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Article

Determinants of incomplete immunization among children aged 12 to 23 months in southern Ethiopia

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Abstract

Incomplete routine immunization remains common in rural Ethiopia, yet why children fall behind the schedule is poorly understood. We conducted a community-based unmatched case–control study of 305 caregiver–child pairs, 103 incompletely immunized cases and 202 fully immunized controls aged 12–23 months, in South Ari District, southern Ethiopia. Poor caregiver knowledge and attitude towards vaccination (adjusted odds ratio 6.38, 95% CI 2.83–14.37) and poor knowledge of the immunization schedule (4.94, 2.68–9.11) showed the strongest associations with incomplete immunization. Misconceptions about vaccine contraindications, postponed appointments, travel time over 25 min and a birth interval of 33 months or less were also independent determinants. Forgetting the appointment date accounted for 62% of the reasons given for postponement. Caregiver-focused counselling, appointment reminders, defaulter tracing, birth-spacing counselling and closer outreach services could improve completion.

Introduction

Immunization is one of the most cost-effective public health interventions and has substantially reduced the burden of vaccine-preventable diseases (VPDs) worldwide; measles vaccination alone averted an estimated 23 million deaths between 2010 and 2018.[1] The routine infant schedule recommended by the World Health Organization (WHO) and implemented in Ethiopia comprises Bacillus Calmette–Guérin (BCG) and oral poliovirus vaccine (OPV) at birth; pentavalent vaccine (diphtheria–tetanus–pertussis, hepatitis B and *Haemophilus influenzae* type b), OPV and pneumococcal conjugate vaccine (PCV) at 6, 10 and 14 weeks; rotavirus vaccine at 6 and 10 weeks; and the first dose of measles-containing vaccine (MCV1) at 9 months, followed by MCV2 at 15 months.[2]

The Expanded Program on Immunization (EPI) aims to reach at least 90% of infants with the primary series, yet many low-income countries have not met this target.[3] Globally, more than 20 million children did not complete the basic series in 2022, and dropout between the first and third doses of diphtheria–tetanus–pertussis vaccine (DTP1–DTP3) was highest in low-income countries (12%), compared with lower-middle-income (5%) and high-income countries (3%).[4] About one in five children in Africa does not receive all recommended vaccines, and the region carries a disproportionate share of under-five deaths from VPDs.[5]

In Ethiopia, the routine schedule has expanded from six to twelve antigens, delivered through an integrated primary health care system using static and outreach sessions.[6,7] Coverage nevertheless remains well below target. Pooled and survey-based analyses indicate that roughly four in ten Ethiopian children do not complete the schedule.[1,8] In the 2019 Mini Demographic and Health Survey, only 44% of children aged 12–23 months had received all basic vaccinations and 40% had received them at the recommended age, a five-percentage-point increase since 2016, with markedly lower coverage in rural than in urban areas.[9] Administrative coverage estimates are consistently higher than survey estimates, which can mask the true size of the problem at district level.[10]

Ethiopian studies have linked incomplete or defaulted immunization to caregiver knowledge of the schedule, marital status, antenatal and postnatal care use, place of delivery, distance to vaccination sites and missed appointments.[11–15] National initiatives, including zero-dose identification and catch-up campaigns, have been introduced,[16] while service delivery remains constrained by health-worker shortages and long waiting times.[17]

In South Ari District, administrative reports from the past three years show persistently high defaulter rates, even though an organized primary health care structure delivers static and outreach immunization services in every kebele. Evidence on the determinants of incomplete immunization in this setting is lacking, and most previous Ethiopian studies were cross-sectional coverage surveys rather than case–control studies designed to identify determinants. This study therefore aimed to identify the determinants of incomplete immunization among children aged 12–23 months in South Ari District, Ari Zone, southern Ethiopia.

Results

Characteristics of participants

Of the 316 sampled caregiver–child pairs, 305 took part (103 cases and 202 controls; response rate 96.5%). The mean caregiver age was 30.2 years (SD 6.6) among controls and 29.0 years (SD 7.4) among cases; the mean child age was 19.2 months (SD 3.4) and 18.4 months (SD 3.8), respectively. Most primary caregivers were mothers (93.6% of controls, 95.1% of cases), married (96.0%, 94.2%) and rural residents (85.1%, 87.4%). A birth interval of ≤33 months was more common among cases (60.2%) than controls (48.5%), as were farming as an occupation (73.8% vs. 62.4%) and no formal education (65.0% vs. 55.4%) (Table 1).

Health service characteristics

Nearly all mothers had attended ANC (98.5% of controls, 93.2% of cases) and delivered in a health facility (98.5%, 94.2%). Mean travel time to the vaccination site was 19.8 min (SD 11.0) for

controls and 23.7 min (SD 12.6) for cases, and more cases than controls travelled >25 min (52.4% vs. 40.1%). Immunization cards were available for 94.6% of controls and 79.6% of cases. Postponed appointments were reported by 68.0% of cases and 56.4% of controls, and missed opportunities for vaccination were common in both groups (66.0% and 61.4%) (Table 2).

Caregiver knowledge, attitudes and perceptions

Good knowledge of the immunization schedule was reported by 75.7% of control caregivers but only 49.5% of case caregivers, and poor overall knowledge and attitude toward vaccination was three times as common among cases (33.0% vs. 9.9%). Neutral misconceptions about vaccine contraindications were more frequent among cases (39.8% vs. 29.7%), while perceived benefit of vaccination and satisfaction with EPI services did not differ between groups (Table 3).

Reasons for postponing vaccination appointments

Forgetting the appointment date was by far the most common reason given for postponing vaccination, accounting for 138 of 221 responses (62.4%), followed by not having been told that vaccination was necessary (51; 23.1%) and illness of the child or mother (22; 10.0%) (Fig. 2).

Determinants of incomplete immunization

Eleven variables with $p \leq 0.25$ in bivariable analysis were entered into the multivariable model. After adjustment, six were independently associated with incomplete immunization (Table 4). Children born after a birth interval of ≤33 months had 1.79 times higher odds of incomplete immunization than those born after a longer interval (AOR 1.79; 95% CI 1.04–3.09). Children whose caregivers travelled >25 min to the vaccination site had 2.22 times higher odds than those travelling ≤25 min (AOR 2.22; 95% CI 1.27–3.85).

Compared with caregivers who rejected misconceptions about vaccine contraindications, those with positive (AOR 4.70; 95% CI 1.29–17.11) and neutral (AOR 6.12; 95% CI 1.61–23.20) misconceptions had higher odds of having an incompletely immunized child. Postponing a vaccination appointment almost doubled the odds of incomplete immunization (AOR 1.92; 95% CI

1.05–3.57). Poor caregiver knowledge of the immunization schedule (AOR 4.94; 95% CI 2.68–9.11) and poor overall knowledge and attitude toward vaccination (AOR 6.38; 95% CI 2.83–14.37) showed the strongest associations.

Discussion

This community-based case–control study found that incomplete immunization among children aged 12–23 months in South Ari District was independently associated with a short birth interval, travel time to the vaccination site, misconceptions about vaccine contraindications, postponed vaccination appointments, poor knowledge of the immunization schedule and poor overall knowledge and attitude toward vaccination. Caregiver knowledge-related factors showed the strongest associations, pointing to demand-side gaps that routine service delivery alone has not closed.

Children born after a birth interval of ≤33 months had higher odds of incomplete immunization. Closely spaced births increase the caregiving workload and compete for the time, attention and household resources needed to attend repeated vaccination sessions. This finding is consistent with the 2016 and 2019 Ethiopian demographic and health surveys[9,18] and with a study from eastern Ethiopia,[19] and it supports integrating birth-spacing counselling into immunization and postnatal contacts.

Travel time of more than 25 min to the vaccination site more than doubled the odds of incomplete immunization, in line with studies from Nigeria and from Siraro and Laelay Adiabo districts in Ethiopia.[14,15,20] That a relatively modest threshold mattered suggests that, in this largely rural district, each additional visit carries a real opportunity cost for caregivers. Long waits at under-staffed facilities may compound this burden.[17] Strengthening outreach sessions and siting vaccination posts closer to underserved villages are therefore likely to improve completion.

Caregivers with positive or neutral misconceptions about vaccine contraindications had higher odds of having an incompletely immunized child than those who rejected such misconceptions,

consistent with studies from Gambela and Machakel district.[2,21] Caregivers who believe that a mild illness or fever contraindicates vaccination may defer due doses, and the notably high odds among uncertain (neutral) caregivers suggest that uncertainty itself leads to postponement. The small reference group (26 caregivers) explains the wide confidence intervals, so the magnitude of these estimates should be interpreted cautiously, although their direction is consistent.

Postponing a vaccination appointment nearly doubled the odds of incomplete immunization, as reported in Kacha Bira and Arbegona districts.[3,13] Most postponements were attributed to forgetting the appointment date (62.4% of responses), with a further 23.1% attributed to not having been told that vaccination was necessary. Forgotten appointments were also a leading reason for defaulting in Dabat, Yirgacheffe and Machakel districts[11,21,22] and in urban India, where parental unawareness and postponing sessions were common reasons for incomplete immunization.[23] Low-cost reminder systems—health extension worker follow-up, community volunteers or SMS reminders where mobile phone access allows—could directly address this gap.

Poor knowledge of the immunization schedule was associated with almost five-fold higher odds of incomplete immunization, consistent with findings from Dabat and Yirgacheffe districts.[11,22] Caregivers who do not know when immunization starts, how many visits are needed or when the measles dose is due are less able to keep to the schedule without prompts. Similarly, poor overall knowledge and attitude toward vaccination showed the strongest association, in line with studies from Gindhir, Laelay Adiabo, Afar and Gambela in Ethiopia and from Nigeria and Cameroon.[2,15,20,24–26] Health education on the schedule and the benefits of each dose, delivered consistently during ANC, delivery, postnatal and immunization contacts, is a practical response.

Several factors associated with incomplete immunization in crude analysis—no ANC, no maternal Td vaccination and home delivery—were not significant after adjustment, probably because few mothers lacked these services and their effects overlapped with caregiver knowledge. Missed opportunities for vaccination were reported by about two-thirds of caregivers in both groups, which

indicates a service-quality problem affecting all children, not only those who end up incompletely immunized. Immunization cards were also less often available among cases, as in Senegal, where card retention was strongly linked to complete immunization;[27] card retention is worth promoting in its own right.

This study has strengths and limitations. Its strengths include its community-based design, random selection of kebeles and participants, separate sampling frames for cases and controls, verification of immunization status from cards where available, and adjustment for confounding with multivariable regression. Several limitations apply. First, immunization status relied on caregiver recall for children without a card (32 of 305; 10.5%), and appointment histories relied on recall, so misclassification and recall bias are possible. Second, sampling frames were built from EPI registers and health extension worker records, so children never registered with the program, including some zero-dose children, may be under-represented. Third, knowledge and attitudes were measured at the interview, after the outcome had occurred, and social desirability may have influenced responses. Fourth, the small number of caregivers in some categories (e.g., home delivery, no ANC and the misconception reference group) produced imprecise estimates. Finally, supply-side factors such as vaccine stock-outs and session cancellations were not measured, there was no qualitative component, and the findings from a single district may not generalize to other settings.

In conclusion, incomplete immunization among children aged 12–23 months in South Ari District is driven mainly by caregiver-level factors—poor knowledge of the schedule, poor knowledge and attitude toward vaccination, misconceptions about contraindications and forgotten or postponed appointments—together with short birth intervals and longer travel to vaccination sites. Programs should strengthen schedule-focused counselling at every maternal and child health contact, correct misconceptions about contraindications, introduce appointment reminders and defaulter tracing by health extension workers, promote birth spacing, and expand outreach sessions for households far

from vaccination posts. Longitudinal and qualitative studies are needed to explore cultural and health-system barriers in more depth.

Methods

Study setting and design

The study was conducted in South Ari District, Ari Zone, South Ethiopia Regional State, from 1 August to 15 September 2025. The district lies 17 km from Jinka town and 767 km from Addis Ababa and comprises 32 kebeles (31 rural, 1 urban). Health services are provided by one primary hospital, six health centers, 26 health posts and private clinics, with routine immunization delivered through static and outreach sessions. The total population the district was estimated as 47,323 and estimated number of surviving infants was 1609 infants.

A community-based unmatched case–control study was conducted. The source population was all children aged 12–23 months living in South Ari District during the study period, regardless of immunization status. Mothers or primary caregivers (aged ≥15 years) who were severely ill, mentally or physically, and unable to respond were excluded.

Case and control definitions

A child was considered fully immunized if, by 12 months of age, they had received one dose of BCG, three doses of pentavalent vaccine, three doses of OPV (excluding the birth dose), three doses of PCV, two doses of rotavirus vaccine and one dose of measles-containing vaccine, in line with the national EPI guideline.[6] **Cases** were children aged 12–23 months who had missed at least one of these doses by 12 months of age. **Controls** were children aged 12–23 months who had received all of these doses by 12 months of age. Immunization status was ascertained from the immunization card and, where no card was available, from the caregiver's recall.

Sample size and sampling

Sample size was calculated with the two-population-proportion formula for unmatched case–control studies (Fleiss with continuity correction) in Epi Info StatCalc, assuming 52.4% of cases and 34.4% of controls had poor caregiver knowledge of vaccination,[12] 95% confidence, 80% power and a case-to-control ratio of 1:2. This gave 96 cases and 192 controls; adding 10% for non-response yielded 316 participants (105 cases and 211 controls).

Six of the 31 rural kebeles were selected by simple random sampling (lottery method), and the single urban kebele was included purposively. A preliminary review of EPI registers at three health posts, three health centers and one primary hospital, supplemented by health extension workers' records and family folders, identified households with eligible children in the selected kebeles. Eligible children were classified as cases or controls, separate sampling frames were prepared for each kebele, and the sample was allocated proportionally to the number of eligible children in each kebele. Participants were then selected from each frame by simple random sampling (Fig. 1).

Data collection and quality control

Data were collected using a structured, interviewer-administered questionnaire adapted from the 2016 Ethiopian Demographic and Health Survey[18] and previous studies.[21] The questionnaire covered socio-demographic and economic characteristics, health service-related factors, and caregiver knowledge, attitudes and perceptions of vaccination. It was prepared in English, translated into Amharic and back-translated into English to check consistency. Seven diploma-level data collectors and two supervisors, recruited from outside the study area, collected data electronically with KoboCollect after two days of training. The questionnaire was pretested on 5% of the sample in Aykamer kebele, outside the selected kebeles, and revised accordingly.

Supervisors and the principal investigator checked questionnaires daily for completeness and consistency. Data collectors were not informed of participants' case or control status.

Measurements

The outcome was immunization status (incomplete vs. complete). Independent variables included caregiver and child age, child sex, residence, marital status, education, occupation, monthly household income, family size and birth interval; antenatal care (ANC), postnatal care (PNC), place of delivery, maternal tetanus–diphtheria (Td) vaccination, health-worker home visits, travel time to the vaccination site, missed opportunities for vaccination, availability of the immunization card and postponed appointments; and caregiver knowledge of the immunization schedule, misconceptions about vaccine contraindications, perceived benefit of vaccination, satisfaction with EPI services, and overall knowledge and attitude toward vaccination. Knowledge of the immunization schedule was assessed with four questions: the age at which immunization starts, the number of visits needed to complete it, the age at measles vaccination and the age at completion. Summed scores were dichotomized as good or poor. Maternal knowledge and attitude toward vaccination was assessed with five items (correct = 2, incorrect = 1). Caregivers scoring above the mean (>1.80) were classified as having good, and those at or below the mean as having poor, knowledge and attitude. Misconceptions about vaccine contraindications were measured with Likert-scale items and classified by mean score as positive (agreeing that conditions such as mild illness or fever contraindicate vaccination), neutral (uncertain) or negative (disagreeing; reference). Perceived benefit of immunization (three items) and satisfaction with EPI services (eight items) were measured on five-point Likert scales and categorized by mean score into three levels. Missed opportunity for vaccination was defined as a visit to a health facility or outreach site at which an eligible child did not receive a due vaccine. Postponed appointment was defined as the caregiver not bringing the child on a scheduled vaccination date.

Statistical analysis

Data were cleaned and exported from KoboToolbox to SPSS version 25 (IBM Corp., Armonk, NY, USA). Descriptive statistics are reported as frequencies and column percentages by case–control

status, compared with Pearson's chi-square test (Fisher's exact test when an expected cell count was <5). Bivariable logistic regression was used to obtain crude odds ratios (CORs), and variables with $p \leq 0.25$ were entered into a multivariable logistic regression model to estimate adjusted odds ratios (AORs) with 95% confidence intervals (CIs); backward stepwise (Wald) selection was run as a check on the final set of determinants. For interpretability, all odds ratios are presented with the higher-risk category as the comparison group and the other category as the reference; for binary variables this is the exact reciprocal of the original estimate. Model fit was assessed with the Hosmer–Lemeshow test ($\chi^2 = 9.88$, df = 8, $p = 0.273$), and the model's Nagelkerke R^2 was 0.263. A p-value < 0.05 was considered statistically significant. The study is reported according to the STROBE guideline for case–control studies (Supplementary Table 1).

Ethics approval and consent to participate

The study was conducted in accordance with the Declaration of Helsinki. Ethical approval was obtained from the Institutional Review Board of the College of Medicine and Health Sciences, Arba Minch University (reference number IRB/23347/25, approved June 11th, 2025), and permission was obtained from the Ari Zone Health Department. The Institutional Review Board approved the verbal informed consent process, which was obtained from each caregiver prior to the interview. No personal identifiers were recorded, and participants were told they could decline or withdraw at any time.

Data availability

The de-identified dataset generated and analysed during the current study is available from the corresponding author on reasonable request, subject to approval by the Arba Minch University Institutional Review Board.

Code availability

No custom code was used. Analyses were performed with standard procedures in SPSS version 25 (IBM Corp.).

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351 **Author contributions**

352 A.A.K., N.B. and T.M.M. conceived and designed the study. A.A.K. collected the data, performed
353 the statistical analysis and wrote the first draft. N.B. and T.M.M. supervised the study and critically
354 revised the manuscript. All authors read and approved the final manuscript.

355 **Competing interests**

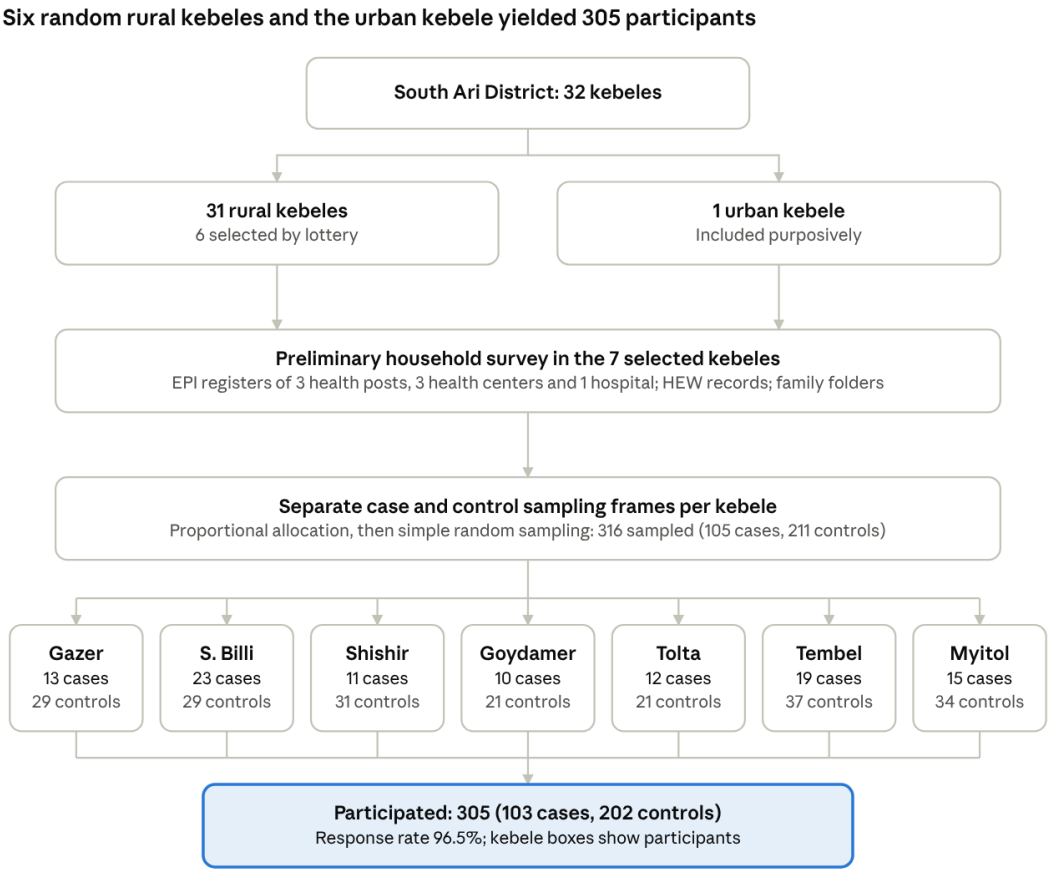
356 The authors declare no competing interests.

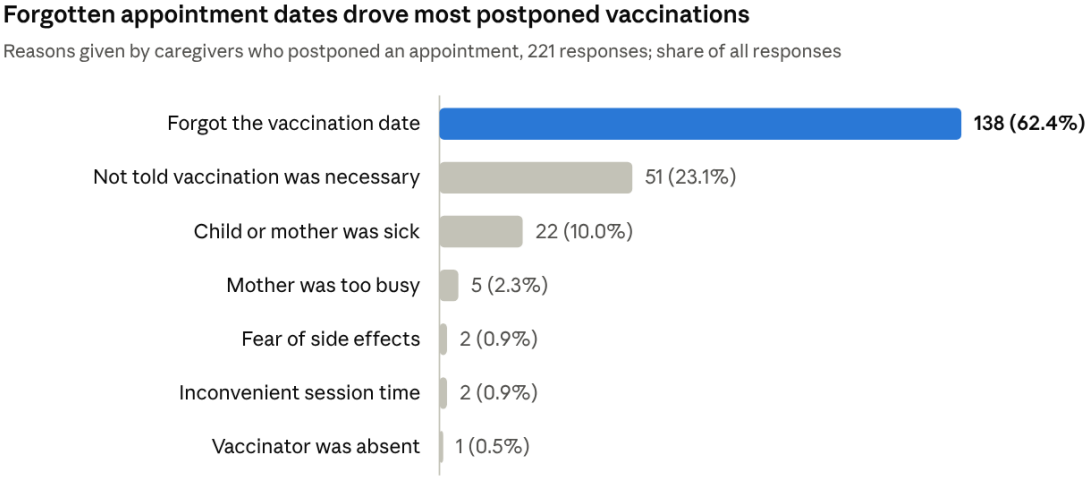
Figure legends

Fig. 1 Sampling procedure for selecting cases and controls. Selection of kebeles and participants in South Ari District, southern Ethiopia, 2025. HEW, health extension worker; EPI, Expanded Program on Immunization.

Fig. 2 Reasons for postponing vaccination appointments. Reasons reported by caregivers, South Ari District, southern Ethiopia, 2025 (n = 221 responses.

Figures


Six random rural kebeles and the urban kebele yielded 305 participants
South Ari District: 32 kebeles
31 rural kebeles
6 selected by lottery
1 urban kebele
Included purposively
Preliminary household survey in the 7 selected kebeles
EPI registers of 3 health posts, 3 health centers and 1 hospital; HEW records; family folders
Separate case and control sampling frames per kebele
Proportional allocation, then simple random sampling: 316 sampled (105 cases, 211 controls)
Gazer
13 cases
29 controls
S. Billi
23 cases
29 controls
Shishir
11 cases
31 controls
Goydamer
10 cases
21 controls
Tolta
12 cases
21 controls
Tembel
19 cases
37 controls
Myitol
15 cases
34 controls
Participated: 305 (103 cases, 202 controls)
Response rate 96.5%; kebele boxes show participants


Forgotten appointment dates drove most postponed vaccinations
Reasons given by caregivers who postponed an appointment, 221 responses; share of all responses
Forgot the vaccination date
138 (62.4%)
Not told vaccination was necessary
51 (23.1%)
Child or mother was sick
22 (10.0%)
Mother was too busy
5 (2.3%)
Fear of side effects
2 (0.9%)
Inconvenient session time
2 (0.9%)
Vaccinator was absent
1 (0.5%)

Tables

Table 1 Socio-demographic and economic characteristics of caregivers and children by immunization status, South Ari District, Ethiopia, 2025 (n = 305).

Variable	Category	Controls (complete), n = 202, n (%)	Cases (incomplete), n = 103, n (%)	p-value
Residence	Rural	172 (85.1)	90 (87.4)	0.597
	Urban	30 (14.9)	13 (12.6)	
Primary caregiver	Mother	189 (93.6)	98 (95.1)	0.579
	Other relative	13 (6.4)	5 (4.9)	
Caregiver age (years)	≤28	98 (48.5)	50 (48.5)	0.996
	>28	104 (51.5)	53 (51.5)	
Child sex	Male	108 (53.5)	65 (63.1)	0.108
	Female	94 (46.5)	38 (36.9)	
Marital status	Married	194 (96.0)	97 (94.2)	0.564 †
	Other [1]	8 (4.0)	6 (5.8)	
Child age (months)	12–17	54 (26.7)	38 (36.9)	0.067
	18–23	148 (73.3)	65 (63.1)	
Caregiver education	No formal education	112 (55.4)	67 (65.0)	0.214
	Primary	75 (37.1)	28 (27.2)	
	Secondary or above	15 (7.4)	8 (7.8)	
Caregiver occupation	Farmer	126 (62.4)	76 (73.8)	0.046
	Employed	76 (37.6)	27 (26.2)	
Monthly income (ETB)	<5000	119 (58.9)	51 (49.5)	0.243
	5001–10,000	74 (36.6)	48 (46.6)	
	>10,000	9 (4.5)	4 (3.9)	
Family size	≤5	155 (76.7)	71 (68.9)	0.141
	>5	47 (23.3)	32 (31.1)	
Birth interval (months)	≤33	98 (48.5)	62 (60.2)	0.053
	>33	104 (51.5)	41 (39.8)	

Pearson's chi-square test unless marked; † Fisher's exact test. [1] Separated, divorced or widowed. ETB, Ethiopian birr.

Table 2 Health service-related characteristics by immunization status, South Ari District, Ethiopia, 2025 (n = 305).

Variable	Category	Controls, n (%)	Cases, n (%)	p-value
ANC follow-up	No	3 (1.5)	7 (6.8)	0.034 †
	Yes	199 (98.5)	96 (93.2)	
PNC follow-up	No	26 (12.9)	16 (15.5)	0.523
	Yes	176 (87.1)	87 (84.5)	
Place of delivery	Home	3 (1.5)	6 (5.8)	0.066 †
	Health facility	199 (98.5)	97 (94.2)	
Maternal Td vaccination	No	9 (4.5)	13 (12.6)	0.009
	Yes	193 (95.5)	90 (87.4)	
Travel time to vaccination site	>25 min	81 (40.1)	54 (52.4)	0.040
	≤25 min	121 (59.9)	49 (47.6)	
Health-worker home visit	No	51 (25.2)	31 (30.1)	0.366
	Yes	151 (74.8)	72 (69.9)	
Missed opportunity for vaccination	Yes	124 (61.4)	68 (66.0)	0.428
	No	78 (38.6)	35 (34.0)	
Immunization card available	No	11 (5.4)	21 (20.4)	<0.001
	Yes	191 (94.6)	82 (79.6)	
Postponed vaccination appointment	Yes	114 (56.4)	70 (68.0)	0.052
	No	88 (43.6)	33 (32.0)	

Pearson's chi-square test unless marked; † Fisher's exact test. ANC, antenatal care; PNC, postnatal care; Td, tetanus–diphtheria vaccine.

374 **Table 3** Caregiver knowledge, attitudes and perceptions by immunization status, South Ari District,

375 Ethiopia, 2025 (n = 305).

Variable	Category	Controls, n (%)	Cases, n (%)	p-value
Perceived benefit of vaccines	Positive	92 (45.5)	55 (53.4)	0.412
	Neutral	67 (33.2)	28 (27.2)	
	Negative	43 (21.3)	20 (19.4)	
Satisfaction with EPI services	Satisfied	70 (34.7)	34 (33.0)	0.941
	Not sure	67 (33.2)	34 (33.0)	
	Not satisfied	65 (32.2)	35 (34.0)	
Knowledge of immunization schedule	Poor	49 (24.3)	52 (50.5)	<0.001
	Good	153 (75.7)	51 (49.5)	
Misconceptions about vaccine contraindications	Positive	120 (59.4)	58 (56.3)	0.046
	Neutral	60 (29.7)	41 (39.8)	
	Negative	22 (10.9)	4 (3.9)	
Knowledge and attitude toward vaccination	Poor	20 (9.9)	34 (33.0)	<0.001
	Good	182 (90.1)	69 (67.0)	

376 Pearson's chi-square test. EPI, Expanded Program on Immunization.

Table 4 Bivariable and multivariable logistic regression of factors associated with incomplete immunization among children aged 12–23 months, South Ari District, Ethiopia, 2025 (n = 305).

Variable	Category	Controls, n	Cases, n	COR (95% CI)	AOR (95% CI)
Child sex	Male	108	65	1.49 (0.92–2.42)	1.61 (0.93–2.79)
	Female	94	38	1	1
Birth interval	≤33 months	98	62	1.60 (0.99–2.60)	1.79 (1.04–3.09) *
	>33 months	104	41	1	1
Caregiver occupation	Farmer	126	76	1.70 (1.01–2.87)	1.22 (0.65–2.30)
	Employed	76	27	1	1
ANC follow-up	No	3	7	4.84 (1.22–19.12)	1.00 (0.17–5.77)
	Yes	199	96	1	1
Travel time to vaccination site	>25 min	81	54	1.65 (1.02–2.66)	2.22 (1.27–3.85) *
	≤25 min	121	49	1	1
Maternal Td vaccination	No	9	13	3.10 (1.28–7.51)	0.94 (0.30–2.90)
	Yes	193	90	1	1
Place of delivery	Home	3	6	4.10 (1.00–16.76)	0.31 (0.05–1.83)
	Health facility	199	97	1	1
Misconceptions about vaccine contraindications	Positive	120	58	2.66 (0.88–8.07)	4.70 (1.29–17.11) *
	Neutral	60	41	3.76 (1.21–11.72)	6.12 (1.61–23.20) *
	Negative	22	4	1	1
Postponed vaccination appointment	Yes	114	70	1.64 (0.99–2.70)	1.92 (1.05–3.57) *
	No	88	33	1	1
Knowledge of immunization schedule	Poor	49	52	3.18 (1.93–5.26)	4.94 (2.68–9.11) **
	Good	153	51	1	1
Knowledge and attitude toward vaccination	Poor	20	34	4.48 (2.42–8.32)	6.38 (2.83–14.37) **
	Good	182	69	1	1

COR, crude odds ratio; AOR, adjusted odds ratio; CI, confidence interval; 1, reference category. * $p < 0.05$; ** $p < 0.001$. Hosmer–Lemeshow $p = 0.273$; Nagelkerke $R^2 = 0.263$.