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Individual and community level maternal factors for zero dose children in Ethiopia using EDHS 2019: A mixed effect model

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2	EDHS 2019: A mixed effect model				
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1 2		
2 3 4	28	Abstract
5 6	29	Introduction: Zero-dose children refer to a child who has not yet received any childhood vaccines.
/ 8 9	30	Globally, zero-dose vaccination status is the major public health problem. In sub-Saharan African
10 11	31	countries, among five children, one did not access the vaccines. But the efforts to identify the
12 13	32	factors contributing to the zero-dose child are not well addressed in Ethiopia.
14 15 16	33	Objectives: To assess individual and community-level maternal factors of zero-dose children in
17 18	34	Ethiopia using EDHS 2019.
19 20	35	Methods: A secondary analysis of a cross-sectional study was used among a total of 3208
21 22 23	36	participants. The STATA-14 was used for descriptive and multilevel binary logistic regression
23 24 25	37	(mixed effect model) analysis. Model selection was conducted using AIC. To identify significant
26 27	38	factors for zero-dose children, a p-value of <0.05 with 95% confidence was used.
28 29	39	Results: The prevalence of zero-dose vaccination status among children aged 12-35 months old
30 31 32	40	was 523 (16.3%, 95%CI, 15%–17.6%). Women with no ANC follow-up (AOR =1.55, 95% CI:
33 34	41	1.02-2.35), none educated women (AOR =1.47, 95% CI: 1.11-1.95), women who gave birth at
35 36	42	home (AOR =1.39, 95% CI: 1.04–1.86), women who had poor wealth index (AOR =2.15, 95%
37 38 30	43	CI: 1.62–2.85), and women from low proportions of community media exposure (AOR =1.39,
39 40 41	44	95% CI: 1.13–1.71) were the risk factors for zero-dose children in Ethiopia.
42 43	45	Conclusion: As compared to the previous studies, the prevalence of zero-dose vaccination status
44 45	46	was low in Ethiopia. Variables like urban residence, no education, home delivery, poor wealth
46 47 48	47	index, no ANC visit, and women from low proportions of community media exposure were the
49 50	48	risk factors for zero-dose children in Ethiopia. Therefore, expanding maternal health services and
51 52	49	media access for women is highly recommended to reduce zero-dose child.
53 54 55		

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50 Key words: zero-dose vaccination, maternal factors, EDHS, Ethiopia

51 Introduction

A zero-dose vaccine child is defined as a child who does not uptake any types of vaccines [1]. Globally, the uptake of childhood vaccines prevents 2.5 million child deaths each year [2, 3]. Onefifth of sub-Saharan African children never get the vaccines [4]. Childhood vaccination is the most cost-effective strategy for vaccine-preventable disease like poliomyelitis, measles, pneumonia, hepatitis B virus, diphtheria, Haemophilus influenza type B (Hib), tuberculosis, diarrhea, and others [5, 6]. Eradicated vaccine-preventable diseases (VPDs) are reemerged because of increasing zero-dose vaccination among children [7-10].

In Africa, due to non-uptake of basic vaccines, 30 million under-five children are attacked by vaccine-preventable diseases, and 500,000 of them die each year [11]. In 2020, about 17 million under-five children in low and middle-income countries will also not take any vaccines [12]. Which means the majority of zero-dose children are from low and middle-income countries, especially in African and Southeast Asian regions [13]. The proportion of zero-dose vaccines is a good indicator of the failure to achieve the national vaccination coverage goal in sub-Saharan Africa (90%) [14]. By 2030, the World Health Organization (WHO) plans to decrease the number of children with no uptake of any vaccine by half [15]. But the COVID-19 pandemic was a threat to the immunization program, which increased the number of zero-dose children by 37% [16].

68 Conducting research on zero-dose vaccines is very important for evidence-based strategies,
69 interventions, and achieving the WHO goal [17]. Additionally, searching for evidence on the
70 burden and factors of the zero-dose vaccine is crucial for childhood disability reduction [18-20].
71 Among factors affecting not taking any vaccine dose are lack of attention for the zero-dose
72 population, rural residence, and low educational status [21-23]. Ethiopia is the fourth-leading

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contributor to global zero-dose children, despite considerable progress in the total number of infants being immunized [24]. As previous evidence showed, the distribution of vaccination among children in Ethiopia varied across the regions, and thus the lowest proportion (21%) of vaccinated children was reported in the Somali and Afar regions, and the highest proportion (89%) of immunized children was reported in the Amhara region [25]. Even though several studies have been conducted in Ethiopia about vaccination coverage, the prevalence of zero-dose children is rare. Even though zero-dose children in Ethiopia are a public health concern, the efforts to identify the factors contributing to the zero-dose vaccine are not well addressed, and therefore studies are needed to assess the prevalence and determinants of zero-dose children in Ethiopia. Therefore, this study aimed to determine the prevalence and identify individual and community-level factors for zero-dose children in Ethiopia using the EDHS 2019 mixed effect model.

84 Methods

85 Study design, area and period

The EDHS-2019 data was collected from March 21 to June 28, 2019 using a cross-sectional study design. Ethiopia is a low-income country located in the Horn of Africa, and its capital city is Addis Ababa. In Ethiopia, Dallol (128 meters above sea level) and Ras Dashen (4620 meters above sea level) are the lowest and highest latitudes above sea level, respectively [26]. Ethiopia has twelve administrative regions, namely Afar, Somalia, Harari, Amhara, Oromia, Gambela, South Ethiopia, Central Ethiopia, Tigray, Benishangul Gumuz, Sidama, and southwest Ethiopia. Addis Ababa and Dire Dawa are the two self-governed cities in Ethiopia. According to the December 27, 2023, worldometre estimate, Ethiopia has a total population of 128,073,400, and the rural population comprises about 77.9% of the total population [27].

Population The source population was all women who had children prior to the survey, and women who had children aged 12-35 months in the enumeration area were included in the study. Variables **Dependent variable:** Zero dose vaccine status (Yes, No) **Independent variables:** wealth index, residence, educational status, place of delivery, cesarean delivery, religion, age of the women, ANC visit, media exposure, region, current breast feeding, current pregnancy **Clustering variable:** EDHS cluster (V001) **Operational definition** Zero dose vaccine status: In this study, children who have not yet received any childhood vaccines are categorized as zero-dose children (yes), and children who have received at least one dose of vaccine are classified as non-zero-dose vaccines (no) [1]. Media exposure: was assessed based on whether people had access to read newsletters, listen to the radio, and watch TV. Accordingly, if they have access to all three media (newsletter, radio, and TV) at least once a week, we categorized them as "yes", otherwise "no" [28]. Sampling method and procedure The EDHS 2019 sample was stratified and selected in two stages. Each region was stratified by urban and rural areas, with a total of 21 sampling strata. A total of 305 EAs, 93 EAs in urban areas, and 212 EAs in rural areas, were selected using proportional EA size allocation techniques. In the selected EAs, household listings were conducted. Then 30 households were selected per cluster using equal-probability systematic selection techniques. Finally, a multistage sampling method

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was used to select 3208 participants who had children aged 12-35 months in the selected EAs. The
detailed section is reported in the EDHS 2019 report [29].

8 121 Data source, collection and quality assurance

We used the secondary analysis of the EDHS 2019 data set. This data was collected using a pretested structured interview technique from March 21 to June 28, 2019. The location of the data was also collected using a geographic positioning system (2 kilometers for urban clusters and 5 kilometers for rural clusters). To assure the quality of the data, pretesting and training for data collectors and supervisors were conducted. The detail section on data source, collection, and quality assurance has been reported in EDHS 2019 [29]. For the purpose of further analysis for the current study, data was requested online from the demographic health survey international at DHS's official website, www.measuredhs.com. Then the data was accessed after 2 working days. After the data was accessed, data cleaning, recoding, and overall data management were conducted.

³³ 132 Data processing and statistical analysis
 ³⁴

After accessing the data from DHS International, cleaning, recoding, sampling weight, and missing data checking were conducted using STATA software version 14. After this, multilevel (mixed-effect) binary logistic regression was used to identify the determinants for zero-dose children. The reason we used such a model was because of the hierarchical nature of the EDHS data and the possibility of considering a natural nesting of data. We built models like the null model (a model with an intercept/no predictors), model I (level one predictors), model II (a model with level two predictors), and model III (mixed effect model). The mixed effect model is:

- ⁵¹₅₂ 140 Logit (Yij)= $\beta 0j+\sum\beta Xi+\Upsilon Zj+\epsilon j$, where $\beta 0j=\beta 0+\mu j$, $\mu j\sim N(0, \sigma 2 u)$ [30].
- 54 141 Where $\varepsilon j = \varepsilon 0 + \varepsilon j$, $\varepsilon j \sim N (0, \sigma 2 \varepsilon)$

2 3	142	Logit (Yii) = $\ln(Yii/(1-Yii))$ or log odds of zero dose child (Yii)= the probability of zero dose
4 5	172	
6 7	143	child for women "i" in the enumeration area and residence of rural and urban region "j".
, 8 9	144	$\beta 0j$ =random intercept of the cluster "j"
10 11	145	"εj"=residual for each cluster "j"
12 13	146	" β "= the fixed effect regression coefficient
14 15 16	147	"Xi"= level one predictor
17 18	148	"YZj"=level II predictor for clusters
19 20	149	To test the clustering effect, the intra-class correlation coefficient was used with a cutoff of >0.05 .
21 22 22	150	(>5%). For each model, Intraclass correlation (ICC (ρ) = $\sigma 2 \epsilon/\sigma 2 \epsilon + \sigma 2\mu$ [31] was calculated. The
23 24 25	151	clustering variable to show the clustering effect of zero-dose children was the EDHS cluster
26 27	152	(V001). The proportional change in variance (PCV=variance of the null model minus variance of
28 29	153	the next model/variance in the null model*100) [31] and Akaike information criteria (AIC = 2k-
30 31 32	154	2lnL, where k is the number of parameters and L is the maximum value of the likelihood function
33 34	155	of the model) were also calculated. Then the best model was selected based on the lowest AIC
35 36	156	value (Table 1). A bi-variable multilevel binary logistic regression analysis was conducted to
37 38 39	157	select the potential candidate variable for multivariable multilevel binary logistic regression
40 41	158	analysis at a p-value of <0.25. In the multivariable multilevel binary logistic regression analysis,
42 43	159	the significant predictors were selected using a p-value of < 0.05 . To estimate the effect measure
44 45	160	of each predictor, an AOR with a 95% confidence level was used.
40 47 48	161	Table 1: A model comparisons for zero dose children in Ethiopia using EDHS 2019.
49 50	162	
51 52	163	
53 54 55 56	164	
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1							
2 3 4	165	Results					
5 6	166	Characteristics of the participants					
7 8 9 10 11	167	Among a total of 3028 participants, about half, 1648 (51.4%), had no education. About 1447					
	168	(45.1%) and 2316 (72.2%) of them gave birth at home and had no ANC visit, respectively.					
12 13	169	Furthermore, 1594 (49.7%) and 2442 (76.1%) of the participants had poor wealth index and were					
14 15 16	170	from rural residence, respectively (Table-2).					
17 18	171	Table-2: characteristics of the participants among women who had child aged 12-35 months					
19 20	172	old in Ethiopia using EDHS 2019.					
21 22 23	173	Prevalence of zero dose children in Ethiopia					
23 24 25	174	The prevalence of zero-dose vaccination status among children aged 12-35 months old was 523					
26 27	175	(16.3%, 95%CI, 15%–17.6%) (Fig-1).					
28 29	176	Fig-1: Prevalence of zero dose children in Ethiopia using EDHS 2019.					
30 31 32	177	Factors associated with zero dose children					
33 34	178	Before we started to use the multilevel binary logistic regression analysis, the clustering of zero-					
35 36	179	dose vaccination status was checked using the clustering variable of the EDHS cluster (V001).					
37 38 39	180	Thus, the ICC value for a model with an intercept (the null model) was 0.38 (38%). This implies					
40 41	181	that there was enough evidence to use multilevel binary logistic regression analysis. Four models					
42 43	182	were built: the null model (a model with only an intercept), model I (a model with individual-level					
44 45 46	183	factors), model II (a model with community-level factors), and model III (a model with a mixed					
40 47 48	184	individual- and community-level factor). For each model, ICC, PCV, LLR, variance and AIC were					
49 50	185	calculated. The model comparison was done with the lowest AIC value. The mixed model (model					
51 52	186	III) had the lowest AIC value (AIC = 3801). Additionally, the PCV, ICC, and LLR for the best					
53 54 55 56	187	model (mixed effect model) were 56.3%, 7.8%, and -1889, respectively (Table-1).					
57 58		8					

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The potentially candidate variables were selected by bi-variable multilevel binary logistic regression with a p value of <0.25. Thus, in the multivariable multilevel binary logistic regression analysis, wealth index, educational status, place of delivery, residence, media exposure, and ANC visit were the significant factors for zero-dose children in Ethiopia. Women with no ANC follow-up were 1.55 (AOR = 1.55, 95% CI: 1.02–2.35) times more likely to not vaccinate all doses of vaccine for their child than those who had an ANC visit. None of the educated women were 1.47 (AOR =1.47, 95% CI: 1.11–1.95) times more likely to not vaccinate all doses of vaccine for their child than those who had secondary and above educational levels. The odds of a zero-dose child among women who gave birth at home were 1.39 (AOR =1.39, 95% CI: 1.04–1.86) times more likely than women who gave birth at the health facility. The odds of a zero-dose child among women who had a poor wealth index were also 2.15 (AOR =2.15, 95% CI: 1.62–2.85) times more likely than rich women. Also, the odds of a zero-dose child among women from a low proportion of community media exposure were 1.39 (AOR =1.39, 95% CI: 1.13–1.71) times more likely than women from a high proportion of community media exposure. Furthermore, the odds of a zerodose child among rural women were 2.29 (AOR =2.29, 95% CI: 1.53-3.42) times higher than those among urban women (Table-3).

Table: 3 individual and community level maternal factors of zero dose children in Ethiopia
using EDHS-2019

206 Discussion

Uptake of all basic vaccines is a pillar for the reduction of child mortality and morbidity from
VPDs. But especially developing countries, including Ethiopia, are faced with the non-uptake of
basic vaccines. Because of this, VPDs are a challenge for many poor countries. Even though it is
still a public health problem, the magnitude and the determinants of zero-dose vaccine status

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among children are not well known. Therefore, in the current study, an attempt has been made to assess the prevalence of zero-dose vaccination status among children and its determinants in Ethiopia. Thus, the prevalence of zero-dose vaccination status among children aged 12-35 months old was 523 (16.3%, 95%CI, 15%-17.6%). This finding was in line with a study conducted in Sub-Saharan Africa (16.5%) [1]. But it was lower than a study conducted in Togo (26.88%) [32]. This might be because in the previous study, the vaccination card was considered to declare the vaccination status of the child, but the mother's report was not considered. This may overestimate the previous finding. The current finding was also lower than a study conducted in Cameroon (91.7%) [33]. The possible reason for the discrepancy might be that the study done in Cameroon was conducted in an area where access to health services is very low (the remote rural districts, the homeless population, and immigrants). This segment of the population is suffering from a lack of basic health services, including immunization. This causes a higher prevalence of zero-dose vaccination status among children.

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Regarding the factors associated with a zero-dose child, it was found that the odds of a zero-dose vaccine were higher among women who delivered at home than those who delivered at a health facility. This finding was supported by a study conducted in Cameroon [33], a study conducted in sub-Saharan Africa [1] and Ethiopia [34]. This can be explained by the fact that women who give birth at home miss childhood vaccines, including birth doses, and they may not get counselling on childhood vaccines, such as the advantages of vaccination, schedules of vaccine doses, and other related information. Moreover, home delivery may have a negative effect on the subsequent healthseeking behavior of women

The odds of a zero-dose child among poor wealth index women were more likely than those amongrich wealth index women. This was supported by a study conducted in low- and middle-income

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countries [35]. This may be justified by the fact that women with low socioeconomic status have a lower acceptability of health-related messages and a lower understanding of the vaccination advantage [36]. Also, women who had no ANC follow-up were more likely to not vaccinate their child at all than women who had ANC follow-up. This finding is supported by a study conducted in India [37] and a study conducted among 82 low- and middle-income countries [38]. This might be associated with the fact that women who do not attend ANC could not get counselling and education services about the advantages and the time schedule of all basic vaccine doses. Alternatively, women who do not attend the ANC service are more likely to not attend health services after birth as well.

Additionally, the odds of zero-dose children among women who were from low proportions of community media exposure were higher than those among women who were from high proportions of community media exposure. This finding was supported by a study conducted in Indonesia [39]. The possible justification for this association may be due to a lack of media access in the community, which could negatively affect knowledge about the advantages and schedule of the childhood vaccine. Alternatively, women who are from low-community media exposure may miss key information released through media outlets. In return, they are more prone to not vaccinating all doses of vaccine for their children. Additionally, mass media exposure, such as through television, radio, newspapers, and the internet, in the community plays an important role in changing the community's attitude, opinion, awareness, and health service-seeking behavior. But women with a low proportion of community media exposure may lack these advantages. In addition, women who had no education also had higher odds of not vaccinating all doses of vaccines for their child than women who had secondary or higher educational levels. A previous study conducted in Nigeria also reported that as educational levels decreased, the zero-dose

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vaccine status decreased [40]. This may be because educational status is highly correlated with the knowledge and acceptance rate of vaccination [41]. Additionally, low educational status could be a barrier to accessing health services, including childhood vaccination. Furthermore, this study revealed that women who were from rural areas were more likely to not vaccinate their children at all than urban women. The access to health services is quite different between urban and rural [42]. This is due to the barriers to accessing preventive services in the rural areas, for example, lack of transportation, the far distance of health institutions, and the lack of adequate health professionals in rural areas who deliver the service [43, 44]. This study has several implications by providing an important tool for designing strategies and policies to reduce the number of zero-dose children in Ethiopia. Using national representativeness, which increases the power of the study, But because we used secondary data and a cross-sectional study design, our study shared the limitations of the secondary data and the cross-sectional study.

269 Conclusion

As compared to the previous studies, the prevalence of zero-dose vaccination status was low in Ethiopia. Variables like urban residence, no education, home delivery, poor wealth index, no ANC visit, and women from low proportions of community media exposure were the risk factors for zero-dose children in Ethiopia. Therefore, expanding maternal health services and media access for women is highly recommended to reduce zero-dose child. BMJ Open: first published as 10.1136/bmjopen-2024-085235 on 7 January 2025. Downloaded from http://bmjopen.bmj.com/ on June 14, 2025 at Department GEZ-LTA Erasmushogeschool

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- 5 275 Ethical declaration
- 7 276 Ethical approval

Since it was a secondary data analysis of EDHS, informed consent from the participants was not
 applicable. Rather, data requests and approval for access were obtained from DHS International.
 All data were fully anonymize before we accessed informed consent from DHS international.

1 2		
3 4	280	Consent for publication
5 6	281	Not required
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9 10 11	283	All relevant data is available in the manuscript.
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312	EDH	SEthiopian Demographic Health Survey			
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314	SNN	PRSouth Nation and Nationality of People Representative			
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Fig-1: Prevalence of zero dose children in Ethiopia using EDHS 2019.



	Null model	Model I	Madal II	Madal III
	0.27	1.09/	210/	7 90/
	38%			/.ð%
$\frac{PCV(\%)}{1 + 1 + 1 + 1 + 1 + 1 + 1}$		20.3%	22.2%	50.3%
	-1950	-1904	-1920	-1889

Table-2: characteristics of the participants among women who had child aged 12-35 months

old in Ethiopia using EDHS 2019.

Variable	Category	Weighted frequency	%
Wealth index	Poor	1594	49.7
	Middle	449	14
	Rich	1,165	36.3
Residence	Urban	766	23.9
	Rural	2442	76.1
Educational status	No education	1648	51.4
	Primary	1080	33.7
	Secondary	296	9.2
	Higher	184	5.7
Religion	Orthodox	929	29
e	Catholic	18	0.6
	Protestant	588	18.3
	Muslim	1633	50.9
	Traditional	32	1
		92	1
n '	Other T.	8	0.2
Region	l igray	261	8.1 11.6
	Alar	3/1	11.0
	Amhara	294	9.2
	Oromia	398	12.4
	Somali	321	10
	Benishangul Gumuz	289	9
	SNNPR	360	11.2
	Gambela	247	7.7
	Harari	251	7.8
	Addis Ababa	180	5.6
	Diredawa	236	7.4
Age	15-24 years	931	29
	25-34 years	1,719	53.6
	\geq 35 years	558	17.4
ANC VISIT	Yes	892	27.8
DI 0.1.1	No	2316	72.2
Place of delivery	Home	1447	45.1
	Health facility	1761	54.9
Media exposure	Yes	1561	48.6
Delinerry h	INO N-	104/	51.4
Delivery by cesarean	INO	3001	93.5
section	Yes	207	6.5
Currently breast feed	Yes	2376	74.1
	No	832	25.9

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1 2 3 4 5	Current pregnant	Yes No	316 2892	9.9 90.1
6 7 8 9 10 11				
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Table: 3 individual and community level maternal factors of zero dose children in Ethiopia

using EDHS-2019

Variables	Null mode	Model I	Model II	Model III(mixed)
ANC follow up	1			Prot
ANC IONOW-UP		1 51(0 00 2 20)		155(102235)*
		$\begin{array}{c} 1.31(0.99, 2.29) \\ \text{Reference} \end{array}$		$\begin{array}{c} 1.55(1.02, 2.5g) \\ \text{Reference} \overline{\mathbf{\sigma}} \end{array}$
Residence				n n
Rural			3 78(2 59 5 53)	2 29 (1 53 3 B)*
Urban			Reference	Reference G
Place of delivery		1.4(1.05, 1.00)		
Home		1.4(1.05, 1.88)		$1.39(1.04, 1.86)^{\circ}$
Health facility		Reference		Reference 5
Community media exposure				for
Low proportion of media exposure			1.34(1.13, 1.62)	1.39 (1.13, 1.7)*
High proportion of media exposure			Reference	Reference 8
Wealth index				L L L L L L L L L L L L L L L L L L L
Poor		2.99 (2.31, 3.87)		2.15 (1.62, 2.85)
Middle		1.3 (1.37, 2.48)		1.42 (0.94, 1.947
Rich				tex
		Reference		Reference
Current breast feeding				nd o
No		1.07(0.68, 2.12)		1.01(0.74, 1.298
Yes		Reference		Reference =
Educational status		4		nir
No education		1.27(0.97, 1.64)		1.47(1.11, 1.95)*
Primary education		0.88(0.69, 1.12)		0.95(0.75, 1.2
Secondary and above		Reference		Reference a
Current pregnancy				ning '
No		1 59 (1 01 2 51)		19(084 240)
Ves		Reference		Reference
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Note: • statistically significant variable	es			hn
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Individual and community level maternal factors for zero dose children in Ethiopia using EDHS 2019: A mixed effect model

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> Individual and community level maternal factors for zero dose children in Ethiopia using mini-EDHS 2019: A mixed effect model Muluken Chanie Agimas¹, Meron Asmamaw Alemayehu¹, Tigabu Kidie Tesfie¹, Werkneh Melkie Tilahun², Worku Necho Asferie⁴, Mekuriaw Nibret Aweke⁶, Moges Tadesse Abebe³, Anteneh Kassa yalew⁵ ¹Department of Epidemiology and Biostatistics, institute of public health, college of medicine and health science, university of Gondar, Gondar, Ethiopia. ²Department of Public Health, College of Medicine and Health Sciences, Debre Markos University, Debre Markos, Ethiopia. ³Department of Nursing, College of Health Science, Debark University, Debark, Ethiopia. ⁴Departments of pediatric and neonatal Nursing, College of Health Science, Debre Tabor University, Debre Tabor, Ethiopia ⁵Department of Public health, college of medicine and Health science, Wolkite University, Wolkite, Ethiopia. ⁶Department of Nutrition, Institute of Public Health, College of Medicine and Health Sciences, University of Gondar, Ethiopia Authors address: 1. Muluken Chanie Agimas (MCA): mulukensrc12@gmail.com 2. Meron Asmamaw Alemayehu (MAA): merryalem101@gmail.com 3. Tigabu Kidie Tesfie (TKT): tigabukidie@gmail.com 4. Werkneh Melkie Tilahun (WMT): werkneh7wmt@gmail.com 5. Worku Necho Asferie (WNA): workunecho@gmail.com 6. Mekuriaw Nibret Aweke (MNA): mekunib@gmail.com 7. Moges Tadesse Abebe (MTA): moges7045@gmail.com 8. Anteneh Kassa yalew (AKY): antenehkassa28@gmail.com **Corresponding author:** Muluken Chanie Agimas (MCA): mulukensrc12@gmail.com For peer review only - http://bmjopen.bmj.com/site/about/guidelines.xhtml

Abstract

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Introduction: Zero-dose children refer to a child who has not yet received any childhood vaccines. 29 Globally, zero-dose children are the major public health problem. In sub-Saharan African 30 countries, among five children, one did not access the vaccines. But the efforts to identify the 31 factors contributing to the zero-dose child are not well addressed in Ethiopia. 32 33 **Objectives**: To assess individual and community-level maternal factors of zero-dose children in Ethiopia using mini-EDHS 2019. 34 Methods: A secondary analysis of a cross-sectional study was used among a total of 3208 35 participants. The STATA-14 was used for descriptive and multilevel binary logistic regression 36 (mixed effect model) analysis. Model selection was conducted using AIC. To identify significant 37

factors for zero-dose children, a p-value of <0.05 with 95% confidence was used.

Results: The prevalence of zero-dose children among children aged 12-35 months old was 523 (16.3%, 95%CI, 15%–17.6%). Women with no antenatal care follow-up (Adjusted odds ratio = 1.55, 95% CI: 1.02–2.35), none educated women (Adjusted odds ratio = 1.47, 95% CI: 1.11–1.95), women who gave birth at home (Adjusted odds ratio = 1.39, 95% CI: 1.04–1.86), women who had poor wealth index (Adjusted odds ratio = 2.15, 95% CI: 1.62–2.85), and women from low proportions of community media exposure (Adjusted odds ratio = 1.39, 95% CI: 1.13–1.71) were the risk factors for zero-dose children in Ethiopia.

46 Conclusion: As compared to the previous studies, the prevalence of zero-dose children was low
47 in Ethiopia. Variables like urban residence, no education, home delivery, poor wealth index, no
48 ANC visit, and women from low proportions of community media exposure were the risk factors

for zero-dose children in Ethiopia. Therefore, expanding maternal health services and media access
for women is highly recommended to reduce zero-dose child mortality.

51 Key words: zero-dose vaccination, maternal factors, Ethiopian Demographic Health Survey,
52 Ethiopia

56 Introduction

A zero-dose vaccine child is defined as a child who does not uptake any types of vaccines [1].
Globally, the uptake of childhood vaccines prevents 2.5 million child deaths each year [2, 3]. Onefifth of sub-Saharan African children never get the vaccines [4]. Childhood vaccination is the most
cost-effective strategy for vaccine-preventable diseases like poliomyelitis, measles, pneumonia,
hepatitis B virus, diphtheria, Haemophilus influenza type B (Hib), tuberculosis, diarrhea, and
others [5, 6]. Zero-dose children are more at risk for vaccine-preventable disease [7-10].

In Africa, due to non-uptake of basic vaccines, 30 million under-five children are attacked by vaccine-preventable diseases, and 500,000 of them die each year [11]. In 2020, about 17 million under-five children in low and middle-income countries were not take any vaccines [12]. Which means the majority of zero-dose children are from low and middle-income countries, especially in African and Southeast Asian regions [13]. The proportion of zero-dose vaccines is a good indicator of the failure to achieve the national vaccination coverage goal in sub-Saharan Africa (90%) [14]. But

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the COVID-19 pandemic was a threat to the immunization program, which increased the numberof zero-dose children by 37% [15].

Conducting research on zero-dose vaccines is very important for evidence-based strategies, interventions, and achieving the WHO goal [16]. Additionally, searching for evidence on the burden and factors of the zero-dose vaccine is crucial for childhood disability reduction [17-19]. Among factors affecting not taking any vaccine dose are lack of attention for the zero-dose population, rural residence, and low educational status [20-22]. Ethiopia is the fourth-leading contributor to global zero-dose children, despite considerable progress in the total number of infants being immunized [23]. As previous evidence showed, the distribution of vaccination among children in Ethiopia varied across the regions, and thus the lowest proportion (21%) of vaccinated children was reported in the Somali and Afar regions, and the highest proportion (89%) of immunized children was reported in the Amhara region [24]. Even though zero-dose children in Ethiopia are a public health concern, the efforts to identify the factors contributing to the zero-dose children and its prevalence are not well addressed. Therefore, studies are needed to assess the prevalence and determinants of zero-dose children in Ethiopia. Therefore, this study aimed to determine the prevalence and identify individual and community-level factors for zero-dose children in Ethiopia using the EDHS 2019 mixed effect model.

Objectives

- To determine the prevalence of zero dose children in Ethiopia using mini-EDHS 2019
 - 88 To identify factors for zero dose children in Ethiopia using mini-EDHS 2019

89 Methods

90 Study design, area and period

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The EDHS-2019 data was collected from March 21 to June 28, 2019, using a cross-sectional study design. Ethiopia is a low-income country located in the Horn of Africa, and its capital city is Addis Ababa. In Ethiopia, Dallol (128 meters above sea level) and Ras Dashen (4620 meters above sea level) are the lowest and highest latitudes above sea level, respectively [25]. Ethiopia has twelve administrative regions, namely Afar, Somalia, Harari, Amhara, Oromia, Gambela, South Ethiopia, Central Ethiopia, Tigray, Benishangul Gumuz, Sidama, and southwest Ethiopia. Addis Ababa and Dire Dawa are the two self-governed cities in Ethiopia. According to the December 27, 2023, worldometer estimate, Ethiopia has a total population of 128,073,400, and the rural population comprises about 77.9% of the total population [26]. **Population** The source population was all women who had children prior to the survey, and women who had children aged 12-35 months in the enumeration area were included in the study. Variables **Dependent variable:** Zero dose children status (Yes, No) **Independent variables:** wealth index, residence, educational status, place of delivery, cesarean delivery, religion, age of the women, ANC visit, media exposure, region, current breast feeding, current pregnancy **Clustering variable:** EDHS cluster (V001) **Operational definition Zero dose children:** are those that have not received any routine vaccine (yes for zero dose children), otherwise classified as non-zero-dose vaccines (no) [27]. Similarly, the mini-EDHS

2019 classify children as zero dose children if not received any routine vaccine and otherwiseclassified as not zero dose children.

Media exposure: was assessed based on whether people had access to read newsletters, listen to
the radio, and watch TV. Accordingly, if they have access to all three media (newsletter, radio,
and TV) at least once a week, we categorized them as "yes", otherwise "no"[28].

Sampling method and procedure

The mini-EDHS 2019 sample was stratified and selected in two stages. Each region was stratified by urban and rural areas, with a total of 21 sampling strata. A total of 305 EAs, 93 EAs in urban areas, and 212 EAs in rural areas, were selected using proportional EA size allocation techniques. In the selected EAs, household listings were conducted. Then 30 households were selected per cluster using equal-probability systematic selection techniques. Finally, a multistage sampling method was used to select 3208 participants who had children aged 12-35 months in the selected EAs. The detailed section is reported in the mini EDHS 2019 report [29].

³ 127 Data source, collection and quality assurance

We used the secondary analysis of the mini-EDHS 2019 data set. This data was collected using a pretested structured interview technique from March 21 to June 28, 2019. The location of the data was also collected using a geographic positioning system (2 kilometers for urban clusters and 5 kilometers for rural clusters). To assure the quality of the data, pretesting and training for data collectors and supervisors were conducted. The detail section on data source, collection, and quality assurance has been reported in mini EDHS 2019 [29]. For the purpose of further analysis for the current study, data was requested online from the demographic health survey international at DHS's official website, http://www.dhsprogram.com. Then the data was accessed after 2

working days. After the data was accessed, variable selection, data cleaning, weighting the sample,

recoding, and overall data management were conducted.

Data processing and statistical analysis

After accessing the data from DHS International, cleaning, recoding, sampling weight, and missing data checking were conducted using STATA software version 14. Descriptive data was displayed by bar graph table and frequency. The "Svy" command was used as the sampling weight of cluster sampling. After this, multilevel (mixed-effect) binary logistic regression was used to identify the determinants for zero-dose children. The reason we used such a model was because of the hierarchical nature of the EDHS data and the possibility of considering a natural nesting of data. We built models like the null model (a model with an intercept/no predictors), model I (level one predictors), model II (a model with level two predictors), and model III (mixed effect model). The mixed effect model is:

Let y_{ij} denote the binary outcome for an individual *i* in neighborhood *j*, and assume y_{ij} follows a Bernoulli distribution with success probability p_{ii} or Binomial $(1, p_{ii})$. Using an appropriate link function such as logit, a binary outcome can be associated with linear predictors as the following, $logit[E(y_{ij})] = logit(p_{ij}) = \alpha_0 + X_{ij}\beta + Z_j\gamma + u_j$ [30].

Where $\alpha 0$ is the regular intercept, Xij β is the product of individual-level predictors and the corresponding unknown parameters, and Zjy is the product of neighborhood-level predictors and the associated parameters. Within-neighborhood correlation is captured by uj which is usually assumed to be a normally distributed random intercept with mean 0 and variance $\sigma 2u$ [31].

To test the clustering effect, the intra-class correlation coefficient was used with a cutoff of >0.05. (>5%). For each model, Intraclass correlation (ICC (ρ) = $\sigma^2 \epsilon/(\sigma^2 \epsilon + \sigma^2 \mu)$; $\sigma^2 \mu = \pi^2/3[32]$ was calculated. The clustering variable to show the clustering effect of zero-dose children was the

3 4	159	EDHS cluster (V001). The proportional change in variance (PCV=variance of the null model
5 6	160	minus variance of the next model/variance in the null model*100), MOR=exp $\sqrt{2}$ x VA x 0.6745
7 8	161	= exp (0.95xVA) [32] and Akaike information criteria (AIC = 2k-2lnL, where k is the number of
9 10 11	162	parameters and L is the maximum value of the likelihood function of the model) were also
12 13	163	calculated. Then the best model was selected based on the lowest AIC value (Table 1). The
14 15	164	significant variables were selected using the p-value less than 0.05 at 95%CL.

Table 1: A model comparison for zero dose children in Ethiopia using mini-EDHS 2019.

) 162	parameters	and L is the maximum value of the	e likelihood funct	tion of the mode	l) were also			
2 3 163	calculated.	Then the best model was selected b	ased on the lowe	st AIC value (T	able 1). The			
164	significant	variables were selected using the p-val	ue less than 0.05	at 95%CL.				
165	Table 1: A	w model comparison for zero dose chi	ldren in Ethiopia	a using mini-EDI	HS 2019.			
Random	effect	Null model	Model I	Model II	Model III			
Variance	9	0.27	0.199	0.21	0.118			
ICC		38%	19%	31%	7.8%			
PCV (%)	Reference	26.3%	22.2%	56.3%			
MOR		19.8	1.93	3.56	1.67			
Log like	lihood	-1950	-1904	-1920	-1889			
AIC		3905	3826	3848	3801			
167 168 169	Results Characteristics of the participants Among a total of 3028 participants, about half, 1648 (51,4%), had no education. About 1447							
170	(45.1%) and 2316 (72.2%) of them gave birth at home and had no ANC visit, respectively.							
171	Furthermo	Furthermore, 1594 (49.7%) and 2442 (76.1%) of the participants had poor wealth index and were						
172	from rural	residence, respectively (Table-2).						
173	Table-2: c	haracteristics of the participants amo	ong women who	had child aged 12	2-35 months			
174	old in Eth	iopia using mini-EDHS 2019.						
	Variable	Category	Weighted frequer	ncy %				

28 29	166	
30	167	Desults
31	101	Results
32 22	168	Characteristics of the participants
33 34	100	Characteristics of the participants
35	169	Among a total of 3028 participants about half 1648 (51.4%) had no education About 1447
36	_ ,,,	

Table-2: characteristics of the participants among women who had child aged 12-35 months

old in Ethiopia using mini-EDHS 2019.

Variable	Category	Weighted frequency	%
Wealth index	Poor	1594	49.7
	Middle	449	14
	Rich	1,165	36.3
Residence	Urban	766	23.9
	Rural	2442	76.1

Educational status Religion Region	No education Primary Secondary Higher Orthodox Catholic Protestant Muslim Traditional Other Tigray Afar Amhara	1648 1080 296 184 929 18 588 1633 32 8 261 371	51.4 33.7 9.2 5.7 29 0.6 18.3 50.9 1 0.2 8.1 11.6
Religion Region	Primary Secondary Higher Orthodox Catholic Protestant Muslim Traditional Other Tigray Afar Amhara	1080 296 184 929 18 588 1633 32 8 261 371	33.7 9.2 5.7 29 0.6 18.3 50.9 1 0.2 8.1 11.6
Region	Secondary Higher Orthodox Catholic Protestant Muslim Traditional Other Tigray Afar Amhara	296 184 929 18 588 1633 32 8 261 371	9.2 5.7 29 0.6 18.3 50.9 1 0.2 8.1 11.6
Religion Region	Higher Orthodox Catholic Protestant Muslim Traditional Other Tigray Afar Amhara	184 929 18 588 1633 32 8 261 371	5.7 29 0.6 18.3 50.9 1 0.2 8.1 11.6
Religion	Orthodox Catholic Protestant Muslim Traditional Other Tigray Afar Amhara	929 18 588 1633 32 8 261 371	29 0.6 18.3 50.9 1 0.2 8.1 11.6
Region	Catholic Protestant Muslim Traditional Other Tigray Afar Amhara	18 588 1633 32 8 261 371	0.6 18.3 50.9 1 0.2 8.1 11.6
Region	Protestant Muslim Traditional Other Tigray Afar Amhara	18 588 1633 32 8 261 371	18.3 50.9 1 0.2 8.1 11.6
Region	Muslim Traditional Other Tigray Afar Amhara	388 1633 32 8 261 371	18.5 50.9 1 0.2 8.1 11.6
Region	Traditional Other Tigray Afar Amhara	1633 32 8 261 371	50.9 1 0.2 8.1 11.6
Region	Traditional Other Tigray Afar Amhara	32 8 261 371	1 0.2 8.1 11.6
Region	Other Tigray Afar Amhara	8 261 371	0.2 8.1 11.6
Region	Tigray Afar Amhara	261 371	8.1 11.6
	Afar Amhara	371	11.6
	Amhara		11.0
		294	9.2
	Oromia	398	12.4
	Somali	321	10
	Benishangul Gumuz	280	0
	SNINDD	269	, 11)
	Gambala	300 247	11.2
	Uanori	247	7.7
	Addig Ababa	180	7.0
	Adulis Ababa	180	5.0
	Diredawa	236	7.4
Age	15-24 years	931	29 52 (
	25-34 years	1,/19	53.6
	\geq 35 years	558	17.4
ANC VISIT	Yes	892	27.8
D1 C 1 1	NO	2316	/2.2
Place of delivery	Home	144/	45.1
	Health facility	1/61	54.9
Media exposure	Yes	1561	48.6
Dellaran h	INO N -	104/	51.4
Delivery by cesarean	INO	3001	93.5
section	Yes	207	6.5
Currently breast feed	Yes	2376	74.1
	No	832	25.9
Current pregnant	Yes	316	9.9
	No	2892	90.1
Prevalence of zero dose	e children in Ethiopia		
The prevalence of zero d	lose children among chi	ldren aged 12-35 mont	ths old was 16
15%–17.6%) (Fig-1).			
	Age ANC visit Place of delivery Media exposure Delivery by cesarean section Currently breast feed Current pregnant Prevalence of zero dose The prevalence of zero dose 15%–17.6%) (Fig-1).	Benishangul Gumuz SNNPR Gambela Harari Addis AbabaAgeDiredawa 15-24 years ≥ 35 yearsAge15-24 years ≥ 35 yearsANC visitYes Health facilityMedia exposureYes NoDelivery by cesarean SectionNoSectionYes NoCurrently breast feed NoYes NoPrevalence of zero dose children in EthiopiaThe prevalence of zero dose children among children15%-17.6%) (Fig-1).	Benishangul Gumuz289 SNNPRSNNPR360 Gambela247 HarariHarari251 Addis Ababa180 DiredawaAge15-24 years931 25-34 years $25-34$ years1,719 ≥ 35 years558 S8ANC visitYes892 NoPlace of deliveryHome1447 Health facilityMedia exposureYes1561 NoNo1647Delivery by cesarean No3001 sectionsectionYes2376 NoNo832 207Current pregnantYesYes316 NoNo2892

(95%CI,

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170	Fig.1: Prevalence of zero dose children in Ethionia using mini-FDHS 2019
1/9	Fig-1. I revalence of zero dose children in Ethiopia using mini-ED115 2019.

180 Factors associated with zero dose children

In the multivariable multilevel binary logistic regression analysis, wealth index, educational status, place of delivery, residence, media exposure, and ANC visit were the significant factors for zero-dose children in Ethiopia at a p-value of less than 0.05. Women with no ANC follow-up was 1.55 (AOR = 1.55, 95% CI: 1.02-2.35, p-value of < 0.001) times higher odds of zero does child than who had an ANC visit. Women with no education were 1.47 (AOR =1.47, 95% CI: 1.11–1.95, p-value of 0.0067) times higher odds of zero dose child than those who had secondary and above educational levels. Women who gave birth at home were 1.39 (AOR =1.39, 95% CI: 1.04–1.86, p-value of < 0.001) times higher odds of zero dose child than women who gave birth at the health facility. Women who had a poor wealth index were also 2.15 times (AOR = 2.15, 95% CI: 1.62– 2.85, p-value of 0.0078) higher odds of zero-dose child than rich women. Also, women from a low proportion of community media exposure were 1.39 (AOR =1.39, 95% CI: 1.13–1.71, p-value of < 0.001) times higher odds of a zero-dose child than women from a high proportion of community media exposure. Furthermore, the women from the rural residence were 2.29 (AOR =2.29, 95% CI: 1.53-3.42, p-value of 0.004) times higher odds of zero-dose child than those among urban women (Table-3).

using mini-EDHS-201	9				-
Variables	Null model	Model I	Model II	Model III(mixed)	p-value
ANC follow-up					
No		1.51(0.99, 2.29)		1.55(1.02, 2.35)*	< 0.001
Yes		Reference		Reference	
Residence					
Rural			3.78(2.59,	2.29 (1.53, 3.42)*	0.004
Urban			5.53)	Reference	

Table: 3 individual and community level maternal factors of zero dose children in Ethiopia
		Reference		
Place of delivery				
Home	1.4(1.05, 1.88)		1.39 (1.04, 1.86)*	< 0.00
Health facility	Reference		Reference	
Community media				
exposure		1.34(1.13,	1.39 (1.13, 1.71)*	< 0.00
Low proportion of media		1.62)	Reference	
exposure		Reference		
High proportion of media				
exposure				
Wealth index				
Poor	2.99 (2.31, 3.87)		2.15 (1.62, 2.85)*	0.007
Middle	1.3 (1.37, 2.48)		1.42 (0.94, 1.94)	
Rich				
~	Reference		Reference	
Current breast feeding				
No	1.07(0.68, 2.12)		1.01(0.74, 1.29)	0.21
Yes	Reference		Reference	
Educational status				
No education	1.27(0.97, 1.64)		1.47(1.11, 1.95)*	0.006
Primary education	0.88(0.69, 1.12)		0.95(0.75, 1.21)	
Secondary and above	Reference		Reference	
Current pregnancy				
No	1.59 (1.01,2.51)		1.9 (0.84, 2.49)	0.34
Yes	Reference		Reference	

199 Discussion

The prevalence of zero dose children among children aged 12-35 months old was 16.3%. Variables like urban residence, no education, home delivery, poor wealth index, no ANC visit, and women from low proportions of community media exposure were the risk factors for zero-dose children in Ethiopia. Therefore, expanding maternal health services and media access for women is highly recommended to reduce zero-dose children. Thus, the prevalence of zero dose children among children aged 12-35 months old was 16.3% (95% CI, 15%–17.6%). This finding was in line with a study conducted in Sub-Saharan Africa (16.5%) [1]. But it was lower than a study conducted in Page 13 of 20

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Togo (26.88%) [33] and the WHO/UNICEF Estimates of National Immunization Coverage 2021 report, which estimated that 30% of surviving infants in Ethiopia were zero-dose children [34]. This might be because in the previous study, the vaccination card was considered to declare the vaccination status of the child, but the mother's report was not considered. This may overestimate the previous finding. The current finding was also lower than a study conducted in Cameroon (91.7%) [35]. The possible reason for the discrepancy might be that the study done in Cameroon was conducted in an area where access to health services is very low (the remote rural districts, the homeless population, and immigrants). This segment of the population is suffering from a lack of basic health services, including immunization. This causes a higher prevalence of zero dose children among children. In Ethiopia between 2000 and 2019, the basic vaccination coverage had progressed from 14.3% to 44.1%. The vaccination coverage was estimated to reach 53.6% by 2025; the reduction in zero dose child implies a significant improvement in vaccination coverage [36].

220 [36].

Regarding the factors associated with a zero-dose child, it was found that the odds of a zero-dose vaccine were higher among women who delivered at home than those who delivered at a health facility. This finding was supported by a study conducted in Cameroon [35], a study conducted in sub-Saharan Africa [1] and Ethiopia [37]. This can be explained by the fact that women who give birth at home miss childhood vaccines, including birth doses, and they may not get counselling on childhood vaccines, such as the advantages of vaccination, schedules of vaccine doses, and other related information. Moreover, home delivery may have a negative effect on the subsequent health-seeking behavior of women

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The odds of a zero-dose child among poor wealth index women were more likely than those among rich wealth index women. This was supported by a study conducted in low- and middle-income countries [38]. This may be justified by the fact that women with low socioeconomic status have a lower acceptability of health-related messages and a lower understanding of the vaccination advantage [39]. Also, women who had no ANC follow-up were more likely to not vaccinate their child at all than women who had ANC follow-up. This finding is supported by a study conducted in India [40] and a study conducted among 82 low- and middle-income countries [41]. This might be associated with the fact that women who do not attend ANC could not get counselling and education services about the advantages and the time schedule of all basic vaccine doses. Alternatively, women who do not attend the ANC service are more likely to not attend health services after birth as well.

Additionally, the odds of zero-dose children among women who were from low proportions of community media exposure were higher than those among women who were from high proportions of community media exposure. This finding was supported by a study conducted in Indonesia [42]. The possible justification for this association may be due to a lack of media access in the community, which could negatively affect knowledge about the advantages and schedule of the childhood vaccine. Alternatively, women who are from low-community media exposure may miss key information released through media outlets. In return, they are more prone to not vaccinating all doses of vaccine for their children. Additionally, mass media exposure, such as through television, radio, newspapers, and the internet, in the community plays an important role in changing the community's attitude, opinion, awareness, and health service-seeking behavior. But women with a low proportion of community media exposure may lack these advantages. In addition, women who had no education also had higher odds of not vaccinating all doses of

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252	vaccines for their child than women who had secondary or higher educational levels. A previous
253	study conducted in Nigeria also reported that as educational levels increased, the zero-dose vaccine
254	status decreased [43]. This may be because educational status is highly correlated with the
255	knowledge and acceptance rate of vaccination [44]. Additionally, low educational status could be
256	a barrier to accessing health services, including childhood vaccination. Furthermore, this study
257	revealed that women who were from rural areas were more likely to not vaccinate their children at
258	all than urban women. The access to health services is quite different between urban and rural [45].
259	This is due to the barriers to accessing preventive services in the rural areas, for example, lack of
260	transportation, the far distance of health institutions, and the lack of adequate health professionals
261	in rural areas who deliver the service [46, 47]. This study has several implications by providing an
262	important tool for designing strategies and policies to reduce the number of zero-dose children in
263	Ethiopia. Therefore, expanding maternal health services and media access for women is highly
264	recommended to reduce zero-dose child.
265	Strength and limitation of the study
266	• Using nationally representative sample increases the power of the study.
267	• Additionally, proportional allocation of sample for each cluster and weighting the sample
268	makes the study nationally representative.
269	• But because we used secondary data and a cross-sectional study design, our study shared
270	the limitations of the secondary data and the cross-sectional study.

⁷ 271 Conclusion

As compared to the previous studies, the prevalence of zero dose children was low in Ethiopia.
 Variables like urban residence, no education, home delivery, poor wealth index, no ANC visit, and
 women from low proportions of community media exposure were the risk factors for zero-dose

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2						
3 4	275	children in Ethiopia. Therefore, expanding maternal health services and media access for women				
5 6	276	is highly recommended to reduce zero-dose child.				
7 8	277	Ethical declaration				
9 10 11	278	Ethical approval				
12 13	279	Since it was a secondary data analysis of EDHS, informed consent from the participants was not				
14 15	280	applicable. Rather, data requests and approval for access were obtained from DHS International.				
16 17 18	281	All data were fully anonymized before we accessed informed consent from DHS international.				
19 20	282	Consent for publication				
21 22	283	Not required.				
23 24	284	Data availability statement				
25 26 27	285	All relevant data is available in the manuscript.				
28 29	286	Conflict of interest				
30 31	287	The author declares no conflict of interest				
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35 36	289	No				
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39 40 41	291	The authors would like to give thanks to DHS International for accessing the data.				
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57 58		15				
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32 33 34	310	Abbreviation and acronym
35 36	311	AICAkaike information criteria
37 38	312	ANCAntenatal Care
39 40 41	313	DHSDemographic Health Survey
42 43	314	EAsEnumeration Areas
44 45 46	315	EDHSEthiopian Demographic Health Survey
40 47 48	316	LLRLog Likelihood Ratio
49 50	317	SNNPRSouth Nation and Nationality of People Representative
51 52 53	318	VPDsVaccine Preventable Diseases
53 54 55	319	Reference
56 57		
58 59		16
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Fig-1: Prevalence of zero dose children in Ethiopia using EDHS 2019.

Individual and community level maternal factors for zero dose children in Ethiopia using EDHS 2019: A mixed effect model

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Individual and community level maternal factors for zero dose children in Ethiopia using

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Abstract

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Introduction: Zero-dose children refer to a child who has not yet received any childhood vaccines.

30	Globally, zero-dose children are the major public health problem. In sub-Saharan African
31	countries, among five children, one did not access the vaccines. But the efforts to identify the
32	factors contributing to the zero-dose child are not well addressed in Ethiopia.
33	Objectives: To assess individual and community-level maternal factors of zero-dose children in
34	Ethiopia using mini-EDHS 2019.
35	Methods: A secondary analysis of a cross-sectional study was used among a total of 3208
36	participants. The STATA-14 was used for descriptive and multilevel binary logistic regression
37	(mixed effect model) analysis. Model selection was conducted using AIC. To identify significant
38	factors for zero-dose children, a p-value of <0.05 with 95% confidence was used.
39	Results: The prevalence of zero-dose children among children aged 12-35 months old was 523
40	(16.3%, 95%CI, 15%–17.6%). Women with no antenatal care follow-up (Adjusted odds ratio =
41	1.55, 95% CI: 1.02–2.35), none educated women (Adjusted odds ratio = 1.47, 95% CI: 1.11–1.95),
42	women who gave birth at home (Adjusted odds ratio = 1.39, 95% CI: 1.04–1.86), women who had
43	poor wealth index (Adjusted odds ratio = 2.15, 95% CI: 1.62-2.85), and women from low
44	proportions of community media exposure (Adjusted odds ratio = $1.39, 95\%$ CI: $1.13-1.71$) were

45 the risk factors for zero-dose children in Ethiopia.

46 Conclusion: As compared to the previous studies, the prevalence of zero-dose children was low
47 in Ethiopia. Variables like urban residence, no education, home delivery, poor wealth index, no
48 ANC visit, and women from low proportions of community media exposure were the risk factors

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> for zero-dose children in Ethiopia. Therefore, expanding maternal health services and media access

for women is highly recommended to reduce zero-dose child mortality.

Key words: zero-dose vaccination, maternal factors, Ethiopian Demographic Health Survey, Ethiopia

- Strength and limitation of the study
 - Using nationally representative sample increases the power of the study.
 - Additionally, proportional allocation of sample for each cluster and weighting the sample makes the study nationally representative.
 - But because we used secondary data and a cross-sectional study design, our study shared the limitations of the secondary data and the cross-sectional study.

Introduction

A zero-dose vaccine child is defined as a child who does not uptake any types of vaccines [1]. Globally, the uptake of childhood vaccines prevents 2.5 million child deaths each year [2, 3]. One-fifth of sub-Saharan African children never get the vaccines [4]. Childhood vaccination is the most cost-effective strategy for vaccine-preventable diseases like poliomyelitis, measles, pneumonia, hepatitis B virus, diphtheria, Haemophilus influenza type B (Hib), tuberculosis, diarrhea, and others [5, 6]. Zero-dose children are more at risk for vaccine-preventable disease [7-10].

In Africa, due to non-uptake of basic vaccines, 30 million under-five children are attacked by vaccine-preventable diseases, and 500,000 of them die each year [11]. In 2020, about 17 million under-five children in low and middle-income countries were not take any vaccines [12]. Which means the majority of zero-dose children are from low and middle-income countries, especially in African and Southeast Asian regions [13]. The proportion of zero-dose vaccines is a good indicator of the

failure to achieve the national vaccination coverage goal in sub-Saharan Africa (90%) [14]. But
the COVID-19 pandemic was a threat to the immunization program, which increased the number
of zero-dose children by 37% [15].

Conducting research on zero-dose vaccines is very important for evidence-based strategies, interventions, and achieving the WHO goal [16]. Additionally, searching for evidence on the burden and factors of the zero-dose vaccine is crucial for childhood disability reduction [17-19]. Among factors affecting not taking any vaccine dose are lack of attention for the zero-dose population, rural residence, and low educational status [20-22]. Ethiopia is the fourth-leading contributor to global zero-dose children, despite considerable progress in the total number of infants being immunized [23]. As previous evidence showed, the distribution of vaccination among children in Ethiopia varied across the regions, and thus the lowest proportion (21%) of vaccinated children was reported in the Somali and Afar regions, and the highest proportion (89%) of immunized children was reported in the Amhara region [24]. Even though zero-dose children in Ethiopia are a public health concern, the efforts to identify the factors contributing to the zero-dose children and its prevalence are not well addressed. Therefore, studies are needed to assess the prevalence and determinants of zero-dose children in Ethiopia. Therefore, this study aimed to determine the prevalence and identify individual and community-level factors for zero-dose children in Ethiopia using the EDHS 2019 mixed effect model.

89 Objectives

- 90 To determine the prevalence of zero dose children in Ethiopia using mini-EDHS 2019
- 91 To identify factors for zero dose children in Ethiopia using mini-EDHS 2019
- 92 Methods

93 Study design, area and period

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The EDHS-2019 data was collected from March 21 to June 28, 2019, using a cross-sectional study design. Ethiopia is a low-income country located in the Horn of Africa, and its capital city is Addis Ababa. In Ethiopia, Dallol (128 meters above sea level) and Ras Dashen (4620 meters above sea level) are the lowest and highest latitudes above sea level, respectively [25]. Ethiopia has twelve administrative regions, namely Afar, Somalia, Harari, Amhara, Oromia, Gambela, South Ethiopia, Central Ethiopia, Tigray, Benishangul Gumuz, Sidama, and southwest Ethiopia. Addis Ababa and Dire Dawa are the two self-governed cities in Ethiopia. According to the December 27, 2023, worldometer estimate, Ethiopia has a total population of 128,073,400, and the rural population comprises about 77.9% of the total population [26]. **Population** The source population was all women who had children prior to the survey, and women who had children aged 12-35 months in the enumeration area were included in the study. Variables **Dependent variable:** Zero dose children status (Yes, No) **Independent variables:** wealth index, residence, educational status, place of delivery, cesarean delivery, religion, age of the women, ANC visit, media exposure, region, current breast feeding, current pregnancy **Clustering variable:** EDHS cluster (V001) **Operational definition Zero dose children:** are those that have not received any routine vaccine (yes for zero dose children), otherwise classified as non-zero-dose vaccines (no) [27]. Similarly, the mini-EDHS

2019 classify children as zero dose children if not received any routine vaccine and otherwiseclassified as not zero dose children.

Media exposure: was assessed based on whether people had access to read newsletters, listen to
the radio, and watch TV. Accordingly, if they have access to all three media (newsletter, radio,
and TV) at least once a week, we categorized them as "yes", otherwise "no"[28].

Sampling method and procedure

The mini-EDHS 2019 sample was stratified and selected in two stages. Each region was stratified by urban and rural areas, with a total of 21 sampling strata. A total of 305 EAs, 93 EAs in urban areas, and 212 EAs in rural areas, were selected using proportional EA size allocation techniques. In the selected EAs, household listings were conducted. Then 30 households were selected per cluster using equal-probability systematic selection techniques. Finally, a multistage sampling method was used to select 3208 participants who had children aged 12-35 months in the selected EAs. The detailed section is reported in the mini EDHS 2019 report [29].

³ 129 **Data source, collection and quality assurance**

We used the secondary analysis of the mini-EDHS 2019 data set. This data was collected using a pretested structured interview technique from March 21 to June 28, 2019. The location of the data was also collected using a geographic positioning system (2 kilometers for urban clusters and 5 kilometers for rural clusters). To assure the quality of the data, pretesting and training for data collectors and supervisors were conducted. The detail section on data source, collection, and quality assurance has been reported in mini EDHS 2019 [29]. For the purpose of further analysis for the current study, data was requested online from the demographic health survey international at DHS's official website, http://www.dhsprogram.com. Then the data was accessed after 2

working days. After the data was accessed, variable selection, data cleaning, weighting the sample,

recoding, and overall data management were conducted.

Data processing and statistical analysis

After accessing the data from DHS International, cleaning, recoding, sampling weight, and missing data checking were conducted using STATA software version 14 and there was no missing data. Descriptive data was displayed by bar graph table and frequency. The "Svy" command was used as the sampling weight of cluster sampling. After this, multilevel (mixed-effect) binary logistic regression was used to identify the determinants for zero-dose children. The reason we used such a model was because of the hierarchical nature of the EDHS data and the possibility of considering a natural nesting of data. We built models like the null model (a model with an intercept/no predictors), model I (level one predictors), model II (a model with level two predictors), and model III (mixed effect model). The mixed effect model is:

Let y_{ij} denote the binary outcome for an individual *i* in neighborhood *j*, and assume y_{ij} follows a Bernoulli distribution with success probability p_{ii} or Binomial $(1, p_{ii})$. Using an appropriate link function such as logit, a binary outcome can be associated with linear predictors as the following, $logit[E(y_{ij})] = logit(p_{ij}) = \alpha_0 + X_{ij}\beta + Z_j\gamma + u_j$ [30].

Where $\alpha 0$ is the regular intercept, Xij β is the product of individual-level predictors and the corresponding unknown parameters, and Zjy is the product of neighborhood-level predictors and the associated parameters. Within-neighborhood correlation is captured by uj which is usually assumed to be a normally distributed random intercept with mean 0 and variance $\sigma 2u$ [31].

To test the clustering effect, the intra-class correlation coefficient was used with a cutoff of >0.05. (>5%). For each model, Intraclass correlation (ICC (ρ) = $\sigma^2 \epsilon/(\sigma^2 \epsilon + \sigma^2 \mu)$; $\sigma^2 \mu = \pi^2/3[32]$ was calculated. The clustering variable to show the clustering effect of zero-dose children was the

EDHS cluster (V001). The proportional change in variance (PCV=variance of the null model minus variance of the next model/variance in the null model*100), MOR=exp $\sqrt{2}$ x VA x 0.6745 $= \exp(0.95 \text{xVA})$ [32] and Akaike information criteria (AIC = 2k-2lnL, where k is the number of parameters and L is the maximum value of the likelihood function of the model) were also calculated. Then the best model was selected based on the lowest AIC value (Table 1). The significant variables were selected using the p-value less than 0.05 at 95%CL.

Table 1: A model comparison for zero dose children in Ethiopia using mini-EDHS 2019.

19 20	Random effect	Null model	Model I	Model II	Model III
20	Variance	0.27	0.199	0.21	0.118
22	ICC	38%	19%	31%	7.8%
23	PCV (%)	Reference	26.3%	22.2%	56.3%
24	MOR	19.8	1.93	3.56	1.67
26	Log likelihood	-1950	-1904	-1920	-1889
27	AIC	3905	3826	3848	3801
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Results

- **Characteristics of the participants**
- Among a total of 3028 participants, about half, 1648 (51.4%), had no education. About 1447

(45.1%) and 2316 (72.2%) of them gave birth at home and had no ANC visit, respectively.

Furthermore, 1594 (49.7%) and 2442 (76.1%) of the participants had poor wealth index and were

from rural residence, respectively (Table-2).

Table-2: characteristics of the participants among women who had child aged 12-35 months

old in Ethiopia using mini-EDHS 2019.

Variable	Category	Weighted frequency	%
Wealth index	Poor	1594	49.7
	Middle	449	14
	Rich	1,165	36.3
Residence	Urban	766	23.9
	Rural	2442	76.1

	Educational status	No education	1648	51.4
		Primary	1080	33.7
		Secondary	296	9.2
		Higher	18/	57
	Poligion	Orthodox	020	20
	Kenglon	Cathalia	929	29
		Catholic	10	0.0
		Protestant	588	18.3
		Muslim	1633	50.9
		Traditional	32	1
		Other	8	0.2
	Region	Tigray	261	8.1
	8	Afar	371	11.6
		Δmhara	294	9.2
		Oromia	308	12 /
		Somali	371	12.4
			321	10
		Benishangul Gumuz	289	9
		SNNPR	360	11.2
		Gambela	247	7.7
		Hararı	251	7.8
		Addis Ababa	180	5.6
		Diredawa	236	7.4
	Age	15-24 years	931	29
		25-34 years	1,719	53.6
		\geq 35 years	558	17.4
	ANC visit	Yes	892	27.8
		No	2316	72.2
	Place of delivery	Home	1447	45.1
		Health facility	1761	54.9
	Media exposure	Yes	1561	48.6
	-	No	1647	51.4
	Delivery by cesarean	No	3001	93.5
	section	Yes	207	6.5
	Currently breast feed	Yes	2376	74.1
		No	832	25.9
	Current pregnant	Yes	316	99
	e viir eine pregnane	No	2892	90.1
177				
178	Prevalence of zero dos	e children in Ethiopia		
179	The prevalence of zero of	lose children among chi	ldren aged 12-35 months	s old was 16.3% (95%CI,
180	15%–17.6%) (Fig-1).			

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181	Fig.1. Prevalence of zero dose children in Ethionia using mini-EDHS 2019
101	rig-1. 1 revalence of zero dose enharen in Ethiopia using mini-EDIIS 2017.

Factors associated with zero dose children

In the multivariable multilevel binary logistic regression analysis, wealth index, educational status, place of delivery, residence, media exposure, and ANC visit were the significant factors for zero-dose children in Ethiopia at a p-value of less than 0.05. Women with no ANC follow-up was 1.55 (AOR = 1.55, 95% CI: 1.02-2.35, p-value of < 0.001) times higher odds of zero does child than who had an ANC visit. Women with no education were 1.47 (AOR =1.47, 95% CI: 1.11–1.95, p-value of 0.0067) times higher odds of zero dose child than those who had secondary and above educational levels. Women who gave birth at home were 1.39 (AOR =1.39, 95% CI: 1.04–1.86, p-value of < 0.001) times higher odds of zero dose child than women who gave birth at the health facility. Women who had a poor wealth index were also 2.15 times (AOR = 2.15, 95% CI: 1.62– 2.85, p-value of 0.0078) higher odds of zero-dose child than rich women. Also, women from a low proportion of community media exposure were 1.39 (AOR =1.39, 95% CI: 1.13–1.71, p-value of<0.001) times higher odds of a zero-dose child than women from a high proportion of community media exposure. Furthermore, the women from the rural residence were 2.29 (AOR =2.29, 95% CI: 1.53-3.42, p-value of 0.004) times higher odds of zero-dose child than those among urban women (Table-3).

Table: 3 individual and community level maternal factors of zero dose children in Ethiopia using mini-EDHS-2019

Null	Model I	Model II	Model III(mixed)	p-value
model				
	AOR	AOR	AOR	
	(95%CI)	(95%CI)	(95%CI)	
	1.51(0.99, 2.29)		1.55 (1.02, 2.35)*	< 0.001
	Reference		Reference	
	Null model	Null Model I model - AOR (95%CI) 1.51(0.99, 2.29) Reference	Null model Model I Model II Model - - AOR AOR (95%CI) 1.51(0.99, 2.29) Reference -	Null model Model I // Model II Model III(mixed) AOR AOR AOR (95%CI) (95%CI) (95%CI) 1.51(0.99, 2.29) 1.55 (1.02, 2.35)* Reference Reference

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Residence Rural		3 78(2 59	2 29 (1 53 3 42)*	0.004
Urban		5.53) Reference	Reference	0.004
Place of delivery				
Home	1.4(1.05, 1.88)		1.39 (1.04, 1.86)*	< 0.001
Health facility	Reference		Reference	
Community media				
exposure		1.34(1.13,	1.39 (1.13, 1.71)*	< 0.001
Low proportion of media		1.62)	Reference	
exposure		Reference		
High proportion of media				
exposure				
Wealth index				
Poor	2.99 (2.31, 3.87)		2.15 (1.62, 2.85)*	0.0078
Middle	1.3 (1.37, 2.48)		1.42 (0.94, 1.94)	
Rich				
	Reference		Reference	
Current breast feeding				
No	1.07(0.68, 2.12)		1.01(0.74, 1.29)	0.21
Yes	Reference		Reference	
Educational status				
No education	1.27(0.97, 1.64)		1.47(1.11, 1.95)*	0.0067
Primary education	0.88(0.69, 1.12)		0.95(0.75, 1.21)	
Secondary and above	Reference	•	Reference	
Current pregnancy				
No	1.59 (1.01,2.51)		1.9 (0.84, 2.49)	0.34
Yes	Reference	4	Reference	
			1	1

Discussion

The prevalence of zero dose children among children aged 12-35 months old was 16.3%. Variables like urban residence, no education, home delivery, poor wealth index, no ANC visit, and women from low proportions of community media exposure were the risk factors for zero-dose children in Ethiopia. Therefore, expanding maternal health services and media access for women is highly recommended to reduce zero-dose children. Thus, the prevalence of zero dose children among children aged 12-35 months old was 16.3% (95% CI, 15%-17.6%). This finding was in line with a study conducted in Sub-Saharan Africa (16.5%) [1]. But it was lower than a study conducted in

Togo (26.88%) [33] and the WHO/UNICEF Estimates of National Immunization Coverage 2021 report, which estimated that 30% of surviving infants in Ethiopia were zero-dose children [34]. This might be because in the previous study, the vaccination card was considered to declare the vaccination status of the child, but the mother's report was not considered. This may overestimate the previous finding. The current finding was also lower than a study conducted in Cameroon (91.7%) [35]. The possible reason for the discrepancy might be that the study done in Cameroon was conducted in an area where access to health services is very low (the remote rural districts, the homeless population, and immigrants). This segment of the population is suffering from a lack of basic health services, including immunization. This causes a higher prevalence of zero dose children among children. In Ethiopia between 2000 and 2019, the basic vaccination coverage had progressed from 14.3% to 44.1%. The vaccination coverage was estimated to reach 53.6% by 2025; the reduction in zero dose child implies a significant improvement in vaccination coverage [36].

222 [36].

Regarding the factors associated with a zero-dose child, it was found that the odds of a zero-dose vaccine were higher among women who delivered at home than those who delivered at a health facility. This finding was supported by a study conducted in Cameroon [35], a study conducted in sub-Saharan Africa [1] and Ethiopia [37]. This can be explained by the fact that women who give birth at home miss childhood vaccines, including birth doses, and they may not get counselling on childhood vaccines, such as the advantages of vaccination, schedules of vaccine doses, and other related information. Moreover, home delivery may have a negative effect on the subsequent health-seeking behavior of women

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The odds of a zero-dose child among poor wealth index women were more likely than those among rich wealth index women. This was supported by a study conducted in low- and middle-income countries [38]. This may be justified by the fact that women with low socioeconomic status have a lower acceptability of health-related messages and a lower understanding of the vaccination advantage [39]. Also, women who had no ANC follow-up were more likely to not vaccinate their child at all than women who had ANC follow-up. This finding is supported by a study conducted in India [40] and a study conducted among 82 low- and middle-income countries [41]. This might be associated with the fact that women who do not attend ANC could not get counselling and education services about the advantages and the time schedule of all basic vaccine doses. Alternatively, women who do not attend the ANC service are more likely to not attend health services after birth as well.

Additionally, the odds of zero-dose children among women who were from low proportions of community media exposure were higher than those among women who were from high proportions of community media exposure. This finding was supported by a study conducted in Indonesia [42]. The possible justification for this association may be due to a lack of media access in the community, which could negatively affect knowledge about the advantages and schedule of the childhood vaccine. Alternatively, women who are from low-community media exposure may miss key information released through media outlets. In return, they are more prone to not vaccinating all doses of vaccine for their children. Additionally, mass media exposure, such as through television, radio, newspapers, and the internet, in the community plays an important role in changing the community's attitude, opinion, awareness, and health service-seeking behavior. But women with a low proportion of community media exposure may lack these advantages. In addition, women who had no education also had higher odds of not vaccinating all doses of

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vaccines for their child than women who had secondary or higher educational levels. A previous study conducted in Nigeria also reported that as educational levels increased, the zero-dose vaccine status decreased [43]. This may be because educational status is highly correlated with the knowledge and acceptance rate of vaccination [44]. Additionally, low educational status could be a barrier to accessing health services, including childhood vaccination. Furthermore, this study revealed that women who were from rural areas were more likely to not vaccinate their children at all than urban women. The access to health services is quite different between urban and rural [45]. This is due to the barriers to accessing preventive services in the rural areas, for example, lack of transportation, the far distance of health institutions, and the lack of adequate health professionals in rural areas who deliver the service [46, 47]. Even though this study has lacks some clinically important variables because of secondary data analysis, it has several implications by providing an important tool for designing strategies and policies to reduce the number of zero-dose children in Ethiopia. Therefore, expanding maternal health services and media access for women is highly recommended to reduce zero-dose child.

268 Conclusion

As compared to the previous studies, the prevalence of zero dose children was low in Ethiopia. Variables like urban residence, no education, home delivery, poor wealth index, no ANC visit, and women from low proportions of community media exposure were the risk factors for zero-dose children in Ethiopia. Therefore, expanding maternal health services and media access for women is highly recommended to reduce zero-dose child.

274 Ethical declaration

275 Ethical approval

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276	Since it was a secondary data analysis of EDHS, informed consent from the participants was not
277	applicable. Rather, data requests and approval for access were obtained from DHS International.
278	All data were fully anonymized before we accessed informed consent from DHS international.
279	Consent for publication
280	Not required.
281	Data availability statement
282	All relevant data is available in the manuscript.
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17 18	305	Kidie Tesfie
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21 22 23	307	Abbreviation and acronym
24 25	308	AICAkaike information criteria
26 27	309	ANCAntenatal Care
28 29 30	310	DHSDemographic Health Survey
31 32	311	EAsEnumeration Areas
33 34 25	312	EDHSEthiopian Demographic Health Survey
36 37	313	LLRLog Likelihood Ratio
38 39	314	SNNPRSouth Nation and Nationality of People Representative
40 41 42	315	VPDsVaccine Preventable Diseases
43 44 45	316	Reference
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Fig-1: Prevalence of zero dose children in Ethiopia using EDHS 2019.



Individual and community level maternal factors for zero dose children in Ethiopia using EDHS 2019: A mixed effect model

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> Individual and community level maternal factors for zero dose children in Ethiopia using mini-EDHS 2019: A mixed effect model Muluken Chanie Agimas¹, Meron Asmamaw Alemayehu¹, Tigabu Kidie Tesfie¹, Werkneh Melkie Tilahun², Worku Necho Asferie⁴, Mekuriaw Nibret Aweke⁶, Moges Tadesse Abebe³, Anteneh Kassa yalew⁵ ¹Department of Epidemiology and Biostatistics, institute of public health, college of medicine and health science, university of Gondar, Gondar, Ethiopia. ²Department of Public Health, College of Medicine and Health Sciences, Debre Markos University, Debre Markos, Ethiopia. ³Department of Nursing, College of Health Science, Debark University, Debark, Ethiopia. ⁴Departments of pediatric and neonatal Nursing, College of Health Science, Debre Tabor University, Debre Tabor, Ethiopia ⁵Department of Public health, college of medicine and Health science, Wolkite University, Wolkite, Ethiopia. ⁶Department of Nutrition, Institute of Public Health, College of Medicine and Health Sciences, University of Gondar, Ethiopia Authors address: 1. Muluken Chanie Agimas (MCA): mulukensrc12@gmail.com 2. Meron Asmamaw Alemayehu (MAA): merryalem101@gmail.com 3. Tigabu Kidie Tesfie (TKT): tigabukidie@gmail.com 4. Werkneh Melkie Tilahun (WMT): werkneh7wmt@gmail.com 5. Worku Necho Asferie (WNA): workunecho@gmail.com 6. Mekuriaw Nibret Aweke (MNA): mekunib@gmail.com 7. Moges Tadesse Abebe (MTA): moges7045@gmail.com 8. Anteneh Kassa yalew (AKY): antenehkassa28@gmail.com **Corresponding author:** Muluken Chanie Agimas (MCA): mulukensrc12@gmail.com For peer review only - http://bmjopen.bmj.com/site/about/guidelines.xhtml

Abstract

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Introduction: Zero-dose children refer to a child who has not yet received any childhood vaccines. 29 Globally, zero-dose children are the major public health problem. In sub-Saharan African 30 countries, among five children, one did not access the vaccines. But the efforts to identify the 31 factors contributing to the zero-dose child are not well addressed in Ethiopia. 32 33 **Objectives**: To assess individual and community-level maternal factors of zero-dose children in Ethiopia using mini-EDHS 2019. 34 Methods: A secondary analysis of a cross-sectional study was used among a total of 3208 35 participants. The STATA-14 was used for descriptive and multilevel binary logistic regression 36 (mixed effect model) analysis. Model selection was conducted using AIC. To identify significant 37

factors for zero-dose children, a p-value of < 0.05 with 95% confidence was used.

Results: The prevalence of zero-dose children among children aged 12-35 months old was 523 (16.3%, 95%CI, 15%–17.6%). Women with no antenatal care follow-up (Adjusted odds ratio = 1.55, 95% CI: 1.02–2.35), none educated women (Adjusted odds ratio = 1.47, 95% CI: 1.11–1.95), women who gave birth at home (Adjusted odds ratio = 1.39, 95% CI: 1.04–1.86), women who had poor wealth index (Adjusted odds ratio = 2.15, 95% CI: 1.62–2.85), and women from low proportions of community media exposure (Adjusted odds ratio = 1.39, 95% CI: 1.13–1.71) were the risk factors for zero-dose children in Ethiopia.

46 Conclusion: As compared to the previous studies, the prevalence of zero-dose children was low
47 in Ethiopia. Variables like urban residence, no education, home delivery, poor wealth index, no
48 ANC visit, and women from low proportions of community media exposure were the risk factors

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49 for zero-dose children in Ethiopia. Therefore, expanding maternal health services and media access

50 for women is highly recommended to reduce zero-dose child mortality.

51 Key words: zero-dose vaccination, maternal factors, Ethiopian Demographic Health Survey,
52 Ethiopia

53 Strength and limitation of the study

- Using nationally representative sample increases the power of the study.
- Additionally, proportional allocation of sample for each cluster and weighting the sample makes the study nationally representative.
 - But because we used secondary data and a cross-sectional study design, our study shared the limitations of the secondary data and the cross-sectional study.
 - Recall bias was also the limitation of the study.

60 Introduction

A zero-dose vaccine child is defined as a child who does not uptake any types of vaccines [1].
Globally, the uptake of childhood vaccines prevents 2.5 million child deaths each year [2, 3]. Onefifth of sub-Saharan African children never get the vaccines [4]. Childhood vaccination is the most
cost-effective strategy for vaccine-preventable diseases like poliomyelitis, measles, pneumonia,
hepatitis B virus, diphtheria, Haemophilus influenza type B (Hib), tuberculosis, diarrhea, and
others [5, 6]. Zero-dose children are more at risk for vaccine-preventable disease [7-10].

In Africa, due to non-uptake of basic vaccines, 30 million under-five children are attacked by vaccine-preventable diseases, and 500,000 of them die each year [11]. In 2020, about 17 million under-five children in low and middle-income countries were not take any vaccines [12]. Which means the majority of zero-dose children are from low and middle-income countries, especially in African
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and Southeast Asian regions [13]. The proportion of zero-dose vaccines is a good indicator of the failure to achieve the national vaccination coverage goal in sub-Saharan Africa (90%) [14]. But the COVID-19 pandemic was a threat to the immunization program, which increased the number of zero-dose children by 37% [15]. Conducting research on zero-dose vaccines is very important for evidence-based strategies, interventions, and achieving the WHO goal [16]. Additionally, searching for evidence on the burden and factors of the zero-dose vaccine is crucial for childhood disability reduction [17-19]. Among factors affecting not taking any vaccine dose are lack of attention for the zero-dose population, rural residence, and low educational status [20-22]. Ethiopia is the fourth-leading contributor to global zero-dose children, despite considerable progress in the total number of infants being immunized [23]. As previous evidence showed, the distribution of vaccination among children in Ethiopia varied across the regions, and thus the lowest proportion (21%) of vaccinated children was reported in the Somali and Afar regions, and the highest proportion (89%) of immunized children was reported in the Amhara region [24]. Even though zero-dose children in Ethiopia are a public health concern, the efforts to identify the factors contributing to the zero-dose children and its prevalence are not well addressed. Therefore, studies are needed to assess the prevalence and determinants of zero-dose children in Ethiopia. Therefore, this study aimed to

determine the prevalence and identify individual and community-level factors for zero-dose
children in Ethiopia using the EDHS 2019 mixed effect model.

Objectives

91 To determine the prevalence of zero dose children in Ethiopia using mini-EDHS 2019

92 To identify factors for zero dose children in Ethiopia using mini-EDHS 2019

93 Methods

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Study design, area and period

The EDHS-2019 data was collected from March 21 to June 28, 2019, using a cross-sectional study design. Ethiopia is a low-income country located in the Horn of Africa, and its capital city is Addis Ababa. In Ethiopia, Dallol (128 meters above sea level) and Ras Dashen (4620 meters above sea level) are the lowest and highest latitudes above sea level, respectively [25]. Ethiopia has twelve administrative regions, namely Afar, Somalia, Harari, Amhara, Oromia, Gambela, South Ethiopia, Central Ethiopia, Tigray, Benishangul Gumuz, Sidama, and southwest Ethiopia. Addis Ababa and Dire Dawa are the two self-governed cities in Ethiopia. According to the December 27, 2023, worldometer estimate, Ethiopia has a total population of 128,073,400, and the rural population comprises about 77.9% of the total population [26]. **Population** The source population was all women who had children prior to the survey, and women who had children aged 12-35 months in the enumeration area were included in the study. Variables **Dependent variable:** Zero dose children status (Yes, No) **Independent variables:** wealth index, residence, educational status, place of delivery, cesarean delivery, religion, age of the women, ANC visit, media exposure, region, current breast feeding, current pregnancy **Clustering variable:** EDHS cluster (V001) **Operational definition Zero dose children:** are those that have not received any routine vaccine (yes for zero dose children), otherwise classified as non-zero-dose vaccines (no) [27]. Similarly, the mini-EDHS

2019 classify children as zero dose children if not received any routine vaccine and otherwiseclassified as not zero dose children.

Media exposure: was assessed based on whether people had access to read newsletters, listen to
the radio, and watch TV. Accordingly, if they have access to all three media (newsletter, radio,
and TV) at least once a week, we categorized them as "yes", otherwise "no"[28].

Sampling method and procedure

The mini-EDHS 2019 sample was stratified and selected in two stages. Each region was stratified by urban and rural areas, with a total of 21 sampling strata. A total of 305 EAs, 93 EAs in urban areas, and 212 EAs in rural areas, were selected using proportional EA size allocation techniques. In the selected EAs, household listings were conducted. Then 30 households were selected per cluster using equal-probability systematic selection techniques. Finally, a multistage sampling method was used to select 3208 participants who had children aged 12-35 months in the selected EAs. The detailed section is reported in the mini EDHS 2019 report [29].

³ 130 Data source, collection and quality assurance

We used the secondary analysis of the mini-EDHS 2019 data set. This data was collected using a pretested structured interview technique from March 21 to June 28, 2019. The location of the data was also collected using a geographic positioning system (2 kilometers for urban clusters and 5 kilometers for rural clusters). To assure the quality of the data, pretesting and training for data collectors and supervisors were conducted. The detail section on data source, collection, and quality assurance has been reported in mini EDHS 2019 [29]. For the purpose of further analysis for the current study, data was requested online from the demographic health survey international at DHS's official website, http://www.dhsprogram.com. Then the data was accessed after 2

working days. After the data was accessed, variable selection, data cleaning, weighting the sample,

recoding, and overall data management were conducted. Data processing and statistical analysis

After accessing the data from DHS International, cleaning, recoding, sampling weight, and missing data checking were conducted using STATA software version 14 and there was no missing data. Descriptive data was displayed by bar graph table and frequency. The "Svy" command was used as the sampling weight of cluster sampling. After this, multilevel (mixed-effect) binary logistic regression was used to identify the determinants for zero-dose children. The reason we used such a model was because of the hierarchical nature of the EDHS data and the possibility of considering a natural nesting of data. We built models like the null model (a model with an intercept/no predictors), model I (level one predictors), model II (a model with level two predictors), and model III (mixed effect model). The mixed effect model is:

Let y_{ij} denote the binary outcome for an individual *i* in neighborhood *j*, and assume y_{ij} follows a Bernoulli distribution with success probability p_{ii} or Binomial $(1, p_{ii})$. Using an appropriate link function such as logit, a binary outcome can be associated with linear predictors as the following, $logit[E(y_{ij})] = logit(p_{ij}) = \alpha_0 + X_{ij}\beta + Z_j\gamma + u_j$ [30].

Where $\alpha 0$ is the regular intercept, Xij β is the product of individual-level predictors and the corresponding unknown parameters, and Zjy is the product of neighborhood-level predictors and the associated parameters. Within-neighborhood correlation is captured by uj which is usually assumed to be a normally distributed random intercept with mean 0 and variance $\sigma 2u$ [31].

To test the clustering effect, the intra-class correlation coefficient was used with a cutoff of >0.05. (>5%). For each model, Intraclass correlation (ICC (ρ) = $\sigma^2 \epsilon/(\sigma^2 \epsilon + \sigma^2 \mu)$; $\sigma^2 \mu = \pi^2/3[32]$ was calculated. The clustering variable to show the clustering effect of zero-dose children was the

3 4	162	EDHS cluster (V001). The proportional change in variance (PCV=variance of the null model
5 6	163	minus variance of the next model/variance in the null model*100), MOR=exp $\sqrt{2}$ x VA x 0.6745
7 8 0	164	= exp (0.95xVA) [32] and Akaike information criteria (AIC = 2k-2lnL, where k is the number of
9 10 11	165	parameters and L is the maximum value of the likelihood function of the model) were also
12 13	166	calculated. Then the best model was selected based on the lowest AIC value (Table 1). The
14 15	167	significant variables were selected using the p-value less than 0.05 at 95%CL.

Table 1: A model comparison for zero dose children in Ethiopia using mini-EDHS 2019.

) 165	parameters	and L is the maximum value of the	e likelihood funct	tion of the mode	el) were also		
2 166	calculated. Then the best model was selected based on the lowest AIC value (Table 1). The						
167	significant	variables were selected using the p-val	ue less than 0.05	at 95%CL.			
168	Table 1: A	a model comparison for zero dose chi	ldren in Ethiopia	a using mini-EDI	HS 2019.		
Random	effect	Null model	Model I	Model II	Model III		
Variance	3	0.27	0.199	0.21	0.118		
ICC		38%	19%	31%	7.8%		
PCV (%)	Reference	26.3%	22.2%	56.3%		
MOR		19.8	1.93	3.56	1.67		
Log like	lihood	-1950	-1904	-1920	-1889		
AIC		3905	3826	3848	3801		
170 171 172	Results Characte	ristics of the participants	1648 (51.4%) h	ad no education	About 1447		
173	(45.1%) and 2316 (72.2%) of them gave birth at home and had no ANC visit, respectively.				respectively.		
174	Furthermo	re, 1594 (49.7%) and 2442 (76.1%) of	the participants ha	ad poor wealth ind	dex and were		
175	from rural residence, respectively (Table-2).						
176	Table-2: c	haracteristics of the participants amo	ong women who	had child aged 1	2-35 months		
177	old in Eth	iopia using mini-EDHS 2019.					
	Variable	Category	Weighted frequer	ncy %			

- **Characteristics of the participants**
- Among a total of 3028 participants, about half, 1648 (51.4%), had no education. About 1447
 - (45.1%) and 2316 (72.2%) of them gave birth at home and had no ANC visit, respectively.
- Furthermore, 1594 (49.7%) and 2442 (76.1%) of the participants had poor wealth index and were
- from rural residence, respectively (Table-2).

Table-2: characteristics of the participants among women who had child aged 12-35 months

Variable	Category	Weighted frequency	%
Wealth index	Poor	1594	49.7
	Middle	449	14
	Rich	1,165	36.3
Residence	Urban	766	23.9
	Rural	2442	76.1

2					
3		Educational status	No education	1648	51.4
4			Primary	1080	33.7
5			Secondary	296	9.2
6 7			Secondary	290	<i></i>
/ 0			Higher	184	5.7
0 0		Religion	Orthodox	929	29
9 10			Catholic	18	0.6
11			Protestant	588	18.3
12			Muslim	1633	50.9
13			Traditional	37	1
14				52	1
15			Other	8	0.2
16		Region	Tigray	261	8.1
17			Afar	371	11.6
18			Amhara	294	9.2
19			Oromia	398	12.4
20 21			Somali	321	10
22			Bonishangul Gumuz	280	0
23			SNINDD	269	<i>)</i> 11)
24			SINNPR	300 247	11.2
25			Gambela	247	/./
26			Harari	251	1.8
27			Addis Ababa	180	5.6
28			Diredawa	236	7.4
29		Age	15-24 years	931	29
30 21		-	25-34 years	1,719	53.6
21 22			\geq 35 years	558	17.4
33		ANC visit	Yes	892	27.8
34			No	2316	72.2
35		Place of delivery	Home	1447	45.1
36			Health facility	1761	54.9
37		Madia avnosura	Ves	1561	18 6
38		Wedia exposure	I CS	1501	48.0 51 <i>A</i>
39		Delivery by eccercor	No	2001	02.5
40		Delivery by cesarean	INO	5001	93.3
41 42		section	Yes	207	6.5
42 13		Currently breast feed	Yes	2376	74.1
44		-	No	832	25.9
45		Current pregnant	Yes	316	9.9
46		1 2	No	2892	90.1
47	178				
48	1,0				
49	179	Prevalence of zero dos	e children in Ethionia		
50	115		e emili en mitemopla		
51	100	The prevalence of zero	losa childran among chil	Idran agad 12 25 months	old was 16 20/ (050/ CI
52 53	190	The prevalence of zero (uose ennuren annong enn	iuren ageu 12-35 monuis	o ulu was 10.370 (9370Cl,
55 54	101	150/ 17 60/) (Eig 1)			
57	TQT	1570-17.070) (FIG-1) .			

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182	Fig-1. Prevalence	of zero dose	children in	Ethionia	using mi	ni-EDHS 2019
102	rig-1. Trevalence	UI ZUI U UUSU	· chinai chi ili	Eunopia	using mi	m-EDIIS 2017.

Factors associated with zero dose children

In the multivariable multilevel binary logistic regression analysis, wealth index, educational status, place of delivery, residence, media exposure, and ANC visit were the significant factors for zero-dose children in Ethiopia at a p-value of less than 0.05. Women with no ANC follow-up was 1.55 (AOR = 1.55, 95% CI: 1.02-2.35, p-value of < 0.001) times higher odds of zero does child than who had an ANC visit. Women with no education were 1.47 (AOR =1.47, 95% CI: 1.11–1.95, p-value of 0.0067) times higher odds of zero dose child than those who had secondary and above educational levels. Women who gave birth at home were 1.39 (AOR =1.39, 95% CI: 1.04–1.86, p-value of < 0.001) times higher odds of zero dose child than women who gave birth at the health facility. Women who had a poor wealth index were also 2.15 times (AOR = 2.15, 95% CI: 1.62– 2.85, p-value of 0.0078) higher odds of zero-dose child than rich women. Also, women from a low proportion of community media exposure were 1.39 (AOR =1.39, 95% CI: 1.13–1.71, p-value of < 0.001) times higher odds of a zero-dose child than women from a high proportion of community media exposure. Furthermore, the women from the rural residence were 2.29 (AOR =2.29, 95% CI: 1.53-3.42, p-value of 0.004) times higher odds of zero-dose child than those among urban women (Table-3).

Table: 3 individual and community level maternal factors of zero dose children in Ethiopia

using mini-EDHS-2019 N.11 Model I Model II Model III(mixed) n voluo Variables AN

140105	INUIT	WIGGET I	Widdel II		p-value
	model				
C follow-up		AOR	AOR	AOR	
No		(95%CI)	(95%CI)	(95%CI)	
Yes		1.51(0.99, 2.29)		1.55 (1.02, 2.35)*	< 0.001
		Reference		Reference	

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Residence Rural		3 78(2 59	2 29 (1 53 3 42)*	0.004
Urban		5.53) Reference	Reference	0.004
Place of delivery				
Home	1.4(1.05, 1.88)		1.39 (1.04, 1.86)*	< 0.001
Health facility	Reference		Reference	
Community media				
exposure		1.34(1.13,	1.39 (1.13, 1.71)*	< 0.001
Low proportion of media		1.62)	Reference	
exposure		Reference		
High proportion of media				
exposure				
Wealth index				
Poor	2.99 (2.31, 3.87)		2.15 (1.62, 2.85)*	0.0078
Middle	1.3 (1.37, 2.48)		1.42 (0.94, 1.94)	
Rich				
	Reference		Reference	
Current breast feeding				
No	1.07(0.68, 2.12)		1.01(0.74, 1.29)	0.21
Yes	Reference		Reference	
Educational status				
No education	1.27(0.97, 1.64)		1.47(1.11, 1.95)*	0.0067
Primary education	0.88(0.69, 1.12)		0.95(0.75, 1.21)	
Secondary and above	Reference		Reference	
Current pregnancy		5		
No	1.59 (1.01,2.51)		1.9 (0.84, 2.49)	0.34
Yes	Reference	4	Reference	

Discussion

The prevalence of zero dose children among children aged 12-35 months old was 16.3%. Variables like urban residence, no education, home delivery, poor wealth index, no ANC visit, and women from low proportions of community media exposure were the risk factors for zero-dose children in Ethiopia. Therefore, expanding maternal health services and media access for women is highly recommended to reduce zero-dose children. Thus, the prevalence of zero dose children among children aged 12-35 months old was 16.3% (95% CI, 15%-17.6%). This finding was in line with a study conducted in Sub-Saharan Africa (16.5%) [1]. But it was lower than a study conducted in

Togo (26.88%) [33] and the WHO/UNICEF Estimates of National Immunization Coverage 2021 report, which estimated that 30% of surviving infants in Ethiopia were zero-dose children [34]. This might be because in the previous study, the vaccination card was considered to declare the vaccination status of the child, but the mother's report was not considered. This may overestimate the previous finding. The current finding was also lower than a study conducted in Cameroon (91.7%) [35]. The possible reason for the discrepancy might be that the study done in Cameroon was conducted in an area where access to health services is very low (the remote rural districts, the homeless population, and immigrants). This segment of the population is suffering from a lack of basic health services, including immunization. This causes a higher prevalence of zero dose children among children. In Ethiopia between 2000 and 2019, the basic vaccination coverage had progressed from 14.3% to 44.1%. The vaccination coverage was estimated to reach 53.6% by 2025; the reduction in zero dose child implies a significant improvement in vaccination coverage [36].

223 [36].

Regarding the factors associated with a zero-dose child, it was found that the odds of a zero-dose vaccine were higher among women who delivered at home than those who delivered at a health facility. This finding was supported by a study conducted in Cameroon [35], a study conducted in sub-Saharan Africa [1] and Ethiopia [37]. This can be explained by the fact that women who give birth at home miss childhood vaccines, including birth doses, and they may not get counselling on childhood vaccines, such as the advantages of vaccination, schedules of vaccine doses, and other related information. Moreover, home delivery may have a negative effect on the subsequent health-seeking behavior of women

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The odds of a zero-dose child among poor wealth index women were more likely than those among rich wealth index women. This was supported by a study conducted in low- and middle-income countries [38]. This may be justified by the fact that women with low socioeconomic status have a lower acceptability of health-related messages and a lower understanding of the vaccination advantage [39]. Also, women who had no ANC follow-up were more likely to not vaccinate their child at all than women who had ANC follow-up. This finding is supported by a study conducted in India [40] and a study conducted among 82 low- and middle-income countries [41]. This might be associated with the fact that women who do not attend ANC could not get counselling and education services about the advantages and the time schedule of all basic vaccine doses. Alternatively, women who do not attend the ANC service are more likely to not attend health services after birth as well.

Additionally, the odds of zero-dose children among women who were from low proportions of community media exposure were higher than those among women who were from high proportions of community media exposure. This finding was supported by a study conducted in Indonesia [42]. The possible justification for this association may be due to a lack of media access in the community, which could negatively affect knowledge about the advantages and schedule of the childhood vaccine. Alternatively, women who are from low-community media exposure may miss key information released through media outlets. In return, they are more prone to not vaccinating all doses of vaccine for their children. Additionally, mass media exposure, such as through television, radio, newspapers, and the internet, in the community plays an important role in changing the community's attitude, opinion, awareness, and health service-seeking behavior. But women with a low proportion of community media exposure may lack these advantages. In addition, women who had no education also had higher odds of not vaccinating all doses of

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vaccines for their child than women who had secondary or higher educational levels. A previous study conducted in Nigeria also reported that as educational levels increased, the zero-dose vaccine status decreased [43]. This may be because educational status is highly correlated with the knowledge and acceptance rate of vaccination [44]. Additionally, low educational status could be a barrier to accessing health services, including childhood vaccination. Furthermore, this study revealed that women who were from rural areas were more likely to not vaccinate their children at all than urban women. The access to health services is guite different between urban and rural [45]. This is due to the barriers to accessing preventive services in the rural areas, for example, lack of transportation, the far distance of health institutions, and the lack of adequate health professionals in rural areas who deliver the service [46, 47]. Recall bias (because of the data were collected a self-report of mothers who have child 1-3 years) and unable to show cause-effect relationship were the limitations of the study. Inaccuracy which was different in size and direction in one group than the other (differential error) or the effect was not the same for groups in the study. The other limitation of this study was lacks some clinically important variables because of secondary data analysis. Even though it has such limitations, the study has several implications by providing an important tool for designing strategies and policies to reduce the number of zero-dose children in Ethiopia. Therefore, expanding maternal health services and media access for women is highly recommended to reduce zero-dose child.

273 Conclusion

As compared to the previous studies, the prevalence of zero dose children was low in Ethiopia.
Variables like urban residence, no education, home delivery, poor wealth index, no ANC visit, and
women from low proportions of community media exposure were the risk factors for zero-dose

3 4	277	children in Ethiopia. Therefore, expanding maternal health services and media access for women
5 6	278	is highly recommended to reduce zero-dose child.
7 8	279	Ethical declaration
9 10 11	280	Ethical approval
12 13	281	Since it was a secondary data analysis of EDHS, informed consent from the participants was not
14 15	282	applicable. Rather, data requests and approval for access were obtained from DHS International.
16 17 18	283	All data were fully anonymized before we accessed informed consent from DHS international.
19 20	284	Consent for publication
21 22	285	Not required.
23 24 25	286	Data availability statement
23 26 27	287	All relevant data is available in the manuscript.
28 29	288	Conflict of interest
30 31 32	289	The author declares no conflict of interest
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35 36	291	No
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7 8 0	301	Software: Muluken Chanie Agimas, Werkneh Melkie Tilahun, Worku Necho Asferie, Mekuria	aw
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33 34	312	Abbreviation and acronym	
35 36	313	AICAkaike information criteria	
37 38	314	ANCAntenatal Care	
39 40 41	315	DHSDemographic Health Survey	
42 43	316	EAsEnumeration Areas	
44 45	317	EDHSEthiopian Demographic Health Survey	
40 47 48	318	LLRLog Likelihood Ratio	
49 50	319	SNNPRSouth Nation and Nationality of People Representative	
51 52	320	VPDsVaccine Preventable Diseases	
53 54 55	321	Reference	
56 57			
58 59		For noor review, only, http://hmionen.hmi.com/site/showidalines.vistory	16
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Fig-1: Prevalence of zero dose children in Ethiopia using EDHS 2019.

Individual and community level maternal factors for zero dose children in Ethiopia using EDHS 2019: A mixed effect model

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Individual and community level maternal factors for zero dose children in Ethiopia using

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Abstract

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Introduction: Zero-dose children refer to a child who has not yet received any childhood vaccines.

30	Globally, zero-dose children are the major public health problem. In sub-Saharan African
31	countries, among five children, one did not access the vaccines. But the efforts to identify the
32	factors contributing to the zero-dose child are not well addressed in Ethiopia.
33	Objectives: To assess individual and community-level maternal factors of zero-dose children in
34	Ethiopia using mini-EDHS 2019.
35	Methods: A secondary analysis of a cross-sectional study was used among a total of 3208
36	participants. The STATA-14 was used for descriptive and multilevel binary logistic regression
37	(mixed effect model) analysis. Model selection was conducted using AIC. To identify significant
38	factors for zero-dose children, a p-value of <0.05 with 95% confidence was used.
39	Results: The prevalence of zero-dose children among children aged 12-35 months old was 523
40	(16.3%, 95%CI, 15%–17.6%). Women with no antenatal care follow-up (Adjusted odds ratio =
41	1.55, 95% CI: 1.02–2.35), none educated women (Adjusted odds ratio = 1.47, 95% CI: 1.11–1.95),
42	women who gave birth at home (Adjusted odds ratio = 1.39, 95% CI: 1.04–1.86), women who had
43	poor wealth index (Adjusted odds ratio = 2.15, 95% CI: 1.62-2.85), and women from low
44	proportions of community media exposure (Adjusted odds ratio = $1.39, 95\%$ CI: $1.13-1.71$) were

45 the risk factors for zero-dose children in Ethiopia.

46 Conclusion: As compared to the previous studies, the prevalence of zero-dose children was low
47 in Ethiopia. Variables like urban residence, no education, home delivery, poor wealth index, no
48 ANC visit, and women from low proportions of community media exposure were the risk factors

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49 for zero-dose children in Ethiopia. Therefore, expanding maternal health services and media access

50 for women is highly recommended to reduce zero-dose child mortality.

51 Key words: zero-dose vaccination, maternal factors, Ethiopian Demographic Health Survey,
52 Ethiopia

- 53 Strength and limitation of the study
 - Using nationally representative sample increases the power of the study.
 - Additionally, proportional allocation of sample for each cluster and weighting the sample makes the study nationally representative.
 - But because we used secondary data and a cross-sectional study design, our study shared the limitations of the secondary data and the cross-sectional study.
 - Recall bias was also the limitation of the study.

60 Introduction

A zero-dose vaccine child is defined as a child who does not uptake any types of vaccines [1].
Globally, the uptake of childhood vaccines prevents 2.5 million child deaths each year [2, 3]. Onefifth of sub-Saharan African children never get the vaccines [4]. Childhood vaccination is the most
cost-effective strategy for vaccine-preventable diseases like poliomyelitis, measles, pneumonia,
hepatitis B virus, diphtheria, Haemophilus influenza type B (Hib), tuberculosis, diarrhea, and
others [5, 6]. Zero-dose children are more at risk for vaccine-preventable disease [7-10].

In Africa, due to non-uptake of basic vaccines, 30 million under-five children are attacked by
vaccine-preventable diseases, and 500,000 of them die each year [11]. In 2020, about 17 million
under-five children in low and middle-income countries were not take any vaccines [12]. Which means
the majority of zero-dose children are from low and middle-income countries, especially in African

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and Southeast Asian regions [13]. The proportion of zero-dose vaccines is a good indicator of the
failure to achieve the national vaccination coverage goal in sub-Saharan Africa (90%) [14]. But
the COVID-19 pandemic was a threat to the immunization program, which increased the number
of zero-dose children by 37% [15].

Conducting research on zero-dose vaccines is very important for evidence-based strategies, interventions, and achieving the WHO goal [16]. Additionally, searching for evidence on the burden and factors of the zero-dose vaccine is crucial for childhood disability reduction [17-19]. Among factors affecting not taking any vaccine dose are lack of attention for the zero-dose population, rural residence, and low educational status [20-22]. Ethiopia is the fourth-leading contributor to global zero-dose children, despite considerable progress in the total number of infants being immunized [23]. As previous evidence showed, the distribution of vaccination among children in Ethiopia varied across the regions, and thus the lowest proportion (21%) of vaccinated children was reported in the Somali and Afar regions, and the highest proportion (89%) of immunized children was reported in the Amhara region [24]. Even though zero-dose children in Ethiopia are a public health concern, the efforts to identify the factors contributing to the zero-dose children and its prevalence are not well addressed. Therefore, studies are needed to assess the prevalence and determinants of zero-dose children in Ethiopia. Therefore, this study aimed to determine the prevalence and identify individual and community-level factors for zero-dose children in Ethiopia using the EDHS 2019 mixed effect model.

Objectives

91 To determine the prevalence of zero dose children in Ethiopia using mini-EDHS 2019

92 To identify factors for zero dose children in Ethiopia using mini-EDHS 2019

93 Methods

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94 Study design, area and period

The EDHS-2019 data was collected from March 21 to June 28, 2019, using a cross-sectional study design. Ethiopia is a low-income country located in the Horn of Africa, and its capital city is Addis Ababa. In Ethiopia, Dallol (128 meters above sea level) and Ras Dashen (4620 meters above sea level) are the lowest and highest latitudes above sea level, respectively [25]. Ethiopia has twelve administrative regions, namely Afar, Somalia, Harari, Amhara, Oromia, Gambela, South Ethiopia, Central Ethiopia, Tigray, Benishangul Gumuz, Sidama, and southwest Ethiopia. Addis Ababa and Dire Dawa are the two self-governed cities in Ethiopia. According to the December 27, 2023, worldometer estimate, Ethiopia has a total population of 128,073,400, and the rural population comprises about 77.9% of the total population [26].

Population

105 The source population was all women who had children prior to the survey, and women who had 106 children aged 12-35 months in the enumeration area were included in the study.

107 Variables

Dependent variable:

109 Zero dose children status (Yes, No)

Independent variables: wealth index, residence, educational status, place of delivery, cesarean
 delivery, religion, age of the women, ANC visit, media exposure, region, current breast feeding,
 current pregnancy

- 7 113 **Clustering variable:** EDHS cluster (V001)
- ¹⁹ 114 **Operational definition**

Zero dose children: are those that have not received any routine vaccine (yes for zero dose 116 children), otherwise classified as non-zero-dose vaccines (no) [27]. Similarly, the mini-EDHS

2019 classify children as zero dose children if not received any routine vaccine and otherwiseclassified as not zero dose children.

Media exposure: was assessed based on whether people had access to read newsletters, listen to
the radio, and watch TV. Accordingly, if they have access to all three media (newsletter, radio,
and TV) at least once a week, we categorized them as "yes", otherwise "no"[28].

Sampling method and procedure

The mini-EDHS 2019 sample was stratified and selected in two stages. Each region was stratified by urban and rural areas, with a total of 21 sampling strata. A total of 305 EAs, 93 EAs in urban areas, and 212 EAs in rural areas, were selected using proportional EA size allocation techniques. In the selected EAs, household listings were conducted. Then 30 households were selected per cluster using equal-probability systematic selection techniques. Finally, a multistage sampling method was used to select 3208 participants who had children aged 12-35 months in the selected EAs. The detailed section is reported in the mini EDHS 2019 report [29].

³ 130 **Data source, collection and quality assurance**

We used the secondary analysis of the mini-EDHS 2019 data set. This data was collected using a pretested structured interview technique from March 21 to June 28, 2019. The location of the data was also collected using a geographic positioning system (2 kilometers for urban clusters and 5 kilometers for rural clusters). To assure the quality of the data, pretesting and training for data collectors and supervisors were conducted. The detail section on data source, collection, and quality assurance has been reported in mini EDHS 2019 [29]. For the purpose of further analysis for the current study, data was requested online from the demographic health survey international at DHS's official website, http://www.dhsprogram.com. Then the data was accessed after 2

working days. After the data was accessed, variable selection, data cleaning, weighting the sample,
 recoding, and overall data management were conducted.
 Data processing and statistical analysis

After accessing the data from DHS International, cleaning, recoding, sampling weight, and missing data checking were conducted using STATA software version 14 and there was no missing data. Descriptive data was displayed by bar graph table and frequency. The "Svy" command was used as the sampling weight of cluster sampling. After this, multilevel (mixed-effect) binary logistic regression was used to identify the determinants for zero-dose children. The reason we used such a model was because of the hierarchical nature of the EDHS data and the possibility of considering a natural nesting of data. We built models like the null model (a model with an intercept/no predictors), model I (level one predictors), model II (a model with level two predictors), and model III (mixed effect model). The mixed effect model is:

Let y_{ij} denote the binary outcome for an individual *i* in neighborhood *j*, and assume y_{ij} follows a Bernoulli distribution with success probability p_{ij} or Binomial $(1, p_{ij})$. Using an appropriate link function such as logit, a binary outcome can be associated with linear predictors as the following, logit[$E(y_{ij})$] = logit(p_{ij}) = $\alpha_0 + X_{ij}\beta + Z_i\gamma + u_i$ [30].

155 Where $\alpha 0$ is the regular intercept, Xij β is the product of individual-level predictors and the 156 corresponding unknown parameters, and Zj γ is the product of neighborhood-level predictors and 157 the associated parameters. Within-neighborhood correlation is captured by uj which is usually 158 assumed to be a normally distributed random intercept with mean 0 and variance $\sigma 2u$ [31].

To test the clustering effect, the intra-class correlation coefficient was used with a cutoff of >0.05. (>5%). For each model, Intraclass correlation (ICC (ρ) = $\sigma^2 \epsilon/(\sigma^2 \epsilon + \sigma^2 \mu)$; $\sigma^2 \mu = \pi^2/3[32]$ was calculated. The clustering variable to show the clustering effect of zero-dose children was the

EDHS cluster (V001). The proportional change in variance (PCV=variance of the null model minus variance of the next model/variance in the null model*100), MOR=exp $\sqrt{2}$ x VA x 0.6745 $= \exp(0.95 \text{xVA})$ [32] and Akaike information criteria (AIC = 2k-2lnL, where k is the number of parameters and L is the maximum value of the likelihood function of the model) were also calculated. Then the best model was selected based on the lowest AIC value (Table 1). The significant variables were selected using the p-value less than 0.05 at 95%CL.

Table 1: A model comparison for zero dose children in Ethiopia using mini-EDHS 2019.

19 Random effect	Null model	Model I	Model II	Model III
20 21 Variance	0.27	0.199	0.21	0.118
22 ICC	38%	19%	31%	7.8%
²³ PCV (%)	Reference	26.3%	22.2%	56.3%
MOR MOR	19.8	1.93	3.56	1.67
26 Log likelihood	-1950	-1904	-1920	-1889
27 AIC	3905	3826	3848	3801
²⁸ 169			L	

28 29	169	
30 31	170	Results
32 33 34	171	Characteristics of the participants
35 36	172	Among a total of 3028 participants, about half, 1648 (51.4%), had no education. About 1447

(45.1%) and 2316 (72.2%) of them gave birth at home and had no ANC visit, respectively.

Furthermore, 1594 (49.7%) and 2442 (76.1%) of the participants had poor wealth index and were

from rural residence, respectively (Table-2).

Table-2: characteristics of the participants among women who had child aged 12-35 months

old in Ethiopia using mini-EDHS 2019.

Variable	Category	Weighted frequency	%
Wealth index	Poor	1594	49.7
	Middle	449	14
	Rich	1,165	36.3
Residence	Urban	766	23.9
	Rural	2442	76.1

2 3				1 (10	51 4
3 4		Educational status	No education	1648	51.4
			Primary	1080	33.7
6			Secondary	296	9.2
7			Higher	184	57
8		Religion	Orthodox	070	20
9		Kengloli	Catholio	18	29
10				10	0.0
11			Protestant	288	18.3
12			Muslim	1633	50.9
13 14			Traditional	32	1
15			Other	8	0.2
16		Region	Tigray	261	8.1
17		1	Afar	371	11.6
18			Amhara	20/	0.2
19			Oromia	209	9.2 12.4
20			Compli	290 201	12.4
21			Somali	321	10
22			Benishangul Gumuz	289	9
25 24			SNNPR	360	11.2
25			Gambela	247	7.7
26			Harari	251	7.8
27			Addis Ababa	180	5.6
28			Diredawa	236	74
29		Age	15-24 years	931	29
30		1160	25-34 years	1 719	53.6
31			> 35 years	558	17.4
32		ANC visit	Ves	802	27.8
27 22			No	2316	72.2
35		Place of delivery	Homo	1447	12.2
36		Flace of delivery	Hould facility	1447	45.1
37			Health facility	1/01	34.9
38		Media exposure	Yes	1501	48.0
39			N0	164/	51.4
40		Delivery by cesarean	No	3001	93.5
41 42		section	Yes	207	6.5
4Z 13		Currently breast feed	Yes	2376	74.1
44		-	No	832	25.9
45		Current pregnant	Yes	316	9.9
46			No	2892	90.1
47	178				
48 40					
50	179	Prevalence of zero dos	e children in Ethiopia		
51	100	The massel	laga abilduru - 1''	Idman a sa 1 10 25 (1	ald was 16 20/ (050/ OT
52 52	180	i ne prevalence of zero o	lose children among chi	laren agea 12-35 months	s old was 16.3% (95%Cl,
55 54	181	15%–17.6%) (Fig-1)			

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182	Fig-1: Prevalence of zero	dose children in Ethio	pia using mini-EDHS 2019.
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183 Factors associated with zero dose children

In the multivariable multilevel binary logistic regression analysis, wealth index, educational status, place of delivery, residence, media exposure, and ANC visit were the significant factors for zero-dose children in Ethiopia at a p-value of less than 0.05. Women with no ANC follow-up was 1.55 (AOR = 1.55, 95% CI: 1.02-2.35, p-value of < 0.001) times higher odds of zero does child than who had an ANC visit. Women with no education were 1.47 (AOR =1.47, 95% CI: 1.11–1.95, p-value of 0.0067) times higher odds of zero dose child than those who had secondary and above educational levels. Women who gave birth at home were 1.39 (AOR =1.39, 95% CI: 1.04–1.86, p-value of < 0.001) times higher odds of zero dose child than women who gave birth at the health facility. Women who had a poor wealth index were also 2.15 times (AOR = 2.15, 95% CI: 1.62– 2.85, p-value of 0.0078) higher odds of zero-dose child than rich women. Also, women from a low proportion of community media exposure were 1.39 (AOR =1.39, 95% CI: 1.13–1.71, p-value of<0.001) times higher odds of a zero-dose child than women from a high proportion of community media exposure. Furthermore, the women from the rural residence were 2.29 (AOR =2.29, 95% CI: 1.53-3.42, p-value of 0.004) times higher odds of zero-dose child than those among urban women (Table-3).

Table: 3 individual and community level maternal factors of zero dose children in Ethiopia using mini-EDHS-2019

Variables	Null	Model I	Model II	Model III(mixed)	p-value
	model				
ANC follow-up		AOR	AOR	AOR	
No		(95%CI)	(95%CI)	(95%CI)	
Yes		1.51(0.99, 2.29)		1.55 (1.02, 2.35)*	< 0.001
		Reference		Reference	

Residence				
Rural		3.78(2.59,	2.29 (1.53, 3.42)*	0.004
Urban		5.53) Reference	Reference	
Place of delivery				
Home	1.4(1.05, 1.88)		1.39 (1.04, 1.86)*	< 0.001
Health facility	Reference		Reference	
Community media				
exposure		1.34(1.13,	1.39 (1.13, 1.71)*	< 0.001
Low proportion of media		1.62)	Reference	
exposure		Reference		
High proportion of media				
exposure				
Wealth index				
Poor	2.99 (2.31, 3.87)		2.15 (1.62, 2.85)*	0.0078
Middle	1.3 (1.37, 2.48)		1.42 (0.94, 1.94)	
Rich				
	Reference		Reference	
Current breast feeding				
No	1.07(0.68, 2.12)		1.01(0.74, 1.29)	0.21
Yes	Reference		Reference	
Educational status				
No education	1.27(0.97, 1.64)		1.47(1.11, 1.95)*	0.0067
Primary education	0.88(0.69, 1.12)		0.95(0.75, 1.21)	
Secondary and above	Reference		Reference	
Current pregnancy				
No	1.59 (1.01,2.51)		1.9 (0.84, 2.49)	0.34
Yes	Reference	5	Reference	

Discussion

The prevalence of zero dose children among children aged 12-35 months old was 16.3%. Variables like urban residence, no education, home delivery, poor wealth index, no ANC visit, and women from low proportions of community media exposure were the risk factors for zero-dose children in Ethiopia. Therefore, expanding maternal health services and media access for women is highly recommended to reduce zero-dose children. Thus, the prevalence of zero dose children among children aged 12-35 months old was 16.3% (95% CI, 15%-17.6%). This finding was in line with a study conducted in Sub-Saharan Africa (16.5%) [1]. But it was lower than a study conducted in

Togo (26.88%) [33] and the WHO/UNICEF Estimates of National Immunization Coverage 2021 report, which estimated that 30% of surviving infants in Ethiopia were zero-dose children [34]. This might be because in the previous study, the vaccination card was considered to declare the vaccination status of the child, but the mother's report was not considered. This may overestimate the previous finding. The current finding was also lower than a study conducted in Cameroon (91.7%) [35]. The possible reason for the discrepancy might be that the study done in Cameroon was conducted in an area where access to health services is very low (the remote rural districts, the homeless population, and immigrants). This segment of the population is suffering from a lack of basic health services, including immunization. This causes a higher prevalence of zero dose children among children. In Ethiopia between 2000 and 2019, the basic vaccination coverage had progressed from 14.3% to 44.1%. The vaccination coverage was estimated to reach 53.6% by 2025; the reduction in zero dose child implies a significant improvement in vaccination coverage [36].

223 [36].

Regarding the factors associated with a zero-dose child, it was found that the odds of a zero-dose vaccine were higher among women who delivered at home than those who delivered at a health facility. This finding was supported by a study conducted in Cameroon [35], a study conducted in sub-Saharan Africa [1] and Ethiopia [37]. This can be explained by the fact that women who give birth at home miss childhood vaccines, including birth doses, and they may not get counselling on childhood vaccines, such as the advantages of vaccination, schedules of vaccine doses, and other related information. Moreover, home delivery may have a negative effect on the subsequent health-seeking behavior of women

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The odds of a zero-dose child among poor wealth index women were more likely than those among rich wealth index women. This was supported by a study conducted in low- and middle-income countries [38]. This may be justified by the fact that women with low socioeconomic status have a lower acceptability of health-related messages and a lower understanding of the vaccination advantage [39]. Also, women who had no ANC follow-up were more likely to not vaccinate their child at all than women who had ANC follow-up. This finding is supported by a study conducted in India [40] and a study conducted among 82 low- and middle-income countries [41]. This might be associated with the fact that women who do not attend ANC could not get counselling and education services about the advantages and the time schedule of all basic vaccine doses. Alternatively, women who do not attend the ANC service are more likely to not attend health services after birth as well.

Additionally, the odds of zero-dose children among women who were from low proportions of community media exposure were higher than those among women who were from high proportions of community media exposure. This finding was supported by a study conducted in Indonesia [42]. The possible justification for this association may be due to a lack of media access in the community, which could negatively affect knowledge about the advantages and schedule of the childhood vaccine. Alternatively, women who are from low-community media exposure may miss key information released through media outlets. In return, they are more prone to not vaccinating all doses of vaccine for their children. Additionally, mass media exposure, such as through television, radio, newspapers, and the internet, in the community plays an important role in changing the community's attitude, opinion, awareness, and health service-seeking behavior. But women with a low proportion of community media exposure may lack these advantages. In addition, women who had no education also had higher odds of not vaccinating all doses of

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vaccines for their child than women who had secondary or higher educational levels. A previous study conducted in Nigeria also reported that as educational levels increased, the zero-dose vaccine status decreased [43]. This may be because educational status is highly correlated with the knowledge and acceptance rate of vaccination [44]. Additionally, low educational status could be a barrier to accessing health services, including childhood vaccination. Furthermore, this study revealed that women who were from rural areas were more likely to not vaccinate their children at all than urban women. The access to health services is guite different between urban and rural [45]. This is due to the barriers to accessing preventive services in the rural areas, for example, lack of transportation, the far distance of health institutions, and the lack of adequate health professionals in rural areas who deliver the service [46, 47]. This study had several limitation for example; recall bias, unable to show cause-effect relationship and some clinically important variables were missed in the analysis. This bias/error was different in size and direction or the effect was not the same for groups in the study. Even though such limitations, the study provides an important tool for designing strategies and policies to reduce the number of zero-dose children in Ethiopia Therefore, expanding maternal health services and media access for women is highly recommended to reduce zero-dose child.

⁾ 271 Conclusion

As compared to the previous studies, the prevalence of zero dose children was low in Ethiopia. Variables like urban residence, no education, home delivery, poor wealth index, no ANC visit, and women from low proportions of community media exposure were the risk factors for zero-dose children in Ethiopia. Therefore, expanding maternal health services and media access for women is highly recommended to reduce zero-dose child.

277 Ethical declaration

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278	Ethical approval
279	Since it was a secondary data analysis of EDHS, informed consent from the participants was not
280	applicable. Rather, data requests and approval for access were obtained from DHS International.
281	All data were fully anonymized before we accessed informed consent from DHS international.
282	Consent for publication
283	Not required.
284	Data availability statement
285	All relevant data is available in the manuscript.
286	Conflict of interest
287	The author declares no conflict of interest
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289	No
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19 20	308	Kidie Tesfie
21 22 23	309	Muluken chanie Agimas (MCA) is guarantor of this article.
24 25	310	Abbreviation and acronym
26 27	311	AICAkaike information criteria
28 29 30	312	ANCAntenatal Care
31 32	313	DHSDemographic Health Survey
33 34	314	EAsEnumeration Areas
35 36 37	315	EDHSEthiopian Demographic Health Survey
38 39	316	LLRLog Likelihood Ratio
40 41	317	SNNPRSouth Nation and Nationality of People Representative
42 43 44	318	VPDsVaccine Preventable Diseases
45 46 47	319	Reference
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Fig-1: Prevalence of zero dose children in Ethiopia using EDHS 2019.

