNICEF, the Gavi Alliance, the University of Bangui, the Institut Pasteur de Bangui, and the Central African Institute of Statistics and Economic and Social Studies (ICASEES).

Approval for fieldwork was obtained from the Ministry of Health, and official correspondence was sent to local administrative and health authorities before the commencement of data collection. Survey teams acquainted themselves with district and community leaders at the onset of field activity.

Informed verbal agreement was secured from all caregivers before participation. The survey processes were articulated in the relevant local language, and participation was optional. No names or personal identifiers are present in any publicly disseminated dataset or report. While names were initially employed during data collection to validate vaccination records in health facility registers, all data were anonymized before analysis, and access to the data server was limited to authorized personnel exclusively.

3. Results

3.1. Socio-economic and demographic profile of households, heads of household, and caregivers

Most households were in rural areas (59.2%) and were relatively evenly distributed across the five wealth quintiles. Approximately 77% of households had one or two children under five years old. Access to communication tools was limited: only 8.6% had internet access, 10.3% owned a television, and 31.7% had a radio. Birth registration coverage was low at 36.7%, and 24.8% of households reported having paid for at least one vaccination-related service (Table 1).

Household heads were predominantly male (88.3%), aged between

Table 1a
Socio-economic and demographic profile of households, heads of household, and caregivers. (a) Household socio-economic, communicational, and system-related characteristics.

Variable	n	Weighted%
Place of residence	4138	
Urban	1600	40.9
Rural	2538	59.2
Wealth quintile	4138	
Lowest quintile	887	20.8
Lower quintile	794	17.4
Middle quintile	807	18.7
Higher quintile	835	19.9
Highest quintile	815	23.3
Number of children <5 years	4138	
1–2	3139	76.7
3	999	23.3
Internet access	4138	
Yes	261	8.6
Presence of television	4138	
Yes	315	10.3
Radio present	4138	
Yes	1193	31.7
Birth registration	4138	
Yes	1386	36.7
Have paid for vaccination	4138	
Yes	855	24.8

With: n = number of subjects; y = years; Weighted % = weighted percentage.

30 and 49 years, and most were married or in a union (86.8%). About 25% had never attended school, while 29.1% had reached secondary education. More than half were engaged in agriculture, fishing, or related activities (56.4%), and the most common religion was Protestantism (54.3%) (Table 1b).

Most caregivers were women aged 20–39 years (87.0%). A substantial proportion (37.3%) had never been to school, and 58.5% were engaged in agriculture or similar work. Protestantism was also the most common religion among caregivers (56.5%). Most caregivers (77.6%) were aware of at least one vaccine-preventable disease. In 94.4% of cases, the interviewed caregiver was the child's mother. The sex distribution of children was balanced (Table 1c).

3.2. Pentavalent vaccine dropout rate

The weighted dropout rate between the first and third doses of the pentavalent vaccine among children aged 12–23 months was 34.5% (95% CI: 32.4–36.6%). This proportion varied considerably across health regions. The health regions with dropout rates above the national average included: HR2 (47.6%), HR3 (43.3%), HR5 (51.8%), and HR6 (52.2%). In contrast, HR7, which is primarily the capital city of Bangui, had the lowest dropout rate at 8.1% (Fig. 1).

Although not the primary focus of this analysis, a cascade-style chart was generated to illustrate the vaccination pathway among children who received Penta 1. Of these, 83% proceeded to Penta 2, 65.5% to Penta 3, and 49.7% eventually received MCV1. Dropout rates between each step were 17%, 17.5%, and 15.8%, respectively, indicating progressive attrition across the vaccination schedule (Fig. 2).

Table 1b
Socio-economic and demographic profile of households, heads of household, and caregivers. (b) Socio-demographic characteristics of the head of household.

Variable	n	Weighted%
Age groups	4138	
Under 20	16	0.4
20–29 years old	1099	26.6
30–39 years old	1568	37.9
40–49 years old	988	23.2
50 and over	467	11.9
Gender	4138	
Male	3660	88.3
Female	478	11.7
Current marital status	4138	
Married/common-law	3591	86.8
Single	280	7.0
Widowed	130	3.1
Separated	121	2.7
Divorced	16	0.4
Level of education	4135	
Never been to school	1155	26.5
Primary	1687	38.7
Secondary	1123	29.1
Higher	170	5.7
Profession	4138	
Farmer/livestock breeder/fisher	2499	56.4
Trader	481	12.4
Other (informal crafts...)	354	10.0
Manual laborer	345	8.7
Civil servant	140	4.1
None	130	3.6
Pupil/Student	69	1.9
Teacher	63	1.6
Health care provider	57	1.4
Religion	4133	
Protestant	2170	54.3
Catholic	1102	27.2
Muslim	339	6.8
Revival/independent church	261	6.2
Other (Adventists…)	169	3.3
No religion	66	1.6
Kimbanguist	17	0.5
Animist	9	0.2

With: n = number of subjects; y = years; Weighted % = weighted percentage.

Table 1c
Socio-economic and demographic profile of households, heads of household, and caregivers. (c) Socio-demographic characteristics of caregivers and gender.

Variable	n	Weighted%
Age group	4138	
Under 20	325	7.8
20–29 years old	2409	58.6
30–39 years old	1181	28.3
40–49 years old	202	4.9
50 and over	21	0.4
Level of education	4132	
Never been to school	1666	37.3
Primary	1716	41.0
Secondary	710	20.2
Higher	40	1.5
Profession	4138	
Farmer/farmer/fisherman	2612	58.5
Shopkeeper	631	17.3
None	494	12.7
Pupil/Student	176	5.3
Other (informal crafts...)	179	5.2
Worker	22	0.6
Health care provider	12	0.3
Teacher	9	0.2
Civil servant	3	0.1
Religion	4132	
Protestant	2261	56.5
Catholic	1067	26.3
Revival/independent church	256	6.1
Muslim	304	6.1
Other (Adventist…)	190	3.7
No religion	28	0.7
Kimbanguist	15	0.4
Animist	11	0.3
Knowledge of at least one vaccine-preventable disease	4138	
Yes	3212	77.6
Relationship with child	4138	
Child's mother	3908	94.4
Child's father	123	2.9
Child's guardian	107	2.7
Child's sex	4138	
Male	2114	51.3
Female	2024	48.7

With: n = number of subjects; y = years; Weighted % = weighted percentage.

3.3. Factors associated with dropout between Penta 1 and Penta 3

Upon adjusting for potential confounding variables, the odds of dropping out between the first and third doses of the pentavalent vaccine were significantly higher in households without a television (aOR = 2.98; 95% CI: 1.88–4.72). The absence of birth registration was independently associated with increased odds of dropout (aOR = 1.56; 95% CI: 1.26–1.94). Moreover, children from homes where the head was involved in agriculture, animal husbandry, or fishing exhibited a heightened probability of dropout (aOR = 3.45; 95% CI: 1.85–6.44), relative to those with no specified employment (Table 2).

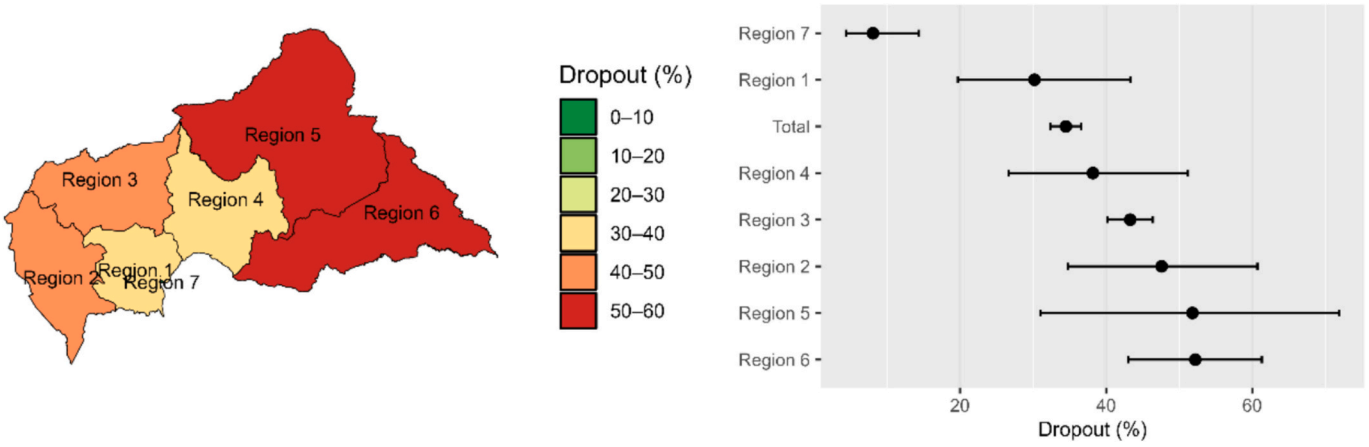

Fig. 1. Weighted dropout rate from Penta 1 to Penta 3 among children aged 12–23 months, by health region — Central African Republic, 2023 vaccination coverage survey.

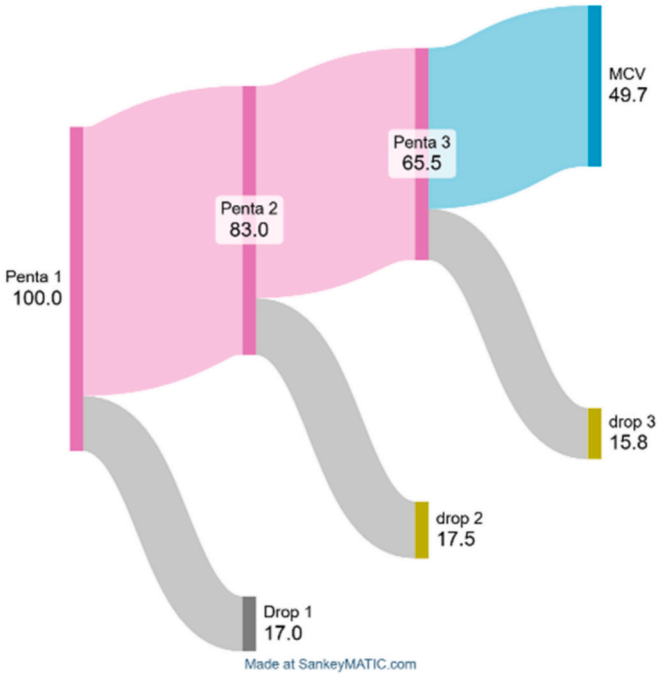

Fig. 2. Vaccination pathway among children who received Penta 1, illustrating sequential dropout through to measles vaccination— Central African Republic, 2023–2024 vaccination coverage survey.

3.4. Reported reasons for missed vaccination categorized by BeSD domains

Reported reasons for missed vaccination among children aged 12–23 months were organized according to the WHO's 2022 Behavioral and Social Drivers (BeSD) framework, which classifies demand-side determinants into four domains: access barriers, information-related barriers, motivation and beliefs, and contextual or household factors (Fig. 3).

Access-related issues emerged as a major driver of dropout. The most frequently cited reason was the distance to the vaccination site (30.9%), followed by vaccine stockouts (14.0%), long waiting times (7.0%), and inconvenient vaccination schedules (5.3%). These findings highlight persistent structural barriers within the immunization delivery system.

Contextual and household factors were also commonly mentioned. Nearly 30% of caregivers reported being too busy to bring the child for vaccination, and 10.8% cited family-related problems, including maternal illness. Additionally, about 3.6% of caregivers indicated that the child was sick or not vaccinated despite being present at the health facility.

Information-related barriers included a lack of awareness about the importance of vaccination or the need for multiple doses (27.3%) and insufficient knowledge of vaccination sites or schedules (16.0%). These results suggest significant gaps in communication and community education.

Motivational and belief-related factors were less frequently reported but remain relevant. These included fear of side effects (10.4%), distrust in vaccines (2.9%), and a negative influence from fathers or guardians (0.6%). No cases of religious restriction were reported.

4. Discussion

This study offers a rare national-level snapshot of vaccine dropout in the CAR, specifically for the pentavalent series among children aged 12–23 months. CAR currently faces serious health system weaknesses, political instability, and immunization access challenges. Our observed dropout rate of 34.5% reflects these challenges and serves as a call to action. While this rate exceeds the 10% threshold set by WHO, it suggests that many children have an initial interaction with the routine immunization system, however, are facing barriers to continued participation.

Compared to other countries facing similar challenges, the dropout rate in the CAR is notably high. In Kenya, for instance, a study reported a pentavalent dropout rate of 13.0% [12]. In Nigeria, the dropout rate has been estimated at 33.6% [13,14]. Other studies have shown rates in Ethiopia—ranging from 11.2% to 60.0% depending on the region [15,16]. In the Democratic Republic of the Congo (DRC), the national dropout rate between the first and third doses of the pentavalent vaccine was estimated at 22.9% in 2023, indicating that more than one in five children who started the pentavalent series did not receive all doses [17]. These disparities reflect underlying systemic challenges commonly observed in areas with fragile health infrastructure, logistical bottlenecks, and inconsistent follow-up mechanisms, which ultimately compromise routine immunization services. Even when children begin vaccination, completing the full series remains a challenge.

The cascade-style chart restricted to children who received Penta 1 highlights substantial dropouts across the immunization schedule. While initial access to services is high in this group, nearly half do not complete the series through to measles vaccination. This suggests that early uptake does not guarantee full adherence, emphasizing the importance of targeted strategies to sustain engagement beyond the first contact.

Table 2
Factors associated with dropout between Penta 1 and Penta 3 among children aged 12–23 months in the CAR.

Variable	Weighted% Dropout	Bivariate		Multivariate	
		OR (95% CI)	p	AOR (95% CI)	p
Place of residence			<0.001		
Urban	24.4	1.00			
Rural	46.9	2.74 (2.27–3.32)			
Wealth quintile			<0.001		
Lowest quintile	43.7	2.88 (2.15–3.86)			
Lower quintile	44.4	2.99 (2.20–4.05)			
Middle quintile	40.0	2.49 (1.86–3.33)			
Higher quintile	37.1	2.20 (1.65–2.94)			
Highest quintile	21.1	1.00			
Number of children <5 years			0.002		
1–2	32.7	1.00			
3	41.0	1.43 (1.14–1.78)			
Internet access			<0.001		
No	39.3	3.22 (2.18–4.75)			
Yes	15.6	1.00			
Presence of television			<0.001		
No	39.0	5.77 (3.77–8.84)		2.98 (1.88–4.72)	<0.001
Yes	10.0	1.00		1.00	
Radio present			<0.001		
No	40.3	1.97 (1.60–2.41)			
Yes	25.5	1.00			
Birth registration			<0.001		
Yes	23.7	1.00		1.00	
No	44.2	2.56 (2.11–3.11)		1.56 (1.26–1.94)	<0.001
Have paid for vaccination			<0.001		
No	38.6	1.61 (1.31–1.97)			
Yes	28.1	1.00			
Age group of the household head			0.941		
Under 20	41.9	1.00			
20–29 years old	33.5	0.70 (0.16–3.02)			
30–39 years old	35.5	0.76 (0.18–3.28)			
40–49 years old	34.5	0.72 (0.17–3.12)			
50 and over	33.8	0.71 (0.16–3.10)			
Gender of the household head			0.134		
Male	35.4	1.00			
Female	30.0	0.79 (0.58–1.08)			
Current marital status of the household head			0.172		
Married/common-law	35.5	1.00			
Separated	23.9	0.57 (0.30–1.10)			
Single	31.0	0.82 (0.57–1.17)			
Divorced	10.6	0.22 (0.03–1.74)			
Widowed	29.6	0.77 (0.42–1.42)			
Educational level of the household head			<0.001		
Never been to school	43.7	6.14 (3.51–10.73)			
Primary	42.9	5.97 (3.47–10.26)			
Secondary	27.0	2.93 (1.69–5.06)			
Higher	11.2	1.00			
Occupation of the household head			<0.001		
None	17.8	1.00		1.00	
Teacher	29.2	1.91 (0.76–4.80)		2.38 (0.90–6.31)	0.081
Civil servant	10.7	0.55 (0.24–1.27)		0.96 (0.39–2.39)	0.935
Farmer/livestock breeder/fisher	48.6	4.38 (2.41–7.99)		3.45 (1.85–6.44)	<0.001
Trader	22.3	1.33 (0.70–2.52)		1.47 (0.75–2.88)	0.265
Manual laborer	29.6	1.95 (1.00–3.80)		1.93 (0.97–3.83)	0.062

(*continued on next page*)

Table 2 (*continued*)

Variable	Weighted% Dropout	Bivariate		Multivariate	
		OR (95% CI)	p	AOR (95% CI)	p
Other (informal crafts…)	27.3	1.74 (0.90–3.36)		1.82 (0.91–3.63)	0.090
Pupil/Student	19.7	1.14 (0.46–2.83)		1.51 (0.58–3.92)	0.393
Health care provider	16.2	0.89 (0.34–2.37)		0.91 (0.34–2.45)	0.854
Religion of the household head			0.081		
None	34.4	1.00			
Catholic	29.5	0.80 (0.35–1.80)			
Protestant	36.7	1.10 (0.49–2.47)			
Kimbanguist	43.4	1.46 (0.34–6.35)			
Muslim	33.4	0.96 (0.41–2.22)			
Revival/Independent church	40.4	1.29 (0.52–3.20)			
Other (e.g., Adventist)	40.7	1.31 (0.51–3.33)			
Caregiver age range			0.550		
Under 20	32.9	1.00			
20–29 years old	33.2	1.02 (0.70–1.47)			
30–39 years old	37.5	1.22 (0.83–1.80)			
40–49 years old	35.7	1.14 (0.65–2.00)			
50 and over	33.8	1.04 (0.29–3.71)			
Caregiver's level of education			<0.001		
Never been to school	49.7	9.63 (3.10–29.90)			
Primary	37.7	5.90 (1.91–18.27)			
Secondary	18.1	2.15 (0.69–6.75)			
Higher	9.3	1.00			
Caregiver's profession			<0.001		
Civil servant/teacher	9.8	1.00			
No profession	26.5	3.33 (0.60–18.51)			
Farmer/livestock breeder/fisher	48.4	8.66 (1.18–63.62)			
Trader	22.1	2.62 (0.35–19.78)			
Manual laborer	20.1	2.32 (0.45–11.87)			
Other (informal crafts…)	20.5	2.38 (0.32–17.68)			
Pupil/Student	14.3	1.54 (0.20–11.73)			
Health care provider	22.5	2.69 (0.19–38.64)			
Religion of caregiver			0.060		
None	9.6	1.00			
Animist	21.7	2.62 (0.13–52.04)			
Catholic	30.2	4.09 (0.52–32.31)			
Protestant	36.5	5.43 (0.69–42.73)			
Kimbanguist	49.8	9.39 (0.84–105.53)			
Muslim	31.7	4.39 (0.55–35.15)			
Revival/independent church	41.2	6.63 (0.81–54.08)			
Other (Adventists…)	41.0	6.58 (0.79–54.50)			
Caregiver's knowledge of at least one vaccine-preventable disease			0.003		
No	42.4	1.47 (1.14–1.90)			
Yes	33.2	1.00			
Relationship to child			0.311		
Child's mother	34.2	1.00			
Child's father	42.6	1.43 (0.75–2.72)			
Child's guardian	43.5	1.48 (0.73–3.00)			
Child's sex			0.870		
Male	34.7	1.00			
Female	34.3	0.99 (0.82–1.19)			

With: OR = crude odds ratio; AOR = adjusted odds ratio; p = p-value; 95% CI = 95% confidence interval.

In our study, we also observed that certain household-level factors seemed to influence dropout. One of the strongest associations was the absence of a television at home, possibly because families in this situation have less access to health information and public messaging. The association observed for television ownership should not be interpreted narrowly as a television effect alone. In this context, it may also reflect broader inequalities in access to information channels, including radio, digital media, and mobile phone-based communication, which can shape awareness of vaccination schedules and the perceived importance of completing all recommended doses. A similar trend has been documented in Indonesia [18,19]. Another inflencial factor was whether the child had a birth certificate. Children without civil registration were more likely to have dropped out, echoing findings from the DRC [4], where lack of civil registration was similarly linked to under-vaccination. In both contexts, the lack of official documentation likely reflects broader patterns of marginalization and limited access to basic

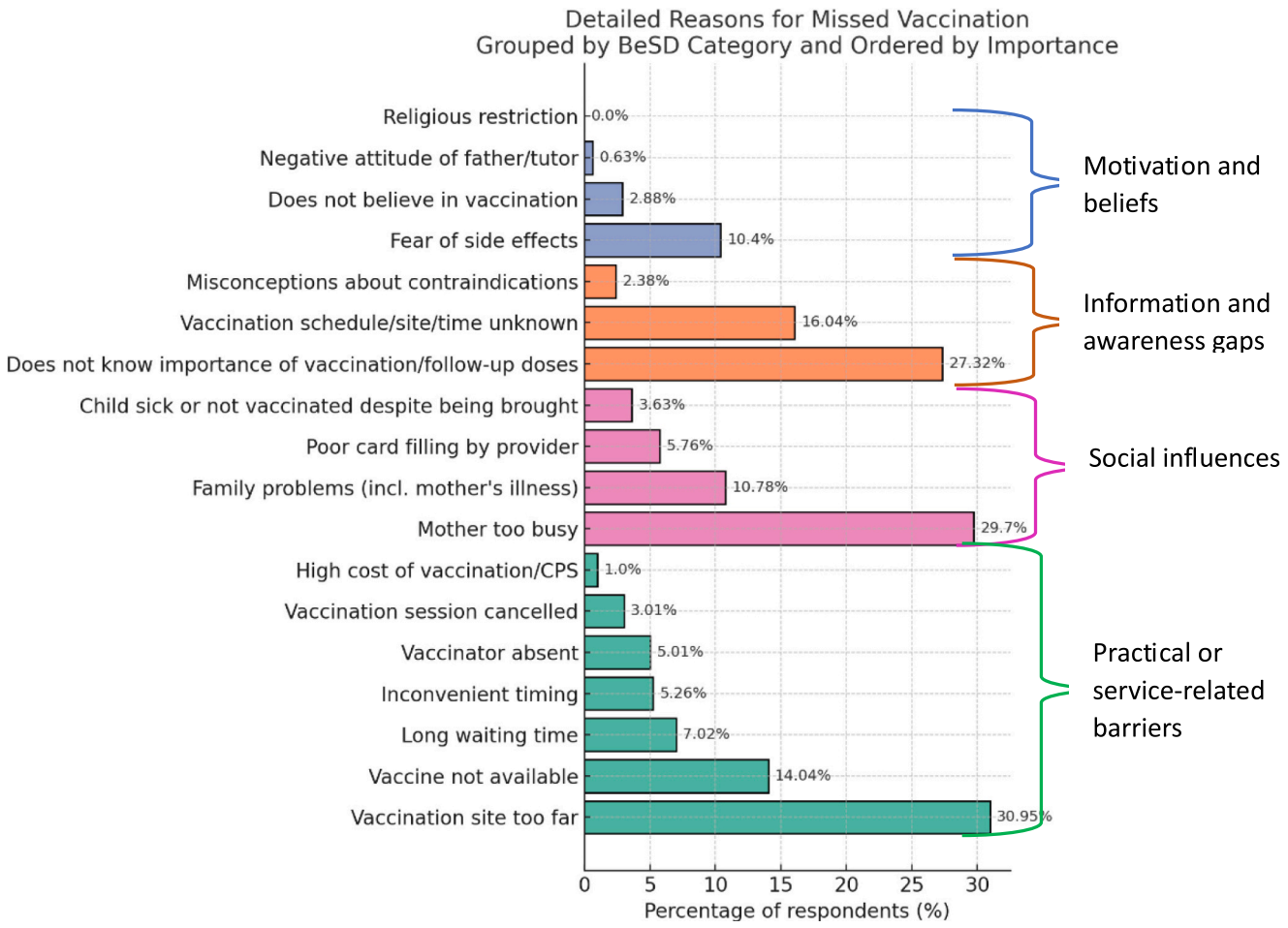

Fig. 3. Reported reasons for missed vaccination, grouped into thematic domains adapted from the BeSD framework.
Reasons were categorized into four contextual domains inspired by the WHO Behavioral and Social Drivers (BeSD) framework: access-related barriers, information gaps, motivational beliefs, and household-level or contextual constraints.

services, including routine immunization. Although the model identified specific variables such as lack of television ownership and absence of birth registration, these factors likely reflect broader forms of structural vulnerability and social marginalization that may limit continuity in routine immunization.

The type of work carried out by household heads also seemed to affect vaccination adherence. Families involved in small-scale farming, fishing, or raising livestock—jobs that are seasonal and physically demanding—were more likely to miss vaccination appointments. This observation is consistent with findings from Sub-Saharan Africa and rural Uganda, where subsistence activities and the burden of agricultural and domestic tasks often limit timely access to immunization services [20,21].

Finally, we looked at the reasons caregivers gave for not completing the vaccination schedule, using the WHO's BeSD framework. As observed in neighboring DRC [22], barriers related to access were the most common. About 31% of caregivers cited the long distance to health centers, and 14% reported vaccine stockouts. Other caregivers described organizational issues such as long waiting times, unknown vaccination schedules, or inconvenient service hours. These programmatic barriers are not unique to the CAR; similar patterns have been extensively documented across sub-Saharan Africa, including in Mozambique [23] and across multiple settings reviewed by Bangura et al. [24].

Our findings suggest that strategies to reduce dropout should be more directly aligned with the barriers reported by caregivers. Where distance to vaccination sites is a major obstacle, outreach approaches, mobile vaccination services, and more context-responsive microplanning may help improve access. Where caregiver time constraints are prominent, adapting service hours, improving the predictability of vaccination sessions, and reducing waiting times may be especially important. In addition, the substantial information gaps identified in this study suggest that improving service availability alone will not be sufficient. Immunization programs should also strengthen interpersonal counseling, community reminders, and simple messages emphasizing the importance of returning for all recommended doses after the first vaccine contact.

However, logistical problems alone do not fully explain dropout. Nearly 27% of caregivers in our study lacked knowledge about the need for multiple vaccine doses or responded that they were unaware of the vaccination schedule. Communication failures of this type reflect missed opportunities for interpersonal counseling and outreach, as highlighted in studies conducted in Ghana [25] and in a systematic review by Galadima et al. [26]. Knowledge gaps thus remain a major driver of incomplete vaccination even when services are accessible. In addition, a smaller yet notable proportion of caregivers cited fears of vaccine side effects, distrust in vaccines, or negative community rumors as reasons for discontinuation. Misinformation—sometimes propagated through religious or social networks—has been identified as a potent barrier in several African contexts [27–29].

These findings make it clear that vaccine dropout does not occur in a vacuum. It is not solely a question of service availability—it also involves parental trust, awareness, motivation, and system follow-up. Children who receive an initial vaccine dose but fail to complete their schedule have already come into contact with the health system,

presenting a valuable opportunity for recovery interventions [22,24].

Strengthening routine immunization contact points require concrete actions. Better tracking systems to identify and follow up with children missing doses are critical. Improvements in microplanning to adapt services to local realities, and greater community engagement through culturally sensitive communication strategies, are also needed. This approach is supported by evidence from interventions using mobile technology and community-based strategies in Nigeria [30] and maternal engagement studies in Uganda [31]. Programs that integrate service delivery improvements with proactive communication efforts have demonstrated greater success in boosting completion rates, as shown in Ethiopia by Tefera et al. [32] and in Southeast Ethiopia by Legesse and Dechasa [33].

This study has several limitations. First, its cross-sectional design does not allow causal inferences to be made about the relationship between the factors studied and pentavalent dropout. Second, recall bias is possible, particularly for children whose vaccination status relied solely on caregiver report in the absence of both home-based records and health facility register documentation. Third, in some insecure areas, data collection was limited to accessible locations, which may have led to underestimation of dropout in the most difficult-to-reach settings. Finally, minor inconsistencies in home-based records may have affected the precision of some vaccination dates. Despite these limitations, the national scope of the sample, the use of survey weights, and the structured analysis of caregiver-reported barriers provide robust evidence on the magnitude of pentavalent dropout, its associated factors, and caregiver-reported barriers in the Central African Republic.

5. Conclusion

This national study underscores a critical gap in immunization continuity in the CAR, where more than one in three children who are immunized with Penta 1 do not receive the third dose, resulting in a dropout rate of 34.5%. The identified associated factors—lack of television ownership, absence of civil registration and involvement of household heads in agricultural activities—suggest that incomplete vaccination results from a combination of structural and social barriers. The caregiver-reported reasons highlight not only physical access difficulties, but also family constraints and substantial gaps in awareness regarding the need for multiple doses. These findings emphasize that strategies to improve immunization coverage must go beyond service availability and actively support families after the first vaccine contact. Strengthening follow-up systems to trace and re-engage children at risk of dropout, adapting service delivery to local constraints, and implementing community-based interventions sensitive to social determinants are critical steps. Moreover, intensified interpersonal communication efforts, grounded in community dynamics and health worker engagement, are essential to convert initial vaccination into full immunization coverage. Furthermore, the progressive increase in dropout across the immunization schedule reveals a worsening loss to follow-up over time, reinforcing the urgency of continuous support throughout the vaccination process. Targeted, locally adapted approaches are therefore necessary to close the gap and sustainably improve vaccination completion rates in fragile health systems.

CRediT authorship contribution statement

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Declaration of competing interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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Data availability

Data will be made available on request.

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