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Factors associated with the access and continuum of vaccination services among children aged 12–23 months in the emerging regions of Ethiopia: evidence from the 2016 Ethiopian demography and health survey

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Abstract

Background: Child vaccination is an instrument for saving millions of lives. Only one in twenty children has access to childhood vaccination in hard to reach areas in developing countries. Although studies have been done on childhood vaccination, factors associated with access and continuum were not considered in Ethiopia. Therefore, this study aimed to identify the factors associated with the access and continuum of childhood vaccination in the emerging regions of Ethiopia based on the 2016 EDHS datasets.

Methods: The two-stage stratified sampling technique was used for the survey carried out on 642 mothers of children aged 12–23 months. Access is the provision of services in shorter waiting times and flexibly at all times and alternative methods of communication. Accordingly, continuum of care reflects the extent to which a series of discrete health care events are being experienced by people coherently and interconnected over time. As a result, access and continuum of childhood vaccination are determined using pentavalent-1 and measles vaccination status of children, respectively. A binary logistic regression model was fitted to identify the factors associated with access and continuum of the vaccination.

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Results: Overall, 25.1% of children aged 12–23 months received all of the recommended childhood vaccines. Sixty-two percent of children accessed and 46.9% had continuum of childhood vaccination in the emerging regions of Ethiopia. Pentavalent_1 to 3 and BCG to measles dropout rates were 33.42 and 17.53%, respectively. Mothers' formal education (AOR = 1.99; 95%CI: 1.20, 3.31), ANC (AOR = 4.13; 95%CI: 2.75,6.19), health facility delivery of last birth (AOR = 1.58; 95%CI: 1.19, 2.82), rich wealth (AOR = 1.57; 95%CI: 1.19, 3.14) and average child birth weight (AOR = 1.67; 95%CI: 1.03, 2.72) were positively associated with childhood access to vaccination. On the other hand, mothers' ANC attendance (AOR = 3.68; 95%CI: 2.48, 5.47) and rich wealth (AOR = 2.07; 95%CI: 1.15, 3.71) were positively associated with the continuum of the services. On the contrary, children with rural resident mothers (AOR = 0.33; 95%CI: 0.14, 0.76) and small birth weight (AOR = 0.51; 95%CI: 0.33, 0.81) were negatively associated to the access and continuum of childhood vaccination, respectively.

Conclusion: Childhood vaccination status was low in the emerging regions of Ethiopia. Variables such as maternal education, birth weight of children, ANC, health facility delivery and wealth were associated with the access and continuum of the vaccination. Therefore, empowering women with education and strengthening maternal healthcare services might enhance childhood vaccination. In addition, the government needs to design a compensation mechanism for the cost relating to childhood vaccination to improve the access and continuum of the service.

Keywords: Access, Continuum, Vaccination, Children, Emerging region, Ethiopia

Background

The Expanded Programme for Immunization (EPI) was initiated by the World Health Organization (WHO) in 1974 [1]. The WHO advocated the availability of immunization for all children of the world by the year 1990 which was a vital step towards the achievement of health for all by the year 2000 [2]. Childhood vaccination is an instrument of saving millions of lives, but about 19.4 million children under the age of 1 year have not received basic vaccines [3]. Immunization prevents 2–3 million deaths every year, and the uptake of new vaccines has been increasing from time to time [3].

Childhood vaccination is effective in protecting children against vaccine-preventable diseases in low- and middle-income countries [4, 5]. In Sub-Saharan Africa and hard to reach (remote areas) of developing countries, only 50% of children and one in twenty had access to childhood vaccination, respectively [6]. In 2018, about 86%(116.3 million) of infants worldwide received three doses of DTP-3 /Penta-3 vaccine [3].

Childhood vaccination is one of the national child survival strategies planned to reach 90% of the measles vaccination coverage in 2010 [7]. In 2015, it was also one of the key intervention strategies to achieve the Health Sector Transformation Plan (HSTP) of Ethiopia [8]. The 2011 EDHS revealed that 66, 56, 64 and 24% of children received BCG, measles, pentavalent-1 and all the recommended vaccines, respectively [9], while the 2016 EDHS showed 69, 54, and 73% of children had BCG, measles, and pentavalent-1 vaccines, accordingly. In addition, 39 and 16% of children were fully vaccinated and never received any childhood vaccinations, respectively [10]. According to the 2016 EDHS report, childhood vaccination was low in the emerging regions of Ethiopia [10]. The vaccination status of children is used to monitor the performance of vaccination services at local, national and international levels to design strategies for the eradication, elimination, and control of vaccine-preventable diseases [11–13].

Although a few studies so far been done in different parts of Ethiopia, the social determinants of vaccination service utilization remain poorly analyzed, particularly in the emerging regions. Therefore, this study aimed to assess factors associated with the access and continuum of childhood vaccination service utilization among children aged 12–23 months in the emerging regions of Ethiopia based on the 2016 EDHS datasets.

Methods

Study settings

The 2016 Ethiopian Demographic and Health Survey (EDHS) was conducted in the nine national regional states and the two city administrations. The regions classified as emerging, Afar, Benishangul-Gumz, Gambella and Somali, are characterized by scattered pastoralists and semi-pastoralist societies suffering from extreme poverty. Absence of clear and detailed regulations, basic infrastructures and services are also their common chrematistics [14, 15]. On the other hand, developed regions such as Amhara, Oromia, Southern Nations, Nationalities and Peoples (SNNP), Tigray and the city administrations, such as Addis Ababa, Dire Dawa and Harari regions are relatively more densely populated [15]. Ethiopia is one of the Sub-Saharan countries found in the horn of Africa with a total population of 73.5 million. The total population of the four emerging

regions was 6926, 933, with the largest in Somali (4,445, 219) and the least in Gambella (307,096). Similarly, the total number of children 0–4 years was 449,699 in Somali and 42,044 in Gambella [16].

Sampling design

The sampling frame used for the 2016 EDHS was the 2007 Population and Housing Census (PHC) of the Central Statistical Agency report of Ethiopia [16]. The sample for the 2016 EDHS was designed to provide estimates of the key indicators of the country as a whole, separately for urban and rural areas, and for each of the nine regions and the two city administrations. The sample was stratified and selected in two stages and each region was stratified into urban and rural areas. Samples of the Enumeration Areas (EAs) were selected independently in each stratum of two stages. Implicit stratification and proportional allocation were used at each lower administrative level.

In the first stage, EAs in urban and rural areas were selected with probability proportional to the EA size (based on the 2007 PHC) and with independent selection in each sampling stratum. A household listing operation was carried out in all of the selected EAs in 2015. The resulting lists of households served as sampling frames for the selection of households in the second stage. Segmentation was done for some of the selected EAs with large households, and only one segment was selected for the survey with a probability proportional to size. Household listing was conducted only in the selected segment, that is, the 2016 EDHS cluster was either an EA or a segment of an EA. In the second stage, the selection of the households per cluster was done using systematic sampling technique. In this study, the 2016 Ethiopian demographic and health survey childhood datasets of the four emerging regions, namely Afar, Benishangul-Gumz, Gambella and Somali were used for analysis.

All women aged 15–49 years and permanently lived in the area and slept in the selected households the night before the surveys were eligible [10]. Children 12–23 months are the source population and the study included 642 mothers and their children aged 12–23 months and data on both were extracted from the 2016 EDHS datasets. Potential independent variables such as socio-demographic, economic, fertility history and health service utilization were also extracted and further recoding of the selected variables was done to match and compare with other similar studies.

Measurement and variables

Access and continuum of childhood vaccination were the dependent variables of the study. Socio-demographic characteristics (age, residence, religion, and marital status), and obstetric history of the women, like places of delivery, birth order, antenatal care, postnatal check-ups in 2 months after birth, number of live children, sex of children, and marital status were the independent variables. Vaccination refers to the administration of antigenic material (a vaccine) to stimulate an individual's immune system to develop adaptive immunity to a pathogen [17] and its coverage is defined as the proportion of a given population that has been vaccinated in a given time period [18]. A fully vaccinated child was expected to receive one dose of BCG, three doses of pentavalent, Pneumococcal Conjugate (PCV), Oral Polio Vaccines (OPV), two doses of Rotavirus and one dose of measles vaccines [19]. Each vaccine had five response categories, namely "no", "vaccination date on the card", "reported by mothers", "vaccination marked on card" and "do not know". The vaccination status of children was recoded as 0 and 1 for each antigen. "No" responses were recoded as "0" and labeled "not received the vaccine", while the other responses "vaccination date on card, reported by mothers, vaccination marked on card" were recoded together as "1" and labeled "received the vaccine". Besides, "do not know responses" were excluded from analysis. As a result, the vaccination status of children was recoded as "0" for "not vaccinated" and "1" for "vaccinated" for each antigen on the basis of the reports of women and information on the child vaccination card. Accordingly, access and the continuum of childhood vaccination were recoded as "0" for "no" and "1" for "yes" for each child. Access is the provision of services in shorter waiting times, more flexibly, electronically, by telephone or alternative methods of communication [20]. As a result, access to childhood vaccination was determined based on pentavalent-1 vaccination status of children. Continuum of care reflects the extent to which a series of discrete health care events are being experienced by people coherently and interconnected over time [20]. Thus, continuum of childhood vaccination was measured by measles vaccination status of children.

Data management and statistical analyses

The extracted EDHS data included socio-demographic characteristics of the women, obstetric history and service utilization child-specific information for all births in the past 5 years of women in the reproductive age group. The 2016 EDHS collected information on childhood vaccination status from vaccination cards and women's verbal reports. The interviewer copied the vaccination dates directly into the questionnaire if the cards were available. However, the interviewer asked respondents to recall the vaccines given to their children when there were no vaccination cards. The cleaned and recoded data were analyzed using STATA version 14. Descriptive statistics such as means, medians, SDs, frequencies and proportions of variables were presented using graphs,

texts, and tables. Bivariable and multivariable logistic regression analyses were conducted to identify factors associated with access, utilization, and continuity of vaccination. Variables with *p*-values < 0.2 [21, 22] during the bivariable analyses were fitted into the multivariable logistic regression analyses. However, *p*-value of 0.2 did not mean that there was a 20% chance that the null hypothesis was correct [22, 23], rather variables with *p*-value of < 0.2 during the bivariable analyses might have a chance to be significantly associated with the outcome variable during the multivariable regression analyses. Adjusted Odds Ratio (AOR) and 95% Confidence Interval (CI) with *p*-value < 0.05 were used to identify variables associated with the outcome variables.

Results

Socio-demographic and economic characteristics

A total of 642 mothers/caregivers of children 12–23 months of age were included in these analyses. The mean age of the participants was 27.86 (± 6.31SD) years, and the median age was 28 years with an Inter Quartile Range (IQR) of 8 years. Furthermore, more than half of the participants were in the age range of 25–34 years; over two-thirds (68.2%) were Muslims; more than 80 % (83.2%) lived in rural areas. Only 8.9 and 19.5% of the respondents and their husbands had secondary and above education, respectively. Similarly, 5.1% of the respondents and 13.2% of their husbands had professional jobs; 93.3% were married (Table 1).

Obstetric related characteristics of participants

More than half (57.5%) of the women received antenatal care services. Accordingly, 44 and 65.6% of the ANC users had four and/or more visits and started the service at the second trimester, respectively. Similarly, only 27.6 and 8.1% of the women had health facility delivery and PNC in 2 months of postpartum period, correspondingly. Nearly 27, 62 and 7% of the participants had ≥6, ≥3 and history of terminated pregnancy, respectively (Table 2).

Source of information, wealth status, and child characteristics

Of the children, 55.6% were female and 60.6% of the caregivers were in the poorest wealth status. The mean and median age of the children were 16.29 (± 3.29SD) months and 16 months with the IQR of 6 months, respectively. About 45% of the children were in the age range of 12–15 months. More than three-fourths (76.5%) of participants had no mobile phones, and almost 85% did not listen radio programs. Nearly 40 and 90% of children had average birth weights and wanted by their families, respectively (Table 3).

Table 1 Socio-demographic and economic characteristics of participants in emerging regions of Ethiopia, 2016

Variables	Frequency	Percent (%)
Age of the respondents in years		
15–24	198	30.8
25–34	329	51.2
≥ 35	115	18.0
Religion of the participants		
Orthodox	61	9.5
Protestant	116	18.1
Muslim	438	68.2
Others	27	4.2
Region of the respondents		
Afar	162	25.2
Somali	196	30.5
Benshangul_Gumuz	152	23.7
Gambella	132	20.6
Residence of the participants		
Urban	108	16.8
Rural	534	83.2
Educational status of the respondents		
No education	458	71.3
Primary	127	19.8
Secondary and above	57	8.9
Sex of household head		
Male	426	66.4
Female	216	33.6
Husband education		
No	408	63.5
Primary	109	17.0
Secondary and above	125	19.5
Current marital status of the respondents		
Unmarried	43	6.7
Married	599	93.3
Husband occupation		
No work	93	14.5
Professional work	85	13.2
Agricultural	293	45.6
Others	171	26.6
Occupation of the respondents		
No work	418	65.1
Professional work	33	5.1
Agricultural	128	19.9
Others	63	9.8

Table 2 Obstetric related characteristics of participants in emerging regions of Ethiopia, 2016

Variables	Frequency	Percent (%)
ANC		
No	273	42.5
Yes	369	57.5
ANC number of visits ($n = 369$)		
1	39	10.6
2–3	168	45.5
≥ 4	162	43.9
First ANC visit started($n = 369$)		
< 3 months	109	29.5
3–7 months	242	65.6
> 7 months	18	4.9
Place of delivery		
At home	465	72.4
At health facility	177	27.6
PNC within 2 months		
No	590	91.9
Yes	52	8.1
Place of PNC($n = 52$)		
At home	15	28.8
At health facility	37	71.2
PNC performed by($n = 52$)		
Doctor	6	11.5
Nurse	28	53.8
Midwife	3	5.8
HEW	15	28.9
Parity		
1	113	17.6
2–5	358	55.8
≥ 6	171	26.6
Number of living children		
1	119	18.5
2	125	19.5
≥ 3	398	62.0
Ever had history of terminated pregnancy		
No	598	93.1
Yes	44	6.9

Table 3 Source of information, wealth status of participants and child characteristics in emerging regions of Ethiopia, 2016

Variables	Frequency	Percent (%)
Sex of child		
Male	357	55.6
Female	285	44.4
Child age in months		
12–15	288	44.9
16–19	224	34.9
20–23	130	20.2
Wealth status		
Poorest	389	60.6
Poor	81	12.6
Middle	43	6.7
Rich	53	8.3
Richest	76	11.8
Own a mobile phone		
No	491	76.5
Yes	151	23.5
Reading newspaper or magazine		
No	620	96.6
Yes	22	3.4
Listening radio		
No	547	85.2
Yes	95	14.8
Watching TV		
No	569	88.6
Yes	73	11.4
Wanted last child		
No	71	11.1
Yes	571	88.9
Child size at birth		
Large	175	27.3
Average	256	39.9
Small	211	32.8
Birth order of the child		
1	113	17.6
2–5	358	55.8
≥ 6	171	26.6
Preceding birth interval in months		
9–23	133	20.7
24–35	188	29.3
> 35	321	50.0

Vaccination status of children

The vaccination status of children 12–23 months of age was analyzed for each antigen in the emerging regions of Ethiopia. Overall, 25.1% (95%CI: 21.80, 28.30) of the children were fully vaccinated in the region. About 57 and 47%of the children received BCG and measles vaccines, accordingly. Seventy-four-point-four and forty-seven-point 2 % of children received OPV 1 and 3, respectively. About 62.0, 41.3, 55.8, 37.5, 52.8, and 45.3% had received Pentavalent 1, 2, PCV 1, 2, Rota 1 and 2, correspondingly. Furthermore, pentavalent and BCG to

measles dropout rates were 33.4 and 17.5%, respectively. As a result, access to childhood vaccination was 62% (95%CI: 58.40, 65.70) and the continuum of vaccination 46.9% with (95%CI: 43.30, 50.80) (Fig. 1).

Factors associated with access to vaccination

The binary logistic regression model showed that educational status of the mothers, residence, weight of children, ANC follow ups and places of birth were significantly associated with access to childhood vaccination. Mothers who lived in rural areas were 67% less likely (AOR = 0.33; 95%CI: 0.14,0.76) access to their children vaccination compared with that of mothers lived in urban areas. Accordingly, participants who had formal education were 1.99 times (AOR = 1.99; 95%CI: 1.20, 3.31) more likely to get access to vaccination for their children compared with women who had no formal education. On the other hand, children who had average birth weights were1.67 times (AOR = 1.67; 95%CI: 1.03, 2.72) more likely to get access to vaccination compared with children who had more birth weights. The odds of childhood access to vaccination among women who had ANC follow ups were 4.13 times (AOR = 4.13; 95%CI: 2.75,6.19) higher than those of their counterparts. Women who gave their last birth at health facilities were 1.58 times (AOR = 1.58; 95%CI: 1.19, 2.82) more likely to have chances to access child vaccinations compared with women who gave birth at home. Similarly, women with

middle (AOR = 2.79; 95%CI: 1.09, 7.14) and rich wealth (AOR = 1.57; 95%CI: 1.19, 3.14) had 2.79 and 1.57-times higher access to childhood vaccination compared with women in poor wealth status (Table 4).

Factors associated with the continuum of vaccination

Potential predictor variables associated with the continuum of vaccination services among children 12–23 months of age were identified using the multivariable logistic regression analyses. Children who had less birth weights were 49% less likely (AOR = 0.51; 95%CI: 0.33, 0.81) to continue vaccination services compared with children who had more birth weights. The odds of the continuum of childhood vaccination among women who had ANC follow ups were 3.68 times (AOR = 3.68; 95%CI: 2.48, 5.47) higher than women who had no ANC. Women in rich wealth status were 2.07 times (AOR = 2.07; 95%CI: 1.15, 3.71) more likely to continue childhood vaccination compared with women in poor wealth status (Table 5).

Discussion

Ethiopia was committed to improve the access and continuum of vaccination to achieve full vaccination via designing health policies and strategies, such as the construction of health posts, training and deployment of health extension workers. The country has also made great gains in decreasing childhood and under-five mortality by two-thirds since
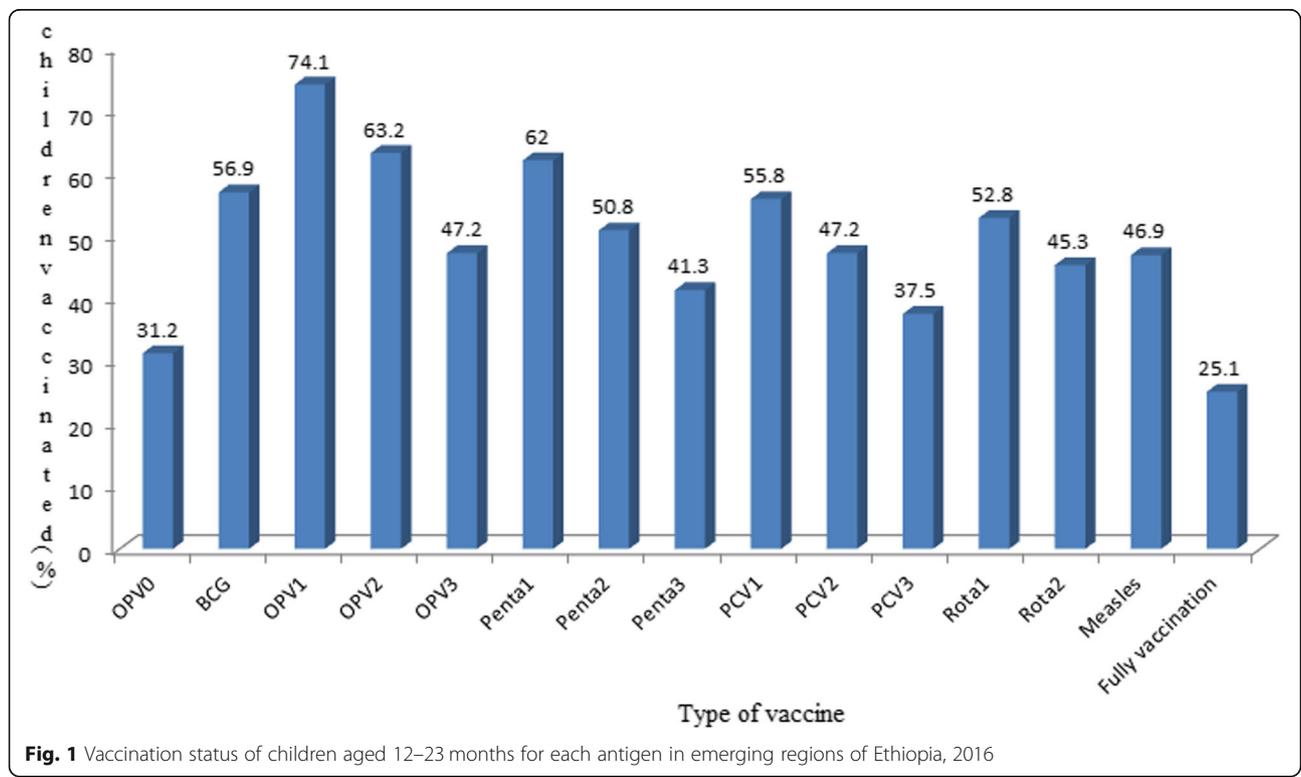
Fig. 1 Vaccination status of children aged 12–23 months for each antigen in emerging regions of Ethiopia, 2016

Table 4 Factors associated with access for childhood vaccination in emerging regions of Ethiopia, 2016

Variables	Access to vaccination		COR (95%CI)	AOR (95% CI)	*P*-value
	Yes	No			
ANC					
No	100	173	1	1	
Yes	298	71	7.26(5.08,10.38)	4.13(2.75,6.19) *	0.0001
Own a mobile phone					
No	282	209	1	1	
Yes	116	35	2.46(1.62,3.73)	1.29(0.75, 2.19)	0.357
Wanted last child					
No	51	20	1	1	
Yes	347	224	0.61(0.35,1.05)	0.74(0.38, 1.44)	0.382
History of terminated pregnancy					
No	367	231	1	1	
Yes	31	13	1.50(0.77,2.93)	1.58(0.71, 3.53)	0.266
Listening radio					
No	322	225	1	1	
Yes	76	19	2.80(1.64,4.75)	1.87(0.98,3.49)	0.052
Place of delivery					
At home	244	221	1	1	
At health facility	154	23	6.07(3.77,9.75)	1.58(1.19, 2.82) *	0.018
Child size at birth					
Large	112	63	1	1	
Average	182	74	1.38(0.92,2.09)	1.67(1.03, 2.72) *	0.039
Small	104	107	0.55(0.36,0.82)	0.63(0.39, 1.03)	0.064
PNC within 2 months					
No	353	237	1	1	
Yes	45	7	4.32(1.91,9.73)	1.63(0.64, 4.13)	0.306
Wealth status					
Poor	249	221	1	1	
Middle	37	6	5.85(3.40,10.05)	2.79(1.09, 7.14) *	0.032
Rich	112	17	5.47(2.27,13.21)	1.57(1.19, 3.14) *	0.012
Education of respondents					
No formal education	245	213	1	1	
Formal education	153	31	4.29(2.80,6.58)	1.99(1.20, 3.31) *	0.007
Residence					
Urban	98	10	1	1	
Rural	300	234	0.13(0.07,0.26)	0.33(0.14,0.76) *	0.010

*significant at *p*-value < 0.05, *COR* Crude Odds Ratio, *AOR* Adjusted Odds Ratio

1990 and meeting its Millennium Development Goal target [24]. However, attaining the Sustainable Development Goal for reducing under-5 mortality from 59 deaths in 2015 [25] to 25 deaths per 1000 live births in 2030 [26] will require improved child health services through ensuring the access and continuum of childhood vaccination services. Despite access to childhood vaccination in the country, many children do not receive the vaccines.

As a result,25.1% (95%CI: 21.80, 28.30) of the children were fully vaccinated that does not lead in achieving the 2020 Health Sector Transformation Plan (HSTP). This finding was consistent with the 2011 EDHS report (24%) [9] and the Kenyan (22.6%) [27]. However, it was lower than those of studies done in Togo, Nigeria (63.7%) [28], Kwahu Afram Plains, Ghana (81.3%) [29], Jigjiga (36.6%) [30], Mecha (75.1%) [31], Ethiopia (38.3%) [32], Sekota

Table 5 Factors associated with the continuum of childhood vaccination in emerging regions of Ethiopia, 2016

Variables	Continuum of vaccination		COR (95%CI)	AOR (95% CI)	*p*-value
	Yes	No			
ANC					
No	66	207	1	1	
Yes	235	134	5.50(3.88,7.80)	3.68(2.48, 5.47) *	0.0001
Own a mobile phone					
No	213	278	1	1	
Yes	88	63	1.82(1.26, 2.64)	1.06(0.75, 1.84)	0.815
Parity					
1	64	49	1	1	
2–5	177	181	0.75(0.49, 1.15)	0.84(0.53, 1.39)	0.482
≥ 6	60	111	0.41(0.25, 0.67)	0.58(0.32, 1.05)	0.074
Place of delivery					
At home	177	288	1	1	
At health facility	124	53	3.81(2.62, 5.52)	1.44(0.89, 2.31)	0.136
History of terminated pregnancy					
No	277	321	1	1	
Yes	24	20	1.39(0.75, 2.57)	1.39(0.67, 2.88)	0.369
Child size at birth					
Large	90	85	1	1	
Average	142	114	1.18(0.80,1.73)	1.34(0.86, 2.08)	0.192
Small	69	142	0.46(0.30,0.69)	0.51(0.33, 0.81) *	0.004
PNC within 2 months					
No	263	327	1	1	
Yes	38	14	3.38(1.79, 6.36)	1.75(0.87, 3.62)	0.121
Wealth status					
Poor	184	286	1	1	
Middle	23	20	1.79(0.96, 3.35)	1.08(0.45, 1.83)	0.954
Rich	94	35	4.18(2.72, 6.42)	2.07(1.15, 3.71) *	0.015
Education of respondents					
No formal education	178	280	1	1	
Formal education	123	61	3.17(2.21, 4.55)	1.41(0.90, 2.21)	0.138
Sex of child					
Male	162	195	0.87(0.64,1.19)	0.81(0.56, 1.16)	0.271
Female	139	146	1	1	
Residence					
Urban	76	32	1	1	
Rural	225	309	0.31(0.20,0.48)	0.90(0.49,1.65)	0.721

*significant at *p*-value < 0.05, *COR* Crude Odds Ratio, *AOR* Adjusted Odds Ratio

Zuria (77.4%) [33], Areka town (75.4%) [34], Wonago (52.4%) [35], and Ambo (35.6%) [36]. However, it was higher than the results of studies in Amibara (8.3%) [37] and the 2005 EDHS report (20%) [38]. Accordingly, 62% (95%CI: 58.40, 65.70) of children aged 12–23 months of age had access to childhood vaccination. The finding was lower than those of studies done in Mecha (98.4%)

[31], Jigjiga (73%) [30], Debre Markos (96.9%) [39], Wonago (99.0%) [35], Kwahu Afram Plains, Ghana (97.3%) [29], but higher than that of a study done in Ambo(36.9%) [36]. The continuum of childhood vaccination services in the current study was 46.9% (95%CI: 43.30, 50.80). The finding was lower than the results of studies done in Debre Markos (91.7%) [39], Ethiopia

(55.7%) [40], Kwahu Afram Plains, Ghana (87.7%) [29], but higher than that of a study done in Ambo (29.9%) [36]. Additionally, pentavalent-1 to 3 and BCG to measles dropout rates in this study were 33.42 and 17.53%, respectively. The possible explanation for this variation might be the differences in study periods and designs. Another justification might be the current analyses was done in pastoral communities where the necessary information about childhood vaccination was not available. Another reasons could be the differences in health system from country to country. Furthermore, the number of vaccine types in the current assessment of childhood complete vaccination status is different from the previous ones, and this can result in variations in vaccination status of children.

Mothers who lived in rural areas negatively influenced the access to childhood vaccination compared with that of mothers lived in urban areas. This finding was supported by the studies done in Mecha [31], East Gojjam [41] and Jigjiga [30]. The possible justification might be that urban resident mothers might have better information and recognize the importance of vaccination.

Women who had formal education positively influenced access to childhood vaccination compared with non-educated ones. This finding was supported by those of studies done in Kenya [27], Jigjiga, Amibara, and Sekota Zuria [30, 32, 33, 37], Ethiopia, and Nigeria [42]. The possible justification might be that educated mothers might have better knowledge about vaccine-preventable diseases and recognize the importance of vaccination.

Women who received ANC during their last pregnancy positively influenced the access and continuum of the vaccination of children compared with mothers who had no ANC at all. This finding is consistent with other findings in Ethiopia [32, 33, 35, 43, 44], Nigeria [45], Uganda [46], and Kenya [47].

The access and continuum of childhood vaccination were higher among women who gave their last birth at health institutions compared with those delivered at home. This finding was also in line with those of studies conducted in Ethiopia [30–33, 48] and Kenya [47]. The higher chance of getting access, continuum and complete childhood vaccination of children born to women who had utilized ANC and/ or institutional delivery services could be related to their familiarity to the healthcare systems during their previous visits and health workers' advice on the vaccination of children.

Women in the rich wealth status positively influenced the access and continuum of the vaccination status of children compared with their counterparts. This finding was consistent with those of other studies in Ethiopia [32, 40, 49], and Bangladesh [50]. The possible justification might be that rich households give more attention to their children. Additionally, they could not suffer from financial scarcity for transportation to get services.

Mothers who had low birth weight children negatively influenced childhood access and continuum of vaccination compared with mothers who had more birth weight children. The possible explanation might be that mothers who had low birth weight children could not take their child for vaccination sessions because they consider their children were not normal and for fear of vaccine side effects. As these mothers might focus on improving their children's weight, they could not give attention to other child health issues.

This study has a number of limitations. It lacks the effect of vaccine management system and service delivery related factors, like logistics, knowledge of clients, attitude and trained human resources as predictors of childhood vaccination. Besides, it did not cover infrastructure and human resources that might have contributed to the low access and continuum of vaccination. Moreover, the study did not address the reasons for low access and continuum of vaccination and the immune status of vaccinated children.

Conclusion
The overall full vaccination status of children was low compared with other findings in the country. Variables such as education of women, birth weight of children, attending ANC, giving birth at a health facility and wealth status were factors associated with access and the continuum of childhood vaccination. Therefore, enhancing women's education and strengthening maternal healthcare services are of paramount importance for improving childhood vaccination status. Furthermore, the government has to design a compensation mechanism for costs relating to childhood vaccination. On top of that, researchers had better evaluate the immune status of vaccinated children and assess the vaccine cold chain management system to provide informed recommendation.

Authors' contributions
AD and AML conceived the study, involved in the study design, data analysis, drafted and critically reviewed the manuscript. Both authors read and approved the final manuscript.

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