Vaccination timeliness and associated factors among children aged 12-23 months in northwest Ethiopia: community-based study

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Research

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Abstract

Background: vaccines are the most effective preventive and success of public health to control and eradicate serious childhood diseases. Timely childhood vaccination can help for children to develop antibody against vaccine preventable diseases. Evidences on childhood vaccination timeliness, however, there are limited in developing countries including Ethiopia. Therefore, this study was aimed at assessing vaccination timeliness and associated factors among children aged 12 to 23 months in Jabitehnan district, northwest Ethiopia.

Methods: A community based cross-sectional study was conducted in Jabitehnan district from February to March 2020. A total of 548 children aged 12-23 months were included using multi-stage and simple random sampling technique. Binary logistic regression model was fitted to identify factors associated with vaccination timeliness. Adjusted odd ratio (AOR) with 95% CI and p-value less than 0.05 were used to declare statistically significant variables.

Results: A total of 13.1% (95 % CI: 10.1-15.8) of children were received childhood vaccines in the recommended time interval. Higher level of maternal education (AOR: 2.73; 95% CI: 1.14-6.50), history of abortion (AOR: 3.45; 95%CI: 1.54-7.74), knowledge (AOR: 1.79; 95%CI: 1.10-3.18) and favorable attitude (AOR: 3.38; 95%CI: 1.83-6.24) were positively associated with vaccination timeliness. While home delivery (AOR: O.35; 95%CI: 0.18-0.68) and rural residence (AOR: 0.31; 95%CI: 0.14-0.65) were negatively associated.

Conclusion: The overall childhood vaccination timeliness status was low in the study area. Children were received the first dose of vaccines within the recommended time relatively higher than the other doses/vaccines. Moreover, children were received measles vaccine earlier and BCG vaccine later than the acceptable time interval. Variables such as residence, maternal level of education, having history of abortion, place of delivery, knowledge and attitudes were affecting vaccination timeliness. Therefore, the policy planners and managers should give emphasis and incorporate vaccination timeliness in the childhood vaccination plan, and better to monitor and evaluate as one potential indicator to enhance the immune status of children. Health planners and managers should also improve women's awareness to enhance their attitude towards childhood vaccination. Furthermore, it is better to promote institutional delivery service utilization to enhance childhood vaccination timeliness.

Introduction

Immunization is the process by which a person is made immune or resistant to an infectious disease, typically by the administration of a vaccine (1). The Expanded Program on Immunization (EPI) was started in early 1974 to give all basic vaccines and immunize every child around the world and launched in Ethiopia since1980 (2). Immunization is a central pillar of universal health coverage (3), and one of the most effective and successful means of public health interventions to control and eradicate serious

diseases (4). It is a highly effective strategy that helps the parents to prevent their children from major infectious diseases, sequelae, hospitalization and even death (5).

World Health Organization (WHO) recommends that vaccines must be administrated during the first year of life within a specified schedule and time range (6). Immunization timeliness is defined as the administration of vaccines at the earliest appropriate age and recommended intervals between vaccine doses (7). Vaccinating children at an appropriate time interval is an important mechanism to protect diseases adequately since early vaccination can result in failure to generate a protective antibody against the diseases and delayed vaccination end up with risk factors for vaccine preventable diseases (8, 9). Increased compliance to vaccine timeliness safeguards that children are protected prior to exposure and controls morbidity through improving population immunity and potential spread of communicable diseases, particularly in the form of disease outbreaks (10, 11).

About 86% of the children receive vaccines and prevents 2-3 million deaths every year from childhood vaccine preventable diseases in the world(12). Despite this success of childhood interventions approximately 1.5 million children died by vaccine preventable diseases each year, particularly in developing countries (13). Low and middle income countries (LMICs) encountered a disproportionately high burden of vaccine-preventable diseases(14). Every year more than 6.3 million children in low- and middle-income countries die before they reach their fifth birthdays and the leading cause of this is ineffectiveness of vaccine administration (15). In sub-Saharan African countries, vaccine preventable diseases (VPDs) are also the major contributors to high child mortality (16).

In Ethiopia, under one mortality is 40 per 1000 live births per year and the leading cause of this death is vaccine preventable diseases(17). Moreover, about 7,951 suspected measles cases and around 3.5 million children become susceptible to measles every year in the country(18).

Although childhood vaccination coverage in Ethiopia has shown improvements (more than 90%) except measles (83%), childhood vaccine preventable disease outbreaks and high associated childhood mortality rate are still common nationwide. It was mainly because of the failure to achieve 'herd-immunity'(18). This indicates that maximizing vaccination timeliness to attain the full benefits of vaccinations is crucial and untimely vaccination coverage may mask the absolute timely vaccination coverage (19).

Childhood vaccination timeliness is low in many African countries, including Ethiopia ranged from 6.2-68% (20-22). Both early and delayed childhood vaccination have their own disadvantages i.e. early vaccination can result in failure to generate a protective antibody against the diseases while delayed vaccination end up with risk factors for vaccine preventable diseases (8, 9).

The high childhood mortality rate due to vaccine preventable diseases indicates that being satisfied with vaccination coverage alone can mislead to false assumption for vaccine preventable disease protection. Studies revealed that a timely childhood vaccination is a good quality indicator for the expanded program

on immunization to protect children from vaccine preventable diseases through enhancing sero - conversion rate of vaccines.

However, there are limited studies in our country on childhood vaccination timeliness. Therefore, this study was aimed at assessing vaccination timeliness and associated factors among children aged 12 to 23 months in Jabitehnan district, northwest Ethiopia.

Methods

Study design and settings

A community based cross-sectional study design was conducted among mothers/caregivers of children aged 12 to 23 months at Jabitehnan district, northwest Ethiopia. The study was done from February to March 2020. Jabitehnan is located 180 Km in the southwest of Bahir Dar (Capital city of Amhara National Regional State) and 387 Km in the northwest of Addis Ababa (Capital city of Ethiopia). The estimated population of the district in 2019/2020 based upon 2007 Central Statistical Agency (CSA) of Ethiopia was 228,246, of whom 112,982 were males and 16,045 (7.03%) were urban inhabitants. It has around 30,905 under five children and around 15,526 under two children and 6163 children aged 12 to 23 months (24). The district has thirty-nine rural and three urban kebeles. On top of that, there are eleven health centers and 41 health posts in the district. All of these health facilities provide both outreach and static childhood vaccination services.

Population and sampling procedures

The source and study population were all children aged 12 to 23 months who had started vaccination and vaccination card or registered in childhood vaccination register in Jabitehnan district and selected kebeles of the district, respectively. All mothers /care givers of children aged 12 to 23 months who had started vaccination and who had a vaccination card or a vaccination register in the selected kebele were included in this study, however, those who were severely ill during data collection and children who had vaccination cards but no registration date of vaccination or date of birth either in the card or in the infant immunization register were excluded from the study.

The sample size was determined using the single population proportion formula by assuming a 6.2% proportion of children received timely vaccination study in northeast Ethiopia (22), 3% margin of error, 95% confidence level, 10 % non-response rate and 2 design effect. The final sample size was 548.

A multi-stage simple random sampling technique was used to select study participants. First the kebeles of the district were stratified to 39 rural and 03 urban. From the total of 42 kebeles in the district ten (one urban and nine rural) were selected randomly using the list of all eligible children aged 12 to 23 months from the family folder and infant immunization registers of the selected health posts. Health extension workers update the information recorded in the family folder at least once per month in every health posts. The list of all eligible children obtained from the health posts family folder were cross-checked

with the infant immunization registers in the health posts and health centers to confirm the missing of eligible children from the sampling frame. The complete list of all eligible children in the selected kebele containing information about the name of a child, his/her parent's full name, household's unique identification number and sub-kebele/*gotte/* was prepared by using family folders and infant immunization registers of the health posts and health centers. Proportional allocation of the sample was made to determine the required sample size from each selected kebele. Finally, simple random sampling technique was employed to select the required number of children from each selected kebele using the listed children as a sampling frame. The mothers/care givers of the index children were identified using the unique ID of the household in the selected kebeles.

Variables and measurement

Vaccination timeliness was the dependent variable, while socio-demographic related factors, such as age, sex of child, income, occupation, marital status, educational status of parents, residence, religion of parents, household size and birth order; access related factors: distance from vaccination site, mode of transportation, season of birth, availability of phone, availability of electronic media and place of vaccination; obstetric related factors: ANC visit, PNC visit, maternal conference participation, TT vaccination, pregnancy status, institutional delivery, birth attendance and parity; maternal awareness related factors: knowledge about vaccination and attitude towards vaccination were the independent variables.

Timely vaccination: a child is considered to be timely vaccinated, If the child received BCG within the first fifty-six days, OPV1, penta1, PCV1 and Rota1 from 39 to 70 days, OPV 2, penta2, PCV2 and Rota 2 from 67 to 98 days, OPV3, penta3 and PCV3 from 95 to 126 days and measles vaccine 270 to 301 days of age of the child (6, 22). On the other hand, the child was considered as early vaccinated when the child received at least one dose of the vaccine below the minimum recommended age for each antigens, and considered as delayed vaccination when the child received at least one dose of the vaccine above the maximum recommended age (6, 22).

Good knowledge: Twelve knowledge assessment item questions each containing (0=no and 1=yes) alternatives were used and those who scored greater than 50 % of the total knowledge measuring score was considered as having good knowledge (25).

Favorable attitude: Eight Likert scale attitude assessment item questions each containing (1=strongly disagree, 2=disagree, 3=neutral, 4=agree and 5= strongly agree) alternatives were used and those who scored 75% or more the attitude measuring score were considered as having favorable attitude (22, 26).

Data collection tools and procedures

The data were collected using interviewer administered semi-structured questionnaire. Five data collectors (nurses) and two supervisors (Health officers) were used for data collection. The questionnaire had socio-demographic, awareness, obstetric characteristics of mothers, and access related factors parts.

The questionnaire was prepared first in English and translated to Amharic and then back to English to maintain consistency. One day training was given for both data collectors and supervisors on the basic techniques of the data collection procedures. Pre-test was conducted at Dembecha district among 28 (5%) mothers/caregivers of children aged 12 to 23 months who had started vaccination and had a vaccination card or a list in the infant immunization register, and necessary modification was made based on the pre-test findings. Completeness and consistency of the data were checked on the spot and daily basis by the supervisors and the principal investigator.

Data processing and analysis

The data were entered, cleaned and coded using Epi data software version 4.6 and exported to Statistical Packages for Social Sciences (SPSS) (version 22.0 Software for analysis. Descriptive statistics, such as mean, median, frequency and percentage were presented using texts, graphs and tables. Binary logistic regression model was used to identify factors associated with childhood vaccination timeliness. Those independent variables with p-value less than 0.2 during bi-variable analysis were taken into multivariable logistic regression analysis (22). Adjusted odd ratio (AOR) with 95% confidence level (95%CI) and p-value less than 0.05 during multivariable logistic regression were used to declare statistically significant association with childhood vaccination timeliness and the strength of association.

Results

Socio-demographic characteristics of participants

A total of 543 mothers/caregivers of children aged 12 to 23 months interviewed with response rate of 99%. Nearly ninety percent (98.7%) of the participants were mothers of children and the remaining 1.7% of the respondents were caregivers. The mean age of the mothers/caregivers was 29.5 years (± 5.96SD) which ranges from 18 - 50 years. Three hundred ninety (71.8%) of the respondents were in the age group of 25 - 34 years. Nearly 90% of the participants were rural residents and over 95% of the respondents were Orthodox Christians. Two–third of the participants were farmers, more than 90% were married and three-fifth (60%) of the participants were unable to read and write. The mean ages of the children were 18.11months (±3.25SD) (Table 1).

Table 1: Scio-demographic characteristics of the participants in Jabitehnan district, Ethiopia, 2020 (n=543)

Characteristics	Frequency	Percent (%)
Age of mothers/caregivers (years)		
15-24	12	2.2
25-34	390	71.8
35 or more	141	26.0
Sex of child		
Male	268	49.4
Female	275	50.6
Age of child (months)		
12-18	278	51.2
19-23	265	48.8
Residence		
Urban	55	10.1
Rural	488	89.9
Religion		
Orthodox	529	97.4
Muslim	14	2.6
Maternal education		
Can’t read and write	345	63.5
Can read and write	90	16.6
Primary (1-8)	69	12.7
Secondary (9-12) and above	39	7.2
Occupation of mothers		
Housewife	141	26.0
Farmer	353	65.0
Others	49	9.0
Current marital status		
Married	504	92.8
Unmarried	39	7.2
Family size		
<5	218	40.1
≥ 5	325	59.9
Paternal education		
Can’t read and write	245	45.1
Can read and write	176	32.4
Primary (1-8)	63	11.6
Secondary (9-12) and above	59	10.9
Paternal occupation		
Farmer	458	84.4
Merchant	45	8.3
Others	40	7.3
House hold monthly income (ETB*)		
<1000	129	23.8
1001-2500	295	54.3
2501 or more	119	21.9

*ETB: Ethiopian Birr

Obstetric history, access to information and maternal awareness

Over sixty percent (61.5%) of mothers/caregivers were attended institutional delivery and 76.6% received PNC services for their recent child. More than one-third (35.4%) of women had 5 or more parity and 56% of respondents did not participate in maternal conference. Almost half (48.3%) of mothers/caregivers had good knowledge and 47.3% mothers/caregivers had favorable attitude towards childhood vaccination. Sixty-nine percent of mothers/care givers had got information about childhood vaccination from health professionals (Table 2).

Table 2: Obstetric history and access to information of the participants in Jabitehnan district, Ethiopia, 2020 (n=543)

Variables	Frequency	Percent (%)
Pregnancy status		
Planned	462	85.1
Un planned	81	14.9
Number of **ANC visit**		
0	68	12.5
≤2	141	26.0
≥ 3	334	61.5
TT dose received		
No	90	16.6
One	75	13.8
two or more	378	69.6
Maternal conference participation		
No	305	56.2
≤ 2	137	25.2
≥3	101	18.6
PNC service utilization		
No	127	23.4
Yes	416	76.6
Place of delivery		
Healthy facilities	334	61.5
Home	209	38.5
Mode of delivery		
Spontaneous	489	90.0
Caesarian section	22	4.1
Instrumental	32	5.9
Parity		
< 5	351	64.6
≥ 5	192	35.4
Mode of transport		
Foot	509	93.7
Vehicle	34	6.3
Time taken to vaccination site (minutes)		
<30	482	88.8
≥30	61	11.2
Seasons of birth		
Summer	169	31.1
Autumn	131	24.1
Winter	99	18.2
Spring	144	26.6
Source of information		
Mobile	11	2.0
Television	55	10.5
Radio	124	22.8
Health workers	376	69.2
Place of vaccines received		
Health center	153	28.2
Health post	132	24.3
Out reach	258	47.5
Knowledge of mothers		

Good	262	48.3
Poor	281	51.7
Attitude of mothers		
Favorable	257	47.3
Unfavorable	286	52.7

Childhood vaccination timeliness

Overall, 13.1% (95%CI: 10.1-15.8) of children aged 12-23 months were received their vaccinations at the recommended time interval. About 18.4 % (95%CI: 15.1- 21.6) and 79.4 % (95%CI: 76.2-82.7) of children aged 12-23 months were received their vaccinations earlier and later than the recommended time interval, respectively. About 42.2, 64.3, 41.4 and 42.9 % of children received BCG, Penta1, Penta3 and measles vaccines in the recommended time interval, respectively. Moreover, 5.5, 2.6 and 16.4% of children were received Penta1, Penta3 and measles vaccines earlier than the acceptable time interval, respectively. On the contrary, 53.6, 30, 53.0 and 23.6% of children took BCG, Penta1, Penta3 and measles vaccines later than the acceptable time interval, correspondingly (Table 3).

Table 3: Vaccination timeliness among children aged 12-23 months in Jabitehnan district, northwest Ethiopia, 2020 (n=543).

Antigens	Vaccinated			Unvaccinated, n (%)
	Early, n (%)	Timely, n (%)	Late, n (%)	
BCG	-	229 (42.2)	291 (53.6)	23 (4.2)
OPV1	30 (5.5)	349 (64.3)	163 (30.0)	1 (0.2)
OPV2	16 (2.9)	270 (49.7)	251 (46.3)	6 (1.1)
OPV3	14 (2.6)	225 (41.4)	288 (53.0)	16 (2.9)
Penta1	30 (5.5)	349 (64.3)	163 (30.0)	1 (0.2)
Penta2	16 (2.9)	270 (49.7)	251 (46.3)	6 (1.1)
Penta3	14 (2.6)	225 (41.4)	288 (53.0)	16 (2.9)
PCV1	30 (5.5)	349 (64.3)	163 (30.0)	1 (0.2)
PCV2	16 (2.9)	270 (49.7)	251 (46.3)	6 (1.1)
PCV3	14 (2.6)	225 (41.4)	288 (53.0)	16 (2.9)
Rota1	30 (5.5)	349 (64.3)	163 (30.0)	1 (0.2)
Rota2	16 (2.9)	270 (49.7)	251 (46.3)	6 (1.1)
Measles	89 (16.4)	233 (42.9)	128 (23.6)	93 (17.1)
All antigens	100 (18.4)	71 (13.1)	431 (79.4)	-

Factors associated with childhood vaccination timeliness

The multivariable logistic regression analysis illustrates that variables such as maternal level of education, residence, history of abortion, place of delivery, knowledge and attitude of mothers towards vaccination were remained to be significantly associated with childhood vaccination timeliness among children aged 12 to 23 months in the study area.

Accordingly, children lived in rural areas were 69% (AOR: 0.31: 95% CI: 0.14-0.65) less likely to receive vaccines at the recommended age than urban children. Mothers/caregivers who gave birth at home were 65% (AOR: 0.35; 95%CI: 0.18-0.68) less likely to be vaccinated timely compared with those who gave birth at health facilities. Children of educated mothers were 2.73 times (AOR: 2.73; 95% CI: 1.14-6.50) more likely to receive childhood vaccination timely than mothers who can't read and write. Children of mothers who had history of abortion were 3.45 times (AOR: 3.45; 95%CI:1.54-7.74) more likely to receive vaccination timely compared with their counterparts. Children of mothers/caregivers with favorable attitude towards childhood vaccination were 3.38 times (AOR: 3.38; 95%CI: 1.83-6.24) more likely to be vaccinated timely than children of mothers with unfavorable attitude. Children of mothers/caregivers with good knowledge about childhood vaccination were 1.79 times (AOR: 1.79; 95%CI: 1.10-3.18) more likely to receive vaccination within the recommended time interval than their counterparts (Table 4).

Table 4: Factors associated with vaccination timeliness among children aged 12 - 23 months in Jabitehnan district, northwest Ethiopia, 2020 (n=543).

Characteristics	Vaccination timeliness		COR (95%CI)	AOR (95%CI)
	Yes	No		
Residence				
Rural	54	434	0.28 (0.15-0.53)	**0.31 (0.14-0.65) ****
Urban	17	38	1.00	1.00
Maternal education				
Can't read and write	36	309	1.00	1.00
Can read and write	14	76	1.58 (0.81-3.10)	1.85 (0.90-3.78)
Primary (1-8)	8	61	1.12 (0.50-2.50)	0.76 (0.30-1.92)
Secondary and above	13	26	4.30 (2.03-9.10)	**2.73 (1.14-6.50) ***
Paternal education				
Can't read and write	22	223	1.00	1.00
Can read and write	24	152	1.60 (0.87-2.96)	1.26 (0.64-2.52)
Primary (1-8)	12	51	2.38 (1.11-5.13)	1.51 (0.56-3.83)
Secondary and above	13	46	2.86 (1.34-6.10)	1.01 (0.28-3.64)
Birth order				
First	21	99	1.00	1.00
Second	12	78	0.72 (0.34-1.56)	0.84 (0.34-2.11)
Three or more	38	295	0.60 (0.34-1.10)	0.76 (0.33-1.74)
Maternal conference				
0	40	265	1.00	1.00
≤2	13	124	0.69 (0.36-1.34)	0.83 (0.34-1.73)
≥ 3	18	83	1.44 (0.78-2.64)	1.14 (0.56-2.34)
History of abortion				
Yes	12	34	2.62 (1.28-5.34)	**3.45 (1.54-7.74) ****
No	59	438	1.00	1.00
Place of delivery				
Home	13	196	0.32 (0.17-0.59)	**0.35 (0.18-0.68) ****
Health facilities	58	276	1.00	1.00
Mode of delivery				
Spontaneous	57	432	1.00	1.00
Others	14	40	2.65(1.36-5.17)	1.71 (0.79-3.74)
PNC utilization				
Yes	61	355	2.01(0.99-4.05)	1.46 (0.56-3.28)
No	10	117	1.00	1.00
Knowledge of mothers				
Good	47	215	2.34 (1.38-3.95)	**1.79 (1.10-3.18) ***
Poor	24	257	1.00	1.00
Attitude of mothers				
Favorable	54	203	4.21(2.37-7.48)	**3.38 (1.83-6.24) ****
Unfavorable	17	269	1.00	1.00
Exposure to media				
Yes	26	132	1.48(0.88-2.51)	1.06 (0.51-1.80)
No	45	340	1.00	1.00

*******Significantly associated at P-value < 0.01*

** Significantly associated at P-value < 0.05*

Discussion

Vaccines are the most effective preventive, public health successful means of controlling and eradicating serious diseases (4). Vaccines are more effective when given with recommended time interval; since early

vaccination can result in failure to generate a protective antibody against the diseases and delayed vaccination leads to more exposure to the diseases (8, 9).

The overall childhood vaccination timeliness among children aged 12 to 23 months in Jabitehnan district were 13.1 % (95%CI: 10.1-15.8). This implies that the remaining 76.9% children were susceptible for vaccine preventable diseases; since failure to be vaccinated on time would increase the susceptibility period of children through limiting the herd immunity (27). This finding was higher than the studies done in Menz Lalo district, northeast Ethiopia, 6.2 % (22) and Kenya 6.1% (20). However, the finding was lower than the results in Pakistan 20.8% (29), Israel 22% (30), Ghana 50.5% (31) and Senegal 72.3%(32). The possible explanation for this discrepancy might be due to differences in study participant characteristics, study period, design and health service accessibility.

Moreover, only 42.2% (95%CI: 38.1-46.8) children were received BCG vaccines timely. It is higher than the findings in Ethiopia (23.9%) (23) and Bangladesh (24%) (33). On the contrary, this finding was lower than compared to studies conducted outside in Pakistan (89.3%) (29), Ghana (88.9%) (31), and Senegal (88.25%) (32). Similarly, 42.9% (95%CI: 38.9-47.0) children were vaccinated measles vaccine in the recommended time interval.

The finding was higher than the findings in Menz Lalo district, northeast Ethiopia (26.4%)(22), and Kenya (28.2%0 (20). However, this finding was lower than as the studies conducted in Bangladesh (64%)(33), Ghana (50.5%) (31) and Senegal (72.3%) (32). The possible explanation for this discrepancy might be due to the differences in the study participants, access to vaccines, and variations in the recommendation of wastage rate to open BCG and Measles vaccines across countries (22). Besides, this study also revealed that 16.4% (95%CI: 13.3-19.8) of children were received measles vaccine earlier than the recommended time interval. The finding was higher than a study conducted in Bangladesh (12%) (33) and lower than a study done in Pakistan (90%) (29). The possible justification might be health workers' appointment before nine months of age to prevent open dose vial wastage, mothers/caregivers being too busy on appointment day and forgotten vaccination appointment (22).

The vaccination timeliness was lower in the higher dose of the antigen for those vaccines which had subsequent doses such as penta1-3, OPV 1-3, PCV1-3 and Rota1-2. This might be due to increased maternal/caregiver's workload with other domestic activities while the child gets older and they may not remember vaccination appointments of a child and fear of side effects (22, 34).

This study also revealed that 5.5and 2.6% of children were received the vaccine earlier than the recommended time interval for Penta1 and penta3 vaccines, respectively. This finding was in line with a study done in Menz Lalo district, northeast Ethiopia 6.8 and 5.2% of children were vaccinated Penta1 and penta3 vaccines, respectively (22). On the other hand, 30 and 53% (95%CI: 49.3-57.6) of children aged 12 to 23 months were vaccinated later than the acceptable time interval for Penta1 and penta3 vaccines, correspondingly. This finding was lower than the findings in Menz Lalo district, northeast Ethiopia, 54.1 and 64.5% of children were received Penta1 and penta3 vaccines later than the recommended time interval, respectively (22). However, this finding was higher than the studies done in Pakistan, 19.1 and

43.4% of children received Penta1 and penta3 vaccines later than the acceptable time interval , correspondingly (29). This discrepancy might be due to mothers/caregivers of children might not remember the appointment date, work load by domestic activities or fear of side effects like fever, pain and swelling.

Rural children were negatively influenced the receiving of vaccines in the recommended age than urban children. This finding was in line with the findings in Ethiopia (23). The possible justification might be due to urban resident mothers might have better information and recognize the importance of vaccination (37).

Children whose mothers gave birth at home were less likely to receive the recommended childhood vaccines in the acceptable time. This finding was supported by the studies conducted in Kenya (11), Ethiopia (23), Pakistan(29), Malawi (38) and Uganda (39). The possible justification might be mothers who gave birth at health facilities might have more opportunity to be informed about child healthcare, including childhood vaccination (29).

Children who were born from educated mothers were more likely to receive their vaccines timely than non-educated mothers. This finding was consistent with the findings of the study done in Bangladesh(33). The possible justification might be educated mothers might have better knowledge about vaccine-preventable diseases and recognize the importance of vaccination.

Children of mothers/caregivers having history of abortion before the birth of the index child were more likely to receive the recommended childhood vaccines with acceptable time interval. This might be due to mothers/caregivers with history of abortion give more emphasis for the health of their child, fear the morbidity of child and understood the burden of childhood infection more than their counterparts.

Children of mothers/caregivers with good knowledge about childhood vaccination were more likely to be vaccinated with the recommended time interval. This is in line with the findings of a study done at Menz Lalo district, northeast Ethiopia (22). This can be suggested mothers/care givers having a better understanding of childhood vaccination schedule, vaccine preventable diseases and reasons for vaccination may bring their child to vaccination site more likely at recommended time. Children of mothers/caregivers with favorable attitude towards childhood vaccination were more likely to be vaccinated timely. This is in line with study conducted in Machakel district, east Gojjam zone (40). This can be suggested mothers/caregivers who had unfavorable attitude about childhood vaccination might not take their child to vaccination site by their appointment.

Limitations of the study

This cross-sectional study has its own limitations. The study participants were selected based on the presence of immunization cards, which might lead to selection bias because infants whose parents did not keep their immunization cards were excluded from the study. This could be over estimate or underestimate the magnitude of vaccination timeliness.

Conclusion

The overall childhood vaccination timeliness status was low compared with the current performance of the vaccination coverage in Ethiopia. Children were received the first dose of OPV, Penta, PCV and Rota vaccines within recommended time relatively higher than the other doses/vaccines. Children received measles vaccine earlier and BCG vaccine later than the acceptable time interval. Variables such as residence, maternal level of education, having history of abortion, place of delivery, knowledge about childhood vaccination and attitudes towards childhood vaccination were affecting vaccination timeliness. Therefore, the policy planners and managers should give emphasis and incorporate vaccination timeliness in the childhood vaccination plan, and better to monitor and evaluate as one potential indicator to enhance the immune status of children. Health planners and managers should also improve women's education and awareness to enhance their attitude towards childhood vaccination to maintain and enhance to bring their children to their health facility in the appointment. Furthermore, it is better to promote institutional delivery service utilization to enhance childhood vaccination timeliness.

Abbreviations

ANC, Antenatal Care; AOR, Adjusted Odds Ratio; BCG, Bacillus Calmette-Guerin; CDC, Communicable Diseases Control; COR, Crude Odds Ratio; EDHS, Ethiopian Demographic Health Survey; EPI, Expanded Program of Immunization; ETB, Ethiopian Birr; FMOH, Federal Ministry of Health; LMICs, Low and Middle Income Countries; OPV, Oral Polio Vaccine; PCV, Pneumococcal Conjugate Vaccine; PNC, Postnatal Care; SPSS, Statistical Packages for Social Sciences; TT, Tetanus Toxoid; WHO, World Health Organization

Declarations

Ethics approval and consent to participate

Ethical approval was obtained from the Ethical Committee of Institute of Public Health, College of Medicine and Health Sciences, University of Gondar (Ref. No. IPH/837/2020). Before the actual data collection was started, concerned body in Jabitehnan Health office was communicated through formal letter issued from the University of Gondar. Official permission and supportive letter were obtained from Jabitehnan health office. Data were anonyms and held on a secure password protected system. Confidentiality during all phases of research activities was kept.

Consent for publication

Not applicable.

Availability of data and materials

All the data were included in the study, and data will be available upon a responsible request from the corresponding author.

Competing Interests

The authors declare that they have no competing interests.

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Authors' Contributions

BE designed the study, developed data collection tools, performed the analysis and interpretation of data, and drafted the paper. AD and LY participated in the development of the study proposal, analysis and interpretation, revised drafts of the paper, revised the manuscript. All authors read, revised, and approved the final manuscript.

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