scientific reports

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Vaccination delay and associated factors among children of age 12–23 months in Gomma district, Oromia, Ethiopia, 2022

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Baby vaccination on time is still a concern, despite the fact that timely and full immunization of children could avert 90% of child mortality attributable to infectious diseases and nutritional problems that are preventable by vaccines. Although numerous research has been conducted on vaccination coverage, only a few studies have highlighted immunization delay and its associated factors in Ethiopia. Additionally, most of them were produced using data from urban populations. Therefore, this study aimed to determine the magnitude of vaccination delay and its associated factors among children aged 12–23 months in the Gomma district, which is one of the prevalently rural districts in Ethiopia. A community-based cross-sectional study was conducted at selected kebeles in the Gomma district from April 1 to 30, 2022, among 528 mother/caregiver-child pairs. A multistage sampling procedure was applied to select the study kebeles and households. Data were collected by face-to-face interviews using a structured questionnaire. The statistical software SPSS version 26 was used for analysis. Bivariable and multivariable binary logistic regression were fitted. Finally, an adjusted odds ratio (AOR) with a 95% CI and a *p* value < 0.05 was used to describe an association. A total of 528 participants were included in the study. The proportion of delayed vaccination was 40.50% (95% CI 36–44%). Home delivery (AOR 4.32; 95% CI 1.30–14.70), lack of post-natal follow-up [AOR 3.13; 95% CI (1.56–6.47)], and birth order of third and above (AOR 3.20; 95% CI 1.12–9.14) were found to be risk factors for vaccination delay. While a maternal age of above 31 years (AOR 0.40; 95% CI 0.10–0.80) was found to be a protective factor against vaccination delay. The proportion of delayed vaccination was considerable. Implementation of interventions that promote institutional delivery, post-natal service utilization, and increasing knowledge of vaccination schedules are important to minimize the proposition of vaccination delay among children in the study area.

Keywords Vaccination delay, Vaccine preventable diseases, Children, Gomma district, Ethiopia

Abbreviations

ANC	Antenatal care
AOR	Adjusted odds ratio
BCG	Bacillus calmette-guerin
CI	Confidence interval
EPI	Expanded Program on Immunization
PNC	Postnatal care
UOR	Unadjusted odds ratio
VPDs	Vaccine-preventable diseases

Globally, 5 million under-five deaths were reported in 2021, most of these deaths being concentrated in sub-Saharan Africa and Southern Asia[1]. Communicable and infectious diseases, along with preterm birth and intrapartum complications, continue to be a major contributor to preventable under-five deaths worldwide[1,2].

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Vaccine-preventable deaths, such as for lower respiratory infections, meningitis, and measles, accounted for one-fifth of all deaths in under-five children[2]. Around 1.5 million children under five die from vaccine-preventable diseases every year[3]. Ethiopia was among the five countries in the world with the highest percentage of unvaccinated under-five children in 2019[3] and was a major contributor to the under-five mortality rate of 55 per 1000 live births[4].

Delays in the startup of child immunization have been a global issue even in the developed world, where the vaccination coverage rate is high[5]. Delayed vaccination increases the risk of VPDs like pertussis, measles, and hemophilus influenza typeb (Hib) up to sixfold and leads to outbreaks[6]. Delaying vaccinations reduces herd immunity, prolongs disease transmission, and increases child mortality[7]. Delays in vaccination can also result in an altered immunization schedule, which exposes the vaccine's non-specific effects and has a negative impact on children's morbidity and mortality[8].

A vaccination delay is defined as a delay of more than 4 weeks after the recommended age for each dose of vaccine[6]. Because transplacental immunity declines rapidly in the first year of life, timely immunization is critical[9]. Deviation from the recommended schedules of the vaccination could potentially reverse the benefits of immunizations[10]. In line with the world health organization's (WHO) recommendation, the Ethiopian Expanded Program of Immunization (EPI) recommends a Bacillus calmette-guerin (BCG) vaccine, four doses of oral polio vaccine (OPV) (0–3), pentavalent (diphtheria-tetanus-pertussis-hepatitis B-Hib-containing vaccine) (1–3), pneumococcal conjugate vaccine (PCV) (1–3), two doses of Rota virus vaccine, and one dose of measles vaccine, with the last vaccine dose (measles vaccine) expected to be given nine months after birth[11]. The EPI considered a child to have all basic vaccinations if the child has received three doses of the PCV, given at age 6, 10, and 14 weeks, and two doses of the rotavirus vaccine (at age 6 and 10 weeks)[11].

Although vaccine timeliness has been adopted as an indicator for evaluation of the quality of immunization services, it has been a relatively neglected aspect of program performance[6]. The magnitudes of delayed PCV 1–3 dose and MCV in China were reported to be 8.1%, 15.5%, 24.6%, and 22.4%, respectively[12]. In Burkina Faso, approximately 23% and 17.2% of children aged 12–23 months had their BCG and measles doses delayed, respectively[13]. In Gambia, 63.3% of the children experienced a delay in the recommended time to receiving at least one of the vaccines[14]. Studies conducted in Ethiopia revealed that the overall magnitude of delayed vaccination was 29.5%[15], with the magnitudes of delayed BCG and measles vaccination being 64.7% and 26%, respectively[16]. Prior studies have shown that factors such as the child's gender, birthplace, residency area, maternal education level, pregnancy intention, antenatal care follow-up, and participation in the pregnant women's seminar were independent predictor variables of vaccination delay[12,15–17].

Ethiopia has been implementing different strategies, such as the combined effects of the reaching every district (RED) approach, a health extension program, and the implementation of enhanced routine immunization activities (ERIAs)[18]. Although vaccination rates are gradually rising in Ethiopia, the country faces significant challenges from inadequate or delayed immunization[4]. Thus, to improve timely and age-appropriate immunization, a better understanding of the reasons for the delay is required[15]. Despite the Ethiopian government's efforts to improve the EPI program through static, outreach, and mobile sites to target groups in every corner of the country in order to reduce VPD, the target has yet to be met. As a result, only 2 out of every 7 children in rural areas receive timely vaccinations[19].

There are considerable previous studies conducted on the coverage of vaccination in Ethiopia[18,20–22]. However, few studies focused on vaccination delay and its associated factors[15,16,23]. Moreover, most of them were done on the population residing in cities[15,23]. As observed in the research area's medical facilities, children's vaccination delays were found to be a common issue, which prompted a scientific investigation into the issue in the area. Additionally, no similar study has been done in the study area. Thus, the objectives of this study were to assess the magnitude of vaccination delay and its associated factors among children of age 12–23 months in Gomma district, southwestern Ethiopia.

Methods

Study design and setting

A community-based cross-sectional study was conducted from April 1 to April 30, 2022, in Gomma district, Jimma Zone, South-West Ethiopia. Gomma district is located at a distance of 396 km away from Addis Ababa, the capital city of Ethiopia. The district is one of the prevalently rural districts in Ethiopia, with 34 rural and 4 urban kebeles. Kebele is the lowest-level administrative unit in Ethiopia, which is accountable to and housed within woredas. According to 2017 population projection data, the total population of the district is 268,273, among which 253,545 (94.5%) and 14,728 (5.5%) are rural and urban kebeles, respectively[24]. Fifteen percent of the total population (41,480) are children under the age of five. The district has one public hospital, six health centers (HCs), and 38 health posts (HP) that are currently providing health services.

Population

All children aged 12–23 months with their mothers/caregivers residing in the Gomma district made up the source population. All children aged 12–23 months with their mothers/caregivers residing in selected kebeles during the study period were the study population. Households with at least one child of age 12–23 months and having a residence of greater than six months and having a vaccination card that showed completed vaccination status were included in the study. Mothers or caregivers who were unable to respond to our questions due to severe illness were excluded from this study.

Sample size determination

The sample size needed for this study was determined for both vaccination delay and factors linked to vaccine delay using evidence from prior research[15,23,25]. A single population proportion calculation was used to determine

the sample size for the prevalence of delayed vaccination, whereas Epi Info V.7.2. statistical software for a cross-sectional study was used to determine the sample size for the associated factors. The study that produced the largest sample size was selected. The actual sample size for this study was determined using a single population proportion formula taking into account the following assumptions: a 95% confidence level, a 5% margin of error, a proportion of delayed vaccination of 29.5% from an earlier Ethiopian study[25], a design effect of 1.5, and a non-respondent/registration-related error of 10%. The final sample size was 528.

Sampling procedure and technique

A multistage sampling techniques was used to select kebeles and households. The district's 38 kebeles were first divided into rural and urban kebeles (4 urban and 34 rural). In the first stage, a simple random sampling technique was used to select 30% of the kebele (cluster) from each stratum, meaning that 10 rural and 2 urban kebeles were randomly selected from a total of 4 urban and 34 rural kebeles.

In the selected kebeles, a total of 1433 children were estimated to be eligible. Initially, a list of all eligible children (1433) between the ages of 12 and 23 months was compiled using the family folders and the immunization records of each health post located in the selected kebeles. The list of eligible children from the health posts family folder was also compared with the immunization records maintained at the health posts to make sure that no eligible child was excluded from the sample frame. In this way, a complete list of all eligible children in the chosen 12 kebeles was created, complete with details like the child's name, the full name of each parent, and the household's unique identification number. The required sample size from each kebele was then determined using a proportional to size allocation.

Finally, using the children listed as a sampling frame obtained from family folders, a simple random sampling technique was used to select the required number of children from each kebele. If an eligible child's mother or caretaker was not present at the time of data collection, a re-visit was scheduled at least three times during the data collection period.(Fig. 1).

Dependent variable

Vaccination delay.

Independent variables

The independent variables examined in this study were based on prior studies[15,16,23] and ranged from socioeconomic issues to variables specific to the mother and her child.

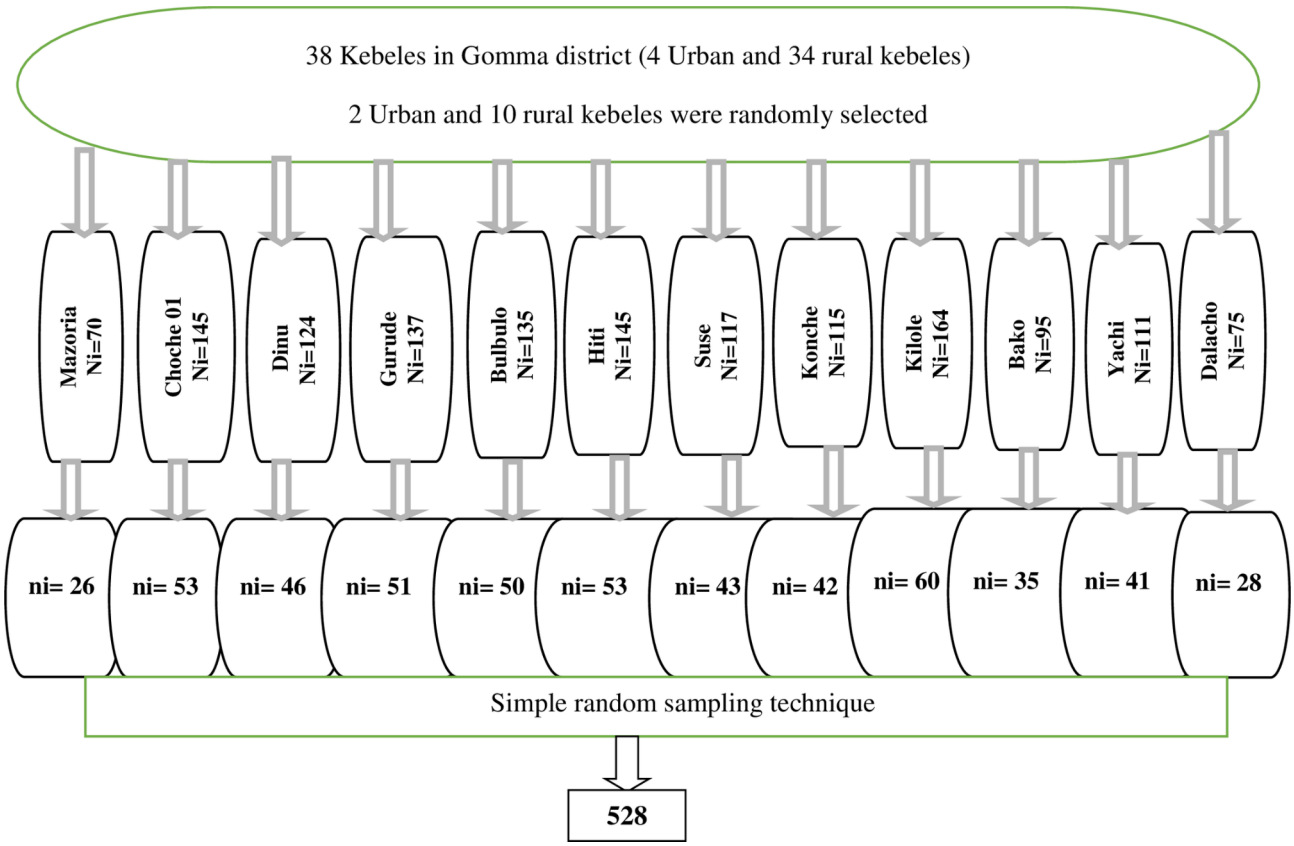

Fig. 1. Diagramatic presentation of proportional allocation of samples into selected kebeles in Gomma district, Oromia, Ethiopia, 2022.

Socio-demographic factors: Sex of child, age of the child, residence, primary guardian of the child, age of the caregiver/mother, marital status, family size, and education level of caregiver/mother and maternal occupation were socio-demographic independent variables.

Maternal/caregiver factors: Knowing immunization end time, the birth place of a child, explaining immunization as important to a child, knowing the time of immunization start up, explaining if VPDs could be serious, maternal illness during the due date, claim of forgetting an appointment date, perceived fear of side effects of the vaccine, history of antenatal care (ANC) utilization and postnatal care (PNC) follow-up were maternal or caregiver related independent variables.

Child and service-related factors: long waiting time at a health facility, lack of appointment from the facility, mode of transportation to health facility, satisfaction from services, child health status during a due date, distance of vaccination site, and birth order of the child were a child and service-related independent variables measured in this study.

Operational definitions

Delayed vaccination: defined as if at least one vaccine was received 4 weeks after the recommended age of vaccination[6,15]. Accordingly, BCG, the pentavalent 1–3, and a measles vaccine dose (MCV1) were categorized as delayed at > 4, > 10, > 14, > 18 and > 40 weeks respectively. On the basis of vaccination cards, we first recoded each variable (Vaccines) as "0" and "1" respectively, for children who delayed for the recommended vaccine and those who did not. The amount was then totaled together and given the label "Vaccination status." The child's vaccination status was noted as "0" if they had gotten all the advised doses of every vaccination on recommended time, classifying them as "Not delayed," or "1" if they had delayed one or more doses, classifying them as "Delayed."

Long waiting time: Mothers who vaccinated their children yet waited at the facility for more than or equal to sixty minutes during the immunization sessions were considered to have a long waiting time[25].

Satisfaction towards care from healthcare providers: Mothers/caregivers perceived needs and expectations in relation to factors such as the health care provider. Very satisfied, satisfied, neutral, dissatisfied, and very dissatisfied were the five Likert scale questions in the tool. It was divided into two categories: satisfied and very satisfied clients were considered satisfied, while neutral, dissatisfied, and very dissatisfied clients were considered unsatisfied.

Distance to a health facility: Women were questioned about if their distance from a health facility made it difficult for them to access medical care from such facilities, including services such as child immunization. This variable has two options: "Yes" (the distance was a big problem) or "No" (the distance was not a big problem).

Data collection tools and procedure

The data was collected by a structured-questions that were adopted from WHO survey questions[15] using the Kobo toolbox version 2022.1.2 by trained health professionals in the face-to-face interview among mothers/caregivers who had children 12–23 months age-old. The vaccination status of the child was obtained from the vaccination card. The data collectors were trained Bachelor of Science (BSc) degree holders in one health sciences. Health extension workers also participated in data collection after taking the training. Two Master of Science (MSc) degree nurses supervised the data collection process to improve data quality.

Data quality control

Two days of training was given on the objectives, significance, concepts under investigation, data collection methods, the process of assigning study participants, the significance of good communication skills and ethical concerns, and the data collection method. A pre-test was conducted on 5% of the total sample size (27 respondents) from the Kebeles that was not included in the main study. All collected data were checked for completeness by the data collectors, supervisor, and investigator on daily basis. Moreover, before the main data analysis, data cleaning and coding were done to minimize errors and check statistical assumptions for outliers and normality based on the variable's measurement level.

Data processing and analysis

Data was exported to SPSS version 26 for the analysis. Descriptive statistics such as frequency, percent, mean, and standard deviation were used to describe the participants' characteristics. Multicollinearity between independent variables was checked using the variance inflation factor (VIF). Potential confounding and interaction effects among the variables were checked using the Mantel–Haenszel test. Bivariate and multivariable binary logistic regression models were used to determine factors that were associated with child vaccination delay. All independent variables that have an association with the outcome variable in bivariate analysis with a p value less than 0.25 were included in the final multivariable binary logistic regression analysis. Both crude and adjusted odds ratios with their corresponding 95% confidence intervals were computed and reported to see the strength of association between the outcome and independent variables. p values < 0.05 were used to declare a significant association. The Hosmer and Lemeshow test was employed to assess the adequacy of the final model. Finally, the results of the analysis were presented in a text, figure, and table.

Ethical considerations

Ethical clearance and approval were obtained from the Salale University Institutional Review Board (IRB) with reference number SLU-IRB/878/14. A letter of cooperation was written to the Gomma District Health Office. The letter of cooperation was also written to health centers (health posts) and local kebele administration offices to get permission for data collection. After informing the study participants of the purpose and procedure, informed written consent was obtained from the study participants. The participants were also assured that they had the right to refuse or withdraw if they were not comfortable at any time. The entire data set gathered from

the participants was kept confidential by omitting any means of personal identification from the questionnaire. This study was performed in line with the principles of the Declaration of Helsinki. COVID-19 prevention protocols were applied during data collection.

Results

Socio-demographic characteristics

A total of 528 mothers/caregivers who had children aged 12–23 months were interviewed with a response rate of 100%. Approximately, 90.5% of the respondents were mothers, with the remaining 9.5% being caregivers. The mean age of the mothers/caregivers was 28.4 (± 4.2) years with the age range of 18–42 years. More than three-fourth (403) of respondents were rural residents, of whom 154 (38.2%) delayed the child's vaccination. About 131 respondents had a family of size 6 or more, of whom more than half (67) delayed at least one vaccination for the child.

Regarding to the children's characteristics, the mean age of the children was 17 (± 3) months. More than half (304) of the children aged 12–17 months, while 224 (42.4%) children belonged to the age group 18–23 months. More than half (288) of the children were males, of whom 121 (42%) delayed the vaccination time. More than half (302) of the children had a birth order of three or more, of those 153 (50.7%) delayed their vaccination (Table 1).

Health service utilization and immunization related characteristics

More than three-fourths (418) of the respondents had PNC follow-up for the index birth, of whom 125 (29.9%) mothers delayed the vaccination of their children. Another 89 (80.9%) mothers who had no PNC follow-up experienced delayed vaccination for their child. About sixty four mothers gave birth at home, of whom 58 (90.6%) delayed at least one vaccination of their child. A total of 295 (55.9%) mothers have known the vaccination starting time, while 452 (85.6%) thought that VPDs could be serious for their child. Although 475 (90%) believed that vaccination is important for their child, 188 (39.6%) of these experienced delayed vaccination for their child (Table 2).

Around 410 (77.7%) of the respondents did not use any transportation means to reach to the vaccination site, of whom 179 (43.7%) delayed vaccination of the child. Majority (97.3%) of mothers reported that they were satisfied with the care provided to them by the healthcare providers. Nearly half (258) of the respondents indicated a long waiting time at health institutions for vaccination, of whom 97 (37.6%) experienced delay in the child's vaccination (Table 3).

Variable	Categories	Delayed N (%)	Not delayed N (%)	Total N (%)
Residence	Rural	154 (38.2)	249 (61.8)	403 (76.3)
	Urban	60 (48)	65 (52)	125 (23.7)
Sex of child	Male	121 (42)	167 (58)	288 (54.5)
	Female	93 (38.7)	147 (61.3)	240 (45.5)
Age of child	12–17 months	128 (42.1)	176 (57.9)	304 (57.6)
	18–23 months	86 (38.4)	138 (61.6)	224 (42.4)
Birth order of the child	First	9 (18.4)	40 (81.6)	49 (9.3)
	Second	52 (29.4)	125 (70.6)	177 (33.5)
	Third and above	153 (50.7)	149 (49.3)	302 (57.2)
Maternal age	< = 30 years	201 (48.6)	213 (51.4)	414 (78.4)
	> = 31 years	13 (11.4)	101 (88.6)	114 (21.6)
Marital status	Never married	0 (0)	6 (100)	6 (1.2)
	Current married	204 (40.3)	302 (59.7)	506 (95.8)
	Divorced	10 (62.5)	6 (37.5)	16 (3.0)
Maternal education	No education	25 (49)	26 (51)	51 (9.7)
	Primary	133 (50.6)	130 (49.4)	263 (49.8)
	Secondary	43 (28.3)	109 (71.7)	152 (28.8)
	College/above	13 (21)	49 (79)	62 (11.7)
Maternal occupation	Housewife	180 (47)	203 (53)	383 (72.5)
	Private worker	20 (25.6)	58 (74.4)	78 (14.8)
	Employed	14 (20.9)	53 (79.1)	67 (12.7)
Father's Occupation	Private	3 (60)	2 (40)	5 (0.9)
	Merchant	76 (38.2)	123 (61.8)	199 (37.7)
	Employee	13 (20)	52 (80)	65 (12.3)
	Farmer	122 (47.1)	137 (52.9)	259 (49.1)

Table 1. Socio-demographic characteristics of the study participants in Gomma district, Oromia, Ethiopia, 2022 (n = 528).

Variable	Categories	Delayed N (%)	Not delayed N (%)	Total N (%)
ANC utilization	No	110 (38.9)	173 (61.1)	283 (53.6)
	Yes	104 (42.4)	141 (57.6)	245 (46.4)
PNC follow-up	No	89 (80.9)	21 (19.1)	110 (20.8)
	Yes	125 (29.9)	293 (70.1)	418 (79.2)
Place of birth	Health facility	156 (33.6)	308 (66.4)	464 (87.9)
	Home	58 (90.6)	6 (9.4)	64 (12.1)
Do you think immunization is important?	No	26 (49.1)	27 (50.9)	53 (10)
	Yes	188 (39.6)	287 (60.4)	475 (90)
Claim of forgetting the vaccination due date?	Yes	72 (63.7)	41 (36.3)	113 (21.4)
	No	142 (34.2)	273 (65.8)	415 (78.6)
Maternal illness during due date?	Yes	31 (49.2)	32 (50.8)	63 (11.9)
	No	183 (39.4)	282 (60.6)	465 (88.1)
Fear of vaccine side effects	Yes	11 (64.7)	5 (35.3)	17 (3.2)
	No	203 (39.7)	308 (60.3)	511 (96.8)
Do you think VPDs could be serious?	No	62 (81.6)	14 (18.4)	76 (14.4)
	Yes	152 (33.6)	300 (66.4)	452 (85.6)
Do you think vaccination achieves immunity?	No	89 (86.4)	14 (13.6)	103 (19.5)
	Yes	125 (29.4)	300 (70.6)	425 (80.5)
Do you know immunization starting time?	Yes	92 (31.2)	203 (68.8)	295 (55.9)
	No	122 (52.4)	111 (47.6)	233 (44.1)
Do you know immunization ending time?	Yes	77 (23.4)	252 (76.6)	329 (62.3)
	No	137 (68.8)	62 (31.2)	199 (37.7)

Table 2. Maternal-related characteristics among study participants in Gomma district, Oromia, Ethiopia, 2022 (n = 528). ANC, antenatal care; PNC, postnatal care; VPDs, vaccine preventable diseases.

Variable	Categories	Delayed N (%)	Not delayed N (%)	Total N (%)
Long waiting at a health facility	Yes	97 (37.6)	161 (62.4)	258 (48.9)
	No	117 (43.3)	153 (56.7)	270 (51.1)
Lack of appointment at a health facility	Yes	31 (42.5)	42 (57.5)	73 (13.8)
	No	183 (40.2)	272 (59.8)	455 (86.2)
Mode of transportation	Vehicle	14 (25.9)	40 (74.1)	54 (10.2)
	On horse/mule	21 (32.8)	43 (67.2)	64 (12.1)
	On foot	179 (43.7)	231 (56.3)	410 (77.7)
Lack of vaccine	Yes	108 (39.6)	165 (60.4)	273 (51.7)
	No	106 (41.6)	149 (58.4)	255 (48.3)
Distance to a health facility	Not a problem	194 (40.4)	286 (59.6)	480 (90.9)
	Big problem	20 (41.7)	28 (58.3)	48 (9.1)
Satisfaction with the practice of providers	Satisfied	202 (39.3)	312 (60.7)	514 (97.3)
	Not satisfied	12 (85.7)	2 (14.3)	14 (2.7)
Ill health of the child during the due date	Yes	39 (41.5)	55 (58.5)	94 (17.8)
	No	175 (40.3)	259 (59.7)	434 (82.2)

Table 3. Health service-related characteristics among study participants in Gomma district, Oromia, Ethiopia, 2022 (n = 528).

Magnitude of vaccination delay

Of the total children, 214 (40.5%) experienced delay in at least one of their vaccination. Of the total (40.5%) children who had delayed vaccination, 18.9%, 11.6%, 7.5%, and 2.5% experienced delay for one, two, three and four vaccines, respectively. Regarding to delay for specific type of vaccine, the delay was 14.8%, 14.4%, 20.1%, 12.7% and 12.7% for BCG, Penta1, Penta2, Penta3 and Measles, respectively (Fig. 2).

Factors associated with delayed vaccination

In the bivariate binary logistic regression analysis, maternal education level, knowledge of the final immunization due date, place of delivery, PNC follow-up, birth order, mode of transportation, and maternal age were significantly associated with vaccination delay. In the multivariable binary logistic regression analysis, knowledge of the final

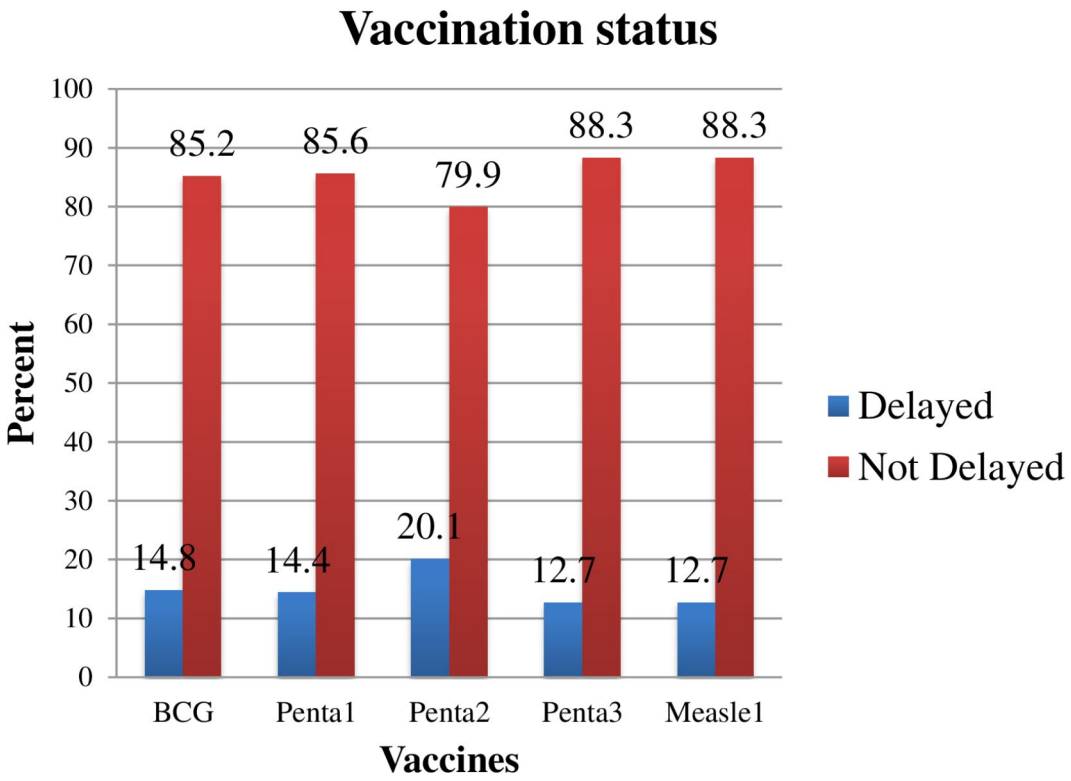

Fig. 2. Vaccination Status of children of 12–23 months of age for each vaccines in Gomma district, Oromia, Ethiopia, 2022.

immunization due date, place of delivery, PNC follow-up, birth order, and maternal age were the factors that were significantly associated with the vaccination delay at the 5% level of significance.

In the multivariable binary logistic regression (Table 4), the odds of delaying vaccination were 3.26 times higher for babies whose mothers did not receive a PNC follow-up compared to babies whose mothers had received a PNC follow-up (AOR 3.26; 95% CI 1.57, 6.76). Children of mothers who gave birth at home were 4.32 times more likely to experience delayed immunization (AOR 4.27; 95% CI 1.21, 15.07) than children of mothers who gave birth in a healthcare facility.

The odds of delayed vaccination were 93% lower for children whose mothers knew the final immunization due date than for children whose mothers did not know (AOR 0.07; 95% CI 0.03, 0.13). Similarly, children whose mothers were 31 years of age or older had a 96% lower likelihood of delayed immunization than children whose mothers were younger than 31 years (AOR 0.04; 95% CI 0.01, 0.08).

Delays in vaccinations were also influenced by birth order. Infants born in the third and higher birth orders were 3.36 times more likely than infants born in the first birth order to experience a vaccination delay (AOR 3.36; 95% CI 1.19, 9.52) (Fig. 3).

Model diagnostics

The Variance Inflation Factor (VIF) was determined to be in the range of 1.05 and 3.15, with the mean VIF value of 1.12, which was below the diagnostic cutoff point[26]. Thus, it is reasonable to conclude that there was no such high correlation between the variables. The Mantel–Haenszel test also showed no significant interactions among the variables. Moreover, the Hosmer and Lemeshow test indicated a good fit of the model (P = 0.203).

Discussion

This study aimed to assess the magnitude and factors associated with vaccination delay among 12–23-month-old children. The overall proportion of vaccination delay in this study was 40.50% (95% CI 36–44%). The delay for BCG, Penta1, Penta2, Penta3, and the Measles vaccine specifically was 14.8%, 14.4%, 20.1%, 12.7%, and 12.7%, respectively. Moreover, the findings of this study demonstrated that maternal age, birth order, place of delivery, PNC follow-up, and knowledge of the final immunization due date were significantly associated with vaccination delay.

This study revealed a significantly higher proportion of delayed vaccinations than a study from Jordan[27], which found that only 8.3% of the children had delayed vaccinations. This might be due to the difference in the study settings. The current study was community-based, which enhanced the likelihood of detecting delayed cases, while the Jordanian study was a prospective cross-sectional study in public health centers[27]. This finding is also higher than what is reported in Saudi Arabia[28] and India[29].

Variable	Delayed N (%)	Not delayed N (%)	UOR (95% CI)	AOR (95% CI)
Birth order				
First	9 (18.4)	40 (81.6)	1	1
Second	52 (29.4)	125 (70.6)	1.85 (0.84, 4.08)	1.75 (0.61, 5.08)
Third & above	153 (50.7)	149 (49.3)	4.56 (2.14, 9.73)***	3.36 (1.19, 9.52)*
Mode of transport				
Vehicles	14 (25.9)	40 (74.1)	1	1
On horse/mule	21 (32.8)	43 (67.2)	1.39 (0.63,3.11)	0.66 (0.24, 1.81)
On foot	179 (43.7)	231 (56.3)	2.21 (1.17, 4.19)*	0.84 (0.38, 1.89)
PNC follow-up				
Yes	125 (29.9)	293 (70.1)	1	1
No	89 (80.9)	21 (19.1)	9.93 (5.91, 16.7)***	3.26 (1.57, 6.76)**
Birth place				
Health facility	156 (33.6)	308 (66.4)	1	1
Home	58 (90.6)	6 (9.4)	19.1 (8.06, 45.2)***	4.27 (1.21, 15.07)*
Maternal education				
College/above	13 (21)	49 (79)	1	1
No education	25 (49)	26 (51)	3.62 (1.59, 8.24)**	1.09 (0.36, 3.35)
Primary	133 (50.6)	130 (49.4)	3.86 (2.00, 7.44)***	1.44 (0.64, 3.23)
Secondary	43 (28.3)	109 (71.7)	1.49 (0.73, 3.01)	1.29 (0.56, 2.99)
Final immunization due date				
Don't know	137 (68.8)	62 (31.2)	1	1
Know	77 (23.4)	252 (76.6)	0.14 (0.09, 0.21)***	0.07 (0.03, 0.13)***
Maternal age				
< = 30 years	201 (48.6)	213 (51.4)	1	1
> = 31 years	13 (11.4)	101 (88.6)	0.14 (0.07, 0.25)***	0.04 (0.01,0.08)***

Table 4. Bivariate and multivariable logistic regression analysis of delayed immunization among 12–23 months old children in Gomma district, Oromia, Ethiopia, 2022 (n = 528). OR, adjusted odds ratio; PNC, postnatal care; UOR, unadjusted odds ratio; 1, reference group; ***statistically significant at p value < 0.001; **< 0.01; *< 0.05.

The proportion of delayed vaccination observed in this study was also higher than the 29.5% recorded in the Tigray region of Ethiopia[15]. The variation in the study population may be the cause of this discrepancy. The study conducted in Tigray consisted solely of urban dwellers as a study population, and there were no issues with access to information or medical services[15]. As such, untimely vaccinations are likely to contribute greatly to the preventable disease burden in Ethiopia, allowing for transmission among those in the age group at which they are the most vulnerable to severe disease[30]. Massive delays like these could also lead to outbreaks of vaccine-preventable diseases. Policymakers at the national and subnational levels should therefore prioritize addressing vaccine delays through outreach programs in addition to achieving widespread vaccination coverage.

Conversely, the proportion of delayed vaccination observed in this study is less than that reported from China (56.3%)[12] and northeast Ethiopia (64.5%)[23]. Furthermore, the proportion of delayed vaccination in the current study is lower than that of a study conducted in the Gambia, where 63.3% of participants had at least one vaccine delayed[14]. The discrepancy between the findings of the current study and the one conducted in China might be attributable to the difference in vaccination schedules. Moreover, in China, the immunization service was managed by well-trained EPI focal persons in immunization clinics who were responsible for identifying and registering children within their catchment areas, tracing defaulters, and raising awareness[12]. This might also account for China's low prevalence of vaccination delays. Given that the study population in the Gambian study consisted of children between the ages of 12 and 59 months, it is possible that the inconsistency in the findings is the result of variations in the study populations. Another factor that could be responsible for this discrepancy was the utilization of different definitions of vaccination delay in the Gambian study (> 8 weeks) and the current one (> 4 weeks).

Giving birth at home was positively associated with vaccination delay in this study. Compared to children whose mothers gave birth in a healthcare facility, children of mothers who delivered at home were more likely to have delayed vaccinations. One reason for this could be that mothers who gave birth at home had no better opportunity to get health education and information on the importance of EPI services than mothers who delivered in a healthcare facility. Studies carried out in the Gambia[14], Toke Kutaye district of Ethiopia[16], and northeast Ethiopia[23], all corroborated this finding. This finding has significant implications because more than half of Ethiopian births take place at home[4], suggesting that one in two children may be at higher risk of delaying vaccinations. Therefore, policymakers should still stress the value of institutionalizing deliveries as a way to learn about EPI services and vaccination schedules.

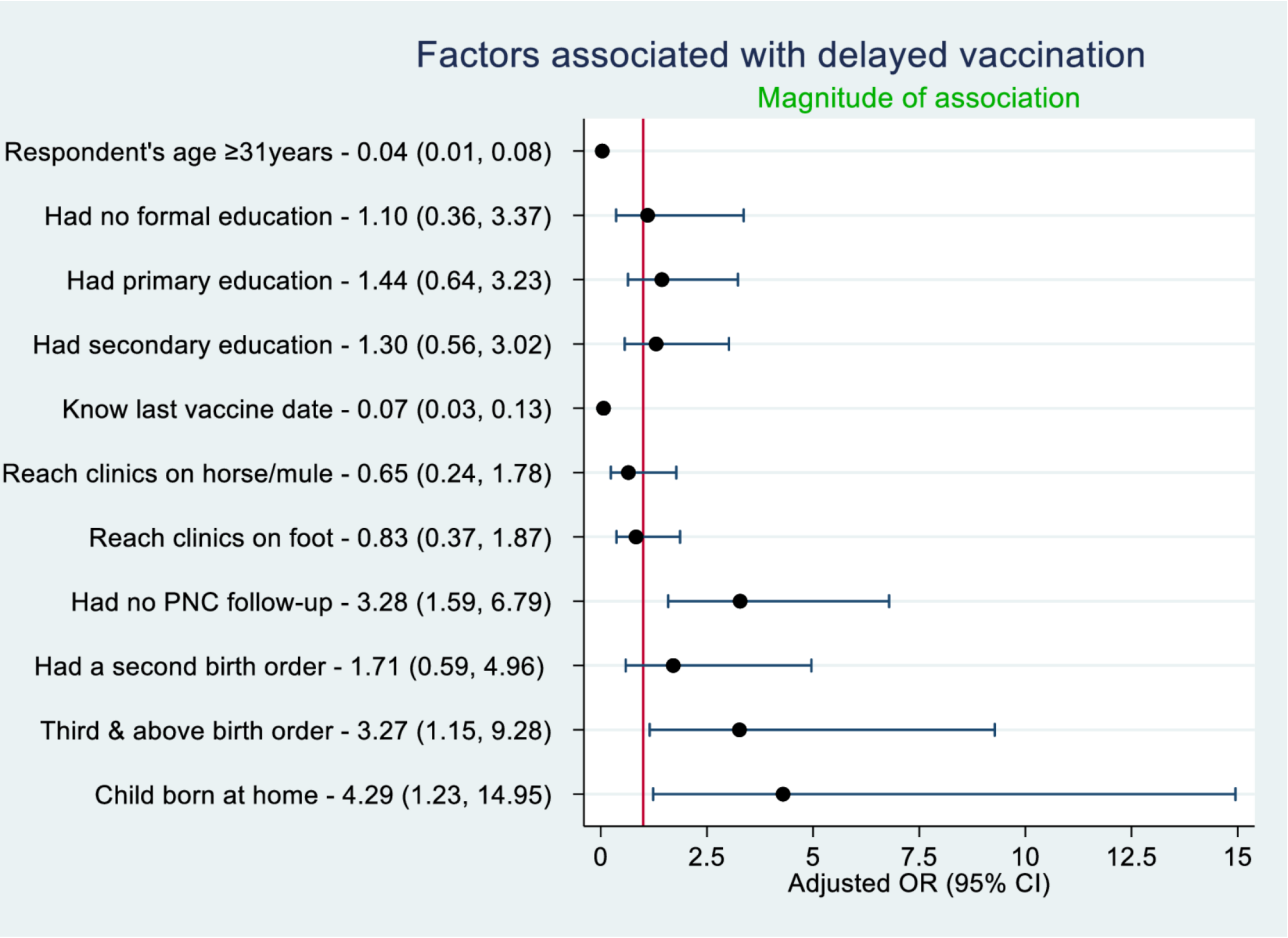

Fig. 3. Forest plot of the magnitude of association between the factors associated with the delayed vaccination of children. Age ≤ 30 years was the reference group for the age variable. The estimates for each category of the education variable were contrasted with those of respondents who had completed college or higher. Vehicles served as a reference group for the variable means of transportation to reach vaccination clinics. The first birth order was used as the reference group for the birth order categories. Home birth was compared to birth in a health facility. PNC, postnatal care.

This study demonstrated that being aware of the final vaccination due date was protective against vaccination delay. Compared to children whose mothers were uninformed of the immunization end time, children whose mothers knew the end time had a lower likelihood of experiencing delayed vaccination. The results are in line with those from China[12] and Ethiopia[21]. This is because the mother who knows the immunization end time is less likely to miss the vaccine due date, as she is more likely to be aware of the immunization schedule. Another reason for this could be that knowing the immunization date empowers and motivates the mother to care for her child and seek out medical facilities so that she can vaccinate her child without delay. Research has also demonstrated that being aware of the vaccine schedule and VPDs would increase the likelihood of vaccinating children on time[16].

According to this study, mothers who didn't receive postnatal care follow-up were more likely to have their child's vaccinations delayed. This result aligned with research from Northwest Ethiopia[30] and Kenya[31]. This could be because mothers who received postnatal follow-up, compared to those who did not, had a better opportunity to learn more about the importance of vaccinations, their schedule, and the consequences of diseases that can be prevented by immunization. It could also be that mothers attending PNC clinics were more aware of the benefits of healthcare and vaccination and had more positive healthcare-seeking behavior.

In the present study, older maternal age (>=31 years) was found to be protective against delayed child vaccination. This might be a result of increased healthcare-seeking behavior as the mother gets older. One possible explanation for this outcome is the higher risk of pregnancy and postnatal problems among older women in general and older primigravida (first-time mothers) in particular. Due to their elevated risk of unfavorable pregnancy outcomes, those women were already being monitored by a healthcare professional, making it simple and quick for them to vaccinate their child. This association between maternal age and vaccine delay, however, is not supported by research from China[32] and Ethiopia[30]. The discrepancy between the findings of the current experiment and the one conducted in China could be due to different immunization schedules. Additionally, China's study was carried out in the distant past (2011 vs. 2022) and used a higher sample size (1146 vs. 528) than

the current study. A study conducted in northwest Ethiopia revealed that caregivers over 35 were less likely than those under 25 to finish their child's vaccinations on schedule[30]. However, research from Burkina Faso showed no significant association between maternal age and immunization delay[13].

A higher birth order was also shown to significantly increase the likelihood of delayed vaccination in the present study. Children of three or more birth orders were more likely to experience delayed vaccination as compared to children with a first birth order. This finding is supported by studies from Israel[33], Saudi Arabia[34], Chile[35], and the Gambia[14]. Another study from Menz Lalo district, northeast Ethiopia[23] showed that decreasing birth order is a protective factor from age-inappropriate vaccination. This finding might be the result of the mother becoming overburdened with demanding conditions as the number of children increases.

In contrast to a study carried out in Burkina Faso[13], the present found no association between residence and the delay in immunization. This study also found no association between vaccination delay and distance from healthcare facilities, unlike what was seen in the Kenyan study[31]. The Ethiopian government's use of the RED approach to immunization may have contributed to this discrepancy.

Strength of the study

The main strength of the present study is the inclusion of a sizable sample size from both urban and rural areas, which would be more representative of the children's population. Another noteworthy aspect of this study was its community-based design, which helped to address areas that institutional studies had missed and enhanced the likelihood of identifying delayed cases. The comprehensive inclusion of sociodemographic information and statistics about mothers and children further boosted this study.

Limitations of the study

As the study was cross-sectional, it might not show a cause-and-effect relationship between dependent and independent variables. The study might have introduced a selection bias because children whose parents did not keep their immunization cards were excluded from the study. Additionally, children older than 23 months who might eventually receive vaccinations were excluded. Failure to incorporate the second dosage of the measles vaccination (MCV2) also limited the current study. Another significant limitation of this study was its failure to account for husband/male partner-related characteristics that could potentially explain the vaccination delay. Given this, the authors urge that future research on the causes of vaccination delays should take into account the roles and perspectives of husbands or male partners.

Implications for policy, practice and research

The evidence revealed in this study further emphasizes the importance of implementing and maintaining vaccine timeliness as an indicator for evaluating the quality of immunization services in Ethiopia. Policies at the national and subnational levels should still stress the value of institutionalizing deliveries as a way to learn about EPI services and vaccination schedules. Future research should focus on conducting large-scale community-based studies that consider the roles and perspectives of husbands or male partners regarding the timeliness of vaccinations.

Conclusion

The proportion of delayed vaccination is considerable in this study, particularly among participants who gave birth at home, didn't follow the post-natal period, children of third and above order, younger maternal age, and didn't know the immunization end time. The study findings indicated that institutional delivery and post-natal follow-up have to be encouraged and awareness creation regarding immunization schedule has to be created by health care providers. Younger mothers and a household with many children also have to be given special attention.

Data availability

The raw data used in this study will be available from the corresponding author on reasonable request.

Received: 6 August 2024; Accepted: 8 April 2025
Published online: 27 May 2025

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Acknowledgements

The authors are indebted to the Salale University College of health science for the approval of the Ethical clearance. The authors would like to thank Gomma district health office and local kebele administration offices for provision of letter of permission. Finally, the authors would like to acknowledge data collectors, and study participants for their valuable cooperation.

Author contributions

B.T.O. made substantial contributions to conception and design of the study, acquisition of data, analysis and interpretation of the results, and wrote the final manuscript. H.Z.A., T.L., D.H. and S.M. were involved in the analysis, interpretation of the data, and in the revision and critical evaluation of the manuscript. All the authors read and approved the final manuscript.

Funding

The authors received no funding for this research work.

Declarations

Competing interests

The authors declare no competing interests.

Ethics approval and consent to participate

Ethical clearance and approval were obtained from the Salale University Institutional Review Board (IRB) with reference number SLU-IRB/878/14. After informing the study participants of the purpose and procedure, informed written consent was obtained from the study participants. The participants were also assured that they had the right to refuse or withdraw if they were not comfortable at any time. The entire data set gathered from the participants was kept confidential by omitting any means of personal identification from the questionnaire. This study was performed in line with the principles of the Declaration of Helsinki. COVID-19 prevention protocols were applied during data collection.

Additional information

Supplementary Information The online version contains supplementary material available at https://doi.org/10.1038/s41598-025-97882-8.

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