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Determinants of childhood vaccination among children aged 12–23 months in Ethiopia: A multilevel analysis using 2019 Ethiopia mini demographic and health survey

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3 **1 Determinants of childhood vaccination among children aged 12–23 months in Ethiopia: A**
4 **2 multilevel analysis using 2019 Ethiopia mini demographic and health survey**
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13 Abstract

14 **Objective:** vaccination is a highly cost-effective critical element than any other healthcare service
15 in reaching larger population globally. Due to different reasons, we are facing new emergence and
16 resurgence of vaccine preventable diseases currently. Thus, study was aimed at identifying current
17 prevalence and associated factors in Ethiopia.

18 **Design:** Community based cross-sectional study

19 **Setting:** We used data from 2019 Ethiopia Mini Demographic and Health Survey (EMDHS). The
20 survey included all the nine regional states and two city administrations of Ethiopia.

21 **Participants:** A weighted sample of 1,008 children 12-23 months of age was included in the
22 analysis.

23 **Main outcome measures:** Multilevel proportional odds model was fitted to identify determinants
24 of childhood vaccination status. In the final model, variables with p-value of less than 5% and an
25 adjusted odds ratio with a 95% CI reported.

26 **Result:** The full childhood vaccination coverage of Ethiopia was 39.09% (95% CI: 36.06%,
27 42.28). Maternal education, being in union, keeping vaccination cards, children received Vitamin
28 A₁, living in Afar, Somali, Gambela, Harari, Dire Dawa regions, and rural residents were factors
29 significantly associated with childhood vaccination.

30 **Conclusion:** The coverage of full childhood vaccination in Ethiopia was low remained unchanged
31 since 2016. The study identified both the individual- and community-level factors affected the
32 vaccination status. Accordingly, public health intervention targeted to these identified factors can
33 increase childhood full vaccination status.

34 **Keywords:** full vaccination; multilevel; ordinal, 12-23 months children; Ethiopia

35 **Strengths and limitations of this study**

- 36 • This study used most recent nationwide secondary data that shows proportion of EPI
37 coverage among children aged 12–23 months in Ethiopia.
- 38 • Data of 1,008 children was extracted from the 2019 Ethiopia mini demographic and health
39 survey (EMDHS) dataset for this analysis.
- 40 • We used multilevel proportional odds model to overcome the hierarchical nature of
41 EMDHS data and to identify both individual and community-level factors of EPI.
- 42 • Recall bias is the most relevant limitation of the study.

45 Introduction

46 According to the United Nations Children Fund (UNICEF), vaccination is a dynamic constituent
47 of frontline health care to access larger population compared to any health or social activities by
48 reducing global annual death by significant proportion(1–4). It save lives and protects peoples’
49 health, improves countries’ productivity and resilience, and helps to ensure a safer and healthier
50 world(5,6). Vaccine preventable diseases become the big burden in war affected parts of the world
51 and underdeveloped countries like Ethiopia(7); despite the existence of highly cost-effective
52 vaccines on global markets(8). The global inequality health care distribution forced many low and
53 middle income countries to live under the bundle of pestilent cumulative old health problems(9).
54 Regardless of advancement and attainments of immunization, new emergence and resurgence of
55 vaccine preventable diseases become very common. There are still people who deprived of
56 accessing immunization in some countries which are becoming the reason for of vaccine
57 preventable diseases at large-scale as the disparities honestly admitted by World Health
58 Organization (WHO) and other studies 2018(10–12). This fact is also true in Ethiopia where
59 studies described that educated and rich people get their children vaccinated by nearly 30% to 31%
60 in the country(13). Due to this fact, globally, an estimated 6.6 million children still die every single
61 year and half of the deaths would have been prevented by vaccination(14).

62 As Africa is of the regions severely affected by global imbalanced immunization resources, the
63 overview of the proportion of the fully immunization become the apparent reflection of the fact
64 (1,15). Some evidences indicated that global vaccine coverage is decreasing in some countries and
65 at global level(16). The study summarized the Demographic Health Surveys (DHS) of Sub-
66 Saharan countries showed that the coverage was limited to 59.40% in 2021(17). In Mogadishu full
67 immunization coverage was 45.2% and (41.4%) in 2020 and 2021 respectively(18,19). In Togo

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3 68 the full immunization coverage was 69.3% in Lome district in 2019(20). In Ethiopia a study in
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5 69 Southeast Ethiopia showed that full immunization coverage was 76.8%(21); however, the most
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8 70 recent pooled prevalence of vaccination amongst 12–23 month old children in the country was
9
10 71 47% in 2020(22). EDHS 2016 demonstrated that coverage of full vaccination was 38.3%(23). The
11
12 72 magnitude of full vaccination increased from 14.3% in 2000 to 38.5% in 2016 from other
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14
15 73 study(24). All evidence indicates the most recent coverage of full vaccination is not adequate as
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17 74 per early increase referenced.

18
19
20 75 There are a number of factors that are superimposed the argument that resources disparities might
21
22 76 be the only cause of poor coverage. A systematic review conducted in Sub-Saharan countries
23
24
25 77 showed lack of knowledge of immunization, distance to access point, financial deprivation, lack
26
27 78 of partners support, and distrust in vaccines and immunization programs were the barrier to
28
29 79 utilization(25). The absence of immunization card, respondents' sex, level of education, marital
30
31 80 status, and organization of health system has been mentioned in another study(20). A study
32
33
34 81 included larger sub Saharan countries showed maternal education, health facility delivery, fathers
35
36 82 secondary education and above, ANC visits, PNC visit, wealth index, media exposure, and
37
38 83 distance to health facility affected full vaccination coverage(17). In Ethiopia, from previous four
39
40
41 84 EDHS, postnatal check-up, awareness, regional difference, educational status, residence, and
42
43 85 women wealth index influenced full vaccination(13,22,26). From other study antenatal care visit,
44
45 86 higher level of maternal education, mothers' good knowledge on immunization, short distance to
46
47 87 health facility, and being born in health institutions determined complete immunization of a
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49 88 child(27).

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53 89 In summary, evidences of poor complete immunization varied from vaccination resource
54
55 90 limitation to the individual and community constraining factors. The initial hope of eradicating

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3 91 vaccine preventable diseases become just a hope and the current reports showed coverage
4
5 92 dwindling again. Despite those mentioned factors, researching for new events leading to decreased
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8 93 coverage which become an issue because of emerging and remerging vaccine preventable
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10 94 outbreaks deserve further country level analysis. Therefore, this study aimed discovering further
11
12 95 prevalence and associated factors to assist in policy improvements.
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14

15 96 **Methods**

16 17 18 97 **Study design**

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20
21 98 This study used the 2019 cross-sectional data of Ethiopian mini demographic and health survey
22
23 99 (EMDHS). The survey dataset used in this analysis was obtained from demographic and health
24
25 100 survey website (<http://dhsprogram.com/data/>) after getting permission to access the data. The mini
26
27 101 survey was conducted in March 2019 to June 2019 for the second time in Ethiopia. The Ethiopian
28
29 102 Public Health Institute (EPHI) in collaboration with Central Statistical Agency (CSA) and Federal
30
31 103 Ministry of Health (FMOH) implemented a nationally representative household survey.
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33
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35 104 **Participants**

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37
38 105 The 2019 EMDHS used the sampling frame created for the upcoming Ethiopia population and
39
40 106 housing census list of 149,093 enumeration areas (EA). Participants of the study were selected
41
42 107 through a stratified two-stage cluster sampling technique. Initially, each region of the country was
43
44 108 stratified into urban and rural areas. Probability proportional to EA size was used to select 305
45
46 109 EAs (93 in urban and 212 in rural areas). In the second stage, lists of households were used as a
47
48 110 sampling frame to select 30 households per cluster by equal probability systematic selection
49
50 111 technique. Eligible women for the interview were all women aged 15-49 and residents of the
51
52 112 selected households. Accordingly, 8,885 women were interviewed out of 9,012 eligible women
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3 113 identified for interviews, giving a response rate of 98.6%. All living children age 12–23 months at
4
5 114 the time of the survey were the source population of the study. The details of the survey methods
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7
8 115 and procedures are available in the 2019 Ethiopia Mini Demographic and Health Survey report
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10 116 (28).

117 **Eligibility criteria**

118 All children born in the 2 years preceding the survey were included in the analysis. However,
119 children who were not alive at the time of the survey were excluded from this study. Accordingly,
120 data of 1,008 children who had born in the last 2 years and surviving were extracted from the 2019
121 EMDHS datasets for this analysis.

122 **Study setting**

123 The EMDHS survey included all the nine regions and two city administrations of the country.
124 Ethiopia is the second most populous country from Africa and located in the horn of Africa.

125 **Measurements of variables of the Study**

126 **Dependent variable**

127 Child vaccination status was the outcome variable of the study. The outcome variable was ordered
128 into three categories: not vaccinated, partially vaccinated and fully vaccinated.

129 **Fully vaccinated:** is a child that has received one dose of Bacille Calmette-Guerin (BCG), three
130 doses of pentavalent, three doses of polio, two doses of Rota, three doses of pneumococcal
131 conjugate vaccine (PCV), and one dose of measles (MCV1).

132 **Partially vaccinated:** is a child who had missed at least one or more of the thirteen vaccines/doses.

133 **Not vaccinated:** is a child that has not received any vaccine at all.

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3 134 The interviewers of the 2019 EMDHS obtained information on vaccination coverage from written
4
5 135 vaccination cards (infant immunization card and other health cards), from mothers' verbal reports,
6
7
8 136 and from health facility records. They request mothers who born child in the three preceding years
9
10 137 of the survey to show the infant immunization card or health card. Subsequently, they copy the
11
12 138 dates of each vaccination given in the corresponding questionnaire. Similarly, they ask mother
13
14
15 139 who did not kept the cards to recall whether the child received that specific vaccination and the
16
17 140 number of doses that the child received. In addition, to complement these data (information
18
19 141 collected based on the mother's recall) the field supervisor collect complementary vaccination
20
21 142 records from health facility for a child who visited a health facility and missed vaccination data.
22
23

24 143 **Independent variables**

25
26
27 144 In this study, we considered both individual and community-level independent variables. The
28
29 145 individual-level variables included were maternal age, maternal educational level, religion, marital
30
31 146 status, relationship to household head, sex of household head, wealth index, number of antenatal
32
33 147 care (ANC) visits, place of delivery, utilized postnatal care, presence of vaccination document,
34
35
36 148 birth order number, preceding birth interval, sex of child, received vitamin A1, total children ever
37
38 149 born, and number of under five children in household. While region, type of place of residence,
39
40
41 150 community women education, community poverty, and community ANC utilization were
42
43 151 community-level factors of the study. Region is a grouping of the first administrative level of
44
45 152 Ethiopia. During the survey period, there were 9 regions and 2 city administrations in the country
46
47
48 153 namely, Tigray, Amhara, Afar, Oromia, Somali, Benishangul-Gumuz, South nations nationalities
49
50 154 and people's region (SNNPR), Gambela, Harari, and two city administrations (Addis Ababa and
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52 155 Dire Dawa). Moreover, community women education, community poverty and community ANC
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54 156 utilization were community-level variables derived by aggregating individual-level factors. They
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3 157 were categorized as “low” or “high” based on the median value since the EMDHS were not
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5 158 normally distributed.
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8 159 **Data processing and statistical analysis**

10 160 The data were cleaned, re-coded and analyzed using STATA/SE version 14.0. Descriptive
11
12
13 161 statistics were used to summarize both the individual- and community-level variables. Sample
14
15 162 weight was applied to manage for sampling errors and non-responses. The hierarchical nature of
16
17 163 the DHS data (or sampling methods DHS apply) violates the assumption of independence or lack
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19 164 of correlation of the residuals. In the DHS survey, observations are interdependent as participants
20
21 165 nested in the same cluster are more likely to function in the same way than participants nested in
22
23 166 different clusters in terms of the outcome of interest. As a result, we used a two-level multilevel
24
25 167 proportional odds model since a single-level traditional statistical model might not be adequate to
26
27 168 control for the clustering effect. Moreover, we used multilevel proportional odds model to consider
28
29 169 the natural ordering of the response variable (not vaccinated, partially vaccinated and fully
30
31 170 vaccinated). Accordingly, four consecutive models were built to identify determinants of child
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33 171 vaccination in Ethiopia. We first fitted the null model or the intercept only model. Then, model 1
34
35 172 was fitted with the individual-level variables only that were initially significant at p-value of <
36
37 173 0.25. Similarly, model 2 (with only community-level factors) was constructed. Finally, model 3 or
38
39 174 the mixed-effects model was fitted with both individual- and community-level factors. The intra-
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41 175 class correlation coefficient (ICC) was used to determine the clustering effect or community
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43 176 variation and it was calculated using the following formula.
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$$\text{ICC} = \frac{V_A}{V_A + \frac{\pi^2}{3}}$$

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4 178 Where: V_A is community level variance and $\frac{\pi^2}{3}$ is individual level variance, which is equal to 3.29.

5
6 179 On the other hand, Proportional Change in Variance (PCV), Median Odds Ratio (MOR), and

7
8 180 Deviance were checked by using the following formulas to determine the fitness of the model.

9
10
11 181 $PCV = \frac{V_0 - V_i}{V_0}$. Where: V_0 is variance in the null model and V_i is variance in the consecutive models.

12
13
14 182 $MOR = e^{0.95V_i}$ where: V_i indicates that cluster variance. The model with the lowest deviance

15
16 183 (Model III) was selected as the best-fitted model. Furthermore, the proportional odds assumption

17
18 184 that states the effect of each factor is assumed to be equal across the outcome categories was

19
20 185 examined by score test. Variance Inflation Factor (VIF) was tested to assess the presence of

21
22 186 multicollinearity among the independent variables and the mean VIF was found to be 1.60,

23
24 187 indicating absence of multicollinearity (min 1.03 and max 2.76). In bivariable analysis, variables

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26 188 with p-value less than 0.25 were considered as candidate variables for the multivariable multilevel

27
28 189 proportional odds analysis. Finally, in the multivariable analysis variables with p-value less than

29
30 190 5% and adjusted proportional odds ratio (APOR) with the 95% confidence interval were reported

31
32 191 as statistically significant variables with child vaccination in Ethiopia.

33 34 35 36 37 192 **Patient and public involvement**

38
39 193 Patients and/or the public were not involved in the design, or conduct, or reporting, or

40
41 194 dissemination plans of this research.

42 43 44 195 **Result**

45 46 47 196 **Individual and community-level characteristics of mothers and children**

48
49 197 The current study included 1,008 mothers who have children aged 12-23 months. Out of the total

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51 198 respondents, more than half (52.78%) were in the range of 25-34, nearly half (48.91%) did not

52
53 199 attended education, and almost one-third (32.14%) were Orthodox religion followers. In this study,

four out of ten mothers (39.98%) were from high income households and the majorities (94.05%) were currently in union. Among the participants, less than half (44.15%) were practiced home delivery, nearly a quarter (24.31%) had no ANC visit, and almost one-tenth (13.99%) received PNC service. Majority of the mothers (71.73%) kept immunization document and 88.1% of the interviewed mothers have less than or equal to 2 under five children in their households. From the total number of children, half (50.30%) were males, 22.72% were first-born, and 59.33% were received the most recent vitamin A1. Three-fourth of respondents (73.51%) was from rural areas and 12.6% were from Oromia region of the country (Table 1).

Table 1: Individual and community-level characteristics of mothers of children aged 12-23 months in Ethiopia, 2019

Variables	Frequency (n)	Percentage (%)
Maternal age		
15-24	298	29.56
25-34	532	52.78
35-49	178	17.66
Maternal education		
No education	493	48.91
Primary	342	33.93
Secondary	99	9.82
Higher	74	7.34
Marital status		
Not in union	60	5.95

In union	948	94.05
Religion		
Orthodox	324	32.14
Protestant	177	17.56
Muslim	481	47.72
Others	26	2.58
Relationship to household head		
Household head	167	16.57
Wife or husband	730	72.42
Others	111	11.01
Sex of household head		
Male	797	79.07
Female	211	20.93
Wealth index		
Poor	469	46.53
Middle	136	13.49
Rich	403	39.98
Number of ANC visits		
None	245	24.31
1-3 times	313	31.05
4 and above	450	44.64
Place of delivery		
Home	445	44.15

Health facility	563	55.85
PNC service		
No	836	86.01
Yes	136	13.99
Sex of child		
Male	507	50.30
Female	501	49.70
Birth order number		
1st born	229	22.72
2nd to 3rd	372	36.90
4th to 5th	204	20.24
6th and above	203	20.14
Presence of vaccination document		
No	285	28.27
Yes	723	71.73
Preceding birth order		
< 24 months	186	18.45
24-48	357	35.42
48 and above	465	46.13
Received Vitamin A1		
No	410	40.67
Yes	598	59.33
Total children ever born		

1-3 children	598	59.33
4-6 children	278	27.58
7 and above	132	13.10
Number of <5 children in household		
≤ 2	888	88.10
> 2	120	11.90
Region		
Tigray	93	9.23
Amhara	111	11.01
Afar	99	9.82
Oromia	127	12.60
Somali	85	8.43
Benishabgul	83	8.23
SNNPR	116	11.51
Gambela	77	7.64
Harari	73	7.24
Addis Ababa	64	6.35
Dire Dawa	80	7.94
Type of place of residence		
Urban	267	26.49
Rural	741	73.51
Community women education		
Low	468	46.43

High	540	53.57
Community poverty		
Low	495	49.11
High	513	50.89
Community ANC utilization		
Low	468	46.43
High	540	53.57

210 **Childhood vaccination status in Ethiopia**

211 The full vaccination coverage among children aged 12-23 months in Ethiopia was 39.09% (95%
 212 CI: 36.06%, 42.28) (Fig. 1). On the other hand, two in ten children (22.32%) of 12-23 months have
 213 not received any vaccination during three years before the 2019 survey period. Among the total
 214 children of 12-23 months included in the study, 70.24% received BCG, 57.84% received the third
 215 dose of pentavalent, 55.75% received the third dose of polio, 60.62% received the second dose of
 216 rotavirus vaccine, 55.16% received the third dose of PCV, and 57.04% received the first dose of
 217 measles vaccination (Fig. 2).

218 **Factors affecting child vaccination in Ethiopia**

219 **The fixed effect analysis result**

220 The multivariable analysis showed that maternal educational level, maternal age, marital status,
 221 presence of vaccination document, received Vitamin A₁, region, place of residence, and
 222 community women education were significantly associated variables with childhood vaccination.
 223 Children who were born from mothers who attended primary, secondary, and higher schools were
 224 2.2 [AOR=2.16; 95% CI: 1.43-3.26], 2 [AOR=2.02; 95% CI: 1.07-3.79], and 2.7 [AOR=2.67; 95%

225 CI: 1.25-5.71] respectively times more likely to be partially or fully vaccinated as compared to
 226 children whose mothers have no education. The odds to be partially or fully vaccinated was 1.8
 227 [AOR=1.79; 95% CI: 1.08-2.99] times higher among children whose mothers were in the age range
 228 of 35-49 as compared to those children whose mothers were in the age range of 15-19. Children
 229 whose mothers were currently in union were 2.2 [AOR=2.21; 95% CI: 1.06-4.58] times more
 230 likely to be partially or fully vaccinated than their counterparts. Children whose mothers kept
 231 vaccination cards were 26 [AOR=26.18; 95% CI: 15.75-43.53] times more likely to be partially or
 232 fully vaccinated as compared to those children whose mothers did not kept vaccination cards.
 233 Compared with children who have not received Vitamin A₁ (the most recent), the likelihood to be
 234 partially or fully vaccinated was 4 [AOR=4.14; 95% CI: 2.9-5.9] times higher for children who
 235 received Vitamin A₁. Children from Afar [AOR=0.14; 95% CI: 0.04-0.45], Somali [AOR=0.19;
 236 95% CI: 0.06-0.60], Gambela [AOR=0.22; 95% CI: 0.06-0.77], Harari [AOR=0.14; 95% CI: 0.04-
 237 0.52], and Dire Dawa [AOR=0.23; 95% CI: 0.06-0.79] regions were less likely to be partially or
 238 fully vaccinated as compared to those children from Tigray region. Children living in rural areas
 239 were 47% [AOR=0.53; 95% CI: 0.30-0.93] less likely to be partially or fully vaccinated than
 240 children living in urban areas of the country. Children in the community with high level of maternal
 241 education had 47% [AOR=0.53; 95% CI: 0.29-0.97] lower odds of partially or fully vaccinated as
 242 compared to children in the community with low maternal education (Table 2).

243 **Table 2: Multivariable multilevel ordinal logistic regression analysis of individual and**
 244 **community-level determinants of child vaccination in Ethiopia, 2019**

	Null	Model I	Model II	Model III
Variables	Model	AOR (95% CI)	AOR (95% CI)	AOR (95% CI)

 Maternal educational level

No education	1	1
Primary	1.97 (1.33, 2.93)**	2.16 (1.43, 3.26)***
Secondary	1.80 (0.97, 3.33)	2.02 (1.07, 3.79)*
Higher	2.85 (1.35, 6.02)	2.67 (1.25, 5.71)*

 Maternal age

15-24	1	1
25-34	1.13 (0.78, 1.63)	1.15 (0.79, 1.66)
35-49	1.81 (1.09, 3.02)*	1.79 (1.08, 2.99)*

 Religion

Orthodox	1	1
Protestant	0.46 (0.27, 0.77)**	0.69 (0.36, 1.30)
Muslim	0.71 (0.47, 1.09)	1.28 (0.73, 2.24)
Other	0.39 (0.14, 1.22)	0.56 (0.18, 1.68)

 Marital status

Not in union	1	1
In union	1.84 (0.89, 3.80)	2.21 (1.06, 4.58)*

 Relationship to HH head

Household head	1	1
Wife or husband	0.79 (0.50, 1.23)	0.72 (0.46, 1.14)
Others	0.67 (0.36, 1.27)	0.62 (0.33, 1.17)

 Household wealth index

Poor	1	1
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1			
2			
3	Middle	0.83 (0.51, 1.35)	0.77 (0.47, 1.29)
4			
5	Rich	1.28 (0.83, 1.97)	1.05 (0.63, 1.74)
6			
7			
8	Number of ANC visits		
9			
10	None	1	1
11			
12	1-3	0.97 (0.61, 1.53)	0.99 (0.63, 1.58)
13			
14	4 and above	1.40 (0.86, 2.29)	1.27 (0.77, 2.09)
15			
16			
17	Place of delivery		
18			
19	Home	1	1
20			
21	Health facility	1.22 (0.82, 1.83)	1.11 (0.74, 1.66)
22			
23			
24	PNC utilized		
25			
26	No	1	1
27			
28	Yes	1.04 (0.67, 1.63)	1.05 (0.67, 1.65)
29			
30			
31	Immunization document		
32			
33	Available	1	1
34			
35	Not available	27.32 (16.44,45.41)***	26.18(15.75,43.53)***
36			
37			
38	Preceding birth interval		
39			
40	< 24 months	1	1
41			
42	24-48 months	1.07 (0.69, 1.65)	1.04 (0.67, 1.62)
43			
44	48 and above	1.05 (0.67, 1.65)	1.06 (0.67, 1.67)
45			
46			
47	Received Vitamin A ₁		
48			
49	No	1	1
50			
51	Yes	4.32 (3.04, 6.15)***	4.14 (2.9, 5.9)***
52			
53			
54	Number of < 5 children		
55			
56			
57			
58			
59			
60			

1			
2			
3			
4	≤ 2 children	1	1
5			
6	>2 children	0.62 (0.36, 1.07)	0.68 (0.39, 1.16)
7			
8	Region		
9			
10	Tigray	1	1
11			
12	Afar	0.08 (0.03, 0.23)***	0.14 (0.04, 0.45)**
13			
14	Amhara	0.59 (0.24, 1.48)	0.5 (0.22, 1.13)
15			
16	Oromia	0.21 (0.09, 0.48)***	0.45 (0.18, 1.09)
17			
18	Somali	0.08 (0.03, 0.22)***	0.19 (0.06, 0.60)**
19			
20	Benishangul	1.13 (0.37, 3.40)	0.74 (0.25, 2.22)
21			
22	SNNPR	0.19 (0.08, 0.45)***	0.48 (0.19, 1.17)
23			
24	Gambella	0.38 (0.12, 1.22)	0.22 (0.06, 0.77)*
25			
26	Harari	0.43 (0.12, 1.48)	0.14 (0.04, 0.52)**
27			
28	Addis Ababa	1.27 (0.39, 4.14)	1.14 (0.37, 3.47)
29			
30	Dire Dawa	0.78 (0.23, 2.62)	0.23 (0.06, 0.79)*
31			
32			
33			
34			
35	Type of place of residence		
36			
37	Urban	1	1
38			
39	Rural	0.25 (0.14, 0.44)***	0.53 (0.30, 0.93)*
40			
41			
42	Community women education		
43			
44	Low	1	1
45			
46	High	1.04 (0.56, 1.94)	0.53 (0.29, 0.97)*
47			
48			
49	Community poverty		
50			
51	Low	1	1
52			
53	High	0.98 (0.55, 1.77)	1.11 (0.62, 2.00)
54			
55			
56			
57			
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59			
60			

Community ANC utilization

Low

1

1

High

1.81 (0.83, 3.96)

0.87 (0.41, 1.83)

245 Key * = $p < 0.05$, * = $p < 0.01$, * = $p < 0.001$

246 **The random effect analysis result**

247 Table 3 presents the random effect analysis result of childhood vaccination status in Ethiopia. The
 248 appropriateness of application of multilevel analysis and the presence of significant variations of
 249 childhood vaccination status between clusters (the clustering effect) was justified by the ICC of
 250 Null model (48.19%). The value of ICC decreased from 48.19% in the null model to 14.55% in
 251 the final model showing the effect of clustering was more or less controlled. In addition, as
 252 depicted in the table below the largest PCV of final model (81.70%) indicates the goodness of
 253 model fitness. In another words, the final model (Model 3) has the highest capacity than model I
 254 or model II alone to explain the variations in childhood vaccination status. On top of that, Model
 255 III was the best explanatory model able to explain the variation in childhood vaccination status
 256 between the clusters since the value of deviance observed in the final model was smallest than the
 257 remaining models (Table 3).

258 **Table 3: Random effects analysis and model fit statistics of child vaccination in Ethiopia,**
 259 **2019**

Parameters	Null Model	Model I	Model II	Model III
Community level Variance (SE)	3.06	0.76	1.21	0.56
PCV (%)	Reference	75.16%	60.46%	81.70%
ICC (%)	48.19%	18.77%	26.89%	14.55%

MOR	5.31	2.29	2.84	2.03
Log-likelihood	-988.74	-684.36	-919.88	-667.78
Deviance	1,977.48	1,368.72	1,839.76	1,335.56
AIC	1983.49	1418.72	1873.77	1413.56
BIC	1998.24	1540.70	1957.34	1603.86

260 Discussion

261 From this analysis, complete immunization in Ethiopia was 39.08%. Compared to other studies in
 262 the country, it is less than 76.8% in South East (21), 47% pooled prevalence(22), and 67% in 2016
 263 from other study(29). It is also less than 59.40% summarized Sub-Saharan coverage(17), 69.21%
 264 in East Africa(29), 45.2% in Mogadishu (18), and 69.3% in Togo in 2019(20). It is 38.3% from
 265 2016 EDHS which is in the confidence interval. This indicates that the current prevalence of full
 266 immunization unchanged over time. The reasons might be political instabilities in the country in
 267 the last five years, while it might also be due to the increased inequalities health service access
 268 regardless of increased population in these years because of less resource development. Un-
 269 education (48.91%) of mothers is also decades old persistent problem; however, it was still
 270 improved from 67% in 2015(26). It is also better than regional recent figure (Sub-Saharan
 271 countries)(17). Although there are some improvements from previous, there is an ample of gaps
 272 from expected standard which might indicate efforts short of effectiveness. Poverty, which is
 273 another old problem, is also persisted as only 39.98% mothers were from high income families.
 274 From other study, 36.6% mothers were from wealthy families(26). Despite the issue with full
 275 vaccination, other socioeconomic factors showed some improvements over the last few years;
 276 however, their effect might be insignificant to influence vaccination due to the unstable market
 277 inflation that might be cancelling its development.

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2
3 278 The evidence from the current study also showed, maternal education had positive association with
4
5 279 higher level complete immunization category which is also similar from other studies(17,24,26).
6
7
8 280 The consistence might indicate that education is an independent predictor of complete
9
10 281 immunization which needs undivided attention. Education is evidenced by individually and
11
12 282 community level influences. Increased maternal age puts mothers in the higher level of full
13
14 283 immunization category. Other studies also showed higher age has association with full
15
16 284 immunization(3,17). This might indicate maturity is an important factor in caring for own child,
17
18 285 which might also indicate early marriage, child bearing at younger age, and age at first birth needs
19
20 286 adequate consideration in birth planning. Children whose mothers remained in union had higher
21
22 287 tendency to be in higher category of full immunization. From previous studies, there are consistent
23
24 288 findings(17,18). This might be an indication that disrupted family might be tight in self-survival
25
26 289 activities than looking after their children and so that staying in union should be encouraged.
27
28
29 290 Mothers who keep evidence of vaccination tend to be in higher category of immunization
30
31 291 coverage. This is also true for some studies(18,19,26). This means, women who keeps children
32
33 292 evidence of vaccination might have indeed great regards for full immunization while carelessness
34
35 293 might start from poor evidence keeping. Children who received Vitamin A₁ had higher chance of
36
37 294 completing full vaccination. The fact that vitamin A supplied towards the end of most vaccine
38
39 295 might raise to this association (12). This might be another persist issue we never eased in previous
40
41 296 efforts as per evidence from this study and could be set as an objective to attain other sub-
42
43 297 objectives. Ethiopia further classified in city administrations, agrarian, and pastoralist regions.
44
45 298 Pastoralists regions like Afar and Somali in relation with agrarian but semi pastoralist regions like
46
47 299 Gambela, Benishangul Gumuz and Harari had higher tendency of failing to low category of full
48
49 300 immunization. All other country level data analysis indicated similar facts(26). This is also
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3 301 confirmed by other studies that compared developed and underdeveloped regions(24,26). The
4
5 302 issue here is very apparent that attention deprived regions should be the next intervention areas.
6
7 303 This problem is relatively similar between the rural and urban place of residence. Other studies
8
9 304 also laud that inequalities between rural and urban residence need careful considerations(13). This
10
11 305 might be apparently due to access, awareness, and availability. This study provided fabulous
12
13 306 information for the scientific community; however, it should advisable to use it in recalling
14
15 307 secondary data, disproportional nature of the data, and cross sectional nature of the data. Authors
16
17 308 followed standards of data handling as per guidelines of DHS, weighted data, and performed
18
19 309 explicit analysis described under method section to relax possible limitations.
20
21
22
23

24 310 **Conclusion**

25
26
27 311 Although full immunization increased from EDHS 2000 to 2016, the current analysis of EMDHS
28
29 312 result showed it was indeed remained unchanged. The analysis identified many factors that might
30
31 313 be contributed for the no changed. Maternal educational level, maternal age, marital status,
32
33 314 presence of vaccination document, received Vitamin A₁, region, place of residence, and
34
35 315 community women education were some of the contributors. Analyzing associated factors showed
36
37 316 some of the factors are old enough causing the problem for decades. Even though the political
38
39 317 situation in the country might also contributed to the persistency of these factors, it is advisable
40
41 318 that accessibility, awareness, available coupled with maternal education and poverty especially
42
43 319 family and maternal capacity remained critical and need all round efforts like further government
44
45 320 commitment, dedicated international supports, and peace and security can override the problem.
46
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51 321 **Abbreviation/Acronyms:** Demographic Health Survey (DHS); Ethiopian Demographic Health
52
53 322 Survey (EDHS); Ethiopian Mini-Demographic Health Survey(EMDHS); World Health
54
55 323 Organization (WHO); United Nations Children's Fund (UNICEF); Adjusted Odds Ratio (AOR);
56
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3 324 Antenatal Care (ANC); Postnatal Care (PNC); Pneumococcal Conjugate Vaccine (PCV); and
4
5 325 Measles Containing Vaccine (MCV); Bacille Calmette-Guerin (BCG); South Nations
6
7 326 Nationalities and Peoples Region (SNNPR); Intra-class Correlation Coefficient (ICC); Median
8
9
10 327 Odds Ratio (MOR), Confidence Interval (CI)
11
12

13 328 **Declarations**

16 329 **Ethics approval and consent to participate**

18 330 This study used secondary data from demographic and health survey data files. Initially, the
19
20 331 MEASURE DHS team was formally requested to access the datasets by completing the online
21
22 332 request form on their website (www.dhsprogram.com). Accordingly, permission to access the data
23
24 333 and the letter of authorization was obtained from ICF international. Therefore, for this study
25
26 334 consent to participate is not applicable. We kept all data confidential, and no effort was made to
27
28 335 identify households or individuals. The Ethiopian Health Nutrition and Research Institute
29
30 336 (EHNRI) Review Board and the National Research Ethics Review Committee (NRERC) at the
31
32 337 Ministry of Science and Technology of Ethiopia, approved EMDHS 2019. The authors also
33
34 338 confirm that all methods were carried out in accordance with relevant guidelines and regulations.
35
36
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38

39 339 **Consent for publication**

41 340 Not applicable
42
43

44 341 **Availability of data and materials**

46 342 The survey dataset used in this analysis are third party data from the demographic and health
47
48 343 survey website (www.dhsprogram.com) and permission to access the data is granted only for
49
50 344 registered DHS data user.
51
52
53

54 345 **Competing interests**

1
2
3 346 The authors have declared that no competing interest existed.
4

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6

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10 349 **Authors' contribution**
11

12
13 350 SS has obtained and analyzed the EMDHS data. SS, GG, SH were equally involved in the
14
15 351 conception of the study, interpreted the results, drafted and critically revised the manuscript. All
16
17 352 authors have read and approved the final version of the manuscript.
18
19

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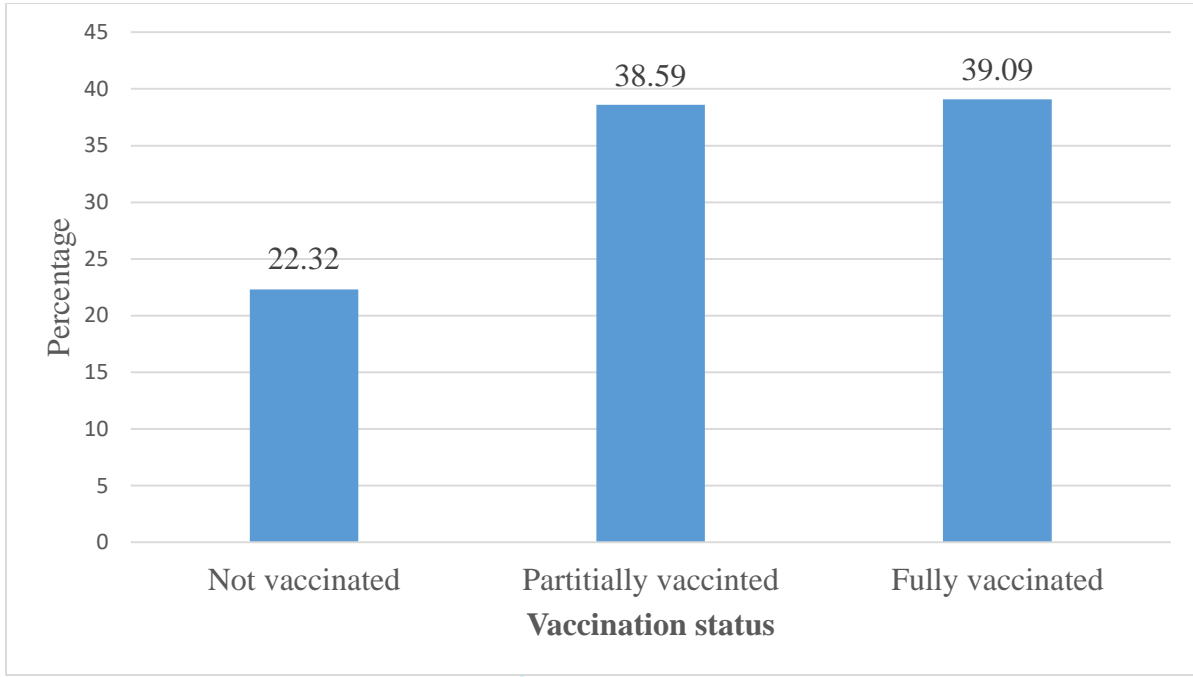


Fig. 1: Vaccination status of children aged 12-23 months in Ethiopia, 2019

review only

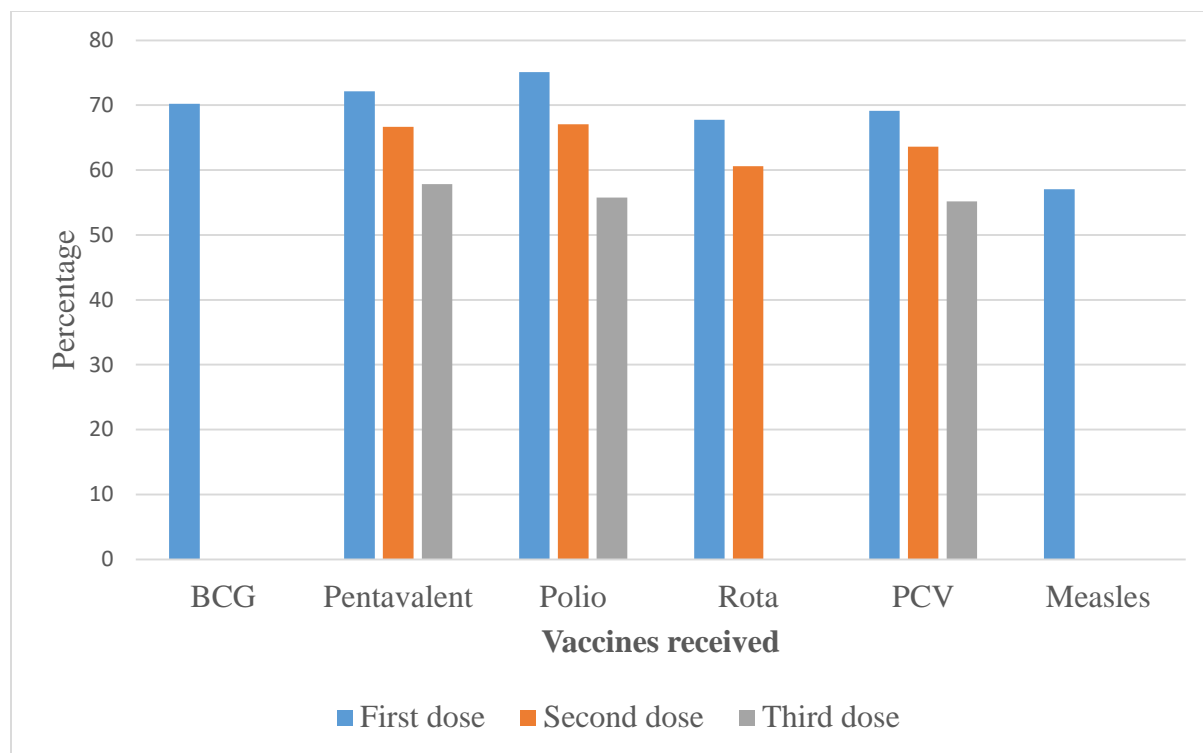


Fig. 2: Percentage of children aged 12-23 months who received a particular vaccine in Ethiopia, 2019

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Determinants of childhood vaccination among children aged 12–23 months in Ethiopia: A community-based cross-sectional study

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3 **1 Determinants of childhood vaccination among children aged 12–23 months in Ethiopia: A**
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5 **2 community-based cross-sectional study**
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12 4 Sewunet Sako^{1*}, Girma Gilano¹ and Samuel Hailegebreal¹
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13 Abstract

14 **Objective:** Childhood vaccination is a cost-effective essential service to reach larger population
15 globally. Due to unclear reasons, new emergence and resurgence of vaccine preventable diseases
16 gets increase. Thus, the aim of this study is to identify prevalence and determinants of childhood
17 vaccination in Ethiopia.

18 **Design:** Community based cross-sectional study

19 **Setting:** We used data from 2019 Ethiopia Mini Demographic and Health Survey (EMDHS). The
20 survey included all the nine regional states and two city administrations of Ethiopia.

21 **Participants:** A weighted sample of 1,008 children 12-23 months of age was included in the
22 analysis.

23 **Main outcome measures:** Multilevel proportional odds model was fitted to identify determinants
24 of childhood vaccination status. In the final model, variables with p-value of less than 5% and an
25 adjusted odds ratio with a 95% CI reported.

26 **Result:** The full childhood vaccination coverage of Ethiopia was 39.09% (95% CI: 36.06%,
27 42.28). Mothers attended primary [AOR=2.16; 95% CI: 1.43-3.26], secondary [AOR=2.02; 95%
28 CI: 1.07-3.79], and higher schools [AOR=2.67; 95% CI: 1.25-5.71], being in union [AOR=2.21;
29 95% CI: 1.06-4.58], kept vaccination cards [AOR=26.18; 95% CI: 15.75-43.53], children received
30 Vitamin A₁ [AOR=4.14; 95% CI: 2.9-5.9], living in Afar [AOR=0.14; 95% CI: 0.04-0.45], Somali
31 [AOR=0.19; 95% CI: 0.06-0.60], Gambela [AOR=0.22; 95% CI: 0.06-0.77], Harari [AOR=0.14;
32 95% CI: 0.04-0.52], Dire Dawa [AOR=0.23; 95% CI: 0.06-0.79] regions, and rural residents
33 [AOR=0.53; 95% CI: 0.30-0.93] were factors significantly associated with childhood vaccination.

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3 34 **Conclusion:** The coverage of full childhood vaccination in Ethiopia was low remained unchanged
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5 35 since 2016. The study identified both the individual- and community-level factors affected the
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7 36 vaccination status. Accordingly, public health intervention targeted to these identified factors can
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9 37 increase childhood full vaccination status.
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13 38 **Keywords:** full vaccination; multilevel; ordinal, 12-23 months' children; Ethiopia
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16 39 **Strengths and limitations of this study**

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- 19 40 • This study used most recent nationwide secondary data that shows proportion of EPI
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21 41 coverage among children aged 12–23 months in Ethiopia.
- 22
23 42 • Data of 1,008 children was extracted from the 2019 Ethiopia mini demographic and health
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25 43 survey (EMDHS) dataset for this analysis.
- 26
27 44 • We used multilevel proportional odds model to overcome the hierarchical nature of
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29 45 EMDHS data and to identify both individual and community-level factors of EPI.
- 30
31 46 • Establishing temporal relationship of causation between childhood vaccination and its
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33 47 determinants was impossible due to the nature of the study design used for the survey.
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35 48 • Recall bias is the most relevant limitation of the study.
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51 Introduction

52 According to the United Nations Children Fund (UNICEF), immunizations is a dynamic
53 constituent of frontline health care to access larger populations. Compared to any other health or
54 social activities, immunization reduces global annual death by significant proportion(1–4). It saves
55 lives and protects people’s health, improves countries’ productivity and resilience, and helps to
56 ensure a safer and healthier world(5,6).

57 According to the Ethiopian Ministry of Health, a child takes OPV₀ and BCG at Birth. At six weeks
58 after birth, a child takes OPV1(oral polio vaccine), Pentavalent1(DPT+HepB+Hib),
59 Pneumococcal1, and Rotavirus1. Then 10 weeks after birth the child takes OPV2, and
60 Pentavalent2, Pneumococcal2, and Rota2. The child takes OPV3, Pentavalent3, Pneumococcal3,
61 Inactivated polio vaccine (IPV) at 14th weeks. Other vaccines such as Measles Containing Vaccine
62 (MCV1) at 9th month and MCV2 at 15th month and human papilloma virus (HPV) at 14th years for
63 girls are given. However, this study only considers vaccines between 1 to 2 years. All vaccines are
64 equally important(7). Currently, Ethiopia do not provide Rubella, Mumps and chickenpox
65 vaccines to immunize children. Depending on the amount of immunity or protection after receiving
66 a dose, a child may require more than one dose for some vaccine(8). Additionally, more than one
67 dose is needed to build high enough immunity to prevent disease and boost immunity that fades
68 over time(9). For vaccines that do not initiate full protection at first introduction, additional dose
69 of vaccine usually repeated(10). However, this does not mean one vaccine is better than the other
70 is or more important than another since it depends on the nature of the disease.

71 Globally, about 6.6 million children die every year and half of the deaths would have been
72 prevented by vaccination(11). The global inequality in health care distribution force many low and
73 middle income countries to live under the bundle of pestilent cumulative old health problems(12).

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3 74 Africa is among the regions severely affected by globally imbalanced immunization resources
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5 75 distribution. Vaccine preventable diseases become the big burden in war affected parts of the world
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7 76 and underdeveloped countries like Ethiopia(13). Despite the existence of highly cost-effective
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9 77 vaccines on global markets, situations such as war, displacements, under vaccination, and poor
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11 78 access to vaccine contributes to the prevalence of vaccine preventable disease(14). The proportion
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13 79 of the full immunization reflects how resources distribution caused the imbalance in childhood
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15 80 vaccination(1,15).

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20 81 Regardless of advancement and attainments of immunization, newly emerging vaccine preventable
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22 82 diseases become still common in Africa(16). There are people who deprived of accessing
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24 83 immunization in some countries and becoming the reason for the prevalence of vaccine
25
26 84 preventable diseases as admitted by World Health Organization (WHO) and other studies(17–19).
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28 85 In Ethiopia a study has described that educated (30%) and rich (31%) people better vaccinate their
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30 86 children(20).

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34 87 Some evidences indicated that global vaccine coverage is decreasing(21). A study summarized the
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36 88 Demographic Health Surveys (DHS) of Sub-Saharan African countries showed that the full
37
38 89 vaccination coverage was 59.40% in 2021(22). In Mogadishu, full immunization was 45.2% and
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40 90 41.4% in 2020 and 2021 respectively(22–24). In Togo, the full immunization coverage was 69.3%
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42 91 in Lome district in 2019(25). In Ethiopia. the full immunization coverage is 76.81% in the
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44 92 Southeast region(26); however, the pooled prevalence amongst 12–23 month old children in
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46 93 Ethiopia is 47%(27). EMDHS 2019 demonstrated that coverage of full vaccination was 44(28)%.
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48 94 The magnitude of full vaccination was increased from 14.3% in 2000 to 44% in 2019(29). From
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50 95 this, we understand that the coverage of full vaccination is not adequate.
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3 96 Many factors that support the argument of resource disparities as a reason for low coverage in
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5 97 some countries. A systematic review conducted in Sub-Saharan African countries showed that lack
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7 98 of knowledge of immunization knowledge, distance to access point, financial deprivation, lack of
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10 99 partners support, and distrust in vaccines and immunization programs were the barrier(30). The
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12 100 absence of immunization card, respondents' sex, level of education, marital status, and
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14 101 organization of health system are mentioned in another study(25). A study included many sub
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16 102 Saharan African countries showed that maternal education, health facility delivery, fathers
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18 103 secondary education and above, ANC visits, PNC visit, wealth index, media exposure, and
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20 104 distance to health facility affected the vaccination coverage(22). In Ethiopia, from previous four
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22 105 EDHS, postnatal check-up, maternal awareness, regional difference (economic, education and life
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24 106 style), educational status, residence, and women wealth index have been influenced
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26 107 vaccination(20,27,31). From another study antenatal care visit, higher level of maternal education,
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28 108 good knowledge of immunization, short distance to health facility, and institutional delivery were
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31 109 the determinants of childhood immunization(32).

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36 110 Different small scale and large scale (national level) studies have been done to identify the
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38 111 determinants of childhood vaccination in the country. However, majority of the studies conducted
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40 112 did not examined natural ordering of child's vaccination status as fully, partially, or not vaccinated
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42 113 at all. Hence, we used multilevel proportional odds model which overcomes the hierarchal nature
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44 114 of the DHS data and considers natural ordering of the outcome variable. In addition, the coverage
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46 115 of full vaccination still remains far behind the national health sector transformation plan II of
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48 116 Ethiopia (75% by 2024/25)(33), showing the need for further study. Therefore, this study aimed
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50 117 determining prevalence of childhood vaccination coverage and its determinants to assist in policy
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52 118 improvements.

119 **Methods**

120 **Study design**

121 This study used the 2019 cross-sectional data of Ethiopian mini demographic and health survey
122 (EMDHS). We obtained the dataset from demographic and health survey website
123 (<http://dhsprogram.com/data/>) after getting permission to access. The mini survey was conducted
124 in March 2019 to June 2019 for the second time in Ethiopia. The Ethiopian Public Health Institute
125 (EPHI) in collaboration with Central Statistical Agency (CSA) and Federal Ministry of Health
126 (FMOH) implemented a nationally representative household survey.

127 **Study setting**

128 The EMDHS survey included all the nine regions and two city administrations of the country.
129 Ethiopia is the second most populous country from Africa and located in the horn of Africa.

130 **Participants**

131 The 2019 EMDHS used the sampling frame created for the upcoming Ethiopia population and
132 housing census list of 149,093 enumeration areas (EA). Participants of the study were selected
133 through a stratified two-stage cluster sampling technique. Initially, they stratified each region in
134 the country into urban and rural areas. Probability proportional to EA size was used to select 305
135 EAs (93 in urban and 212 in rural areas). In the second stage, lists of households were used as a
136 sampling frame to select 30 households per cluster by equal probability systematic selection
137 technique. Eligible participants for the interview were all women aged 15-49 years and who were
138 the residents of the selected households. Accordingly, 8,885 women were interviewed out of 9,012
139 eligible women, giving a response rate of 98.6%. All living children age 12–23 months at the time

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3 140 of the survey were the source population of the study. The details of the survey methods and
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5 141 procedures are available in the 2019 EMDHS report (29).
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8 142 **Eligibility criteria**

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10 143 All children born in the 2 years preceding the survey were included in the analysis. However,
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12 144 children who were not alive at the time of the survey were excluded from this study. Accordingly,
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14 145 data of 1,008 children who had born in the last 2 years and surviving were extracted from the 2019
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16 146 EMDHS datasets for this analysis (Fig. 1).
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19 147 **Measurements of variables of the Study**

20 148 **Dependent variable**

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23 149 Child vaccination status was the outcome variable of the study. We categorized the outcome
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25 150 variable as not vaccinated, partially vaccinated and fully vaccinated.
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30 151 **Fully vaccinated:** is a child that has received one dose of Bacille Calmette-Guerin (BCG), three
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32 152 doses of pentavalent, three doses of polio, two doses of Rota, three doses of pneumococcal
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34 153 conjugate vaccine (PCV), and one dose of measles (MCV1).
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38 154 **Partially vaccinated:** is a child who had missed at least one or more of the thirteen vaccines/doses.
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41 155 **Not vaccinated:** is a child that has not received any vaccine at all.
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43 156 The interviewers of the 2019 EMDHS obtained information on vaccination coverage from written
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45 157 vaccination cards (infant immunization card and other health cards), from mothers' verbal reports,
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47 158 and from health facility records. They request mothers who born child in the three preceding years
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49 159 of the survey to show the infant immunization card or health card. Subsequently, they copy the
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51 160 dates of each vaccination given in the corresponding questionnaire. Similarly, they ask mother
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54 161 who did not kept the cards to recall whether the child received that specific vaccination and the
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3 162 number of doses that the child received. In addition, to complement these data (information
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5 163 collected based on the mother's recall) the field supervisor collects complementary vaccination
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7 164 records from health facility for a child who visited a health facility and missed vaccination data.
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10 165 Finally, a Health Facility Questionnaire was used to record vaccination information for all children
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12 166 without a vaccination card seen during the mother's interview; however, we dropped records with
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15 167 the missing data.

168 **Independent variables**

169 In this study, we considered both individual and community-level variables. The individual-level
170 variables included are maternal age, maternal educational level, religion, marital status,
171 relationship to household head, sex of the household head, wealth index, number of antenatal care
172 (ANC) visits, place of delivery, utilized postnatal care, presence of vaccination document, birth
173 order number, preceding birth interval, sex of child, vitamin A1, total children ever born, and
174 number of under five children in household. Region, type of place of residence, community women
175 education, community poverty, and community ANC utilization are community-level factors of
176 the study. Region is a grouping of the first administrative level of Ethiopia. During the survey
177 period, there were 9 regions and 2 city administrations in the country namely, Tigray, Amhara,
178 Afar, Oromia, Somali, Benishangul-Gumuz, South nations nationalities and people's region
179 (SNNPR), Gambela, Harari, and two city administrations (Addis Ababa and Dire Dawa).
180 Moreover, community women education, community poverty and community ANC utilization
181 were community-level variables derived by aggregating individual-level factors. They were
182 categorized as "low" or "high" based on the median value since the EMDHS were not normally
183 distributed.

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3 184 Information regarding the wealth index is derived from data collected in the Household
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5 185 Questionnaire. The questionnaire includes queries concerning the household's ownership of
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8 186 several consumer items such as television and car; dwelling characteristics such as flooring
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10 187 material; type of drinking water source; toilet facilities; and other characteristics related to wealth
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12 188 status. Each household asset for which information is collected is assigned a weight or factor score
13
14 189 generated through principal components analysis (PCA). The resulting asset scores are
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16 190 standardized about a standard normal distribution with a mean of zero and a standard deviation of
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18 191 one. These standardized scores then used to create the breakpoints that define wealth quintiles as
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20 192 Lowest, Second, Middle, Fourth, and Highest(34). Here, we further categorized the wealth index
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22 193 into poor (lowest plus poor), average (middle), and rich (rich plus highest).
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27 194 **Data processing and statistical analysis**

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29 195 The data were cleaned, re-coded and analyzed using STATA/SE version 14.0. We used numbers,
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31 196 mean, percentage or proportions to describe both the individual- and community-level variables.
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33 197 We used sample weight to manage sampling errors and non-responses. The hierarchical nature of
34
35 198 the DHS data (DHS sampling methods) violates the assumption of independence or lack of
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37 199 correlation of the residuals. In the DHS survey, observations are interdependent as participants
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39 200 nested in the same cluster may behave in the same way and differ to other clusters in terms of the
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41 201 outcome of interest. consequently, we used a two-level multilevel proportional odds model, as
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43 202 single-level traditional statistical model might not be adequate to control for the clustering effect.
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45 203 Moreover, we used multilevel proportional odds model to consider the natural ordering of the
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47 204 response variable (not vaccinated, partially vaccinated and fully vaccinated). Accordingly, we built
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49 205 four consecutive models to identify determinants of child vaccination in Ethiopia. We first fitted
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51 206 the null model or the intercept only model. Then, model 1 was fitted with the individual-level
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3 207 variables. Similarly, we fitted model 2 (with community-level factors). Finally, model 3 or the
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5 208 mixed-effects model was fitted with both individual- and community-level factors. The intra-class
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7 209 correlation coefficient (ICC) was used to determine the clustering effect or community variation
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9 210 and it was calculated using the following formula.

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13 211
$$\text{ICC} = \frac{V_A}{V_A + \frac{\pi^2}{3}}$$

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17 212 Where: V_A is community level variance and $\frac{\pi^2}{3} = 3.29$ is individual level variance. On the other
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19 213 hand, we checked Proportional Change in Variance (PCV), Median Odds Ratio (MOR), and
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21 214 Deviance by using the following formulas to determine the fitness of the model. $\text{PCV} = \frac{V_0 - V_i}{V_0}$.

22
23 215 Where: V_0 is a variance in the null model and V_i is a variance in the consecutive models. $\text{MOR} =$
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25 216 $e^{0.95V_i}$ where: V_i indicates that cluster variance. The last model showed the lowest deviance
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27 217 (Model III) and become the best-fitted model. Furthermore, we examined the proportional odds
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29 218 assumption that assume the equal effect of each factor across the outcome categories by score test.
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31 219 We checked Variance Inflation Factor (VIF) and found 1.60 to assess the presence of
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33 220 multicollinearity. The finding is in the acceptable range. In bi-variable analysis, we kept variables
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35 221 with p-value less than 0.25 for the multivariable multilevel proportional odds analysis. Finally, in
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37 222 the multivariable analysis, we reported variables with p-value less than 5%, adjusted proportional
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39 223 odds ratio (APOR) and 95% confidence interval.

24 224 **Patient and public involvement**

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26 225 Patients and/or the public were not involved in the design, or conduct, or reporting, or
27
28 226 dissemination plans of this research.

29 227 **Result**

228 **Individual and community-level characteristics of mothers and children**

229 The current study included 1,008 mothers who have children aged 12-23 months. Out of the total
 230 respondents, more than half (52.78%) were in the age range of 25-34 years, nearly half (48.91%)
 231 have not attended education, and almost one-third (32.14%) were Orthodox religion followers.
 232 Four out of ten mothers (39.98%) were from high income households and the majorities (94.05%)
 233 were currently in union. Among the participants, less than half (44.15%) were practiced home
 234 delivery, nearly a quarter (24.31%) had no ANC visit, and almost one-tenth (13.99%) received
 235 PNC service. Majority of the mothers (71.73%) kept immunization document and 88.1% of the
 236 interviewed mothers have less than or equal to two under five children in their households. From
 237 the total number of children, half (50.30%) were males, 22.72% were first-born, and 59.33% were
 238 received the most recent vitamin A1. Three-fourth of respondents (73.51%) was from rural areas
 239 and 12.6% were from Oromia region of the country (Table 1).

240 **Table 1: Individual and community-level characteristics of mothers of children aged 12-23**
 241 **months in Ethiopia, 2019 (n=1008)**

Variables	Frequency (n)	Percentage (%)
Maternal age		
15-24	298	29.56
25-34	532	52.78
35-49	178	17.66
Maternal education		
No education	493	48.91
Primary	342	33.93

Secondary	99	9.82
Higher	74	7.34
Marital status		
Not in union	60	5.95
In union	948	94.05
Religion		
Orthodox	324	32.14
Protestant	177	17.56
Muslim	481	47.72
Others	26	2.58
Relationship to household head		
Household head	167	16.57
Wife or husband	730	72.42
Others	111	11.01
Sex of household head		
Male	797	79.07
Female	211	20.93
Wealth index		
Poor	469	46.53
Middle	136	13.49
Rich	403	39.98
Number of ANC visits		
None	245	24.31

1-3 times	313	31.05
4 and above	450	44.64
Place of delivery		
Home	445	44.15
Health facility	563	55.85
PNC service		
No	836	86.01
Yes	136	13.99
Sex of child		
Male	507	50.30
Female	501	49.70
Birth order number		
1st born	229	22.72
2nd to 3rd	372	36.90
4th to 5th	204	20.24
6th and above	203	20.14
Presence of vaccination document		
No	285	28.27
Yes	723	71.73
Preceding birth order		
< 24 months	186	18.45
24-48	357	35.42
48 and above	465	46.13

Received Vitamin A1

No	410	40.67
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Yes	598	59.33
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Total children ever born

1-3 children	598	59.33
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4-6 children	278	27.58
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7 and above	132	13.10
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Number of <5 children in household

≤ 2	888	88.10
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> 2	120	11.90
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Region

Tigray	93	9.23
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Amhara	111	11.01
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Afar	99	9.82
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Oromia	127	12.60
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Somali	85	8.43
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Benishabgul	83	8.23
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SNNPR	116	11.51
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Gambela	77	7.64
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Harari	73	7.24
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Addis Ababa	64	6.35
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Dire Dawa	80	7.94
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Type of place of residence

Urban	267	26.49
Rural	741	73.51
Community women education		
Low	468	46.43
High	540	53.57
Community poverty		
Low	495	49.11
High	513	50.89
Community ANC utilization		
Low	468	46.43
High	540	53.57

242 **Childhood vaccination status in Ethiopia**

243 The full vaccination coverage among children aged 12-23 months in Ethiopia was 39.09% (95%
 244 CI: 36.06%, 42.28) (Fig. 2). On the other hand, two in ten children (22.32%) of 12-23 months' age
 245 have not received any vaccination in three years before the 2019 survey period. Among the
 246 children of 12-23 months' age included in the study, 70.24% received BCG, 57.84% received the
 247 third dose of pentavalent, 55.75% received the third dose of polio, 60.62% received the second
 248 dose of rotavirus vaccine, 55.16% received the third dose of PCV, and 57.04% received the first
 249 dose of measles vaccination (Fig. 3).

250 **Factors affecting child vaccination in Ethiopia**

251 **The fixed effect analysis result**

252 The multivariable analysis showed that maternal educational level of mothers, maternal age,
 253 marital status, presence of vaccination document, received Vitamin A₁, region, and place of
 254 residence, were significantly associated with childhood vaccination. Children whose mothers
 255 attended primary, secondary, and higher education have 2.2 [AOR=2.16; 95% CI: 1.43-3.26], 2
 256 [AOR=2.02; 95% CI: 1.07-3.79], and 2.7 [AOR=2.67; 95% CI: 1.25-5.71] times higher partial or
 257 full vaccination respectively compared to born to mothers with no education. The odds of partial
 258 or full vaccination was 1.8 [AOR=1.79; 95% CI: 1.08-2.99] times higher among children whose
 259 mothers are in the age range of 35-49 compared to 15-19 age group. Mothers who are currently in
 260 union have 2.2 [AOR=2.21; 95% CI: 1.06-4.58] times more likely to vaccinate their children either
 261 partially or fully. keeping vaccination cards was 26 [AOR=26.18; 95% CI: 15.75-43.53] times
 262 more likely associated with partial or full vaccination compared to not keeping vaccination cards.
 263 Children who have received Vitamin A₁ have higher likelihood of partial or full vaccination
 264 [AOR=4.14; 95% CI: 2.9-5.9]. Children from Afar [AOR=0.14; 95% CI: 0.04-0.45], Somali
 265 [AOR=0.19; 95% CI: 0.06-0.60], Gambela [AOR=0.22; 95% CI: 0.06-0.77], Harari [AOR=0.14;
 266 95% CI: 0.04-0.52], and Dire Dawa [AOR=0.23; 95% CI: 0.06-0.79] regions have less partial or
 267 full vaccination compared to the Tigray region children. Children living in rural areas have 47%
 268 [AOR=0.53; 95% CI: 0.30-0.93] reduced partial or full vaccination than children living in urban
 269 areas of the country (Table 2).

270 **Table 2: Multivariable multilevel ordinal logistic regression analysis of individual and**
 271 **community-level determinants of child vaccination in Ethiopia, 2019**

	Null	Model I	Model II	Model III
Variables	Model	AOR (95% CI)	AOR (95% CI)	AOR (95% CI)

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60**Maternal educational level**

No education	1	1
Primary	1.97 (1.33, 2.93)**	2.16 (1.43, 3.26)***
Secondary	1.80 (0.97, 3.33)	2.02 (1.07, 3.79)*
Higher	2.85 (1.35, 6.02)	2.67 (1.25, 5.71)*

Maternal age

15-24	1	1
25-34	1.13 (0.78, 1.63)	1.15 (0.79, 1.66)
35-49	1.81 (1.09, 3.02)*	1.79 (1.08, 2.99)*

Religion

Orthodox	1	1
Protestant	0.46 (0.27, 0.77)**	0.69 (0.36, 1.30)
Muslim	0.71 (0.47, 1.09)	1.28 (0.73, 2.24)
Other	0.39 (0.14, 1.22)	0.56 (0.18, 1.68)

Marital status

Not in union	1	1
In union	1.84 (0.89, 3.80)	2.21 (1.06, 4.58)*

Relationship to HH head

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Household head	1	1
Wife or husband	0.79 (0.50, 1.23)	0.72 (0.46, 1.14)
Others	0.67 (0.36, 1.27)	0.62 (0.33, 1.17)
Household wealth index		
Poor	1	1
Middle	0.83 (0.51, 1.35)	0.77 (0.47, 1.29)
Rich	1.28 (0.83, 1.97)	1.05 (0.63, 1.74)
Number of ANC visits		
None	1	1
1-3	0.97 (0.61, 1.53)	0.99 (0.63, 1.58)
4 and above	1.40 (0.86, 2.29)	1.27 (0.77, 2.09)
Place of delivery		
Home	1	1
Health facility	1.22 (0.82, 1.83)	1.11 (0.74, 1.66)
PNC utilized		
No	1	1
Yes	1.04 (0.67, 1.63)	1.05 (0.67, 1.65)
Immunization document		

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3	Available	1	1
4			
5			
6	Not available	27.32 (16.44,45.41)***	26.18(15.75,43.53)***
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9	Preceding birth interval		
10			
11			
12	< 24 months	1	1
13			
14			
15	24-48 months	1.07 (0.69, 1.65)	1.04 (0.67, 1.62)
16			
17			
18	48 and above	1.05 (0.67, 1.65)	1.06 (0.67, 1.67)
19			
20			
21	Received Vitamin A₁		
22			
23			
24	No	1	1
25			
26			
27	Yes	4.32 (3.04, 6.15)***	4.14 (2.9, 5.9)***
28			
29			
30	Number of < 5 children		
31			
32			
33	≤ 2 children	1	1
34			
35			
36	>2 children	0.62 (0.36, 1.07)	0.68 (0.39, 1.16)
37			
38			
39	Region		
40			
41			
42	Tigray	1	1
43			
44			
45	Afar	0.08 (0.03, 0.23)***	0.14 (0.04, 0.45)**
46			
47			
48	Amhara	0.59 (0.24, 1.48)	0.5 (0.22, 1.13)
49			
50			
51	Oromia	0.21 (0.09, 0.48)***	0.45 (0.18, 1.09)
52			
53			
54	Somali	0.08 (0.03, 0.22)***	0.19 (0.06, 0.60)**
55			
56			
57			
58			
59			
60			

1			
2			
3	Benishangul	1.13 (0.37, 3.40)	0.74 (0.25, 2.22)
4			
5			
6	SNNPR	0.19 (0.08, 0.45)***	0.48 (0.19, 1.17)
7			
8			
9	Gambella	0.38 (0.12, 1.22)	0.22 (0.06, 0.77)*
10			
11			
12	Harari	0.43 (0.12, 1.48)	0.14 (0.04, 0.52)**
13			
14			
15	Addis Ababa	1.27 (0.39, 4.14)	1.14 (0.37, 3.47)
16			
17			
18	Dire Dawa	0.78 (0.23, 2.62)	0.23 (0.06, 0.79)*
19			
20			
21	Type of place of residence		
22			
23			
24	Urban	1	1
25			
26			
27	Rural	0.25 (0.14, 0.44)***	0.53 (0.30, 0.93)*
28			
29			
30	Community women		
31			
32	education		
33		1	1
34			
35	Low	1.04 (0.56, 1.94)	0.75 (0.51, 1.10)*
36			
37			
38	High		
39			
40			

272 Key * = $p < 0.05$, ** = $p < 0.01$, *** = $p < 0.001$

273 The random effect analysis result

274 Table 3 presents the random effect analysis result of childhood vaccination status in Ethiopia. The
 275 appropriateness of application of multilevel analysis and the presence of significant variations of
 276 childhood vaccination status between clusters (the clustering effect) was justified by the ICC of
 277 Null model (48.19%). The value of ICC decreased from 48.19% in the null model to 14.55% in

278 the final model showing how the effect of clustering changed. In addition, as depicted in the table
 279 below the largest PCV of the final model (81.70%) indicates the goodness of model fitness. The
 280 final model (Model 3) has the highest capacity than model I or model II alone to explain the
 281 variations in childhood vaccination status. On top of that, Model III is the best explanatory model
 282 to show the variation in the childhood vaccination. The deviance observed in the final model was
 283 smaller than that of other models (Table 3).

284 **Table 3: Random effects analysis and model fit statistics of child vaccination in Ethiopia,**
 285 **2019**

Parameters	Null Model	Model I	Model II	Model III
Community level Variance (SE)	3.06	0.76	1.21	0.56
PCV (%)	Reference	75.16%	60.46%	81.70%
ICC (%)	48.19%	18.77%	26.89%	14.55%
MOR	5.31	2.29	2.84	2.03
Log-likelihood	-988.74	-684.36	-919.88	-667.78
Deviance	1,977.48	1,368.72	1,839.76	1,335.56
AIC	1983.49	1418.72	1873.77	1413.56
BIC	1998.24	1540.70	1957.34	1603.86

286 Discussion

287 In Ethiopia, full vaccination was 39.08%. Compared to other studies in the country, it is less than
 288 that of South East Ethiopia 76.8%(26), country-level pooled prevalence (47%)(27), and 67% in
 289 2016 from other study(35). It is also less than 59.40% Sub-Saharan vaccination coverage(22),
 290 69.21% East Africa(35), 45.2% Mogadishu (23), and 69.3% in Togo coverage(25). It is in the

1
2
3 291 same confidence intervals as 38.3% of 2016 EDHS. This indicates that the current prevalence of
4
5 292 full vaccination was unchanged since 2016. The reasons might be the political instabilities in the
6
7 293 country for the last five years. Dropout rate (18.8%) may also negatively affected childhood
8
9 294 vaccination coverage of the country. The inequalities to access health services regardless of
10
11 295 increased population in those years might be another reason. Lack of maternal education (48.91%)
12
13 296 also affected vaccination coverage undesirably; however, it was 67% in 2015(31). It is also better
14
15 297 than the Sub-Saharan African countries average(22). This shows that although there are some
16
17 298 improvements, the deviation from standard is big. Only 39.98% of mothers were from higher
18
19 299 income families. The finding is consistent with 36.6% coverage from other study(31).
20
21
22
23

24 300 Among the associated factors, maternal education had positive association with higher full or
25
26 301 partial vaccination, which is also similar to findings from other studies(22,31,36). The consistence
27
28 302 might indicate that education is an independent predictor of full or partial Ffivaccination, which
29
30 303 needs focused attention. Increased maternal age puts mothers in the higher level of full
31
32 304 immunization category. Other studies also showed that higher age has association with full
33
34 305 immunization(3,22). This might indicate that maternal maturity is an important factor for higher
35
36 306 childhood vaccination in contrast to the early marriage. This means child bearing at younger age,
37
38 307 and age at first birth needs adequate attention. Children whose mothers remained in union had
39
40 308 higher tendency to be in higher category of full vaccination. From previous studies, there are
41
42 309 consistent findings(22,23). This might be an indication that disrupted families might endanger
43
44 310 children's life and so that family union should be promoted. Mothers who keep evidence of
45
46 311 vaccination tend to be in higher category of vaccination coverage. This is also true for some
47
48 312 studies(23,24,31). This means, women who keeps children evidence of vaccination might have
49
50 313 indeed great regards for full immunization while carelessness might start from poor evidence
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3 314 keeping. Children who received Vitamin A₁ had higher chance of being vaccination category. The
4
5 315 fact that vitamin A is schedule towards the end of most immunization program might raise to this
6
7
8 316 association (19). This might be another persist issue we never eased in previous efforts as per
9
10 317 evidence from this study and could be set as an objective to attain other sub-objectives. Ethiopia
11
12 318 further classified in city administrations, agrarian, and pastoralist regions. Pastoralists regions such
13
14 319 as Afar and Somali and semi pastoralist regions such as Gambela, Benishangul Gumuz and Harari
15
16 320 had higher tendency of failing into low category of full immunization. This is also reported by
17
18 321 other studies (31). This is also confirmed by other studies that compared developed and
19
20 322 underdeveloped regions in Ethiopia(31,36). This apparently shows that attention deprived regions
21
22 323 should be the next intervention areas. This problem is relatively similar between the rural and
23
24 324 urban place of residences. Other studies also laud that inequalities between rural and urban
25
26 325 residence need careful considerations(20). This might be apparently due to access, awareness, and
27
28 326 availability of resources.
29
30
31
32

33
34 327 Besides the positive information, this study has also some limitations such as missing data in some
35
36 328 records, the disproportion of sample in each region, secondary source data, and time-lapse between
37
38 329 data collection and this analysis. When observable evidence of vaccination is not available, data
39
40 330 collectors asked mothers orally and that may cause some recall and social desirability bias.
41
42 331 However, a Health Facility Questionnaire was used to record vaccination information for all
43
44 332 children without a vaccination card seen during the mother's interview(34). Moreover, we are
45
46 333 unable to include some relevant variables like psychosocial variables of parents, vaccine hesitancy
47
48 334 and other related variables since this study used a secondary data of a national survey. The authors
49
50 335 followed international protocols of DHS data process and analyses, weighted data, carefully
51
52 336 interpreted finding within the period, and included complete records.
53
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337 **Conclusion**

338 Although full vaccination increased from EDHS 2000 to 2016, the current analysis of EMDHS
339 2019 result showed that it was remained unchanged. Our analysis identified many factors that
340 might be contributed for the absence of changes. Maternal educational level, maternal age, marital
341 status, presence of vaccination document, received Vitamin A₁, region, and place of residence,
342 were some of the contributors. Analyzing associated factors showed some of the factors are old
343 enough causing the problem for decades. Even though the political situation in the country might
344 also contributed to the persistency of these factors, it is advisable to work on accessibility,
345 awareness, and available are vital. Maternal education and poverty especially family and maternal
346 capacity remained critical and need all round efforts such as further government commitment,
347 dedicated international supports, and peace and security can override the problem.

348 **Abbreviation/Acronyms:** Demographic Health Survey (DHS); Ethiopian Demographic Health
349 Survey (EDHS); Ethiopian Mini-Demographic Health Survey(EMDHS); World Health
350 Organization (WHO); United Nations Children’s Fund (UNICEF); Adjusted Odds Ratio (AOR);
351 Antenatal Care (ANC); Postnatal Care (PNC); Pneumococcal Conjugate Vaccine (PCV); and
352 Measles Containing Vaccine (MCV); Bacille Calmette-Guerin (BCG); South Nations
353 Nationalities and Peoples Region (SNNPR); Intra-class Correlation Coefficient (ICC); Median
354 Odds Ratio (MOR), Confidence Interval (CI)

355 **Declarations**

356 **Ethics approval and consent to participate**

357 This study used secondary data from demographic and health survey data files. Initially, the
358 MEASURE DHS team was formally requested to access the datasets by completing the online

1
2
3 359 request form on their website (www.dhsprogram.com). Accordingly, permission to access the data
4
5 360 and the letter of authorization was obtained from ICF international. Therefore, for this study
6
7
8 361 consent to participate is not applicable. We kept all data confidential, and no effort was made to
9
10 362 identify households or individuals. The Ethiopian Health Nutrition and Research Institute
11
12 363 (EHNRI) Review Board and the National Research Ethics Review Committee (NRERC) at the
13
14 364 Ministry of Science and Technology of Ethiopia, approved EMDHS 2019. The authors also
15
16 365 confirm that all methods were carried out in accordance with relevant guidelines and regulations.
17
18
19

20 366 **Consent for publication**

21
22 367 Not applicable
23

24 368 **Availability of data and materials**

25
26
27 369 The survey dataset used in this analysis are third party data from the demographic and health
28
29 370 survey website (www.dhsprogram.com) and permission to access the data is granted only for
30
31 371 registered DHS data user.
32
33

34 372 **Competing interests**

35
36
37 373 The authors have declared that no competing interest existed.
38

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40
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42
43

44 376 **Authors' contribution**

45
46 377 SS has obtained and analyzed the EMDHS data. SS, GG, SH were equally involved in the
47
48 378 conception of the study, interpreted the results, drafted and critically revised the manuscript. All
49
50 379 authors have read and approved the final version of the manuscript.
51
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53

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4
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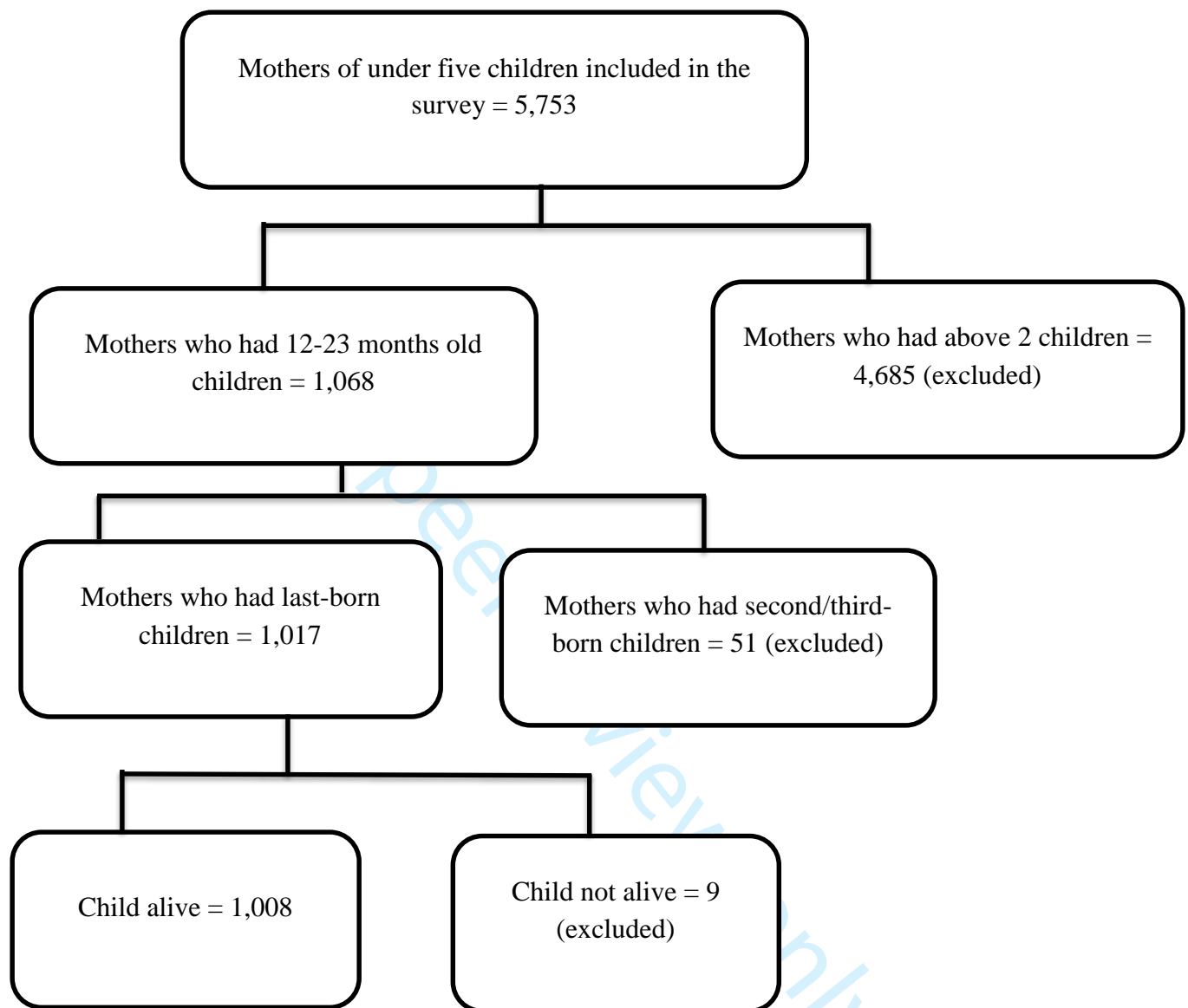


Fig. 1: Eligibility assessment for childhood vaccination coverage among children aged 12-23 month's in Ethiopia, 2019

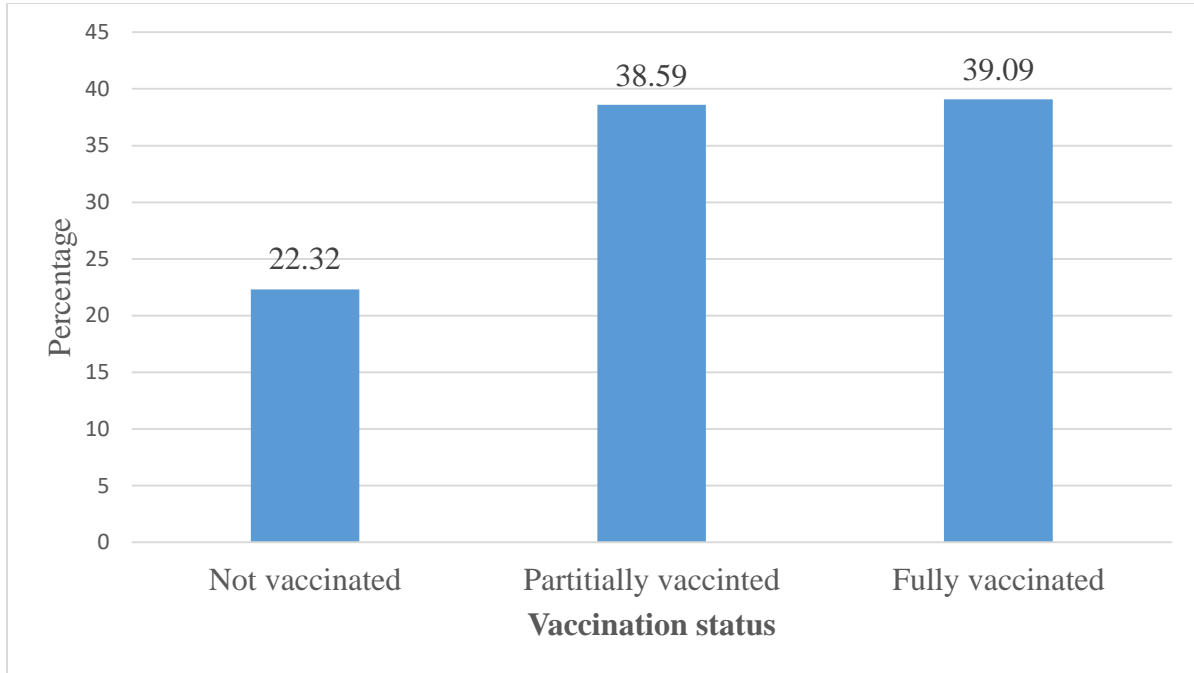


Fig. 2: Vaccination status of children aged 12-23 months in Ethiopia, 2019

review only

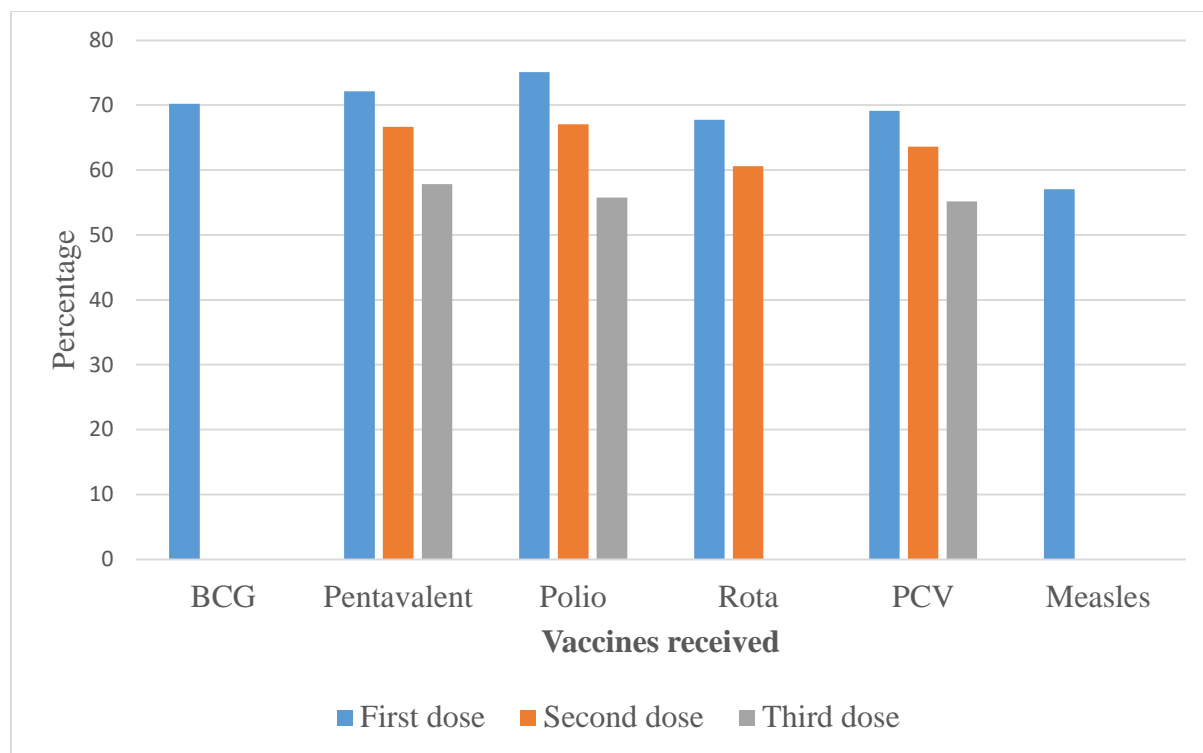


Fig. 3: Percentage of children aged 12-23 months who received a particular vaccine in Ethiopia, 2019

STROBE Statement—Checklist of items that should be included in reports of cross-sectional studies

	Item No	Recommendation	Reported on page #
Title and abstract	1	(a) Indicate the study's design with a commonly used term in the title or the abstract	1
		(b) Provide in the abstract an informative and balanced summary of what was done and what was found	2
Introduction			
Background/rationale	2	Explain the scientific background and rationale for the investigation being reported	4-6
Objectives	3	State specific objectives, including any prespecified hypotheses	6
Methods			
Study design	4	Present key elements of study design early in the paper	7
Setting	5	Describe the setting, locations, and relevant dates, including periods of recruitment, exposure, follow-up, and data collection	7
Participants	6	(a) Give the eligibility criteria, and the sources and methods of selection of participants	7
Variables	7	Clearly define all outcomes, exposures, predictors, potential confounders, and effect modifiers. Give diagnostic criteria, if applicable	8-10
Data sources/ measurement	8*	For each variable of interest, give sources of data and details of methods of assessment (measurement). Describe comparability of assessment methods if there is more than one group	8-9
Bias	9	Describe any efforts to address potential sources of bias	-
Study size	10	Explain how the study size was arrived at	8
Quantitative variables	11	Explain how quantitative variables were handled in the analyses. If applicable, describe which groupings were chosen and why	10-11
Statistical methods	12	(a) Describe all statistical methods, including those used to control for confounding	NA
		(b) Describe any methods used to examine subgroups and interactions	NA
		(c) Explain how missing data were addressed	-
		(d) If applicable, describe analytical methods taking account of sampling strategy	NA
		(e) Describe any sensitivity analyses	NA
Results			
Participants	13*	(a) Report numbers of individuals at each stage of study—eg numbers potentially eligible, examined for eligibility, confirmed eligible, included in the study, completing follow-up, and analysed	NA
		(b) Give reasons for non-participation at each stage	NA
		(c) Consider use of a flow diagram	NA
Descriptive data	14*	(a) Give characteristics of study participants (eg demographic, clinical, social) and information on exposures and potential confounders	12-16
		(b) Indicate number of participants with missing data for each variable of interest	NA
Outcome data	15*	Report numbers of outcome events or summary measures	16
Main results	16	(a) Give unadjusted estimates and, if applicable, confounder-adjusted estimates and their precision (eg, 95% confidence interval). Make clear which confounders were adjusted for and why they were included	16-21
		(b) Report category boundaries when continuous variables were categorized	NA
		(c) If relevant, consider translating estimates of relative risk into absolute risk for a meaningful time period	NA
Other analyses	17	Report other analyses done—eg analyses of subgroups and interactions, and	NA

		sensitivity analyses	
Discussion			
Key results	18	Summarise key results with reference to study objectives	22
Limitations	19	Discuss limitations of the study, taking into account sources of potential bias or imprecision. Discuss both direction and magnitude of any potential bias	24
Interpretation	20	Give a cautious overall interpretation of results considering objectives, limitations, multiplicity of analyses, results from similar studies, and other relevant evidence	23-24
Generalisability	21	Discuss the generalisability (external validity) of the study results	22-24
Other information			
Funding	22	Give the source of funding and the role of the funders for the present study and, if applicable, for the original study on which the present article is based	26

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Determinants of childhood vaccination among children aged 12–23 months in Ethiopia: A community-based cross-sectional study

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Primary Subject Heading:	Public health
Secondary Subject Heading:	Health services research
Keywords:	Community child health < PAEDIATRICS, PREVENTIVE MEDICINE, PUBLIC HEALTH

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3 1 **Determinants of childhood vaccination among children aged 12–23 months in Ethiopia: A**
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5 2 **community-based cross-sectional study**
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13 Abstract

14 **Objective:** Childhood vaccination is a cost-effective essential service to reach larger population
15 globally. Due to unclear reasons, new emergence and resurgence of vaccine preventable diseases
16 gets increase. Thus, the aim of this study is to identify prevalence and determinants of childhood
17 vaccination in Ethiopia.

18 **Design:** Community based cross-sectional study

19 **Setting:** We used data from 2019 Ethiopia Mini Demographic and Health Survey (EMDHS). The
20 survey included all the nine regional states and two city administrations of Ethiopia.

21 **Participants:** A weighted sample of 1,008 children 12-23 months of age was included in the
22 analysis.

23 **Main outcome measures:** Multilevel proportional odds model was fitted to identify determinants
24 of childhood vaccination status. In the final model, variables with p-value of less than 5% and an
25 adjusted odds ratio with a 95% CI reported.

26 **Result:** The full childhood vaccination coverage of Ethiopia was 39.09% (95% CI: 36.06%,
27 42.28). Mothers attended primary [AOR=2.16; 95% CI: 1.43-3.26], secondary [AOR=2.02; 95%
28 CI: 1.07-3.79], and higher schools [AOR=2.67; 95% CI: 1.25-5.71], being in union [AOR=2.21;
29 95% CI: 1.06-4.58], kept vaccination cards [AOR=26.18; 95% CI: 15.75-43.53], children received
30 Vitamin A₁ [AOR=4.14; 95% CI: 2.9-5.9], living in Afar [AOR=0.14; 95% CI: 0.04-0.45], Somali
31 [AOR=0.19; 95% CI: 0.06-0.60], Gambela [AOR=0.22; 95% CI: 0.06-0.77], Harari [AOR=0.14;
32 95% CI: 0.04-0.52], Dire Dawa [AOR=0.23; 95% CI: 0.06-0.79] regions, and rural residents
33 [AOR=0.53; 95% CI: 0.30-0.93] were factors significantly associated with childhood vaccination.

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2
3 34 **Conclusion:** The coverage of full childhood vaccination in Ethiopia was low remained unchanged
4
5 35 since 2016. The study identified both the individual- and community-level factors affected the
6
7 36 vaccination status. Accordingly, public health intervention targeted to these identified factors can
8
9 37 increase childhood full vaccination status.
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13 38 **Keywords:** full vaccination; multilevel; ordinal, 12-23 months' children; Ethiopia
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15

16 39 **Strengths and limitations of this study**

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18

- 19 40 • This study used most recent nationwide secondary data that shows proportion of EPI
20
21 41 coverage among children aged 12–23 months in Ethiopia.
22
- 23 42 • We used multilevel proportional odds model to overcome the hierarchical nature of
24
25 43 EMDHS data and to identify both individual and community-level factors of EPI.
26
27 44 • This study did not include some important variables like psychosocial variables of parents,
28
29 45 vaccine hesitancy and other related variables since the study used secondary data of a
30
31 46 national survey.
32
33 47 • Establishing temporal relationship of causation between childhood vaccination and its
34
35 48 determinants was impossible due to the nature of the study design used for the survey.
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37 49 • Recall bias is the most relevant limitation of the study.
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52 Introduction

53 According to the United Nations Children Fund (UNICEF), immunizations is a dynamic
54 constituent of frontline health care to access larger populations. Compared to any other health or
55 social activities, immunization reduces global annual death by significant proportion(1–4). It saves
56 lives and protects people’s health, improves countries’ productivity and resilience, and helps to
57 ensure a safer and healthier world(5,6).

58 According to the Ethiopian Ministry of Health, a child takes OPV₀ and BCG at Birth. At six weeks
59 after birth, a child takes OPV1(oral polio vaccine), Pentavalent1(DPT+HepB+Hib),
60 Pneumococcal1, and Rotavirus1. Then 10 weeks after birth the child takes OPV2, and
61 Pentavalent2, Pneumococcal2, and Rota2. The child takes OPV3, Pentavalent3, Pneumococcal3,
62 Inactivated polio vaccine (IPV) at 14th weeks. Other vaccines such as Measles Containing Vaccine
63 (MCV1) at 9th month and MCV2 at 15th month and human papilloma virus (HPV) at 14th years for
64 girls are given. However, this study only considers vaccines between 1 to 2 years. All vaccines are
65 equally important(7). Currently, Ethiopia do not provide Rubella, Mumps and chickenpox
66 vaccines to immunize children. Depending on the amount of immunity or protection after receiving
67 a dose, a child may require more than one dose for some vaccine(8). Additionally, more than one
68 dose is needed to build high enough immunity to prevent disease and boost immunity that fades
69 over time(9). For vaccines that do not initiate full protection at first introduction, additional dose
70 of vaccine usually repeated(10). However, this does not mean one vaccine is better than the other
71 is or more important than another since it depends on the nature of the disease.

72 Globally, about 6.6 million children die every year and half of the deaths would have been
73 prevented by vaccination(11). The global inequality in health care distribution force many low and
74 middle income countries to live under the bundle of pestilent cumulative old health problems(12).

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3 75 Africa is among the regions severely affected by globally imbalanced immunization resources
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5 76 distribution. Vaccine preventable diseases become the big burden in war affected parts of the world
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7 77 and underdeveloped countries like Ethiopia(13). Despite the existence of highly cost-effective
8
9 78 vaccines on global markets, situations such as war, displacements, under vaccination, and poor
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11 79 access to vaccine contributes to the prevalence of vaccine preventable disease(14). The proportion
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13 80 of the full immunization reflects how resources distribution caused the imbalance in childhood
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15 81 vaccination(1,15).

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20 82 Regardless of advancement and attainments of immunization, newly emerging vaccine preventable
21
22 83 diseases become still common in Africa(16). There are people who deprived of accessing
23
24 84 immunization in some countries and becoming the reason for the prevalence of vaccine
25
26 85 preventable diseases as admitted by World Health Organization (WHO) and other studies(17–19).
27
28 86 In Ethiopia a study has described that educated (30%) and rich (31%) people better vaccinate their
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30 87 children(20).

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34 88 Some evidences indicated that global vaccine coverage is decreasing(21). A study summarized the
35
36 89 Demographic Health Surveys (DHS) of Sub-Saharan African countries showed that the full
37
38 90 vaccination coverage was 59.40% in 2021(22). In Mogadishu, full immunization was 45.2% and
39
40 91 41.4% in 2020 and 2021 respectively(22–24). In Togo, the full immunization coverage was 69.3%
41
42 92 in Lome district in 2019(25). In Ethiopia. the full immunization coverage is 76.81% in the
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44 93 Southeast region(26); however, the pooled prevalence amongst 12–23 month old children in
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46 94 Ethiopia is 47%(27). EMDHS 2019 demonstrated that coverage of full vaccination was 44(28)%.
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48 95 The magnitude of full vaccination was increased from 14.3% in 2000 to 44% in 2019(29). From
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50 96 this, we understand that the coverage of full vaccination is not adequate.
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3 97 Many factors that support the argument of resource disparities as a reason for low coverage in
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5 98 some countries. A systematic review conducted in Sub-Saharan African countries showed that lack
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8 99 of knowledge of immunization knowledge, distance to access point, financial deprivation, lack of
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10 100 partners support, and distrust in vaccines and immunization programs were the barrier(30). The
11
12 101 absence of immunization card, respondents' sex, level of education, marital status, and
13
14 102 organization of health system are mentioned in another study(25). A study included many sub
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16
17 103 Saharan African countries showed that maternal education, health facility delivery, fathers
18
19 104 secondary education and above, ANC visits, PNC visit, wealth index, media exposure, and
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21 105 distance to health facility affected the vaccination coverage(22). In Ethiopia, from previous four
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23 106 EDHS, postnatal check-up, maternal awareness, regional difference (economic, education and life
24
25 107 style), educational status, residence, and women wealth index have been influenced
26
27 108 vaccination(20,27,31). From another study antenatal care visit, higher level of maternal education,
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29 109 good knowledge of immunization, short distance to health facility, and institutional delivery were
30
31 110 the determinants of childhood immunization(32).

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36 111 Different small scale and large scale (national level) studies have been done to identify the
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38 112 determinants of childhood vaccination in the country. However, majority of the studies conducted
39
40 113 did not examined natural ordering of child's vaccination status as fully, partially, or not vaccinated
41
42 114 at all. Hence, we used multilevel proportional odds model which overcomes the hierarchal nature
43
44 115 of the DHS data and considers natural ordering of the outcome variable. In addition, the coverage
45
46 116 of full vaccination still remains far behind the national health sector transformation plan II of
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48 117 Ethiopia (75% by 2024/25)(33), showing the need for further study. Therefore, this study aimed
49
50 118 determining prevalence of childhood vaccination coverage and its determinants to assist in policy
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52 119 improvements.

120 **Methods**

121 **Study design**

122 This study used the 2019 cross-sectional data of Ethiopian mini demographic and health survey
123 (EMDHS). We obtained the dataset from demographic and health survey website
124 (<http://dhsprogram.com/data/>) after getting permission to access. The mini survey was conducted
125 in March 2019 to June 2019 for the second time in Ethiopia. The Ethiopian Public Health Institute
126 (EPHI) in collaboration with Central Statistical Agency (CSA) and Federal Ministry of Health
127 (FMOH) implemented a nationally representative household survey.

128 **Study setting**

129 The EMDHS survey included all the nine regions and two city administrations of the country.
130 Ethiopia is the second most populous country from Africa and located in the horn of Africa.

131 **Participants**

132 The 2019 EMDHS used the sampling frame created for the upcoming Ethiopia population and
133 housing census list of 149,093 enumeration areas (EA). Participants of the study were selected
134 through a stratified two-stage cluster sampling technique. Initially, they stratified each region in
135 the country into urban and rural areas. Probability proportional to EA size was used to select 305
136 EAs (93 in urban and 212 in rural areas). In the second stage, lists of households were used as a
137 sampling frame to select 30 households per cluster by equal probability systematic selection
138 technique. Eligible participants for the interview were all women aged 15-49 years and who were
139 the residents of the selected households. Accordingly, 8,885 women were interviewed out of 9,012
140 eligible women, giving a response rate of 98.6%. All living children age 12–23 months at the time

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3 141 of the survey were the source population of the study. The details of the survey methods and
4
5 142 procedures are available in the 2019 EMDHS report (29).
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8 143 **Eligibility criteria**

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10 144 All children born in the 2 years preceding the survey were included in the analysis. However,
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12 145 children who were not alive at the time of the survey were excluded from this study. Accordingly,
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14 146 data of 1,008 children who had born in the last 2 years and surviving were extracted from the 2019
15
16 147 EMDHS datasets for this analysis (Fig. 1).
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18

19 148 **Measurements of variables of the Study**

20 149 **Dependent variable**

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23 150 Child vaccination status was the outcome variable of the study. We categorized the outcome
24
25 151 variable as not vaccinated, partially vaccinated and fully vaccinated.
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29 152 **Fully vaccinated:** is a child that has received one dose of Bacille Calmette-Guerin (BCG), three
30
31 153 doses of pentavalent, three doses of polio, two doses of Rota, three doses of pneumococcal
32
33 154 conjugate vaccine (PCV), and one dose of measles (MCV1).
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37 155 **Partially vaccinated:** is a child who had missed at least one or more of the thirteen vaccines/doses.
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40 156 **Not vaccinated:** is a child that has not received any vaccine at all.
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43 157 The interviewers of the 2019 EMDHS obtained information on vaccination coverage from written
44
45 158 vaccination cards (infant immunization card and other health cards), from mothers' verbal reports,
46
47 159 and from health facility records. They request mothers who born child in the three preceding years
48
49 160 of the survey to show the infant immunization card or health card. Subsequently, they copy the
50
51 161 dates of each vaccination given in the corresponding questionnaire. Similarly, they ask mother
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53 162 who did not kept the cards to recall whether the child received that specific vaccination and the
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3 163 number of doses that the child received. In addition, to complement these data (information
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5 164 collected based on the mother's recall) the field supervisor collects complementary vaccination
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7 165 records from health facility for a child who visited a health facility and missed vaccination data.
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10 166 Finally, a Health Facility Questionnaire was used to record vaccination information for all children
11
12 167 without a vaccination card seen during the mother's interview; however, we dropped records with
13
14
15 168 the missing data.

169 **Independent variables**

170 In this study, we considered both individual and community-level variables. The individual-level
171 variables included are maternal age, maternal educational level, religion, marital status,
172 relationship to household head, sex of the household head, wealth index, number of antenatal care
173 (ANC) visits, place of delivery, utilized postnatal care, presence of vaccination document, birth
174 order number, preceding birth interval, sex of child, vitamin A1, total children ever born, and
175 number of under five children in household. Region, type of place of residence, community women
176 education, community poverty, and community ANC utilization are community-level factors of
177 the study. Region is a grouping of the first administrative level of Ethiopia. During the survey
178 period, there were 9 regions and 2 city administrations in the country namely, Tigray, Amhara,
179 Afar, Oromia, Somali, Benishangul-Gumuz, South nations nationalities and people's region
180 (SNNPR), Gambela, Harari, and two city administrations (Addis Ababa and Dire Dawa).
181 Moreover, community women education, community poverty and community ANC utilization
182 were community-level variables derived by aggregating individual-level factors. They were
183 categorized as "low" or "high" based on the median value since the EMDHS were not normally
184 distributed.

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3 185 Information regarding the wealth index is derived from data collected in the Household
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5 186 Questionnaire. The questionnaire includes queries concerning the household's ownership of
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8 187 several consumer items such as television and car; dwelling characteristics such as flooring
9
10 188 material; type of drinking water source; toilet facilities; and other characteristics related to wealth
11
12 189 status. Each household asset for which information is collected is assigned a weight or factor score
13
14 190 generated through principal components analysis (PCA). The resulting asset scores are
15
16 191 standardized about a standard normal distribution with a mean of zero and a standard deviation of
17
18 192 one. These standardized scores then used to create the breakpoints that define wealth quintiles as
19
20 193 Lowest, Second, Middle, Fourth, and Highest(34). Here, we further categorized the wealth index
21
22 194 into poor (lowest plus poor), average (middle), and rich (rich plus highest).
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27 195 **Data processing and statistical analysis**

28
29 196 The data were cleaned, re-coded and analyzed using STATA/SE version 14.0. We used numbers,
30
31 197 mean, percentage or proportions to describe both the individual- and community-level variables.
32
33 198 We used sample weight to manage sampling errors and non-responses. The hierarchical nature of
34
35 199 the DHS data (DHS sampling methods) violates the assumption of independence or lack of
36
37 200 correlation of the residuals. In the DHS survey, observations are interdependent as participants
38
39 201 nested in the same cluster may behave in the same way and differ to other clusters in terms of the
40
41 202 outcome of interest. consequently, we used a two-level multilevel proportional odds model, as
42
43 203 single-level traditional statistical model might not be adequate to control for the clustering effect.
44
45 204 Moreover, we used multilevel proportional odds model to consider the natural ordering of the
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47 205 response variable (not vaccinated, partially vaccinated and fully vaccinated). Accordingly, we built
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49 206 four consecutive models to identify determinants of child vaccination in Ethiopia. We first fitted
50
51 207 the null model or the intercept only model. Then, model 1 was fitted with the individual-level
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3 208 variables. Similarly, we fitted model 2 (with community-level factors). Finally, model 3 or the
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5 209 mixed-effects model was fitted with both individual- and community-level factors. The intra-class
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7 210 correlation coefficient (ICC) was used to determine the clustering effect or community variation
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10 211 and it was calculated using the following formula.

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13 212
$$\text{ICC} = \frac{V_A}{V_A + \frac{\pi^2}{3}}$$

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16
17 213 Where: V_A is community level variance and $\frac{\pi^2}{3} = 3.29$ is individual level variance. On the other
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19
20 214 hand, we checked Proportional Change in Variance (PCV), Median Odds Ratio (MOR), and
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22
23 215 Deviance by using the following formulas to determine the fitness of the model. $\text{PCV} = \frac{V_0 - V_i}{V_0}$.

24
25
26 216 Where: V_0 is a variance in the null model and V_i is a variance in the consecutive models. $\text{MOR} =$
27
28 217 $e^{0.95V_i}$ where: V_i indicates that cluster variance. The last model showed the lowest deviance
29
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31 218 (Model III) and become the best-fitted model. Furthermore, we examined the proportional odds
32
33 219 assumption that assume the equal effect of each factor across the outcome categories by score test.
34
35 220 We checked Variance Inflation Factor (VIF) and found 1.60 to assess the presence of
36
37 221 multicollinearity. The finding is in the acceptable range. In bi-variable analysis, we kept variables
38
39 222 with p-value less than 0.25 for the multivariable multilevel proportional odds analysis. Finally, in
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41
42 223 the multivariable analysis, we reported variables with p-value less than 5%, adjusted proportional
43
44 224 odds ratio (APOR) and 95% confidence interval.

45 46 47 225 **Patient and public involvement**

48
49
50 226 Patients and/or the public were not involved in the design, or conduct, or reporting, or
51
52
53 227 dissemination plans of this research.

54 55 228 **Result**

229 **Socio-demographic characteristics of mothers and children**

230 The current study included 1,008 mothers who have children aged 12-23 months. Out of the total
 231 respondents, more than half (52.78%) were in the age range of 25-34 years, nearly half (48.91%)
 232 have not attended education, and almost one-third (32.14%) were Orthodox religion followers.
 233 Four out of ten mothers (39.98%) were from high income households and the majorities (94.05%)
 234 were currently in union (Table 1).

235 **Table 1: Socio-demographic characteristics of mothers of children aged 12-23 months in**
 236 **Ethiopia, 2019 (n=1008)**

Variables	Frequency (n)	Percentage (%)
Maternal age		
15-24	298	29.56
25-34	532	52.78
35-49	178	17.66
Maternal education		
No education	493	48.91
Primary	342	33.93
Secondary	99	9.82
Higher	74	7.34
Marital status		
Not in union	60	5.95
In union	948	94.05
Religion		

Orthodox	324	32.14
Protestant	177	17.56
Muslim	481	47.72
Others	26	2.58
Wealth index		
Poor	469	46.53
Middle	136	13.49
Rich	403	39.98
Region		
Tigray	93	9.23
Amhara	111	11.01
Afar	99	9.82
Oromia	127	12.60
Somali	85	8.43
Benishabgul	83	8.23
SNNPR	116	11.51
Gambela	77	7.64
Harari	73	7.24
Addis Ababa	64	6.35
Dire Dawa	80	7.94
Type of place of residence		
Urban	267	26.49
Rural	741	73.51

Community women education

Low	468	46.43
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High	540	53.57
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Community poverty

Low	495	49.11
------------	-----	-------

High	513	50.89
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Community ANC utilization

Low	468	46.43
------------	-----	-------

High	540	53.57
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237

238 Healthcare service utilization related characteristics of mothers

239 Among the participants, less than half (44.15%) were practiced home delivery, nearly a quarter
 240 (24.31%) had no ANC visit, and almost one-tenth (13.99%) received PNC service. Majority of the
 241 mothers (71.73%) kept immunization document and 88.1% of the interviewed mothers have less
 242 than or equal to two under five children in their households. From the total number of children,
 243 half (50.30%) were males, 22.72% were first-born, and 59.33% were received the most recent
 244 vitamin A1. Three-fourth of respondents (73.51%) was from rural areas and 12.6% were from
 245 Oromia region of the country (Table 2).

246 **Table 2: Healthcare service utilization related characteristics of mothers with children aged**
 247 **12–23 months in Ethiopia, 2019 (n=1008)**

Number of ANC visits

None	245	24.31
-------------	-----	-------

1-3 times	313	31.05
4 and above	450	44.64
Place of delivery		
Home	445	44.15
Health facility	563	55.85
PNC service		
No	836	86.01
Yes	136	13.99
Sex of child		
Male	507	50.30
Female	501	49.70
Birth order number		
1st born	229	22.72
2nd to 3rd	372	36.90
4th to 5th	204	20.24
6th and above	203	20.14
Presence of vaccination document		
No	285	28.27
Yes	723	71.73
Preceding birth order		
< 24 months	186	18.45
24-48	357	35.42
48 and above	465	46.13

Received Vitamin A1

No	410	40.67
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Yes	598	59.33
------------	-----	-------

Total children ever born

1-3 children	598	59.33
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4-6 children	278	27.58
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7 and above	132	13.10
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Number of <5 children in household

≤ 2	888	88.10
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> 2	120	11.90
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248

Childhood vaccination status in Ethiopia

250 The full vaccination coverage among children aged 12-23 months in Ethiopia was 39.09% (95%
 251 CI: 36.06%, 42.28) (Fig. 2). On the other hand, two in ten children (22.32%) of 12-23 months' age
 252 have not received any vaccination in three years before the 2019 survey period. Among the
 253 children of 12-23 months' age included in the study, 70.24% received BCG, 57.84% received the
 254 third dose of pentavalent, 55.75% received the third dose of polio, 60.62% received the second
 255 dose of rotavirus vaccine, 55.16% received the third dose of PCV, and 57.04% received the first
 256 dose of measles vaccination (Fig. 3).

Factors affecting child vaccination in Ethiopia
The fixed effect analysis result

259 The multivariable analysis showed that maternal educational level of mothers, maternal age,
 260 marital status, presence of vaccination document, received Vitamin A₁, region, and place of
 261 residence, were significantly associated with childhood vaccination. Children whose mothers
 262 attended primary, secondary, and higher education have 2.2 [AOR=2.16; 95% CI: 1.43-3.26], 2
 263 [AOR=2.02; 95% CI: 1.07-3.79], and 2.7 [AOR=2.67; 95% CI: 1.25-5.71] times higher partial or
 264 full vaccination respectively compared to born to mothers with no education. The odds of partial
 265 or full vaccination was 1.8 [AOR=1.79; 95% CI: 1.08-2.99] times higher among children whose
 266 mothers are in the age range of 35-49 compared to 15-19 age group. Mothers who are currently in
 267 union have 2.2 [AOR=2.21; 95% CI: 1.06-4.58] times more likely to vaccinate their children either
 268 partially or fully. keeping vaccination cards was 26 [AOR=26.18; 95% CI: 15.75-43.53] times
 269 more likely associated with partial or full vaccination compared to not keeping vaccination cards.
 270 Children who have received Vitamin A₁ have higher likelihood of partial or full vaccination
 271 [AOR=4.14; 95% CI: 2.9-5.9]. Children from Afar [AOR=0.14; 95% CI: 0.04-0.45], Somali
 272 [AOR=0.19; 95% CI: 0.06-0.60], Gambela [AOR=0.22; 95% CI: 0.06-0.77], Harari [AOR=0.14;
 273 95% CI: 0.04-0.52], and Dire Dawa [AOR=0.23; 95% CI: 0.06-0.79] regions have less partial or
 274 full vaccination compared to the Tigray region children. Children living in rural areas have 47%
 275 [AOR=0.53; 95% CI: 0.30-0.93] reduced partial or full vaccination than children living in urban
 276 areas of the country (Table 3).

277 **Table 3: Multivariable multilevel ordinal logistic regression analysis of individual and**
 278 **community-level determinants of child vaccination in Ethiopia, 2019**

	Null	Model I	Model II	Model III
Variables	Model	AOR (95% CI)	AOR (95% CI)	AOR (95% CI)

1			
2			
3	Maternal educational level		
4			
5	No education	1	1
6			
7	Primary	1.97 (1.33, 2.93)**	2.16 (1.43, 3.26)***
8			
9	Secondary	1.80 (0.97, 3.33)	2.02 (1.07, 3.79)*
10			
11	Higher	2.85 (1.35, 6.02)	2.67 (1.25, 5.71)*
12			
13			
14			
15	Maternal age		
16			
17	15-24	1	1
18			
19	25-34	1.13 (0.78, 1.63)	1.15 (0.79, 1.66)
20			
21	35-49	1.81 (1.09, 3.02)*	1.79 (1.08, 2.99)*
22			
23			
24	Religion		
25			
26	Orthodox	1	1
27			
28	Protestant	0.46 (0.27, 0.77)**	0.69 (0.36, 1.30)
29			
30	Muslim	0.71 (0.47, 1.09)	1.28 (0.73, 2.24)
31			
32	Other	0.39 (0.14, 1.22)	0.56 (0.18, 1.68)
33			
34			
35			
36	Marital status		
37			
38	Not in union	1	1
39			
40	In union	1.84 (0.89, 3.80)	2.21 (1.06, 4.58)*
41			
42			
43	Immunization document		
44			
45	Available	1	1
46			
47	Not available	27.32 (16.44, 45.41)***	26.18 (15.75, 43.53)***
48			
49			
50	Received Vitamin A₁		
51			
52	No	1	1
53			
54	Yes	4.32 (3.04, 6.15)***	4.14 (2.9, 5.9)***
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Region			
	Tigray	1	1
	Afar	0.08 (0.03, 0.23)***	0.14 (0.04, 0.45)**
	Amhara	0.59 (0.24, 1.48)	0.5 (0.22, 1.13)
	Oromia	0.21 (0.09, 0.48)***	0.45 (0.18, 1.09)
	Somali	0.08 (0.03, 0.22)***	0.19 (0.06, 0.60)**
	Benishangul	1.13 (0.37, 3.40)	0.74 (0.25, 2.22)
	SNNPR	0.19 (0.08, 0.45)***	0.48 (0.19, 1.17)
	Gambella	0.38 (0.12, 1.22)	0.22 (0.06, 0.77)*
	Harari	0.43 (0.12, 1.48)	0.14 (0.04, 0.52)**
	Addis Ababa	1.27 (0.39, 4.14)	1.14 (0.37, 3.47)
	Dire Dawa	0.78 (0.23, 2.62)	0.23 (0.06, 0.79)*

31 Type of place of residence

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	Urban	1	1
	Rural	0.25 (0.14, 0.44)***	0.53 (0.30, 0.93)*

38 Community women

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40 education

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	Low	1.04 (0.56, 1.94)	0.75 (0.51, 1.10)*
	High		

47 279 Key * = $p < 0.05$, * = $p < 0.01$, * = $p < 0.001$

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50 280 The random effect analysis result

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53 281 Table 3 presents the random effect analysis result of childhood vaccination status in Ethiopia. The

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55 282 appropriateness of application of multilevel analysis and the presence of significant variations of

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283 childhood vaccination status between clusters (the clustering effect) was justified by the ICC of
 284 Null model (48.19%). The value of ICC decreased from 48.19% in the null model to 14.55% in
 285 the final model showing how the effect of clustering changed. In addition, as depicted in the table
 286 below the largest PCV of the final model (81.70%) indicates the goodness of model fitness. The
 287 final model (Model 3) has the highest capacity than model I or model II alone to explain the
 288 variations in childhood vaccination status. On top of that, Model III is the best explanatory model
 289 to show the variation in the childhood vaccination. The deviance observed in the final model was
 290 smaller than that of other models (Table 4).

291 **Table 4: Random effects analysis and model fit statistics of child vaccination in Ethiopia,**
 292 **2019**

Parameters	Null Model	Model I	Model II	Model III
Community level Variance (SE)	3.06	0.76	1.21	0.56
PCV (%)	Reference	75.16%	60.46%	81.70%
ICC (%)	48.19%	18.77%	26.89%	14.55%
MOR	5.31	2.29	2.84	2.03
Log-likelihood	-988.74	-684.36	-919.88	-667.78
Deviance	1,977.48	1,368.72	1,839.76	1,335.56
AIC	1983.49	1418.72	1873.77	1413.56
BIC	1998.24	1540.70	1957.34	1603.86

293 Discussion

294 In Ethiopia, full vaccination was 39.08%. Compared to other studies in the country, it is less than
 295 that of South East Ethiopia 76.8%(26), country-level pooled prevalence (47%)(27), and 67% in

2016 from other study(35). It is also less than 59.40% Sub-Saharan vaccination coverage(22), 69.21% East Africa(35), 45.2% Mogadishu (23), and 69.3% in Togo coverage(25). It is in the same confidence intervals as 38.3% of 2016 EDHS. This indicates that the current prevalence of full vaccination was unchanged since 2016. The reasons might be the political instabilities in the country for the last five years. Dropout rate (18.8%) may also negatively affected childhood vaccination coverage of the country. The inequalities to access health services regardless of increased population in those years might be another reason. Lack of maternal education (48.91%) also affected vaccination coverage undesirably; however, it was 67% in 2015(31). It is also better than the Sub-Saharan African countries average(22). This shows that although there are some improvements, the deviation from standard is big. Only 39.98% of mothers were from higher income families. The finding is consistent with 36.6% coverage from other study(31).

Among the associated factors, maternal education had positive association with higher full or partial vaccination, which is also similar to findings from other studies(22,31,36). The consistence might indicate that education is an independent predictor of full or partial Ffivaccination, which needs focused attention. Increased maternal age puts mothers in the higher level of full immunization category. Other studies also showed that higher age has association with full immunization(3,22). This might indicate that maternal maturity is an important factor for higher childhood vaccination in contrast to the early marriage. This means child bearing at younger age, and age at first birth needs adequate attention. Children whose mothers remained in union had higher tendency to be in higher category of full vaccination. From previous studies, there are consistent findings(22,23). This might be an indication that disrupted families might endanger children's life and so that family union should be promoted. Mothers who keep evidence of vaccination tend to be in higher category of vaccination coverage. This is also true for some

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3 319 studies(23,24,31). This means, women who keeps children evidence of vaccination might have
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5 320 indeed great regards for full immunization while carelessness might start from poor evidence
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7 321 keeping. Children who received Vitamin A₁ had higher chance of being vaccination category. The
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10 322 fact that vitamin A is schedule towards the end of most immunization program might raise to this
11
12 323 association (19). This might be another persist issue we never eased in previous efforts as per
13
14 324 evidence from this study and could be set as an objective to attain other sub-objectives. Ethiopia
15
16 325 further classified in city administrations, agrarian, and pastoralist regions. Pastoralists regions such
17
18 326 as Afar and Somali and semi pastoralist regions such as Gambela, Benishangul Gumuz and Harari
19
20 327 had higher tendency of failing into low category of full immunization. This is also reported by
21
22 328 other studies (31). This is also confirmed by other studies that compared developed and
23
24 329 underdeveloped regions in Ethiopia(31,36). This apparently shows that attention deprived regions
25
26 330 should be the next intervention areas. This problem is relatively similar between the rural and
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28 331 urban place of residences. Other studies also laud that inequalities between rural and urban
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30 332 residence need careful considerations(20). This might be apparently due to access, awareness, and
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32 333 availability of resources.

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38 334 Besides the positive information, this study has also some limitations such as missing data in some
39
40 335 records, the disproportion of sample in each region, secondary source data, and time-lapse between
41
42 336 data collection and this analysis. When observable evidence of vaccination is not available, data
43
44 337 collectors asked mothers orally and that may cause some recall and social desirability bias.
45
46 338 However, a Health Facility Questionnaire was used to record vaccination information for all
47
48 339 children without a vaccination card seen during the mother's interview(34). Moreover, we are
49
50 340 unable to include some relevant variables like psychosocial variables of parents, vaccine hesitancy
51
52 341 and other related variables since this study used a secondary data of a national survey. The authors
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3 342 followed international protocols of DHS data process and analyses, weighted data, carefully
4
5 343 interpreted finding within the period, and included complete records.
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7

8 344 **Conclusion**

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11 345 Although full vaccination increased from EDHS 2000 to 2016, the current analysis of EMDHS
12
13 346 2019 result showed that it was remained unchanged. Our analysis identified many factors that
14
15 347 might be contributed for the absence of changes. Maternal educational level, maternal age, marital
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17 348 status, presence of vaccination document, received Vitamin A₁, region, and place of residence,
18
19 349 were some of the contributors. Analyzing associated factors showed some of the factors are old
20
21 350 enough causing the problem for decades. Even though the political situation in the country might
22
23 351 also contributed to the persistency of these factors, it is advisable to work on accessibility,
24
25 352 awareness, and available are vital. Maternal education and poverty especially family and maternal
26
27 353 capacity remained critical and need all round efforts such as further government commitment,
28
29 354 dedicated international supports, and peace and security can override the problem.
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35 355 **Abbreviation/Acronyms:** Demographic Health Survey (DHS); Ethiopian Demographic Health
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37 356 Survey (EDHS); Ethiopian Mini-Demographic Health Survey(EMDHS); World Health
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39 357 Organization (WHO); United Nations Children’s Fund (UNICEF); Adjusted Odds Ratio (AOR);
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41 358 Antenatal Care (ANC); Postnatal Care (PNC); Pneumococcal Conjugate Vaccine (PCV); and
42
43 359 Measles Containing Vaccine (MCV); Bacille Calmette-Guerin (BCG); South Nations
44
45 360 Nationalities and Peoples Region (SNNPR); Intra-class Correlation Coefficient (ICC); Median
46
47 361 Odds Ratio (MOR), Confidence Interval (CI)
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52 362 **Declarations**

53 54 363 **Ethics approval and consent to participate**

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2
3 364 This study used secondary data from demographic and health survey data files. Initially, the
4
5 365 MEASURE DHS team was formally requested to access the datasets by completing the online
6
7
8 366 request form on their website (www.dhsprogram.com). Accordingly, permission to access the data
9
10 367 and the letter of authorization was obtained from ICF international. Therefore, for this study
11
12 368 consent to participate is not applicable. We kept all data confidential, and no effort was made to
13
14 369 identify households or individuals. The Ethiopian Health Nutrition and Research Institute
15
16 370 (EHNRI) Review Board and the National Research Ethics Review Committee (NRERC) at the
17
18 371 Ministry of Science and Technology of Ethiopia, approved EMDHS 2019. The authors also
19
20 372 confirm that all methods were carried out in accordance with relevant guidelines and regulations.
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24 373 **Consent for publication**

25
26 374 Not applicable

27 28 375 **Availability of data and materials**

29
30 376 The survey dataset used in this analysis are third party data from the demographic and health
31
32 377 survey website (www.dhsprogram.com) and permission to access the data is granted only for
33
34 378 registered DHS data user.
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39 379 **Competing interests**

40
41 380 The authors have declared that no competing interest existed.
42
43

44 381 **Funding**

45
46 382 The authors received no specific funding for this work.
47
48

49 383 **Authors' contribution**

50
51 384 SS has obtained and analyzed the EMDHS data. SS, GG, SH were equally involved in the
52
53 385 conception of the study, interpreted the results, drafted and critically revised the manuscript. All
54
55 386 authors have read and approved the final version of the manuscript.
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3 **387 Acknowledgments**
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5 **388** The authors are grateful to Measure DHS, ICF International Rockville, Maryland, USA for
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7
8 **389** allowing us to use the 2019 EMDHS data.
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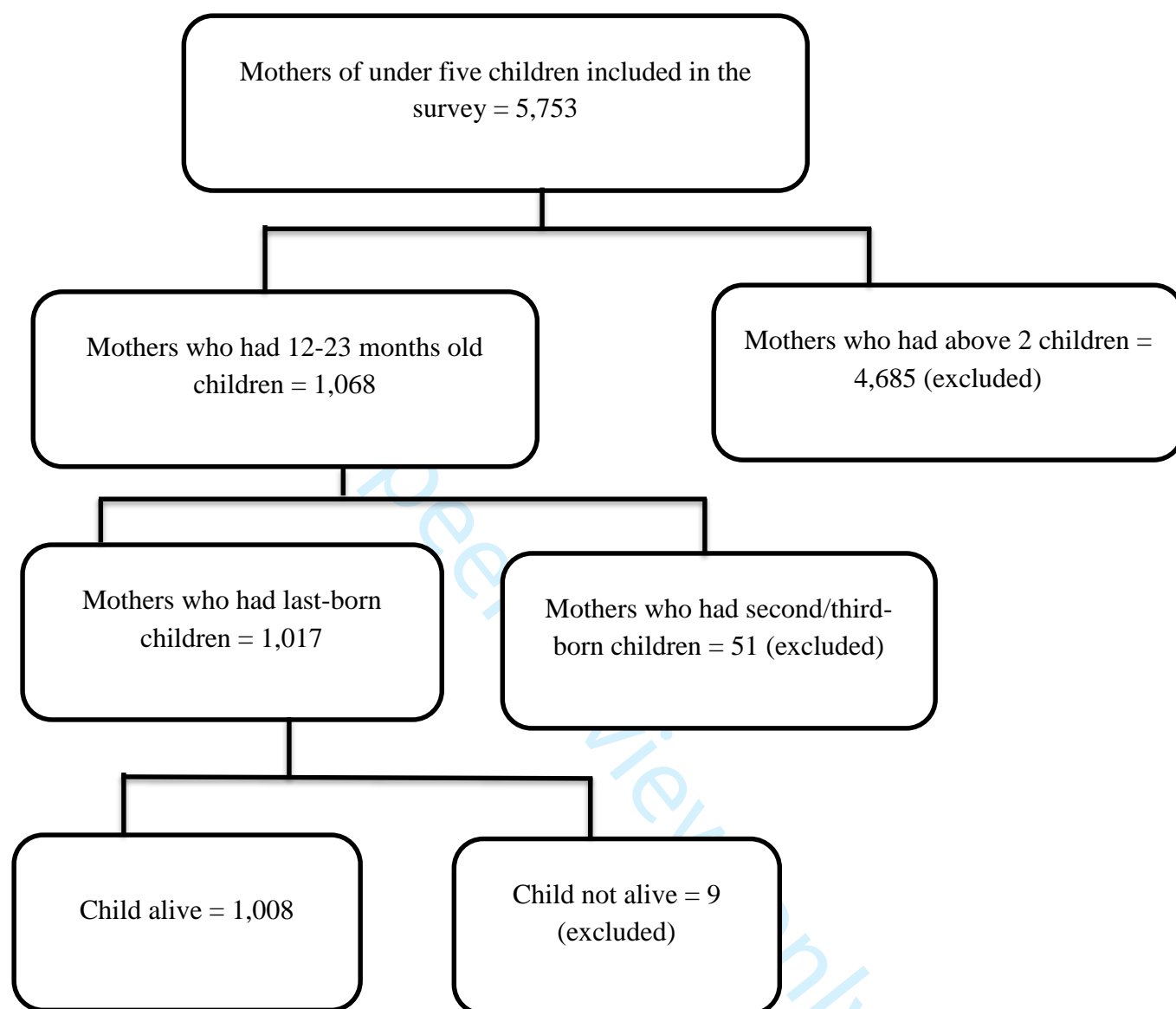


Fig. 1: Eligibility assessment for childhood vaccination coverage among children aged 12-23 month's in Ethiopia, 2019

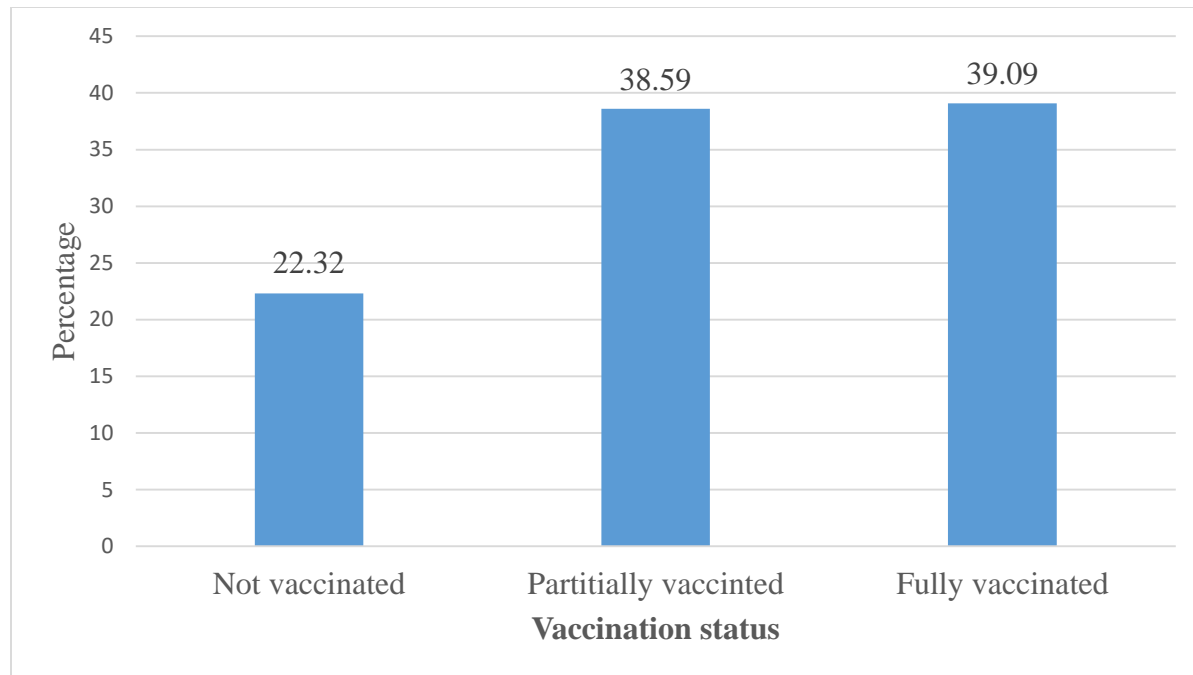


Fig. 2: Vaccination status of children aged 12-23 months in Ethiopia, 2019

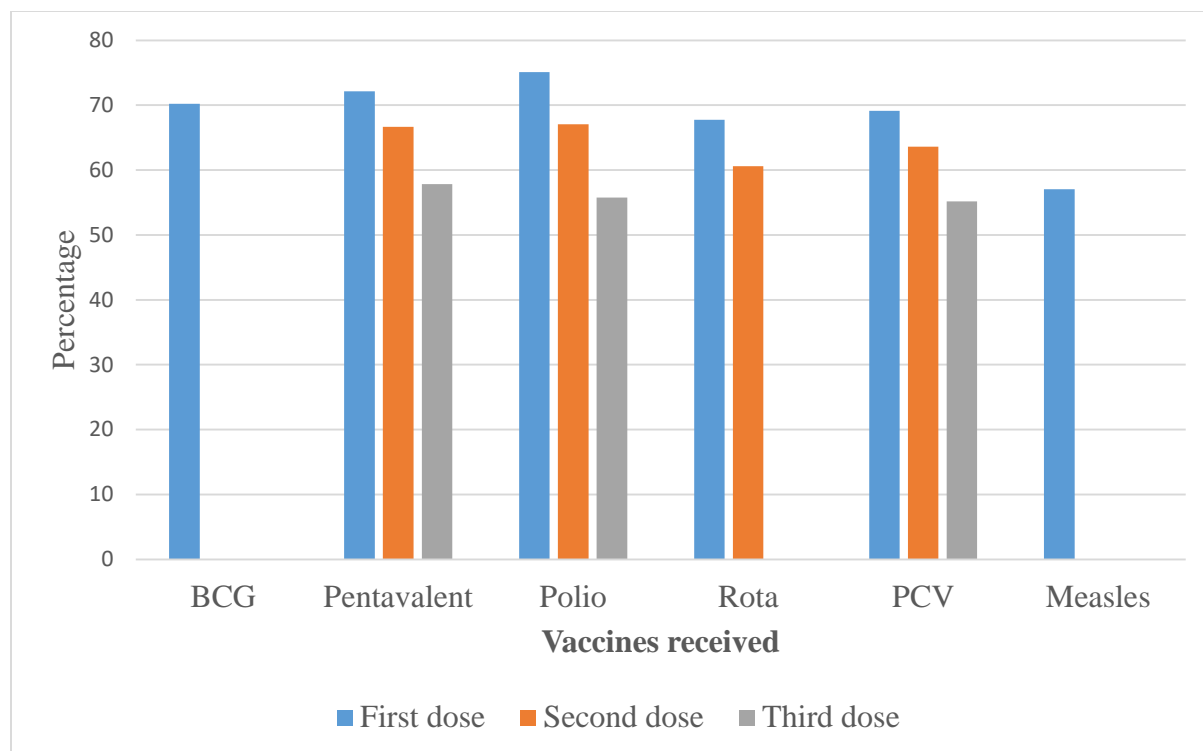


Fig. 3: Percentage of children aged 12-23 months who received a particular vaccine in Ethiopia, 2019

STROBE Statement—Checklist of items that should be included in reports of cross-sectional studies

	Item No	Recommendation	Reported on page #
Title and abstract	1	(a) Indicate the study's design with a commonly used term in the title or the abstract	1
		(b) Provide in the abstract an informative and balanced summary of what was done and what was found	2
Introduction			
Background/rationale	2	Explain the scientific background and rationale for the investigation being reported	4-6
Objectives	3	State specific objectives, including any prespecified hypotheses	6
Methods			
Study design	4	Present key elements of study design early in the paper	7
Setting	5	Describe the setting, locations, and relevant dates, including periods of recruitment, exposure, follow-up, and data collection	7
Participants	6	(a) Give the eligibility criteria, and the sources and methods of selection of participants	7
Variables	7	Clearly define all outcomes, exposures, predictors, potential confounders, and effect modifiers. Give diagnostic criteria, if applicable	8-10
Data sources/ measurement	8*	For each variable of interest, give sources of data and details of methods of assessment (measurement). Describe comparability of assessment methods if there is more than one group	8-9
Bias	9	Describe any efforts to address potential sources of bias	-
Study size	10	Explain how the study size was arrived at	8
Quantitative variables	11	Explain how quantitative variables were handled in the analyses. If applicable, describe which groupings were chosen and why	10-11
Statistical methods	12	(a) Describe all statistical methods, including those used to control for confounding	NA
		(b) Describe any methods used to examine subgroups and interactions	NA
		(c) Explain how missing data were addressed	-
		(d) If applicable, describe analytical methods taking account of sampling strategy	NA
		(e) Describe any sensitivity analyses	NA
Results			
Participants	13*	(a) Report numbers of individuals at each stage of study—eg numbers potentially eligible, examined for eligibility, confirmed eligible, included in the study, completing follow-up, and analysed	NA
		(b) Give reasons for non-participation at each stage	NA
		(c) Consider use of a flow diagram	NA
Descriptive data	14*	(a) Give characteristics of study participants (eg demographic, clinical, social) and information on exposures and potential confounders	12-16
		(b) Indicate number of participants with missing data for each variable of interest	NA
Outcome data	15*	Report numbers of outcome events or summary measures	16
Main results	16	(a) Give unadjusted estimates and, if applicable, confounder-adjusted estimates and their precision (eg, 95% confidence interval). Make clear which confounders were adjusted for and why they were included	16-21
		(b) Report category boundaries when continuous variables were categorized	NA
		(c) If relevant, consider translating estimates of relative risk into absolute risk for a meaningful time period	NA
Other analyses	17	Report other analyses done—eg analyses of subgroups and interactions, and	NA

		sensitivity analyses	
Discussion			
Key results	18	Summarise key results with reference to study objectives	22
Limitations	19	Discuss limitations of the study, taking into account sources of potential bias or imprecision. Discuss both direction and magnitude of any potential bias	24
Interpretation	20	Give a cautious overall interpretation of results considering objectives, limitations, multiplicity of analyses, results from similar studies, and other relevant evidence	23-24
Generalisability	21	Discuss the generalisability (external validity) of the study results	22-24
Other information			
Funding	22	Give the source of funding and the role of the funders for the present study and, if applicable, for the original study on which the present article is based	26

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