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Further analysis of determinants of Pentavalent and Measles immunizations dropouts among children under five years of age in Ethiopia from Mini-EDHS 2019

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Abstract

Background Globally, immunization prevents an estimated 2–3 million deaths from illnesses that can be prevented by vaccination. The predictors of Pentavalent and Measles immunization dropout were not investigated sufficiently. Therefore, this analysis was meant to determine the coverage, burden, and predictors of Pentavalent and Measles immunizations in Ethiopia.

Materials and methods This study was a further analysis of the Mini Ethiopian Demographic Health Survey (EDHS) 2019, conducted with a nationally representative sample. In this study, immunization data was collected from a total sample of 3208 children of which 2004 (34.8%) children who received pentavalent 1 were considered for this study. Univariable, bi-variable, and multilevel mixed effect analysis was done using STATA version 17 Software. The mixed-effect model with the lowest AIC and BIC (information criteria) was chosen. A factor was designated as a significant predictor of immunization dropout if its p-value was less than 0.05 at 95% CI. The best-fitting model among the fitted models was ultimately chosen using the Akaike and Bayesian Information Criteria (AIC and BIC).

Result The mean age of the head of the household was 37.6. The majority (68.9%) of the residents were from rural areas and of the total population, 64.9% have no formal education. Being residents of Afar increased the odds of dropping out by 3.28 (AOR = 3.28; 95% CI: 1.12, 9.56), whereas being residents of Addis Ababa reduced their odds of dropping out from prentavalent 3 by 68.1% (AOR = 0.319; 95% CI: 0.122, 0.833) compared to their Tigray counterparts. The dropout rate of Pentavalent 1 to measles 1 vaccination was 4.33 times higher among residents of Afar (AOR = 4.33; 95% CI: 1.38, 13.56). As the level of wealth increases, the quintile increases from poorer to richer compared to those in the poorest wealth quantile category, and marital status also affects the immunization dropout rate of their children.

Conclusions Immunization coverage of Ethiopian children was low and the dropout from pentavalent 1 and measles vaccination was high compared to the national and international targets to improve immunization coverage

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and reduce dropout. So different cost-effective interventions like Education provision for the community, decision-making facilitation, behavioral change support, and multi-system participation were required to increase vaccination coverage and reduce the vaccine dropout among children in Ethiopia.

Keywords Pentavalent, Measles, Immunizations, Dropout, Ethiopia

Introduction

Immunization is a process by which a person becomes protected against a disease through vaccination [1]. Vaccination is a proven tool for preventing and controlling childhood infectious diseases [2]. Currently, immunization prevents 3.5–5 million deaths every year from diseases like diphtheria, tetanus, pertussis, influenza, and measles [3]. It can be taken as one of the most successful and cost-effective public health interventions [3] and also the safest way to protect against disease, as vaccines produce an immune response similar to that produced by natural infection but without the serious risks of death or disability [4]. As such, immunization is a key component of primary health care and an indisputable human right [3]. as it is critical to the prevention and control of infectious disease outbreaks and the battle against antimicrobial resistance [3].

Immunization dropout among children is a term that refers to the situation when children who receive the first dose of a vaccine do not complete the full series of doses required for optimal protection against disease [5]. This can lead to lower immunization coverage and an increased risk of outbreaks of preventable diseases such as measles, polio, or meningitis [6]. The rates of immunization dropout should be decreased to achieve full immunization coverage and prevent a possible outbreak of preventable diseases. If the dropout rates are greater than 10% for certain areas, it usually indicates a serious quality problem that needs to be addressed [7, 8]. It is a serious problem in Ethiopia, affecting the health and well-being of many children [9]. The UNICEF report reviled that the immunization coverage for pentavalent 3 and measles vaccines among 12–23-month-old children in Ethiopia was 50.7% and 51.9%, respectively indicating a clear disparity among regions, with some regions having coverage as low as 20% [9]. Other studies depicted that the dropout rate for the pentavalent vaccine ranged from 14 to 17.6% and for the measles vaccine was 18–23.4% [10, 11].

Immunization dropout rates vary significantly between countries and regions and can be influenced by factors such as living in rural areas, lack of transportation, non-compliance with the order of arrival during vaccination in health facilities, lack of a reminder system, vaccine misinformation, and fear of virus transmission during the COVID era [5, 12, 13].

The other factors contributing to high dropout was the social norms and a lack of family support as some communities, percieved immunization as the sole responsibility of mothers, or a lack of support from their husbands [14, 15]; Families or Caregivers may lose trust in the health system if they encounter problems such as vaccine stockouts, long waiting times, rude or unprofessional health workers, or a lack of information and counseling on vaccination [14, 15]. Moreover, other factors like concern about side effects, are also widely reported, as caregivers may be worried about the possible adverse reactions of vaccines, especially if they are not well informed about them or if they receive multiple doses at once [14, 15]. Some caregivers may also believe in myths or rumors about the negative effects of vaccines on their children's health or fertility [14, 15].

The existing body of literature on the prevalence and factors influencing immunization dropout rates is limited, particularly studies employing robust and representative methodologies. Consequently, this study aims to ascertain the extent, coverage, and determinants of Pentavalent and Measles vaccine uptake in Ethiopia. This will be achieved by analyzing data from the nationally representative 2019 Ethiopia Demographic and Health Survey (EDHS) and employing multilevel analytical techniques to provide a more comprehensive understanding of the immunization landscape.

Methods and materials

Study design, setting, and period

Ethiopia is in north-eastern Africa between 30 and 150 North latitudes and 330 and 480 East longitudes. The country has nine regional states (Amhara, Oromia, Tigray, Benishangul-Gumuz, Somali, Afar, Harari, Southern Nations Nationalities and Peoples (SNNP), and Gambella and two city administrations (Addis Ababa and Dire Dawa) [16]. Ethiopia is a landlocked country with a diverse and growing population. Currently Ethiopian population reached 123 million people in (2022) with population growth rate of 2.7% annually, birth rate of 32.4 births per 1,000 people (2021), fertility rate of 4.0 births per woman in 2023 [17]. In 2023, 22.1% of Ethiopian population lives in urban areas (2023), with Addis Ababa being the largest city with about 2.8 million inhabitants followed by Dire Dawa administration. The life expectancy at birth in Ethiopia is 66.6 years for both sexes combined in 2022 (66.1 years for males and 69.7 years for females). The infant mortality rate is 29.9 deaths per 1,000 live births in 2023 and the under-five mortality rate is 41.2 deaths per 1,000 live births (2023) [18].

The mini–Ethiopia Demographic and Health Survey (EDHS) 2019 was the latest nationally representative survey, used as the foundation for this study.

Sampling procedures and population

The survey was conducted with a nationally representative sample and provided estimates at the national and regional levels for rural and urban areas. The EDHS used a two-stage cluster sampling design using rural and urban regions as strata. In the first stage, enumeration areas (EA) were selected with a probability proportional to EA size, with independent selection in each sampling stratum. In the second stage, an appropriate number of households per cluster were selected with an equal probability of systematic selection. Two vaccines (Pentavalent 3 and measles 1) were selected purposively. Pentavalent 1 is used as a base line and denominator to calculate the Pentavalent 3 and measles dropout. Pentavalent 3 and measles 1 dropout are a measure of the proportion of children who received the first dose of pentavalent or measles vaccine but did not complete the full course of immunization. It is necessary in monitoring vaccination activities of a country as it can indicate the quality and accessibility of immunization services. A high dropout rate may suggest problems such as inadequate supply of vaccines, poor communication and education, lack of follow-up and reminder systems, or low demand and acceptance of immunization among the population. Moreover, pentavalent 3 and measles 1 dropout are a useful indicator for evaluating the performance and impact of immunization programs in a country.

To select children out of a total of 5753 Ethiopian children included in the ETKR81DT file of the mini-2019 EDHS dataset, immunization-related data were collected from a total of 3208 children. From the rest (2545 children's) their immunization status was not collected. Out of the total number of children whose families were interviewed, and their vaccination cards were seen, 1143 were recorded as not receiving the pentavalent vaccine, and 42 were registered as not knowing the vaccination status of the children. Finally, in this study, 2004 (34.8%) children who received Pentavalent One were considered the target group for the dropout rate assessment. Further information regarding the sampling technique and questionnaire, in general, can be accessed from the EDHS 2016 report [19]. Data sets for the study population were downloaded from the DHS website through a formal request (Fig. 1).

Study variables and measurements

An outcome variable was the immunization dropout rate among children. Immunization dropout rates are measured by comparing the number of infants who start the immunization schedule with the number who complete it, using the Pentavalent vaccine or measles vaccine as proxy vaccines [7]. The pentavalent one-to-three dropout and the Pentavalent one-to-measles dropout were considered for assessing the dropout. The immunization dropout model is a way of measuring the percentage of children who start but do not complete the vaccination schedule for pentavalent and measles vaccines. Pentavalent vaccine protects against five diseases: diphtheria, tetanus, pertussis, hepatitis B, and Hemophilus influenzae type b. Measles vaccine protects against measles, a highly contagious viral infection.

The simplified equations for calculating the dropout rates are as follows:

Pentavalent 1 to pentavalent 3 dropout rate = (Penta1-Penta3)/Penta1×100%.

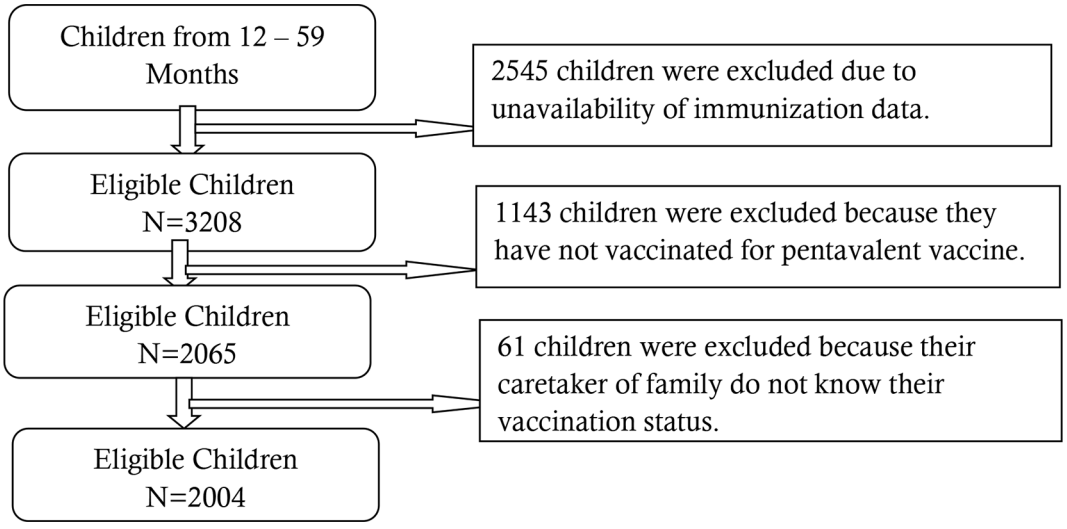

Fig. 1 Inclusion and exclusion criteria for analysis of immunization dropout among under five children in Ethiopia

Pentavalent 1 to measles vaccine dropout rate = (Penta1-Measles)/Penta1×100%.

Where:

Penta1 is the number (or percentage) of infants receiving the first dose of pentavalent vaccine.

Penta3 is the number (or percentage) of infants receiving the third dose of pentavalent vaccine.

Measles is the number (or percentage) of infants receiving the measles vaccine. These equations show how many children are lost between the first and the last doses of the vaccines [20]. A high dropout rate indicates that there are problems with the accessibility, quality, or acceptability of the immunization services. The goal is to have a dropout rate of less than 10% for both pentavalent and measles vaccines. The proportion of the children who received pentavalent one and continued routine immunization until pentavalent three [20].

Independent variables

Through reviewing previously conducted studies, variables such as socio-demographic factors and community-level factors related to family and study population were identified (Table 1). In addition, maternal and child obstetric and morbidity histories were also assessed from the mini-2019 EDHS datasets.

Statistical analysis

The data analysis started with a summary of the socio-demographic characteristics. Other important factors were included in the assessment of immunization dropout (Pentavalent and Measles immunization) using frequency distribution analysis. The data were analyzed using STATA version 17 statistical software. The data were weighted using sampling weight, primary sampling unit, and strata before any statistical analysis to ensure the representativeness of the survey and to consider the sampling design when calculating standard errors to get reliable statistical estimates [42].

Table 1 Lists of variables reviewed for immunization coverage and dropout in Ethiopia, 2024

Variables reviewed	Category	References
Regions, places of residences,	Socio-demographic characteristics	[5, 12, 13]
Lack of a reminder system, vaccine misinformation, and fear of virus transmission	Communication & myths	[5, 12, 13]
Social norms, family support, gender role,	Culture and social norms	[14, 15]
Penta3 coverage, Measles 1 (Fully vaccinated) coverage	Immunization coverage	[21–26]
Dropout (pentavalent, measles).	Immunization dropout	[14, 27–41]
Childcare habit, distance from health facility	Health seeking behavior	[14, 15]

To determine the relationship between immunization dropouts and other factors as well as control confounders, logistic regression assumptions (chi-square and multicollinearity) were tested. To ensure the accuracy of the standard error and an unbiased estimate, it is important to overcome the violated independence assumption and consider the variability between clusters in multi-level advanced statistical modelling.

- Variables with a P-value of 0.2 were candidates for the multivariable, a two-stage mixed-effects logistic regression. For each independent variable, a bivariable multilevel mixed-effect logistic regression model was fitted. The mixed-effect model with the lowest AIC and BIC (information criteria) was chosen. A factor was designated as a significant predictor of immunization dropout if its p-value was less than 0.05. The odds ratio was used to measure how strong the link was, with a 95% confidence interval. The fitness and performance of the model was done using various criteria, like likelihood ratio tests, Akaike information criterion (AIC), Bayesian information criterion (BIC), R-squared, mean squared error (MSE), sensitivity, specificity, and area under the curve (AUC). The Chosen model has the best balance between fit and parsimony. As such the estimation of the association between immunization dropout and explanatory variables was performed using the fixed effects sub-model. The intra-cluster correlation coefficient (ICC) with standard deviation was employed to measure cluster variance. A null model (a model without independent variables), a model considering only individual-level factors, a model considering community-level variables, and We fitted the four models, including the null model, the household-level model that considers individual and family-level factors, the community-level model, and the final model that considers both individual household and community factors together. The best-fitting model among the fitted models was ultimately chosen using the Akaike and Bayesian Information Criteria (AIC and BIC).

Results

Socio-demographic and child characteristics

Among the total 2004 children included in this study, about 1380 (68.8%) of the children's families were from rural areas. Regarding the region, most of the children, 254 (12.7%), 230 (11.5%), were enrolled from Oromia & Tigray, respectively. Four out of five household heads in the children's family were male, and about 887 (44.3%) of them were protestant religion followers. Most of the household heads, 746 (64.9%) and 1025 (51.1%), had no

Table 2 The socio-demographic characteristics of Ethiopian children's family in the year 2019

Variable	Category	Frequency	Percent
Residence	**Urban**	**624**	**31.14**
	Rural	1,380	68.86
Region	Tigray	230	11.48
	Afar	118	5.89
	Amhara	218	10.88
	Oromia	254	12.67
	Somali	101	5.04
	Benishangul	208	10.38
	SNNPR	200	9.98
	Gambela	151	7.53
	Harari	152	7.58
	Addis Adaba	169	8.43
	Dire Dawa	203	10.13
Sex of the respondent	Male	1,620	80.84
	Female	384	19.16
Religion	Orthodox	736	36.7
	Catholic	11	0.55
	Muslim	355	17.7
	Protestant	887	44.3
	Others	15	0.7
Education of the respondent	No education	746	64.9
	Primary	235	20.4
	Secondary and above	167	14.5
Family size	Less than five	1025	51.1
	6 to 10	922	46
	Above 10	57	2.8
Household head age	Mean	37.6	
Age of the child	Less than or equal to 12 months	681	33.6
	Above 12 months	1323	66
Births in the last five years	One	1073	53.5
	More than one	931	46.5
Sex of the child	Male	1021	50.9
	Female	983	49.1
Birth order	Mean	3.4	

education and lived with a maximum of five family members, respectively. Out of a total of 2004 children, 1323 (66%) were above the age of one year, while the rest of them, 328 (16.4%) and 353 (17.6%), were in the age categories of less than six and six to 12 months, respectively. More than half, 1073 (53.5%) households, had one birth in the past five years. Out of the total children, 1021 (50.9%) were males, whereas the rest (983, 49.1%) were females (Table 2).

Magnitude of pentavalent and measles vaccines dropout

Out of the total children who received Pentavalent 1, 535 (26.7%, 95% CI: 24.8–28.7%) dropped out for Penta three. In addition, out of the children who received Pentavalent 1, a total of 788 (39.3%) dropped out of the measles vaccine (Fig. 2).

Determinants of immunization dropout

The fourth models included all eligible children, households, and community-level factors that were found to be optimal (smallest AIC) and are considered the final model. **Null Model** includes no predictors and serves as a baseline to compare other models. It only includes the intercept. **Model II** includes individual-level variables such as religion, education, sex of the household head, age of the household head, maternal marital status, sex of the child, child age category, and number of family members. **Model III** adds regional-level variables to the individual-level variables in Model II. It accounts for differences in PENTA dropout rates across different regions. And **Model IV** includes both individual-level and regional-level variables, as well as place of residence (urban vs. rural). It provides the most comprehensive analysis by considering all factors.

In the final models, factors such as household wealth indexes, married marital status, and living in Addis Ababa reduced the likelihood of Pentavalent 3 vaccine dropout compared to their counterparts. This study identified that the immunization coverage of Ethiopian children

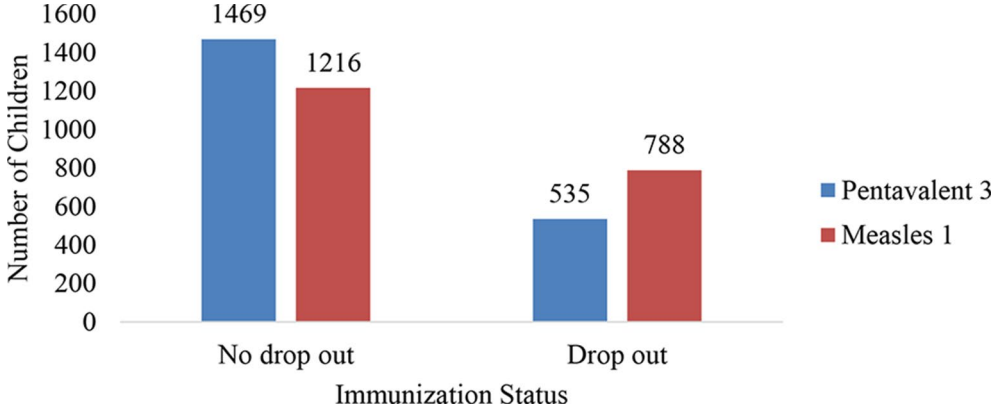

Fig. 2 Magnitude of Penta three and Measles vaccines dropout in Ethiopia in the year 2019

was73.3% and 60.7% respectively for Pentavalent 3 and Measles 1. Moreover, the dropout rate of Pentavalent 1–3 was 26.7%, and Pentavalent 1–measles 1 was 39.3%. Different factors were associated with the dropout rate of Pentavalent 1 to 3. Being residents of Afar increased the odds of dropping out by 3.28 (AOR=3.28; 95% CI: 1.12, 9.56), and being residents of Addis Ababa reduced their odds of dropping out by 68.1% (AOR=0.319; 95% CI: 0.122, 0.833) compared to their Tigray counterparts. And the dropout rate of Pentavalent 1 to measles 1 vaccination was4.33 times higher among residents of Afar (AOR=4.33; 95% CI: 1.38, 13.56). As the level of wealth increases, the quintile increases from poorer to richer compared to those in the poorest wealth quantile category, and marital status also affects the immunization dropout rate of their children. Measles 1 coverage in Ethiopia in the year 2019 was 60.7% (95% CI: 58.5–62.8). The dropout rate of Pentavalent 1 to measles 1 vaccination was likely to be 4.33 times higher among residents of Afar (Tables 3 and 4).

Table 3 Determinants of Pentavalent three vaccines dropout in Ethiopia during 2019

Variables	Categories	PENTA dropout	Null model	Model II	Model III	Model IV
Religion	Orthodox	143		1		1
	Catholic	3		4.31(1.18–15.67)		3.34(0.75–14.85)
	Muslim	112		2.39(1.41–4.03)		1.76(0.96–3.21)
	Protestant	274		1.92(1.17–3.14)		1.45(0.89–2.35)
	Others	3		1.55(0.32–7.55)		1.46(0.25–8.54)
Highest level of education	No education	197		1		1
	Primary	55		11.02(0.63–1.67)		1.04(0.62–1.72)
	Above secondary	32		0.98(0.56–1.70)		1.05(0.60–1.84)
Sex of the HH head	Male	438		1		
	Female	97		0.64(0.43–0.96)		0.73(0.48–1.13)
Age of the HH Head	Poorest	158		1		1
	Poorer	108		0.31(0.16–0.60)		0.31(0.16–0.60)
	Middle	79		0.43(0.22–0.82)		0.42(0.21–0.82)
	Richer	89		0.55(0.29–1.04)		0.54(0.28–1.02)
	Richest	101		0.25(0.14–0.46)		0.33(0.17–0.62)
Current maternal marital status	Married	492		0.35(0.17–0.72)		0.35(0.17–0.70)
	Single	43		1		
Sex of the Child	Male	262		1		
	Female	273		1.25(0.85–1.84)		1.21(0.83–1.76)
Number of Family sizes	Maximum Of Five	244		1		
	6 To 10	270		1.39(0.88–2.19)		1.40(0.88–2.23)
	Above 10	21		1.49(0.36–6.05)		1.65(0.43–6.30)
Region	Tigray	44				1
	Afar	60			5.49(3.08–9.87)	3.27(1.12–9.55)
	Amhara	38			0.84(0.47–1.47)	0.61(0.26–1.41)
	Oromia	86			2.09(1.29–3.37)	1.70(0.72–4.01)
	Somali	47			3.96(1.80–8.70)	1.87(0.48–7.21)
	Benishangul	45			1.15(0.69–1.91)	0.94(0.41–2.14)
	SNNPR	70			2.15(1.31–3.54)	1.82(0.80–4.11)
	Gambela	38			1.41(0.74–2.67)	0.93(0.34–2.53)
	Harari	41			1.78(1.01–3.13)	1.17(0.47–2.91)
	Addis Adaba	10			0.36(0.19–0.69)	0.31 (0.12–0.83)
	Dire Dawa	56			1.83(1.09–3.06)	1.50(0.65–3.49)
Place Of Residence	Urban	108			1	
	Rural	427			1.65(1.17–2.32)	1.01(0.62–1.61)
	Variance		0.61	0.19	0.19	0.009
	ICC		0.15(0.03)	0.05(0.04)	0.05(0.02)	0.002(0.04)
	AIC		343536.9	179982.4	326870.5	174335.4
Model Comparison	MOR			1.12	1.12	0.24
	PCV			0.68	0.68	0.98

HH Household, *SNNPR* Southern Nation Nationalities and People's Region, *AIC* Akaike Information Criterion, *BIC* Bayesian Information Criterion, *MOR* Median Odds Ratio and *PCV* Proportional Change in Variance

Table 4 Determinants of Measles vaccine dropout in Ethiopia by the year 2019

Variables	Category	Dropout	Model I(Null)	Model II	Model III	Model IV
Religion	Orthodox	246		1		1
	Catholic	4		4.85(1.92–12.22)		3.76(1.16–12.23)
	Muslim	162		2.83(1.56–5.14)		2.30(1.11–4.77)
	Protestant	366		2.40(1.52–3.79)		2.01(1.26–3.19)
	others	10		5.15(0.55–48.07)		4.12(0.42–40.20)
Level of education of the HH head	No education	293		1		
	Primary	89		1.07(0.65–1.74)		1.05(0.64–1.72)
	Secondary and above	56		0.87(0.49–1.56)		0.88(0.50–1.54)
Sex of the HH head	Male	643		1		1
	Female	145		0.71(0.46–1.10)		0.69(0.42–1.16)
Household wealth index	Poorest	165		1		
	poorer	153		1.17(0.64–2.17)		1.19(0.65–2.16)
	middle	128		1.26(0.68–2.33)		1.33(0.72–2.45)
	richer	125		0.86(0.42–1.74)		0.91(0.45–1.81)
	richest	217		0.81(0.42–1.53)		1.16(0.43–2.67)
Maternal marital status	Single/widowed/divorced	46		1		
	Married	742		1.01(0.50–2.02)		1.02(0.49–2.10)
Births in the last five years	One	380		1		
	Above one	408		0.96(0.66–1.40)		0.97(0.67–1.41)
	Birth order	-		0.94(0.82–1.08)		0.96(0.83–1.10)
Sex of the child	Male	404		1		1
	Female	384		1.14(0.75–1.73)		1.11(0.73–1.69)
Family size	<=5	381		1		1
	6 to 10	377		1.22(0.80–1.86)		1.26(0.83–1.93)
	above 10	30		3.79(1.10-13.08)		3.82(1.07–13.54)
Region	Tigray	78			1	1
	Afar	58			1.73(1.12–2.67)	4.33(1.38–13.55)
	Amhara	77			0.97(0.63–1.50)	0.65(0.29–1.47
	Oromia	125			1.75(1.15–2.66)	1.21(0.55–2.68)
	Somali	50			1.68(0.96–2.94)	0.93(0.36–2.40)
	Benishangul	72			0.96(0.60–1.53)	0.59(0.23–1.53)
	SNNPR	84			1.26(0.79–1.99)	0.73(0.29–1.85)
	Gambela	63			1.26(0.73–2.18)	1.14(0.43–3.02)
	Harari	66			1.45(0.86–2.44)	0. 94(0.37–2.40)
	Addis Adaba	43			0.67(0.39–1.16)	0.61(0.26–1.45)
	Dire Dawa	72			1.01(0.65–1.56)	0.81(0.33–1.99)
Place of residence	Urban	211			1	1
	Rural	577			1.18(0.86–1.56)	1.29(0.60–2.76)
Variance			0.26	0.22	0.15	0.18
AIC			406068.9	172037.7	400807.5	171336.4
ICC			0.07(0.02)	0.06(0.04)	0.04(0.02)	0.05(0.04)
Model comparison	MOR			1.2	0.99	1.09
	PCV			0.15	0.42	0.30

HH Household, *SNNPR* Southern Nation Nationalities and People's Region, *AIC* Akaike Information Criterion, *BIC* Bayesian Information Criterion, *MOR* Median Odds Ratio and *PCV* Proportional Change in Variance

Discussion

Assessing vaccination dropout is important as it helps to identify the reasons why some people do not complete the recommended vaccination schedule and help policy makers design effective intervention to address the barriers and play vital role in addressing inequity in vaccination among children. Pentavalent 3 immunization coverage is a measure of the percentage of children who have received three doses of the pentavalent vaccine, which protects against five diseases: diphtheria, pertussis, tetanus, hepatitis B, and *Haemophilus influenzae* type b (Hib) [43].

The study revealed that a significant portion of Ethiopian children received the full series of Pentavalent 3 and

Measles 1 vaccines. The rate at which children did not return for subsequent doses (dropout rate) was considerable. Factors influencing whether children received all recommended vaccinations included geographic location, with children from Afar being more likely to miss vaccinations compared to those from Tigray, while children from Addis Ababa were less likely to miss vaccinations. Additionally, an increase in family wealth was associated with higher vaccination completion rates. Marital status was also identified as a factor, with variations in immunization coverage observed among different marital groups.

The coverage of Pentavalent 3 immunization coverage in Ethiopia was73.3%. Pentavalent 3 vaccine coverage is a vital indicator for assessing immunization program performance in certain areas as a reflection of the completeness of child immunization status. This coverage is a bit less compared to the Pentavalent 3 coverage in Afghanistan (82.3%) [22], Kenya (77.3%) [23] and greater than 80% for Ghana, Malawi, Tanzania, Rwanda, Zambia, other SSA and the European Region (93%) [21]. Pentavalent 3 coverage in Ethiopia was far less than the global Pentavalent 3 immunization target set by the WHO to achieve 90% in all countries and regions by 2030 [45]. But promising when compared to the global coverage of pentavalent vaccines, which was 76% in 2022 [21]. But the coverage was high compared to Pentavalent coverage in Congo (60%) and the Western Pacific Region (32%) [21].

Th analysis showed that the dropout of Pentavalent 1–3 was 26.7%. The dropout rate of pentavalent 1–3 was almost similar with the pooled prevalence of vaccination dropout, which was reported to be 26.06% in sub-Saharan Africa [27] and Much higher compared to the systematic reviews and meta-analyses that reported 7.0% and 4.0% among children aged 12–23 months, respectively, in Gambia [28]; and the dropout rate of Pentavalent 3 was lower compared to the study done in Nepal (30.4%) [29].

Pentavalent 1 to measles 1 dropout in this study was 39.3%. This finding was far higher compared to the study conducted in Kenya (12%) [46]; and a study in southwest Ethiopia (25.8%) [30].

In this study, different factors were associated with dropout rates of Pentavalent 1 to 3, including being residents of Afar, which increases the odds of having a drop out by 3.28, where us being residents of Addis Ababa reduced the dropout rate by 68.1% compared to children who resided in the Tigray region.

The dropout rate of Pentavalent 1 to measles 1 vaccination was 4.33 times more likely among residents of Afar. This study was comparable with the study done in Afar regions depicting the high dropout is associated with some supply related factors like long waiting time for vaccination services, being not visited by health extension workers [8] and due to the demand side factors like low ANC follow-up, poor knowledge on vaccination and low participation on women development army [8]. Which can further be linked to the factors such as misinformation, mistrust, religious or cultural beliefs, or a perceived low risk of disease. So, these regional/ contextual differences highlighted the need for context-specific strategies and interventions to address the barriers and challenges of immunization coverage and reduce dropout rates among children.

This study depicted married women were 64.7% less likely to have their children dropout from the Pentavalent 3 vaccination compared to unmarried mothers. Marital status may have different effects on immunization coverage in different settings and populations. A study conducted in Koforidua reported mothers who were divorced were three times less likely to complete immunization than those who were cohabiting, married, or widowed in Ghana [33]. A study conducted in Ethiopia also found that the marital status of the mother was significantly associated with the full immunization status of children aged 12–23 months [34]. This finding was also supported by different studies done elsewhere in the world. For example, a study by Boke et al. (2022) in Dabat district, Northwest Ethiopia, found that unmarried women were more likely to have incomplete vaccination for their children than married women [47]. Another study by Hailu et al. (2022) in Awash district, Afar regional state, Ethiopia, found that married women were less likely to have immunization dropout for their children than unmarried women [7] and a report by UNICEF (2019) on child marriage, adolescent pregnancy and school dropout in South Asia, highlighted the interrelated challenges and risks faced by young girls who are married or pregnant before the age of 18 [48]. This can be due to the fact that unmarried women may face more social and economic barriers to access immunization services, such as stigma, discrimination, lack of support, and poverty [47]. Or married women may have more awareness and motivation to vaccinate their children, as well as more social and financial support from their husbands and families [7]. Moreover, child marriage and adolescent pregnancy often result in high marital instablity, school dropout and that girls who drop out of school may have less access to information and services on immunization, as well as less decision-making power and autonomy over their own and their children's health [48].

A wealth quintile is a measure of the relative economic status of a household within a population, usually divided into five groups from poorest to richest [49]. This study depicted immunization dropout decreases as the level of wealth quintile increases from poorer to richer compared to those in the poorest wealth quintile category. this study go in line with the study that suggested wealth quintile has a significant influence on immunization

coverage and dropout rates, with the poorest quintile being less likely to be fully vaccinated than the richest quintile. Another study also supported this study as individuals in the poorest wealth quintile were 27% less likely to be fully vaccinated than those in the richest quintile [35] and children whose mothers were in the lowest wealth quintile had a higher probability of dropping out of pentavalent and measles vaccination than those whose mothers were in the highest wealth quintile [36]. A possible explanation for this disparity is that wealthier households have better access to health facilities, information, and services, and can afford the direct and indirect costs of immunization [35, 36].

Being a follower of Catholicism increases the likelihood of measles dropout by 3.76, Muslim by 2.30 and by 2.01 compared to their Orthodox religious followers' counterparts. This can be explained as different religions may have different beliefs, practices, and attitudes towards vaccination, which can affect the decision-making process of parents and their access to immunization services. However, religion is not the only factor that influences immunization coverage, as there are also other social, economic, and environmental determinants that need to be considered. This can be because the demand and acceptance of vaccines among communities are influenced by cultural, religious, or social factors [14, 32]. According to a systematic review of studies that measure parental vaccine attitudes and beliefs in childhood vaccination [37], Another study in 66 low- and middle-income countries found that Muslim children had a 76% higher DPT prevalence than Christian children after adjusting for wealth, maternal education, and area of residence [50]. Moreover, a study that compared the nutritional and immunization status of under-five children in India and Bangladesh found that the religion of the mother showed an influence on the immunization status of children in India but not in Bangladesh [39]. As Hindu mothers were more likely to have their children fully immunized than Muslim mothers in India. The study suggested that there might be religion-related differences in health awareness and health service utilization among religious groups [39]. But a study that examined the association of religion with maternal and child health indicators in sub-Saharan Africa [38] found that religious affiliation was associated with some indicators, such as antenatal care visits, skilled birth attendance, and child mortality, but not with others, such as immunization coverage.

In this study, households with more than 10 family members per house were 3.82 times more likely to drop out of getting measles vaccinations compared to households with a family size of five or below. A study conducted in rural settings in the Gambia found that children from families with more than 20 members had reduced odds of completing their vaccination schedule as compared to those with at most 20 household members [40]. A similar study conducted in Saudi Arabia found a positive association between the extent of non-adherence to immunizations and having a greater number of children in the family [41], and other studies also supported the idea that a larger family size may increase the workload and financial burden of mothers, reduce their attention and care for each child, and thus make them more likely to drop out of immunization [51, 52]. Conversely, a study conducted in Italy found that there was no significant relationship between parents' socio-demographic characteristics, including family size, and children's immunizations [33].

Conclusion

The study sample consisted of 2004 children from 1073 (53.5%) households that had a recent birth in the last five years. The gender ratio was almost equal, with 1021 (50.9%) male children and 983 (49.1%) female children.

The dropout rate for Penta three vaccine among the children who received Pentavalent one was 26.7%, which means that 535 children did not complete the immunization schedule. Similarly, the dropout rate for the measles vaccine among the same group of children was 39.3%, which means that 788 children missed the opportunity to be protected against measles. The final model included the most relevant factors for pentavalent and measles vaccine dropout at child, household, and community levels. Children from poorer households, unmarried mothers, younger age groups, and other regions than Addis Ababa had higher chances of Pentavalent dropout. Measles dropout was more likely for children from larger families, Muslim religion, and Afar region.

Recommendations

Based on the above findings we recommend Federal Ministry of health (FMoH) to prioritize the delivery of essential vaccines, considering different inclusive priority issues discussed above as a factor for dropout. And implement catch-up vaccination in different modalities for children who missed their routine vaccinations and invest in health workforce training, supervision, and motivation to improve the equity, quality and safety of immunization services. And finally improving data collection, monitoring, and evaluation to identify and address gaps and challenges in immunization coverage at different level of health structure.

We also recommend research institutions and universities to conduct more robust method of assessing magnitude and factors affecting high immunization dropout rate in Ethiopia.

Practice implications

The findings of this study can be used to guide the development of programs aimed at preventing Pentavalent and Measles immunization dropout in Ethiopia by informing policymakers and other stakeholders about this emerging immunization dropout related problem among Pentavalent and Measles immunization dropout among children.

Abbreviations and acronyms

A p-value	Is a measure of how likely it is that the observed data would occur if the null hypothesis were true
AIC	Akaike Information Criteria
ANC	Ante Natal Care
AOR	Adjusted Odds Ratio
BCG	Stands for bacille Calmette-Guérin, which is a vaccine for tuberculosis (TB) disease
BIC	Bayesian Information Criteria
CI	Confidence Interval
DTP	Is an abbreviation for diphtheria, tetanus, and pertussis vaccine. It is a combination vaccine that protects against these three infectious diseases that can cause serious complications or death
DTP-HepB-Hib	Is a combination vaccine that protects against five infectious diseases: diphtheria, tetanus, pertussis (whooping cough), hepatitis B, and Haemophilus influenzae type b (Hib). It is also called Pentavalent
EA	Enumeration Areas
EDHS	Ethiopian Demographic and Health Survey
Hib	Haemophilus influenzae type b
MR	Stands for measles and rubella vaccine
OPV	Stands for oral polio vaccine
PCV	Stands for pneumococcal conjugate vaccine, which is a type of vaccine that protects against pneumococcal disease
PENTA	Pentavalent vaccine
PNC	Post Natal Care
RMNCH	Reproductive Maternal Neonatal and health
SNNP	Southern Nations Nationalities and Peoples
STATA	Stata is a statistical software package developed by StataCorp for data manipulation, visualization, statistics, and automated reporting
WHO	World Health Organization

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Author contributions

MT, AB, IM and LDR were involved in the study from the conception to designing, acquisition of data, analysis, and interpretation, and drafting of the manuscript. AB, LDR, IM, TG, AN, UJ, ADw, DA, AA, MG, FM, BB, and IM were involved in the interpretation and drafting of the manuscript. All authors read and approved the final manuscript and agreed to be personally accountable for the author's contributions and to ensure that questions related to the accuracy or integrity of any part of this study.

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Data availability

Data utilized in this study were obtained from the 'ETKR81DT' file within the mini-2019 Ethiopia Demographic and Health Survey (EDHS) dataset, with a specific emphasis on immunization metrics. This dataset is publicly accessible via the DHS Program's website, (https://www.dhsprogram.com), contingent upon receiving the necessary authorization.

Declarations

Ethics approval and consent to participate

After registration the data was retrieved from the webpage for the Mini 2019 Ethiopia Demographic and Health Survey (EDHS) which can be accessed at (http://www.dhsprogram.com). The only aim of the information collection was to carry out a research study. We did not reveal any specific families or individuals and kept all information confidential. EDHS has received permission from the Ethiopian Health Nutrition and Research Institute (EHNRI) Review Board and the National Research Ethics Review Committee (NRERC) of the Ministry of Science and Technology in Ethiopia. The obtained data were treated strictly confidential and were used only for this study.

Consent for publication

Not applicable

Competing interests

The authors declare no competing interests.

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