

Health system determinants of incomplete childhood immunization in Côte d'Ivoire: Evidence from a multicenter cross-sectional Study

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Abstract

Background

Childhood immunization remains a cornerstone of public health for preventing vaccine-preventable diseases and reducing child mortality. Despite sustained efforts, Côte d'Ivoire continues to report suboptimal vaccination coverage, with persistent inequities across regions. While previous studies have largely focused on caregiver- and demand-side barriers, evidence on modifiable health system determinants remains limited. This study examined health system factors associated with incomplete childhood immunization in Côte d'Ivoire to inform strategies for improving equitable immunization coverage.

Methods

A multicenter cross-sectional analytical study was conducted from July to November 2025 across 16 health districts in seven health regions of Côte d'Ivoire. Data were collected from 44 health facilities and 286 parents or caregivers of children aged 0–59 months using standardized questionnaires administered through the Open Data Kit platform. Facility-level data assessed human resources, service organization, vaccine availability, and logistics, while household surveys examined access to immunization services and child vaccination status. Multivariable logistic regression was used to identify factors independently associated with incomplete childhood immunization.

Results

Of the 286 children included, 51.7% were under- or incompletely vaccinated. The strongest predictors of incomplete immunization were unavailability of vaccination services (adjusted OR = 7.62; 95% CI: 2.68–21.63), vaccine stock-outs (adjusted OR = 7.35; 95% CI: 1.95–29.04), and infrequent community health worker visits (adjusted OR = 3.32; 95% CI: 1.77–6.24). Children from households where the head was unemployed were also significantly more likely to be incompletely vaccinated (adjusted OR = 5.39; 95% CI: 1.36–21.29). Perceived proximity to a health facility was associated with lower odds of incomplete vaccination (adjusted OR = 0.48; 95% CI: 0.27–0.87).

Conclusion

Incomplete childhood immunization in Côte d'Ivoire is driven predominantly by modifiable health system constraints rather than geographic access alone. Strengthening service availability, ensuring uninterrupted vaccine supply, expanding community health worker engagement, and improving routine immunization delivery are critical to reducing immunization inequities and reaching zero-dose and under-

vaccinated children. These findings provide actionable evidence to strengthen immunization systems and accelerate progress toward Immunization Agenda 2030.

Introduction

Childhood immunization is one of the most effective and cost-efficient public health interventions, preventing an estimated 3–5 million deaths annually from vaccine-preventable diseases and substantially reducing childhood morbidity and mortality worldwide [1–3]. Over the past decades, global immunization programs have achieved remarkable progress; however, gains have slowed since the COVID-19 pandemic, resulting in widening immunity gaps and increasing numbers of zero-dose and under-vaccinated children, particularly in low- and middle-income countries (LMICs) [4, 5]. The Immunization Agenda 2030 (IA2030) identifies equitable access to immunization services as a global priority and emphasizes strengthening primary health care and health systems to ensure that no child is left behind.

Sub-Saharan Africa continues to experience some of the largest inequities in childhood immunization. Although substantial investments have expanded vaccine availability, many children remain incompletely vaccinated because of persistent health system challenges, including shortages of skilled health workers, interrupted vaccination services, vaccine stock-outs, weak supply chains, inadequate outreach services, and limited community engagement [6, 7]. These barriers disproportionately affect rural and underserved populations, contributing to missed opportunities for vaccination and widening health inequities.

In Côte d'Ivoire, this shield is showing cracks, particularly in areas where daily challenges hinder vaccination coverage. According to data from the Ministry of Health, only 36% of Ivorian children are fully vaccinated, and nearly 9% have not received any doses [8]. WHO/UNICEF estimates further indicate that more than 135,000 children remained zero-dose in 2022. In response, the Government of Côte d'Ivoire implemented the National Strategic Vaccination Plan (2021–2025) and introduced targeted catch-up strategies, including the Big Catch-Up initiative, to identify and vaccinate zero-dose and under-vaccinated children. Despite these efforts, substantial disparities persist across regions and population groups, suggesting that barriers extend beyond caregiver demand and include broader health system constraints. Despite the 2021–2025 National Strategic Vaccination Plan (PSNV) and catch-up campaigns such as the one launched in December 2024 to reach “zero dose” (ZD) children, coverage targets are not being met. In 2022, more than 135,000 children received no vaccinations, and rural areas account for a significant proportion of these cases, with a zero-dose (ZD) rate of 6.9% compared to 10.3% in urban areas [9].

Previous studies have primarily examined socioeconomic characteristics, caregiver knowledge, vaccine hesitancy, and geographic accessibility as determinants of childhood immunization. Comparatively fewer studies have comprehensively assessed modifiable health system factors—including service availability, health workforce capacity, vaccine logistics, and community health worker engagement—that

directly influence the delivery and continuity of routine immunization services [10, 11]. Understanding these determinants is essential for designing effective interventions to strengthen health systems, improve service delivery, and reduce inequities in immunization coverage.

This study therefore examined health system determinants associated with incomplete childhood immunization in Côte d'Ivoire using data collected from health facilities and households across multiple health regions. By identifying modifiable barriers within the health system, the study aims to generate evidence to inform policies and programme strategies for strengthening routine immunization services, improving equitable access, and accelerating progress towards Immunization Agenda 2030 and universal immunization coverage.

Methods

Study design and setting:

A multicenter cross-sectional analytical study was conducted in 16 health districts across seven (7) health regions in Côte d'Ivoire. Based on the 2024 vaccination database for regions and health districts from the Expanded program of immunization, health regions (RS) were categorized by performance level. The three (03) performance criteria used were rubella-measles vaccination coverage (RR1), the specific dropout rate (SDR), and the number of “zero doses,” to which ratings were assigned.

Next, a three-tiered stratification of the seven health regions was carried out according to performance levels, with two health districts (HD) per region, for a total of fourteen HDs. In each of these HDs, a primary health care facility (PHCF) in a rural area was selected in agreement with the health district director (Fig. 1).

Duration, type of study, Study population

The analytical cross-sectional study was conducted from July to November 2025. It targeted 44 health facility managers responsible for vaccination services and 286 parents or guardians of children under five years of age, including 148 children who were unvaccinated or under-vaccinated and 138 children who were fully vaccinated.

Data collection:

Data were collected using structured questionnaires programmed on ODK Collect. The questionnaires were developed for this study. Health facility-level data and Health District data covered human resources, service organization, vaccine supply, and cold-chain capacity. Household data captured socio-demographic characteristics, access to services, and vaccination status. The items focused on dedicated human resources, vaccine availability, accessibility, and vaccination services. Data were

collected using questionnaires accessible on tablets. Data collection was conducted through individual interviews.

Statistical analysis:

Quantitative data were analyzed using Python. Descriptive statistics, bivariate analyses, and multivariable logistic regression were performed. Odds ratios with 95% confidence intervals were reported.

The data were entered into ODK Collect and analyzed using PYTHON and QGIS software. Each variable was subjected to descriptive analysis. Quantitative variables were expressed as means and standard deviations. Qualitative variables were described in terms of frequency and percentage for each variable category.

The search for factors associated with vaccination status was conducted in two stages.

First, the degrees of association (correlation) between all variables were explored using the correlation coefficient r through the Cramer et al. matrix for qualitative variables. For quantitative variables, a Pearson biserial correlation was performed. The two correlations were merged into a single square matrix.

If $r = 0$, there was no association between the variables studied.

If $r > 0$, there was an association favorable to non-vaccination.

If $r < 0$, there was an association favorable to vaccination.

Correlation coefficients with vaccination status were then extracted from the matrix and classified as weak or moderate.

When the correlation coefficients were < 0.20 , the associations were considered weak. The vaccination profile was not dictated by a single major factor, but by a set of small cumulative influences.

When the correlation coefficients were > 0.20 , the associations were considered moderate. These variables therefore played a real role.

Results

Characteristics of participating health facilities

A total of 44 health facilities providing routine immunization services were included in the study. These comprised 18 urban health centers (41.0%), 13 rural health centers (29.5%), and 13 district referral hospitals (29.5%) (Table 1). The distribution of facility types ensured representation of the major levels of service delivery within the study districts.

Urban health centers were the most visited facilities, followed by referral hospitals.

Table 1
Distribution of health facilities by type of facility surveyed (N = 44)

Types of health facilities	Respondents	
	n	%
Rural health center	13	29,5
Urban health center	18	41
District referral hospital	13	29,5
Total	44	100

Performance of routine immunization services

Important operational challenges affecting routine immunization services were identified across participating facilities. Nearly one-third of health facilities (29.3%) reported delays in vaccine supply that resulted in temporary suspension of vaccination sessions. One-quarter (25.0%) experienced vaccine stock-outs during the study period, while syringe shortages were less common (6.8%) (Table 2). The reasons for non-vaccination were mainly vaccine stockouts and delays in supply. These findings indicate persistent weaknesses in vaccine logistics and supply chain management that may compromise continuity of routine immunization services.

Table 2
Distribution of health facilities according to supply delays that led to the suspension of vaccination sessions in 2025 and stockouts of vaccines and syringes (N = 44)

Vaccine and syringe management	n	%
Supply delays causing vaccination sessions to be suspended		
No	32	72,7
Yes	12	29,3
Vaccine stock shortages		
No	33	75
Yes	11	25
Syringe stock shortages		
No	41	93,2
Yes	3	6,8

Characteristics of households and children

A total of 286 households with children aged 0–59 months participated in the study, of whom 148 (51.7%) had children classified as incompletely vaccinated and 138 (48.3%) had fully vaccinated children. Most household heads worked in the informal sector (68.9%), whereas only 11.2% were employed in the formal sector and 5.2% were unemployed (Table 3). Nearly half of caregivers (46.5%) perceived the nearest health facility to be very close to their residence, while 15.0% considered it distant.

Community health worker (CHW) engagement varied substantially across households. Nearly half of households (43.7%) reported receiving no CHW visits during the previous year, whereas only 3.5% reported frequent CHW visits. These findings suggest considerable variability in community-based support for routine immunization.

Table 3
Occupation and perceptions of distance to health center and frequency of visits by community health workers among heads of households (N = 286)

Characteristics of heads of households	n %	
Occupation of the head of household		
Formal	32	11,2
Informal	197	68,9
Unemployed	15	5,2
Other	42	14,7
Assessment of distance based on the time taken to reach the health center		
Very close	133	46,5
Moderate	110	38,5
Distant	43	15
Frequency of visits by community health workers		
High	10	3.5
Medium	56	19.6
Low	95	33.2
None	125	43.7

The majority of heads of households worked in the informal sector. The majority of parents of target children surveyed considered themselves to be “very close” to health centers. A very high proportion of households had received the required number of visits from community health workers (CHWs).

Factors associated with incomplete vaccination

Multivariable logistic regression identified several independent health system and household factors associated with incomplete childhood immunization (Table 4). Service interruption due to unavailability of vaccination services showed the strongest association with incomplete vaccination (adjusted OR = 7.62; 95% CI: 2.68–21.63; $p < 0.001$). Similarly, children living in households that reported vaccine stock-outs had more than seven-fold higher odds of incomplete vaccination (adjusted OR = 7.35; 95% CI: 1.95–29.04).

Table 4
Predictive factors for non-vaccination of children aged 0 to 59 months (N = 286)

Variables	OR	IC 95%	p-value
Unavailability of health personnel	7,62	[2,68 – 21,63]	< 0,001
Low number of ASC visits	3,32	[1,77 – 6,24]	< 0,001
Vaccine shortages	7,35	[1,95 – 29,04]	0,003
Perception that the health center was close	0,48	[0,27 – 0,87]	0,016
Unemployed head of household	5,39	[1,36 – 21,29]	0,016
Head of household working in the formal sector	0,47	[0,15 – 1,47]	0,192
Head of household working in the informal sector	1,54	[0,72 – 3,31]	0,25
Perception that the health center was far away	1,52	[0,64 – 3,56]	0,33
Average number of ASC visits	1,18	[0,57 – 2,46]	0,66
High number of ASC visits	1,38	[0,32 – 5,87]	0,66

Community health worker engagement was also an important determinant. Children from households receiving few CHW visits were over three times more likely to be incompletely vaccinated than those receiving regular visits (adjusted OR = 3.32; 95% CI: 1.77–6.24). Household socioeconomic status also influenced vaccination status, with children from households headed by unemployed individuals having significantly greater odds of incomplete vaccination (adjusted OR = 5.39; 95% CI: 1.36–21.29).

Conversely, caregivers who perceived the health facility to be located close to their residence had significantly lower odds of incomplete vaccination (adjusted OR = 0.48; 95% CI: 0.27–0.87), suggesting that perceived accessibility remains an important facilitator of routine immunization uptake.

Discussion

This study identified several modifiable health system determinants of incomplete childhood immunization in Côte d'Ivoire. After adjustment for potential confounders, shortages of health personnel,

inadequate community health worker (CHW) outreach, vaccine stock-outs, poor perceived geographic accessibility of health facilities, and household socioeconomic status were independently associated with incomplete vaccination. These findings underscore that improving immunization coverage requires both supply-side strengthening and demand-side interventions.

The strongest predictor of incomplete immunization was the unavailability of health personnel. Children attending facilities with insufficient staff had substantially higher odds of incomplete vaccination. This finding aligns with prior research in sub-Saharan Africa, where insufficient staffing reduced vaccination opportunities [12]. Moreover, previous evaluations of Côte d'Ivoire's Expanded Programme on Immunization have similarly highlighted staffing gaps as a major barrier [13]. Knowledge about vaccination was both a barrier and a facilitating factor, while communication skills and trust in vaccination were facilitating factors. Healthcare providers' lack of awareness about vaccination, their concerns, and their mistrust were described as the main barriers [14].

Vaccine stock-outs were also strongly associated with incomplete vaccination. This corroborates evidence from other low-income settings where disruptions in vaccine supply discouraged return visits and eroded trust in health services [15]. Similarly, a national review of Côte d'Ivoire's PEV also noted frequent disruptions in vaccine supply [16]. According to a study from Nguefack, vaccine management is a major bottleneck. In fact, The primary reason for non-vaccination was vaccine stockouts (21.1%), 15.4% of Community Health Centers experienced stockouts, and 30.8% faced supply delays that led to interruptions in vaccination [17].

Community health worker engagement emerged as another important determinant. Households receiving fewer CHW visits had significantly higher odds of incomplete vaccination. This is consistent with studies in sub-Saharan Africa, where CHWs bridge gaps between communities and health systems [18]. In line with this, the CHW model has been found to improve vaccination uptake through tailored community engagement [19].

Perceived proximity of health facilities was inversely associated with incomplete vaccination, emphasizing that caregivers' perceptions of accessibility matter. Previous work has shown that perceived distance and transportation constraints deter vaccination, even when facilities are nearby [20].

Household socioeconomic conditions also influenced vaccination. Children in unemployed-headed households were more likely to be incompletely vaccinated, echoing findings from other sub-Saharan studies [21]. Social determinants of health, including income and employment, have long been recognized as strong predictors of vaccination coverage [22]. Thus, addressing these inequities will require targeted social interventions. One study noted that vaccination stakeholders should prioritize access to education and health services in rural and remote areas, as well as for poor segments of the population, by supporting community health workers and awareness programs, and by providing financial support to increase vaccination coverage and prevent missed opportunities for vaccination [23].

The findings have implications for immunization policy in Côte d'Ivoire. Strengthening routine immunization will require integrated interventions that simultaneously improve health workforce capacity, ensure uninterrupted vaccine supply, reinforce community health worker programmes, and reduce geographical and socioeconomic barriers. These interventions are consistent with the objectives of Immunization Agenda 2030 and the national strategy to achieve equitable immunization coverage.

This study has several strengths, including the use of primary data collected from both health facilities and households across multiple health regions, allowing simultaneous assessment of supply- and demand-side determinants. However, some limitations should be acknowledged. The cross-sectional design precludes causal inference, some variables relied on caregiver self-report and may be affected by recall bias, and residual confounding cannot be excluded despite multivariable adjustment. Nevertheless, the identified determinants are consistent with existing evidence and provide actionable information for strengthening routine immunization services in Côte d'Ivoire.

Conclusion

Incomplete childhood immunization in Côte d'Ivoire is primarily associated with modifiable health system constraints, including interruptions in vaccination service delivery, vaccine stock-outs, limited community health worker engagement, and socioeconomic vulnerability. These findings underscore the importance of strengthening routine immunization systems beyond improving physical access to services. Ensuring uninterrupted vaccine availability, enhancing service delivery, reinforcing community health worker programs, and prioritizing underserved populations are critical to improving equitable immunization coverage. The findings provide evidence to inform policies and program strategies aimed at strengthening routine immunization services, reaching zero-dose and under-vaccinated children, and accelerating progress towards Immunization Agenda 2030 in Côte d'Ivoire and similar settings.

Declarations

Ethical considerations:

Clinical trial number: N/A

Ethical approval was obtained from the National Ethics Committee of Côte d'Ivoire. Written informed consent was obtained from all participants. All experiments were performed in accordance with relevant guidelines and regulations (such as the Declaration of Helsinki).

Authorization from the National Ethics Committee, referenced US DPT OF HHS REGISTRATION #2: IRB000111917 dated 09/15/2025, was obtained prior to the start of the survey.

A request for authorization was sent to regional health directors, district health directors, and local authorities (regional councils, town halls, and governors of autonomous districts).

At the time of data collection, an information note was read before any interview or focus group discussion. The written consent of the interviewees was obtained using a signed informed consent form. Confidentiality and anonymity clauses were respected.

Availability of data and materials

The datasets generated and/or analyzed during the current study are available from the corresponding author on reasonable request.

Consent for publication

Not applicable.

Competing interests

The authors declare that they have no competing interests.

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Authors' contributions

YKS, AGF and MNA designed the study and proposed the first draft of the manuscript. YYS and MNA conducted data collection and data analysis. SKJ and AGF coordinated data collection. The other authors revised and contributed to the successive drafts. The final version of the paper was revised and approved by all the authors.

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Figures



Figure 1

Distribution of selected districts housing rural health centers visited in 2025

Supplementary Files

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- [HealthFacilityServiceDeliveryQuestionnaire.docx](#)
- [HouseholdQuestionnaireImmunizationServiceDelivery.docx](#)
- [DistrictHealthServiceDSServiceDeliveryQuestionnaire.docx](#)