

Timeliness and Completion of Routine Childhood Vaccination and Associated Factors among Children Aged 0–59 Months in Tiko Health District, Southwest Region, Cameroon

Ngo Billong Christiane Peggy^{1*}, Ojong-Ebot Ayukndip¹, Talongwa Roberto², Adiogo Dieudonnee³

¹Department of Public Health, Texila American University, Guyana, South America

²Department of Public Health, University of Dshang, Cameroon

³Department of Public Health and Hygiene, Faculty of Health Sciences, University of Douala, Douala, Cameroon

***Correspondence to be addressed:** E-mail - billchristiane@gmail.com

Cite this article as: Ngo Billong Christiane Peggy, Ojong-Ebot Ayukndip, Talongwa Roberto, Adiogo Dieudonnee. Timeliness and Completion of Routine Childhood Vaccination and Associated Factors among Children Aged 0–59 Months in Tiko Health District, Southwest Region, Cameroon. Texila Int J Acad Res. 2026;13(4).

<https://doi.org/10.21522/TIJAR.2014.13.04.Art014>

Received: 28.08.2026

Accepted: 23.09.2026

Published: 30.10.2026

Article Type: Original Research

Abstract Childhood vaccination remains a major public health challenge; global third-dose coverage of the combined diphtheria, tetanus, and pertussis (DTP3) vaccine reached 85% in 2025, yet 13.5 million children remained zero-dose. In Cameroon, national third-dose coverage of the combined diphtheria, tetanus and pertussis vaccine (DTP3) rose to 82.5% in 2024, but sub-national performance remains undocumented: a South-West Region study reported only 47.7% coverage. Whether the Tiko Health District follows this national pattern of declining coverage between initial and subsequent doses had not previously been documented. This cross-sectional study assessed vaccination coverage, timeliness, and associated factors in the Tiko Health District, combining a review of 800 vaccination records and a survey of 604 caregivers of children aged 0–59 months. Age-appropriate vaccination completion was 30.3% (242/800). Coverage declined markedly from 98.6% for Bacillus Calmette-Guerin (BCG) and 76.0% for Pentavalent 1 (Penta1) to 48.1% for Pentavalent 3 (Penta3) and 9.0% for the first measles-rubella (MR) dose. Timeliness remained high for later doses (95.3% for Penta3) despite low coverage. Untimely vaccination was significantly associated with caregivers' lack of schedule knowledge adjusted odds ratio [aOR] = 4.3; 95% confidence interval [CI]: 2.41–7.92, absence of reminders (aOR = 2.2; 95% CI: 1.30–3.66), and age of child under 5 years in the household (aOR = 3.22; 95% CI: 1.26–8.26). Routine immunisation in Tiko shows high initial access but substantial attrition across subsequent doses, indicating that retention, rather than initial uptake, is Tiko's principal challenge. Caregiver knowledge and reminders emerged as the strongest modifiable determinants of timeliness, pointing to clear priorities for improving retention and equity in the district.

Keywords Childhood Vaccination, Cameroon, Immunization Services, Vaccination Timeliness, Vaccination Completion, Vaccination Coverage.

Introduction

Vaccination remains one of the most effective public health interventions for reducing childhood morbidity and mortality from vaccine-preventable diseases. However, the performance of an immunisation programme depends not only on the proportion of children who receive recommended vaccines, but also on the timeliness of vaccine administration and the completion of the vaccination schedule. Delayed vaccination prolongs the period during which a child remains insufficiently protected, while dropout between successive doses compromises the development of optimal immunity. These shortcomings may sustain pockets of susceptibility and facilitate the transmission of vaccine-preventable diseases, even when overall administrative coverage appears satisfactory.

In Cameroon, despite recent progress, gaps in routine immunisation remain. According to the United Nations Children's Fund (UNICEF), national coverage with the third dose of the diphtheria, tetanus, and pertussis vaccine (DTP3), a key indicator of routine immunisation programme performance, increased from 79.2% in 2022 to 82.5% in 2023 and remained at 82.5% in 2024, still below programme targets [1]. This marks a sustained improvement compared with the 2018 Cameroon Demographic and Health Survey, in which full basic vaccination coverage among children aged 12–23 months was substantially lower [7], though the persistence of a gap below programme targets indicates that progress has not yet translated into full closure of the coverage gap. Globally, DTP3 coverage was estimated at 85% in 2024, while coverage for the first measles-containing vaccine dose (MCV1) reached 84% [2]. The most recent World Health Organization (WHO)/UNICEF Estimates of National Immunization Coverage (WUENIC) confirm this plateau at the global level [11, 12], underscoring that the retention challenge documented in this study reflects a

pattern observed well beyond Cameroon. These figures indicate that achieving high and equitable vaccine coverage remains challenging, particularly in settings where children discontinue vaccination after the initial doses.

Sub-national evidence from the South-West Region further suggests that district-level performance can fall well below these national figures: a household survey conducted in the Mbonge Health Area found that only 47.7% of children aged 9–23 months were fully vaccinated according to cards and caregiver recall [22], underscoring the need for district-specific data such as those generated by the present study.

Beyond vaccination coverage, several studies have emphasised the importance of assessing the actual age at vaccine administration. An analysis of 70,006 children across 33 Sub-Saharan African countries, using data from 2020, revealed that 25.9% of children received BCG at least one month late, 49.1% received the third dose of the pentavalent vaccine (Penta3) late, and 63.9% received the first measles vaccine dose late. Vaccination delays were also significantly associated with incomplete vaccination schedules by 12 months of age. Specifically, delayed Penta3 vaccination was associated with a 50% increase in the odds of schedule non-completion (aOR = 1.50; 95% CI: 1.35–1.64) [3]. These findings suggest that vaccination coverage measured independently of administration timing may conceal substantial periods of vulnerability among children.

This issue has also been documented in Cameroon. In the Dschang Health District, Zeufack et al. (2023) assessed vaccination timeliness among children aged 0 to 23 months. Among children with documented vaccination dates, the proportion vaccinated within the recommended timeframes ranged from approximately 42% to 76% depending on the antigen, while the prevalence of missed opportunities for vaccination was estimated at

23.8%. Furthermore, approximately 18% of children with usable vaccination records were not fully vaccinated [4].

These findings highlight the substantial gap between vaccine receipt and vaccination according to recommended schedules. Deficiencies in vaccination timeliness and completion may result from interactions between child- and caregiver-related factors, including knowledge of the vaccination schedule and socioeconomic characteristics, as well as health system factors such as session organisation, missed opportunities, vaccine availability, geographical accessibility, and service quality. These challenges may be particularly pronounced in settings affected by humanitarian or security crises. In 2024, UNICEF estimated that 3.4 million people, including 1.9 million children, required humanitarian assistance in Cameroon due to armed conflicts, population displacement, epidemics, and other crises that may disrupt access to essential health services, including immunisation [5].

The Tiko Health District, located in Cameroon's South-West Region, operates within this context and may face socioeconomic, organisational, and service access constraints that affect continuity of childhood immunisation. However, data simultaneously assessing vaccination coverage, timeliness of vaccine administration, schedule completion, and factors associated with these performance indicators remain limited in this district. This study therefore aims to evaluate the performance of immunisation services in the Tiko Health District, with particular emphasis on vaccination timeliness and schedule completion.

Methods and Materials

Study Design and Setting

A cross-sectional quantitative study was conducted in the Tiko Health District of the South-West Region of Cameroon, to assess the timeliness and completion of routine childhood

immunisation and to identify associated socio-demographic, caregiver-related, and health-system factors.

Sample Size Determination

The study used two complementary data sources: a household-based survey and a retrospective review of childhood vaccination records from selected health facilities. A formal statistical sample size calculation was not performed. Instead, a pragmatic, non-probability sampling approach was used, taking into consideration the availability and accessibility of eligible study participants and vaccination records during the study period, as well as the time and logistical resources available for data collection.

For the household survey, eligible caregivers of children aged 0–59 months were recruited from the selected communities during the study period. A total of 604 eligible caregivers were included in the household survey. Caregivers were eligible if they were responsible for the care of an eligible child and provided the required information for the assessment of the child's vaccination status and factors potentially associated with vaccination timeliness. Of the 604 caregivers interviewed, 603 had complete information on vaccination timeliness and were therefore included in the bivariate and multivariate analyses. One record was excluded from the regression analysis because the outcome variable for timeliness was missing. Thus, the analytical sample for factors associated with untimely vaccination was 603 participants, as reported in Table 5.

For the facility-based record review, five health facilities were purposively selected to provide representation of the different facility settings and types included in the study. The sampling frame comprised vaccination records for children aged 0–59 months available in the selected facilities during the period from 04 June to 1er July 2026. Records were eligible for inclusion if they belonged to children aged 0–59 months and contain sufficient

vaccination information to determine vaccination status and/or timeliness. Records that were illegible or lacked sufficient identifying information were excluded.

A total of approximately 800 eligible vaccination records were reviewed across five health facilities. All eligible records available during the record review period were included. Table 1 shows the number of records reviewed from each facility. The facility records were used to estimate antigen-specific vaccination coverage, age-appropriate vaccination completion, and vaccination timeliness.

The two datasets served complementary purposes: household-level data were used to examine caregiver, socioeconomic, and health-system factors associated with untimely vaccination, while facility-based records were used to describe vaccination coverage, completion and timeliness.

Sampling Technique

This study employed two sampling approaches for the two different data sets.

For the household survey, a multistage sampling technique was used to select households. The sampling process involved the sequential selection of health areas, communities, and households.

- **Stage 1 — Selection of health areas:** The sampling frame consisted of the health areas of the Tiko Health District. Health areas were randomly selected using balloting.

- **Stage 2 — Selection of communities:** Within the selected health areas, communities were selected from the sampling frame obtained from the district health service, using simple random sampling.

- **Stage 3 — Selection of households:** Households in the selected communities were identified using the community register provided by the Community Health Workers (CHWs). The required number of households was selected using systematic random sampling, with the sampling interval calculated by dividing the total number of eligible households by the required number of households.

For this study, a household was defined as a group of people living under the same roof and feeding in the same pot. Households were eligible if there was a child aged 0–59 months. If a selected household was ineligible, vacant, could not be located after the revisit, or declined participation, it was replaced using the next household according to the predetermined sampling procedure.

For the health facility record review, purposive sampling was used. Facilities were selected to ensure representation according to geographical setting, facility type, and volume of immunisation services, while ensuring that adequate vaccination records were available for review (Table 1).

Table 1. Selection of Health Facilities

S/N	Health facility	Health area	Setting	Facility type	Basis for selection	Number of records reviewed
1	CMA Mutengene	Mutengene	Urban	Public	Facility used regularly	152
2	Mbingo,mutengune	Likomba	Urban	Confessional	Reception/Staff attitude	154
3	IHC Holforth	Holforth	Urban	Public	Facility used regularly	307
4	HC Tiko Town	Tiko Town	Rural	Public	Crowding	165
5	HC Misellele	Misellele	Rural	Public	Distance	22

Facilities were selected to jointly represent three operational characteristics observed to influence immunisation service performance during the scoping phase, routine service utilisation volume ("facility used regularly"), staff, caregiver interaction quality ("reception/staff attitude"), and physical access constraints ("crowding", "distance"), so that the reviewed records and surveyed caregivers reflect the range of conditions encountered across the district rather than a single facility profile.

Data Collection Methods

Data for this study were collected at two levels. First, data were collected from existing records in selected health facilities. Trained research assistants systematically reviewed vaccination registers and child health records for children aged 0–59 months, extracting information on date of birth, sex, dates of administration of all routine vaccines, and health facility code. Maternal identification information was used only for cross-checking when necessary, while maintaining confidentiality. This approach enabled an objective assessment of vaccination timeliness and completion based on official records.

Second, for the household survey (individual interviews), structured questionnaires were administered to primary caregivers of children aged 0–59 months in selected households through face-to-face interviews conducted by trained research assistants. Data were collected on socio-demographic characteristics, children's vaccination status, caregiver-reported reasons for delayed or missed vaccination, knowledge and attitudes toward immunisation, access to health information and services, perceived quality of vaccination services, distance and transportation barriers, and vaccination card retention. Caregivers were asked to present the child's vaccination card for verification; when unavailable, caregiver recall was cautiously used and documented during data collection.

Questionnaire for Risk Factors and Demographic Data

A structured questionnaire was used to collect socio-demographic, socioeconomic, caregiver-related, and health-system data potentially associated with incomplete and untimely routine childhood vaccination. Information collected included child and caregiver characteristics, caregiver education and occupation, household characteristics, knowledge of the routine immunisation schedule, vaccination reminders, access to health information and immunisation services, distance and transportation barriers, waiting conditions, and perceived quality of vaccination services. Vaccination status was verified using the child's vaccination card when available. These data enabled the assessment of factors associated with incomplete and untimely routine vaccination among children aged 0–59 months in the Tiko Health District.

Data Variables

Age-appropriate vaccination completion and timely vaccination were the primary outcome variables. Age-appropriate vaccination completion was defined as receipt of all vaccine doses due according to the child's age at the time of assessment, based on the national routine immunisation schedule applicable during the study period. For each child, we determined age at assessment, identified the vaccines and doses due by that age, and compared documented vaccination history with the expected schedule. Children who had received all doses due for their age were classified as complete for age (coded 1), while those who had missed one or more doses due by their age were classified as incomplete for age (coded 0).

Timely vaccination was defined as receipt of each vaccine dose within the recommended age or interval specified in the national routine immunisation schedule applicable during the study period. Operationally, we defined timely as receipt of the vaccine dose at the

recommended age or within four weeks after the recommended age, provided the minimum interval between doses was respected. The recommended schedule consisted of BCG and OPV-0 at birth; DTP-HepB-Hib 1, PCV-13 1, OPV-1 and Rotavirus 1 at 6 weeks; DTP-HepB-Hib 2, PCV-13 2, OPV-2 and Rotavirus 2 at 10 weeks; DTP-HepB-Hib 3, PCV-13 3 and OPV-3 at 14 weeks; MR1 and Yellow Fever vaccines at 9 months, and MR2 at 15 months.

For each child, the recorded date of administration of each vaccine dose was compared with the scheduled age or minimum interval for that dose. A vaccine dose was classified as timely (coded 1) if it was administered within the predefined acceptable time window around the recommended date/age the exact allowable window for each dose is specified in Table 2 and as untimely (coded 0) if it was administered outside this

window. The acceptable time window was defined based on the Cameroon national immunisation schedule and applied consistently across vaccine doses. For vaccines administered as a series, timeliness of subsequent doses was assessed using the recommended minimum interval from the preceding dose. Children whose relevant vaccination date was not documented were classified as having missing timeliness data rather than being assumed to have received the vaccine late. At the child level, timely vaccination was determined by assessing whether all vaccine doses due and documented for the child's age had been received within their respective recommended time windows. The analysis also assessed timeliness separately for individual vaccine doses to identify points in the immunisation schedule at which delays were most frequent.

Table 2. Vaccine Operational Definition

Vaccine Dose	Recommended Age	Timely if administered
BCG	At birth	On the day of birth or within 28 days after birth
Penta 1	6 weeks	At 6 weeks through 10 weeks of age
Penta 2	10 weeks	At 10 weeks through 14 weeks of age and at least 4 weeks after Penta 1
Penta 3	14 weeks	At 14 weeks through 18 weeks of age and at least 4 weeks after Penta 2
MR 1	9 months	At 9 months through 10 months of age
MR 2	15 months	At 15 months through 16 months of age and at least 6 months after MR 1

Explanatory variables included child and caregiver socio-demographic characteristics, socioeconomic factors, caregiver knowledge of the routine immunisation schedule, receipt of vaccination reminders, number of children under five years in the household, distance to vaccination services, transportation barriers, waiting conditions, and perceived quality of immunisation services.

Data Analysis

Quantitative data were analysed using SPSS version 25. Descriptive statistics were used to

summarize participants' characteristics and vaccination outcomes. Categorical variables were presented as frequencies and percentages, while continuous variables were summarized using means and standard deviations or medians and interquartile ranges, as appropriate. Vaccination coverage, age-appropriate vaccination completion, and timeliness were estimated as proportions.

Age-appropriate vaccination completion was defined as a binary outcome variable (complete for age = 1; incomplete for age = 0)

by comparing each child's documented vaccination history with the doses expected for their age under the applicable national immunisation schedule. Bivariate logistic regression was performed to assess associations between explanatory variables and untimely vaccination, and crude odds ratios (cORs) with 95% confidence intervals (CIs) were reported. Variables considered for the multivariable model were entered into a multivariable logistic regression analysis to identify factors independently associated with untimely vaccination. Variable selection was based on a combination of epidemiological relevance, and findings from the bivariate analysis. Variables considered important a priori based on their potential relationship with vaccination timeliness, including child, caregiver, household, socioeconomic, and health system characteristics, were considered for inclusion. In addition, variables with a p-value <0.20 in the bivariate analysis were considered candidates for the multivariate model. We reported adjusted odds ratios (aORs) with 95% CIs and set statistical significance at $p < 0.05$.

Ethical Consideration

Ethical clearance was obtained from the Regional Ethics Committee for Human Health Research of the Southwest Region of Cameroon (04/CRERSH/SW/C/02/2026). Authorisations were sought from the Southwest Regional Delegation of Public Health (P42/MINSANTE/SWR/RDPH/RCB.PT/04/2026), the Regional Expanded Programme on Immunization (EPI) Officer Southwest (P12/MINSANTE/SWR/RDPH/EPI), and Tiko Health District (N°2026/28vol/MINSANTE/RDPHSW/THD/504). All procedures involving human

participants were conducted in accordance with the ethical standards of the institutional and national research committees and in compliance with the principles of the Declaration of Helsinki [13]. Written informed consent to participate was obtained from all study participants before data collection. The study was conducted in accordance with the International Council for Harmonisation Good Clinical Practice (ICH-GCP) guidelines [15] and reported in accordance with the Strengthening the Reporting of Observational Studies in Epidemiology (STROBE) statement [14].

Results

Socio-demographic and Health-Facility Characteristics of Children Included in the Record Review

For the record review, a total of 800 children were included, comprising 660 (82.5%) aged 0–11 months and 140 (17.5%) aged 12–59 months. The ages of children reviewed ranged from 0 to 59 months, with a mean age of 6.3 months (standard deviation [SD] = 3.8). The median age was 6 months, with an interquartile range (IQR) of 3 to 9 months. Regarding sex, 407 (50.9%) of the children were female and 393 (49.1%) were male.

More than half of the children (458, 57.3%) attended confessional health facilities, followed by public facilities (324, 40.5%), while only 18 (2.3%) attended private facilities. Among the five health areas, Mutengene Health Area accounted for the largest proportion of participants, 424 (53.0%), followed by Likomba, 182 (22.8%). More than half of the children, 459 (57.4%), resided in urban areas (Table 2).

Table 3. Socio-demographic Characteristics of the Vaccination Records Reviewed

Variable	Category	Frequency n (%) N = 800	Completed n (%) N = 242	Not completed n (%) N = 558
Age	0–11 m	660 (82.5)	233 (35.3)	427 (64.7)
	12–59 m	140 (17.5)	9 (6.4)	131 (93.6)
Sex	Male	393 (49.1)	132 (33.6)	261 (66.4)

	Female	407 (50.9)	110 (27.0)	297 (73.0)
Health facility type	Confessional	458 (57.3)	180 (39.3)	278 (60.7)
	Private	18 (2.3)	5 (27.8)	13 (72.2)
	Public	324 (40.5)	57 (17.6)	267 (82.4)
Health area	Holforth	14 (1.8)	3 (21.4)	11 (78.6)
	Likomba	182 (22.8)	51 (28.0)	131 (72.0)
	Missellele	3 (0.4)	1 (33.3)	2 (66.7)
	Mutengene	424 (53.0)	174 (41.0)	250 (59.0)
	Tiko Town	177 (22.1)	13 (7.3)	164 (92.7)
Setting	Rural	341 (42.6)	60 (17.6)	281 (82.4)
	Urban	459 (57.4)	182 (39.7)	277 (60.3)

Age-appropriate Vaccination Completion

The overall age-appropriate vaccination completion was 30.3% (242/800). Vaccination completion was considerably higher among younger children, with 35.3% (233/660) of those aged 0–11 months completing their vaccination schedule, compared with only 9 (6.4%) among those aged 12–59 months. Vaccination completion was slightly higher

among males (33.6%) than females (27.0%). The highest proportion of completed vaccination was observed among children attending confessional health facilities (39.3%). Incomplete vaccination was most common among children attending public facilities (82.4%). Vaccination completion was substantially higher among urban children (39.7%) than among rural children (17.6%) (Figure 1).

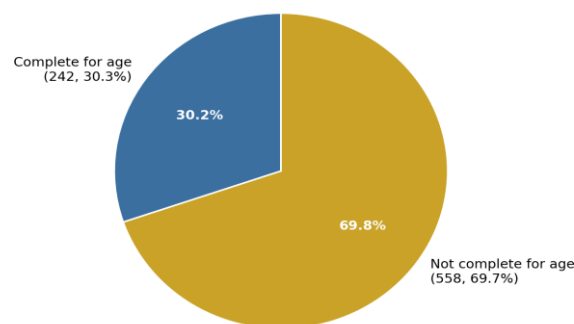


Figure 1. Pie Chart Showing Age-appropriate Vaccination Completion (N = 800)

Prevalence of Timely Vaccination among those Who Received the Vaccines

Overall, vaccination coverage declined progressively with subsequent doses in the immunisation schedule. BCG vaccine had the highest coverage, with 789 (98.6%) children vaccinated. However, only 356 (45.1%) of the vaccinated children received the vaccine within

the recommended time. Pentavalent vaccine dose 1 was received by 608 (76.0%) children, and notably, all vaccinated children received the vaccine within the recommended age interval. Coverage declined for Pentavalent dose 3, with 385 (48.1%) children vaccinated, among which 367 (95.3%) received the vaccine on time. Vaccination coverage was particularly low for the measles-rubella vaccines. Only 72

(9.0%) children had received the first dose of the measles-rubella vaccine, although 70 (97.2%) of those vaccinated received it within the recommended age. Similarly, only 2 (0.3%)

children had received the second dose of the measles-rubella vaccine, and both vaccinations were administered on time (Table 3).

Table 4. Prevalence of Timely Vaccination

Vaccine	Vaccinated n (%)	Timely n (%)
BCG	789 (98.6)	356 (45.1)
Penta 1	608 (76.0)	608 (100)
Penta 3	385 (48.1)	367 (95.3)
MR 1	72 (9.0)	70 (97.2)
MR 2	2 (0.3)	2 (100)

Factors Associated with Untimely Routine Vaccination among Caregivers

The analysis in this section draws on the second data source described in the Methods, the household survey of primary caregivers ($n \approx 604$) rather than the facility record review ($N = 800$) used in sections 4.1 and 4.2. This sub-sample was used because vaccination reminders, caregiver knowledge, and other caregiver-reported determinants examined here were captured only through the household survey instrument.

In the bivariate logistic analysis, caregiver education, age of child under five years, knowledge of the routine immunisation schedule, receipt of vaccination reminders, and waiting conditions at the vaccination clinic showed statistical significance.

In the adjusted multivariate analysis, knowledge of the routine immunisation (RI) schedule, receipt of vaccination reminders, and age of child under five years remained independently associated with untimely routine childhood vaccination. Caregivers who lacked knowledge of the RI schedule had over four times higher odds of untimely vaccination compared with those who were knowledgeable (aOR = 4.3, 95% CI: 2.41–7.92; $p < 0.001$). Likewise, caregivers who did not receive vaccination reminders had more than twice the odds of untimely vaccination compared with those who received reminders (aOR = 2.2, 95%

CI: 1.30–3.66; $p = 0.003$). Age of child under 5 years showed a complete reversal after adjustment because of confounding. Children aged 0–11 months had approximately 3.2 times the adjusted odds of untimely vaccination compared with children aged 12–59 months (aOR = 3.22, 95% CI: 1.26–8.26; $p = 0.015$).

Although caregivers with low education had higher odds of untimely vaccination than those with higher education, the association was not statistically significant after adjustment (aOR = 1.5, 95% CI: 0.89–2.47; $p = 0.127$). Similarly, age group, place of residence, and satisfaction with waiting conditions were not independently associated with untimely vaccination. Caregivers aged <30 years had similar odds of untimely vaccination compared with those aged ≥ 30 years (aOR = 0.99, 95% CI: 0.61–1.61; $p = 0.975$), while residence in Mutengene was not associated with untimely vaccination compared with Tiko (aOR = 0.96, 95% CI: 0.54–1.72; $p = 0.810$). Likewise, dissatisfaction with waiting conditions was not significantly associated with untimely vaccination (aOR = 2.2, 95% CI: 0.61–7.64; $p = 0.231$).

Occupation, distance to the nearest vaccination center, overall patient satisfaction, and health worker communication were not significantly associated with untimely routine childhood vaccination in the bivariate analysis and were therefore not retained as independent predictors (Table 4).

Table 5. Bivariate and Multivariate Analysis of Factors Associated with Untimely Routine Immunisation Childhood Vaccination

Variable	Category	Timely n (%)	Untimely n (%)	cOR (95% CI)	P	aOR (95% CI)	P
Age group	≥30	242 (84.3)	45 (15.7)	1		1	
	<30	273 (86.4)	43 (13.6)	0.8 (0.54–1.33)	0.546	0.99 (0.61–1.61)	0.975
Education	High	361 (87.2)	53 (12.8)	1			
	Low	154 (81.5)	35 (18.5)	1.5 (0.97–2.47)	0.085	1.5 (0.89–2.47)	0.127
Residence	Tiko	390 (84.8)	70 (15.2)	1			
	Mutengene	125 (87.4)	18 (12.6)	0.8 (0.46–1.39)	0.521	0.96 (0.54–1.72)	0.810
Age of child months	12–59 months	16 (66.7)	8 (33.3)	1			
	0–11 months	499 (86.2)	80 (13.8)	0.3 (0.13–0.77)	0.018	3.22 (1.26–8.26)	0.015
Occupation	Employed	304 (84.7)	55 (15.3)	1			
	Unemployed	211 (86.5)	33 (13.5)	0.8 (0.54–1.38)	0.620	—	—
Distance	≤5 km	277 (86.0)	45 (14.0)	1			
	>5 km	238 (84.7)	43 (15.3)	1.1 (0.71–1.75)	0.730	—	—
Knowledge of RI schedule	Yes	474 (88.1)	64 (11.9)	1		1	
	No	39 (61.9)	24 (38.1)	4.6 (2.6–8.1)	<0.001	4.3 (2.41–7.92)	<0.001
Reminders	Yes	402 (88.0)	55 (12.0)	1		1	
	No	113 (77.4)	33 (22.6)	2.1 (1.32–3.45)	0.003	2.2 (1.30–3.66)	0.003
Patient satisfaction	Satisfied	510 (85.4)	87 (14.6)	1			
	Not satisfied	5 (83.3)	1 (16.7)	1.2 (0.14–10.16)	1*	—	—
Waiting conditions satisfactory	Yes	503 (85.7)	84 (14.3)	1		1	
	No	10 (71.4)	4 (28.6)	2.3 (0.73–7.81)	0.135*	2.2 (0.61–7.64)	0.231
HW communication	Always	497 (85.7)	83 (14.3)	1			
	Not always	13 (76.5)	4 (23.5)	1.8 (0.59–5.79)	0.509	—	—

Note: (n, number of participants; cOR, crude odds ratio; aOR, adjusted odds ratio; * Fisher's exact test)

Discussion

Age-appropriate Vaccination Completion

This study revealed substantial gaps in routine age-appropriate vaccination completion in the Tiko Health District. Although initial vaccine uptake was high, only 30.3% of children were classified as having completed age-appropriate vaccination. Antigen-specific coverage showed a progressive decline across the vaccination continuum, from 98.6% for BCG and 76.0% for Penta1 to 48.1% for

Penta3. This pattern indicates that the principal challenge is not necessarily initial contact with immunisation services, but rather retention of children through successive vaccination contacts.

This finding is consistent with Yakum et al., who reported that only 37% of children aged 12–59 months were fully vaccinated across six health districts in Yaoundé, while 16% were zero-dose [8]. The authors also reported BCG coverage of 78%, illustrating persistent gaps in routine immunisation completion in Cameroon. Although the magnitude of vaccination

completion differed between the two studies, both demonstrate that high initial contact with immunisation services does not necessarily translate into completion of the recommended series. This study therefore adds evidence from the Tiko Health District that continuity of vaccination remains an important programme challenge, even where initial vaccine uptake is relatively high. Recent WHO/UNICEF estimates for Cameroon similarly indicate persistent differences between initial and subsequent vaccine doses [6], reinforcing the need to focus not only on access to the first vaccine dose but also on retention throughout the vaccination schedule. It is worth noting that the six health districts studied by Yakum et al., were located in Yaoundé, an urban setting, whereas Tiko is a semi-urban district; this contextual difference in setting should be considered when interpreting the comparison between the two studies.

The decline from Penta1 to Penta3 is particularly important. Penta1 coverage was 76.0%, compared with 48.1% for Penta3, representing a substantial loss of children between the first and third doses. This pattern suggests that opportunities to establish initial contact with caregivers are not being translated into sustained attendance. Possible explanations include missed appointments, competing household responsibilities, inadequate reminder and recall mechanisms, and insufficient follow-up of children who fail to return. A comparable pattern has been documented elsewhere in Cameroon: Ateudjieu et al. (2020), using administrative register data in the neighbouring Fouban Health District (West Region), reported a general dropout rate of 50.0% between BCG and measles-rubella vaccination [18], suggesting that substantial attrition across the vaccination continuum is not unique to Tiko but reflects a broader sub-national programmatic challenge. Part of the difficulty in benchmarking such attrition may also stem from definitional inconsistency: in a scoping review covering 103 low- and middle-

income countries, Wariri et al. (2022) found no consistent standard for defining or measuring vaccination timeliness and completion across studies [19], underscoring the need for harmonised indicators when comparing performance across districts such as Tiko.

Prevalence of Timely Vaccination

Vaccination timeliness also varied substantially across antigens. Despite the very high BCG coverage (98.6%), only 45.1% of BCG-vaccinated children received it within the recommended period. In contrast, 100% of Penta1 and 95.3% of Penta3 recipients were vaccinated on time. This apparent contrast between high timeliness among children who received later doses and declining overall coverage is important. It suggests that among children who remained connected to vaccination services, vaccination was generally delivered within the expected period.

These findings differ from those of Chiabi et al. at the Yaoundé Gynaeco-Obstetric and Paediatric Hospital, where BCG coverage reached 99.8% and 83.2% of BCG vaccinations were timely; timeliness was also above 93% for vaccines scheduled at 6 and 14 weeks [9]. Differences in service accessibility, study population, and health-service organization may partly explain this variation. More importantly, the high timeliness observed for Penta1 and Penta3 among vaccinated children in Tiko, despite the sharp decline in coverage, suggests that retention and completion of the vaccination series — rather than timeliness among children who remain engaged with services — constitute a major programmatic challenge.

Caregiver knowledge of the routine immunisation schedule emerged as the strongest independent factor associated with untimely vaccination. Children whose caregivers lacked knowledge of the schedule had more than four times higher odds of untimely vaccination (aOR = 4.3; 95% CI: 2.41–7.92; $p < 0.001$). This finding suggests that

knowledge of when vaccines are due may be more directly relevant to timely utilisation of vaccination services than general awareness of immunisation alone. This finding is strongly supported by Ngandjon et al. in Foumbot, Cameroon, who found that parents who were aware of the vaccination schedule were 3.52 times more likely to have fully vaccinated their children (OR = 3.52; 95% CI: 1.43–8.65) [10]. Their study also reported 60% vaccine acceptance and identified poor knowledge of vaccine-preventable diseases as an important concern.

These findings highlight caregiver knowledge as a modifiable determinant and support strengthening health education and systematic communication of the next vaccination appointment at every contact. This finding has an important programmatic implication: providing vaccination at the health facility alone may be insufficient if caregivers do not clearly understand which vaccine is due, when it is due, and when they should return.

The absence of vaccination reminders was also independently associated with untimely vaccination (aOR = 2.2; 95% CI: 1.30–3.66; $p = 0.003$), indicating that reminder and recall mechanisms could play an important role in maintaining children within the vaccination continuum. This finding aligns with the meta-analysis of Harvey, Reissland and Mason (2015), who found, across 28 trials involving nearly 15,000 parent-child dyads, that reminder and recall interventions significantly increased childhood immunisation uptake [20]. Evidence specific to phone-based reminders, however, remains more heterogeneous: Eze, Lawani and Acharya (2021), in a meta-analysis of 18 studies from low- and middle-income countries, reported a positive effect of SMS reminders on vaccination coverage and timeliness [17], whereas Yunusa et al. rated the overall quality of evidence for mobile phone reminders as low to moderate, with effects on timeliness often statistically non-significant [21]. This suggests that reminder strategies, and

their mode of delivery, may need to be locally adapted and validated rather than assumed to be uniformly effective in the Tiko context. The number of children under five years in the household was also independently associated with untimely vaccination (aOR = 3.22; 95% CI: 1.26–8.26; $p = 0.015$), potentially reflecting competing childcare and household responsibilities. Conversely, caregiver education was not independently associated with timeliness after adjustment (aOR = 1.5; 95% CI: 0.89–2.47; $p = 0.127$). This contrasts with Yakum et al., who found that maternal education was strongly associated with full vaccination, with children of mothers with higher education having substantially greater odds of being fully vaccinated (OR = 8.25; $p = 0.0018$) [8]. The difference may suggest that, in Tiko, specific knowledge of the vaccination schedule is more influential for timeliness than formal educational attainment itself.

Overall, the findings indicate that routine immunisation performance in Tiko is characterised by high initial access but inadequate retention and completion across the vaccination continuum. This interpretation is consistent with both recent Cameroonian empirical evidence and WHO/UNICEF vaccination estimates. Strengthening caregiver knowledge, reminder and recall systems, defaulter tracking, community outreach, and routine monitoring of vaccination dropout should therefore be prioritised to improve vaccination completion and timeliness in the Tiko Health District.

Risk Factors Associated with Untimely Routine Childhood Vaccination

The study identified several caregiver- and household-related factors associated with factor associated with untimely routine childhood vaccination. In the adjusted analysis, poor caregiver knowledge of the routine immunisation schedule was the strongest factor associated with untimely vaccination

(aOR = 4.3; 95% CI: 2.41–7.92; $p < 0.001$), while lack of vaccination reminders was associated with more than twice the odds of delayed vaccination (aOR = 2.2; 95% CI: 1.30–3.66; $p = 0.003$). The age of child under five years in the household was also significantly associated with vaccination timeliness (aOR = 3.22; 95% CI: 1.26–8.26; $p = 0.015$), suggesting that competing childcare responsibilities may affect adherence to vaccination schedules.

In contrast, caregiver age, education, residence, occupation, distance to vaccination services, satisfaction, and waiting conditions were not independently associated with untimely vaccination after adjustment. These findings highlight caregiver knowledge, reminder systems, and household responsibilities as key areas for interventions aimed at improving vaccination timeliness and completion. These associations should nonetheless be interpreted with some caution, as several explanatory variables including knowledge of the immunisation schedule and receipt of reminders relied on caregiver report. Modi et al. (2018), in a systematic review of recall quality in low- and middle-income settings, found that caregiver recall of vaccination-related information is often imperfect and can both overestimate and underestimate true vaccination behaviour [16], suggesting that triangulation with documented records, where feasible, would further strengthen future assessments of these determinants in Tiko.

Strengths and Limitations

Strengths: The relatively large sample of 800 vaccination records strengthened the assessment of vaccination coverage, completion, and timeliness. Importantly, assessing timeliness alongside vaccination completion provided additional insight into whether children received vaccines at the recommended ages. Multivariable analysis also

enabled the identification of key modifiable factors associated with untimely vaccination.

Limitations: The cross-sectional design limited the ability to establish causal relationships between identified factors and vaccination outcomes. The purposive selection of health facilities and because no formal sample size calculation was performed, may also limit the generalisability of the findings to the entire Tiko Health District. In addition, caregiver-reported vaccination information, when vaccination cards were unavailable, may have introduced recall bias. Finally, because 82.5% of children were aged 0–11 months, coverage estimates for vaccines scheduled later in childhood, particularly MR2, should be interpreted cautiously, as many children had not yet reached the eligible age.

Conclusion

Routine childhood immunisation in the Tiko Health District shows high initial uptake but substantial attrition across subsequent doses, leaving age-appropriate completion low. Caregiver knowledge of the schedule and receipt of reminders were the strongest modifiable predictors of timeliness. Strengthening caregiver communication, reminder and recall systems, and defaulter tracking should be prioritised to improve completion, timeliness, and equity in the district.

Data Management

Survey data were not accessible to participants at participating health facilities. Responses were transmitted electronically to KoboCollect, linked to the investigator's account. Access to the dataset was restricted to the study statistician for analysis. Participants were identified using unique study identification numbers, and direct identifiers were excluded from the analytical dataset. Regular secure backups of exported datasets were maintained separately from the primary database.

Competing Interests

The authors declare no competing interests.

Acknowledgements

The authors sincerely acknowledge the Tiko Health District Management Team and the participating health facilities for facilitating the implementation of this study. We also thank the healthcare workers, research assistants, parents, and caregivers who contributed their time and experiences to the research. Their cooperation and participation were invaluable to the completion of this study.

Ethical Approval

Ethical clearance was obtained from the Regional Ethics Committee for Human Health Research of the Southwest Region of Cameroon (04/CRERSH/SW/C/02/2026). Authorisations were sought from the Southwest Regional Delegation of Public Health (P42/MINSANTE/SWR/RDPH/RCB.PT/04/2026), the Regional EPI Officer Southwest (P12/MINSANTE/SWR/RDPH/EPI/), and Tiko Health District (N°2026/28vol/MINSANTE/RDPHSW/THD/504). All procedures involving human participants were conducted in accordance with the ethical standards of the institutional and national research committees and in compliance with the principles of the Declaration of Helsinki. Written informed

consent to participate was obtained from all study participants before data collection.

Authors' Contributions

N.B.C.P., T.R., O.E.A and D.A. participated in the study design. N.B.C.P. oversaw pilot testing and data collection. N.B.C.P., T.R., O.E.A., and D.A. contributed to the writing and review of the manuscript and approved the final version. N.B.C.P, T.R., O.E.A and D.A. assisted in statistical analysis and interpretation of results. N.B.C.P. had overall responsibility for the study design, overseeing survey distribution, and interpretation of results.

Funding

This research received no specific grant from any funding agency in the public, commercial, or not-for-profit sectors.

Data Availability

The datasets generated and analysed in this study are not publicly available due to institutional regulations but can be obtained from the corresponding author upon reasonable request. All data access requests will be subject to review by the Ethics Committee of the Cameroonian Ministry of Public Health and the Regional Ethics Committee for Human Health Research for the South West Region, to ensure adherence to ethical and legal requirements.

References

- [1]. United Nations Children's Fund (UNICEF). Health & HIV: Cameroon [Internet]. Yaoundé: UNICEF Cameroon; 2025 [cited 2026 Aug 14]. Available from: UNICEF Cameroon website.
- [2]. World Health Organization, United Nations Children's Fund. Global childhood vaccination coverage holds steady, yet over 14 million infants remain unvaccinated [Internet]. Geneva: WHO; 2025 Jul 15 [cited 2026 Aug 14]. Available from: World Health Organization website.
- [3]. Janusz CB, Frye M, Mutua MK, Wagner AL, Banerjee M, Boulton ML. Vaccine delay and its association with undervaccination in children in sub-Saharan Africa. *Am J Prev Med.* 2021;60(1 Suppl 1):S72–S79. doi:10.1016/j.amepre.2020.10.003.
- [4]. Zeufack AGD, Njinkui DN, Youdom SW, Ateudjieu J. Timeliness and missed opportunities for vaccination among children aged 0 to 23 months in Dschang Health District, West Region, Cameroon: a cross-sectional survey. *PLOS Glob Public Health.* 2023;3(6):e0001721. doi:10.1371/journal.pgph.0001721.

- [5]. United Nations Children's Fund (UNICEF). Humanitarian Action for Children 2024: Cameroon [Internet]. Yaoundé: UNICEF Cameroon; 2024 [cited 2026 Aug 14]. Available from: UNICEF Cameroon website.
- [6]. World Health Organization, United Nations Children's Fund. Cameroon: WHO and UNICEF estimates of immunization coverage: 2023 revision [Internet]. Geneva: World Health Organization; 2024 [cited 2026 Aug 14]. Available from: World Health Organization.
- [7]. Institut National de la Statistique (INS), ICF. Enquête Démographique et de Santé du Cameroun 2018. Yaoundé, Cameroon and Rockville (MD): INS and ICF; 2020.
- [8]. Yakum MN, Atanga FD, Ajong AB, Eba Ze LE, Shah Z. Factors associated with full vaccination and zero vaccine dose in children aged 12–59 months in 6 health districts of Cameroon. *BMC Public Health*. 2023;23:1693. doi:10.1186/s12889-023-16609-4.
- [9]. Chiabi A, Nguefack FD, Njapndounke F, Kobela M, Kenfack K, Nguefack S, et al. Vaccination of infants aged 0 to 11 months at the Yaoundé Gynaeco-Obstetric and Pediatric Hospital in Cameroon: how complete and how timely? *BMC Pediatr*. 2017;17:206. doi:10.1186/s12887-017-0954-1.
- [10]. Ngandjon JK, Ostermann T, Kenmoe V, Laengler A. Insights into predictors of vaccine hesitancy and promoting factors in childhood immunization programs—a cross-sectional survey in Cameroon. *Int J Environ Res Public Health*. 2022;19(5):2721. doi:10.3390/ijerph19052721.
- [11]. World Health Organization, United Nations Children's Fund. WHO and UNICEF estimates of national immunization coverage (WUENIC): 2024 revision [Internet]. Geneva: World Health Organization; 2025 [cited 2026 Aug 14]. Available from: World Health Organization.
- [12]. World Health Organization, United Nations Children's Fund. Global childhood immunization coverage inches forward despite conflict and hesitancy [Internet]. Geneva: World Health Organization; 2026 Jul 15 [cited 2026 Aug 14]. Available from: World Health Organization.
- [13]. World Medical Association. World Medical Association Declaration of Helsinki: ethical principles for medical research involving human subjects. *JAMA*. 2013;310(20):2191–2194. doi:10.1001/jama.2013.281053.
- [14]. von Elm E, Altman DG, Egger M, Pocock SJ, Gøtzsche PC, Vandenbroucke JP; STROBE Initiative. The Strengthening the Reporting of Observational Studies in Epidemiology (STROBE) statement: guidelines for reporting observational studies. *Lancet*. 2007;370(9596):1453–1457. doi:10.1016/S0140-6736(07)61602-X.
- [15]. International Council for Harmonisation of Technical Requirements for Pharmaceuticals for Human Use. ICH harmonised guideline E6(R3): Guideline for Good Clinical Practice. Geneva: ICH; 2025.
- [16]. Modi RN, King C, Bar-Zeev N, Colbourn T. Caregiver recall in childhood vaccination surveys: systematic review of recall quality and use in low- and middle-income settings. *Vaccine*. 2018;36(29):4161–4170. <https://doi.org/10.1016/j.vaccine.2018.05.089>.
- [17]. Eze P, Lawani LO, Acharya Y. Short message service (SMS) reminders for childhood immunisation in low-income and middle-income countries: a systematic review and meta-analysis. *BMJ Glob Health*. 2021;6(7):e005035. <https://doi.org/10.1136/bmjgh-2021-005035>.
- [18]. Ateudjieu J, Yakum MN, Goura AP, Tembei AM, Ingrid DK, Bit'a'a Landry B, et al. EPI immunization coverage, timeliness and dropout rate among children in a West Cameroon health district: a cross sectional study. *BMC Public Health*. 2020;20(1):228. <https://doi.org/10.1186/s12889-020-8340-6>.
- [19]. Wariri O, Okomo U, Kwarshak YK, Utazi CE, Murray K, Grundy C, et al. Timeliness of routine childhood vaccination in 103 low- and middle-income countries, 1978–2021: a scoping review to map measurement and methodological gaps. *PLOS Glob Public Health*. 2022;2(7):e0000325. <https://doi.org/10.1371/journal.pgph.0000325>.
- [20]. Harvey H, Reissland N, Mason J. Parental reminder, recall and educational interventions to improve early childhood immunisation uptake: a

systematic review and meta-analysis. *Vaccine*. 2015;33(25):2862–2880.

<https://doi.org/10.1016/j.vaccine.2015.04.085>.

[21]. Yunusa U, Garba SN, Umar AB, Idris SH, Bello UL, Abdulrashid I, et al. Mobile phone reminders for enhancing uptake, completeness and timeliness of routine childhood immunization in low- and middle-income countries: a systematic

review and meta-analysis. *Vaccine*. 2021;39(2):209–221.

<https://doi.org/10.1016/j.vaccine.2020.11.043>.

[22]. Ewang BF, Eyong ME, Cumber SN, Nkfusai CN, Yankam BM, Anye CS, et al. Vaccination coverage under the Expanded Program on Immunization in South West Cameroon. *Int J Matern Child Health AIDS*. 2020;9(2):164–173.