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Complete List of Authors:	Agimas, Muluken Chanie; University of Gondar College of Medicine and Health Sciences, epidemiology; University of Gondar College of Medicine and Health Sciences, epidemiology Alemayehu, Meron Asmamaw; University of Gondar, Epidemiology Tesfie, Tigabu Kidie; University of Gondar, Department of Epidemiology and Biostatistics Tilahun, Werkneh Melkie ; Debre Markos University, Department of Public Health Asferie, Worku; Debre Tabor University, Departments of pediatric and neonatal Nursing Aweke, Mekuriaw Nibret; University of Gondar, Department of Nutrition ABEBE, MOGES; Debark University, Department of Nursing Yalew, Anteneh; Wolkite University, Department of Public health
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Individual and community level maternal factors for zero dose children in Ethiopia using EDHS 2019: A mixed effect model

Muluken Chanie Agimas[1], Meron Asmamaw Alemayehu[1], Tigabu Kidie Tesfie[1], Werkneh Melkie Tilahun[2], Worku Necho Asferie[4], Mekuriaw Nibret Aweke[6], Moges Tadesse Abebe[3], Anteneh Kassa yalew[5]

[1]Department of Epidemiology and Biostatistics, institute of public health, college of medicine and health science, university of Gondar, Gondar, Ethiopia.

[2]Department of Public Health, College of Medicine and Health Sciences, Debre Markos University, Debre Markos, Ethiopia.

[3]Department of Nursing, College of Health Science, Debark University, Debark, Ethiopia.

[4]Departments of pediatric and neonatal Nursing, College of Health Science, Debre Tabor University, Debre Tabor, Ethiopia

[5]Department of Public health, college of medicine and Health science, Wolkite University, Wolkite, Ethiopia.

[6]Department 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

Abstract

Introduction: Zero-dose children refer to a child who has not yet received any childhood vaccines. Globally, zero-dose vaccination status is the major public health problem. In sub-Saharan African countries, among five children, one did not access the vaccines. But the efforts to identify the factors contributing to the zero-dose child are not well addressed in Ethiopia.

Objectives: To assess individual and community-level maternal factors of zero-dose children in Ethiopia using EDHS 2019.

Methods: A secondary analysis of a cross-sectional study was used among a total of 3208 participants. The STATA-14 was used for descriptive and multilevel binary logistic regression (mixed effect model) analysis. Model selection was conducted using AIC. To identify significant factors for zero-dose children, a p-value of <0.05 with 95% confidence was used.

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

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.

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

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 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].

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

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.

Methods

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

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].

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.

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. 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:

Logit (Yij)=β0j+∑βXi+ ϒZj+εj, where β0j=β0 + μj, μj~N (0, σ2 u) [30].

Where εj=ε0+εj, εj~N (0, σ2 ε)

Logit (Yij) =ln(Yij/(1-Yij)) or log odds of zero dose child, (Yij)= the probability of zero dose child for women "i" in the enumeration area and residence of rural and urban region "j".

β0j=random intercept of the cluster "j"

"εj"=residual for each cluster "j"

"β"= the fixed effect regression coefficient

"Xi"= level one predictor

"ϒZj"=level II predictor for clusters

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) = σ2 ε/σ2 ε +σ2μ [31] 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) [31] 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).** A bi-variable multilevel binary logistic regression analysis was conducted to select the potential candidate variable for multivariable multilevel binary logistic regression analysis at a p-value of <0.25. In the multivariable multilevel binary logistic regression analysis, the significant predictors were selected using a p-value of < 0.05. To estimate the effect measure of each predictor, an AOR with a 95% confidence level was used.

Table 1: A **model comparisons for zero dose children in Ethiopia using EDHS 2019.**

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 EDHS 2019.

Prevalence of zero dose children in Ethiopia

The prevalence of zero-dose vaccination status among children aged 12-35 months old was 523 (16.3%, 95%CI, 15%–17.6%) **(Fig-1).**

Fig-1: Prevalence of zero dose children in Ethiopia using EDHS 2019.

Factors associated with zero dose children

Before we started to use the multilevel binary logistic regression analysis, the clustering of zero-dose vaccination status was checked using the clustering variable of the EDHS cluster (V001). Thus, the ICC value for a model with an intercept (the null model) was 0.38 (38%). This implies that there was enough evidence to use multilevel binary logistic regression analysis. Four models were built: the null model (a model with only an intercept), model I (a model with individual-level factors), model II (a model with community-level factors), and model III (a model with a mixed individual- and community-level factor). For each model, ICC, PCV, LLR, variance and AIC were calculated. The model comparison was done with the lowest AIC value. The mixed model (model III) had the lowest AIC value (AIC = 3801). Additionally, the PCV, ICC, and LLR for the best model (mixed effect model) were 56.3%, 7.8%, and -1889, respectively **(Table-1).**

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 zero-dose 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

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

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.

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 health-seeking behavior of women

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 [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

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.

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.

Ethical declaration

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.

Consent for publication

Not required

Data availability statement

All relevant data is available in the manuscript.

Conflict of interest

The author declare no conflict of interest

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Author Contributions

Conceptualization: Muluken Chanie Agimas

Formal analysis: Muluken Chanie Agimas, Meron Asmamaw Alemayewhu, Tigabu Kidie Tesfie, Werkneh Melkie Tilahun

Investigation: Muluken Chanie Agimas and Meron Asmamaw Alemayewhu

Methodology: Muluken Chanie Agimas, Worku Necho Asferie, Mekuriaw Nibret Aweke, Moges Tadesse Abebe, Anteneh Kassa yalew, Tigabu Kidie Tesfie

Software: Muluken Chanie Agimas, Werkneh Melkie Tilahun, Worku Necho Asferie, Mekuriaw Nibret Aweke, Moges Tadesse Abebe, Anteneh Kassa yalew, Tigabu Kidie Tesfie

Supervision: Muluken Chanie Agimas, Anteneh Kassa yalew

Validation: Muluken Chanie Agimas, Worku Necho Asferie, Mekuriaw Nibret Aweke, Moges Tadesse Abebe, Anteneh Kassa yalew, Tigabu Kidie Tesfie

Visualization: Muluken Chanie Agimas, Worku Necho Asferie, Mekuriaw Nibret Aweke, Moges Tadesse Abebe, Anteneh Kassa yalew

Writing – review & editing: Muluken Chanie Agimas, Worku Necho Asferie, Mekuriaw Nibret Aweke, Moges Tadesse Abebe, Anteneh Kassa yalew, Meron Asmamaw Alemayewhu, Tigabu Kidie Tesfie

Abbreviation and acronym

AIC……Akaike information criteria

ANC……Antenatal Care

DHS…..Demographic Health Survey

EAs-……Enumeration Areas

EDHS……Ethiopian Demographic Health Survey

LLR……Log Likelihood Ratio

SNNPR……South Nation and Nationality of People Representative

VPDs……..Vaccine Preventable Diseases

Reference

1. Ozigbu, C.E., et al., *Correlates of Zero-Dose Vaccination Status among Children Aged 12–59 Months in Sub-Saharan Africa: A Multilevel Analysis of Individual and Contextual Factors.* 2022. **10**(7): p. 1052.
2. Antai, D.J.B.i.d., *Inequitable childhood immunization uptake in Nigeria: a multilevel analysis of individual and contextual determinants.* 2009. **9**: p. 1-10.
3. Wiysonge, C.S., et al., *Individual and contextual factors associated with low childhood immunisation coverage in sub-Saharan Africa: a multilevel analysis.* 2012. **7**(5): p. e37905.
4. Bobo, F.T., et al., *Child vaccination in sub-Saharan Africa: Increasing coverage addresses inequalities.* 2022. **40**(1): p. 141-150.
5. Fokoun, C.J.H.V. and Immunotherapeutics, *Strategies implemented to address vaccine hesitancy in France: a review article.* 2018. **14**(7): p. 1580-1590.
6. Nathanson, N. and O.M.J.A.j.o.e. Kew, *From emergence to eradication: the epidemiology of poliomyelitis deconstructed.* 2010. **172**(11): p. 1213-1229.
7. Kretsinger, K., et al., *Polio eradication in the World Health Organization African Region, 2008–2012.* 2014. **210**(suppl_1): p. S23-S39.

8. Waziri, N.E., et al., *Polio eradication in Nigeria and the role of the National Stop Transmission of Polio program, 2012–2013.* 2014. **210**(suppl_1): p. S111-S117.
9. Brownwright, T.K., Z.M. Dodson, and W.G.J.B.p.h. van Panhuis, *Spatial clustering of measles vaccination coverage among children in sub-Saharan Africa.* 2017. **17**(1): p. 1-7.
10. Wobudeya, E., et al., *Epidemiology of tuberculosis in children in Kampala district, Uganda, 2009–2010; a retrospective cross-sectional study.* 2015. **15**: p. 1-8.
11. Mihigo, R., et al., *Routine immunization in the WHO African region: progress, challenges and way forward.* 2015. **19**(2): p. 2-7.
12. Organization, W.H., *WHO UNICEF coverage estimates WHO World Health Organization: Immunization, Vaccines and Biologicals. Vaccine preventable diseases Vaccines monitoring system 2019 Global Summary Reference Time Series: DTP3.[Cited 2020 Feb 12]*. 2012.
13. Rachlin, A., et al., *Routine vaccination coverage—worldwide, 2021.* 2022. **71**(44): p. 1396.
14. Jheeta, M. and J.J.B.o.t.W.H.O. Newell, *Childhood vaccination in Africa and Asia: the effects of parents' knowledge and attitudes*. 2008, SciELO Public Health. p. 419-419A.
15. Lindstrand, A., et al., *Implementing the immunization agenda 2030: a framework for action through coordinated planning, monitoring & evaluation, ownership & accountability, and communications & advocacy.* 2023.
16. *WHO/UNICEF Estimates of National Immunization Coverage (WUENIC), progress and challenges with Achieving Universal Immunization Coverage, URL: https://www.who.int/publications/m/item/progress-and-challenges* 2022.
17. Chido-Amajuoyi, O.G., et al., *Prevalence and correlates of never vaccinated Nigerian children, aged 1–5 years.* 2018. **36**(46): p. 6953-6960.
18. Cata-Preta, B.O., et al., *Zero-dose children and the immunisation cascade: Understanding immunisation pathways in low and middle-income countries.* 2021. **39**(32): p. 4564-4570.
19. Arambepola, R., et al., *Using geospatial models to map zero-dose children: Factors associated with zero-dose vaccination status before and after a mass measles and rubella vaccination campaign in Southern province, Zambia.* 2021. **6**(12): p. e007479.
20. Galles, N.C., et al., *Measuring routine childhood vaccination coverage in 204 countries and territories, 1980–2019: a systematic analysis for the Global Burden of Disease Study 2020, Release 1.* 2021. **398**(10299): p. 503-521.
21. Murhekar, M.V. and M.S.J.T.L.G.H. Kumar, *Reaching zero-dose children in India: Progress and challenges ahead.* 2021. **9**(12): p. e1630-e1631.
22. Johri, M., S. Rajpal, and S.J.T.L.G.H. Subramanian, *Progress in reaching unvaccinated (zero-dose) children in India, 1992–2016: a multilevel, geospatial analysis of repeated cross-sectional surveys.* 2021. **9**(12): p. e1697-e1706.
23. VanderEnde, K., et al., *Global routine vaccination coverage—2017.* 2018. **67**(45): p. 1261.
24. *Gavi. Reaching zero-dose children.Accessed from: https://www.gavi.org/ouralliance/strategy/phase-5-2021-2025/equity-goal/zero-dose-children-missed-communities on 2 February, 2024.*
25. Nour, T.Y., et al., *Predictors of immunization coverage among 12–23 month old children in Ethiopia: systematic review and meta-analysis.* 2020. **20**(1): p. 1-19.
26. Alfaro-Murillo, J.A., et al., *The case for replacing live oral polio vaccine with inactivated vaccine in the Americas.* 2020. **395**(10230): p. 1163-1166.
27. Francome, C., W.J.S.s. Savage, and medicine, *Caesarean section in Britain and the United States 12% or 24%: is either the right rate?* 1993. **37**(10): p. 1199-1218.

28. Fetene, S.M., T.J.B.P. Gebremedhin, and Childbirth, *Uptake of postnatal care and its determinants in Ethiopia: a positive deviance approach.* 2022. **22**(1): p. 601.
29. Indicators, K.J.E. and ICF, *Mini demographic and health survey.* 2019.
30. Derseh, N., K. Gelaye, and A. Muluneh, *Spatiotemporal Patterns and Determinants of Undernutrition Among Late Adolescent Girls in Ethiopia Using Ethiopian Demographic and Health Surveys 2000 to 2016: Spatiotemporal and Multilevel Approach.* 2021.
31. Merlo, J., et al., *A brief conceptual tutorial of multilevel analysis in social epidemiology: using measures of clustering in multilevel logistic regression to investigate contextual phenomena.* 2006. **60**(4): p. 290-297.
32. Mangbassim, N.T., et al., *Prevalence and factors associated with "zero-dose" in children 12 to 23 months in Togo.* 2023. **9**: p. 12.
33. Nchinjoh, S.C., et al., *Factors Associated with Zero-Dose Childhood Vaccination Status in a Remote Fishing Community in Cameroon: A Cross-Sectional Analytical Study.* 2022. **10**(12): p. 2052.
34. Moyer, C.A., et al., *The relationship between facility delivery and infant immunization in Ethiopia.* 2013. **123**(3): p. 217-220.
35. Hajizadeh, M.J.J.E.C.H., *Socioeconomic inequalities in child vaccination in low/middle-income countries: what accounts for the differences?* 2018.
36. Glewwe, P.J.J.o.h.r., *Why does mother's schooling raise child health in developing countries? Evidence from Morocco.* 1999: p. 124-159.
37. Krishnamoorthy, Y. and T.J.F.P. Rehman, *Impact of antenatal care visits on childhood immunization: a propensity score-matched analysis using nationally representative survey.* 2022. **39**(4): p. 603-609.
38. Farrenkopf, B.A., et al., *Understanding household-level risk factors for zero dose immunization in 82 low-and middle-income countries.* 2023. **18**(12): p. e0287459.
39. Machmud, P.B., et al., *Mother's Media Use and Children's Vaccination Status in Indonesia: A Community-Based Cross-Sectional Study.* 2022. **9**: p. 2333794X221092740.
40. Sato, R.J.V., *Geospatial and Time Trend of Prevalence and Characteristics of Zero-Dose Children in Nigeria from 2003 to 2018.* 2022. **10**(9): p. 1556.
41. Forshaw, J., et al., *The global effect of maternal education on complete childhood vaccination: a systematic review and meta-analysis.* 2017. **17**(1): p. 1-16.
42. Douthit, N., et al., *Exposing some important barriers to health care access in the rural USA.* 2015. **129**(6): p. 611-620.
43. Grant, R., et al., *Transportation barriers to child health care access remain after health reform.* 2014. **168**(4): p. 385-386.
44. Weigel, P.A., et al., *Variation in primary care service patterns by rural-urban location.* 2016. **32**(2): p. 196-203.

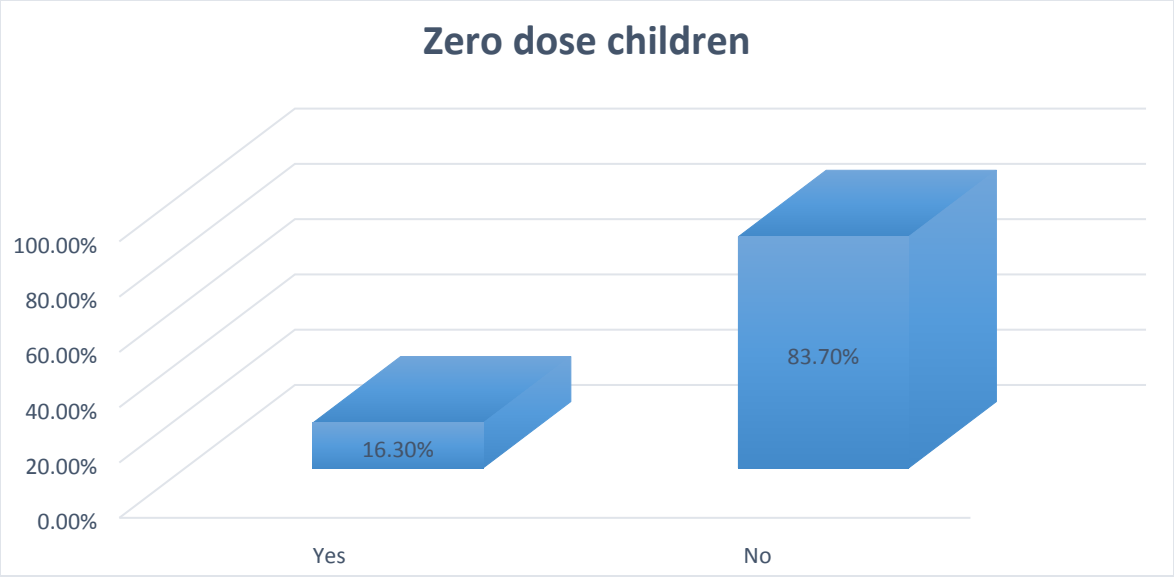

Fig-1: Prevalence of zero dose children in Ethiopia using EDHS 2019.

Table 1: A **model comparisons for zero dose children in Ethiopia using EDHS 2019.**

Random effect	Null model	Model I	Model II	**Model III**
Variance	0.27	0.199	0.21	**0.118**
ICC	38%	19%	31%	**7.8%**
PCV (%)	Reference	26.3%	22.2%	**56.3%**
Log likelihood	-1950	-1904	-1920	**-1889**
AIC	3905	3826	3848	**3801**

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
	Catholic	18	0.6
	Protestant	588	18.3
	Muslim	1633	50.9
	Traditional	32	1
	Other	8	0.2
Region	Tigray	261	8.1
	Afar	371	11.6
	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
	≥ 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 section	No	3001	93.5
	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

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

Variables	Null model	Model I	Model II	Model III(mixed)
ANC follow-up				
No		1.51(0.99, 2.29)		**1.55(1.02, 2.36)***
Yes		Reference		Reference
Residence				
Rural			3.78(2.59, 5.53)	**2.29 (1.53, 3.42)***
Urban			Reference	Reference
Place of delivery				
Home		1.4(1.05, 1.88)		**1.39 (1.04, 1.86)***
Health facility		Reference		Reference
Community media exposure				
Low proportion of media exposure			1.34(1.13, 1.62)	**1.39 (1.13, 1.71)***
High proportion of media exposure			Reference	Reference
Wealth index				
Poor		2.99 (2.31, 3.87)		**2.15 (1.62, 2.85)***
Middle		1.3 (1.37, 2.48)		1.42 (0.94, 1.91)
Rich		Reference		Reference
Current breast feeding				
No		1.07(0.68, 2.12)		1.01(0.74, 1.23)
Yes		Reference		Reference
Educational status				
No education		1.27(0.97, 1.64)		**1.47(1.11, 1.93)***
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)
Yes		Reference		Reference

Note: * statistically significant variables

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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 Agimas[1], Meron Asmamaw Alemayehu[1], Tigabu Kidie Tesfie[1], Werkneh Melkie Tilahun[2], Worku Necho Asferie[4], Mekuriaw Nibret Aweke[6], Moges Tadesse Abebe[3], Anteneh Kassa yalew[5]

[1]Department of Epidemiology and Biostatistics, institute of public health, college of medicine and health science, university of Gondar, Gondar, Ethiopia.

[2]Department of Public Health, College of Medicine and Health Sciences, Debre Markos University, Debre Markos, Ethiopia.

[3]Department of Nursing, College of Health Science, Debark University, Debark, Ethiopia.

[4]Departments of pediatric and neonatal Nursing, College of Health Science, Debre Tabor University, Debre Tabor, Ethiopia

[5]Department of Public health, college of medicine and Health science, Wolkite University, Wolkite, Ethiopia.

[6]Department 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

Abstract

Introduction: Zero-dose children refer to a child who has not yet received any childhood vaccines. Globally, zero-dose children are the major public health problem. In sub-Saharan African countries, among five children, one did not access the vaccines. But the efforts to identify the factors contributing to the zero-dose child are not well addressed in Ethiopia.

Objectives: To assess individual and community-level maternal factors of zero-dose children in Ethiopia using mini-EDHS 2019.

Methods: A secondary analysis of a cross-sectional study was used among a total of 3208 participants. The STATA-14 was used for descriptive and multilevel binary logistic regression (mixed effect model) analysis. Model selection was conducted using AIC. To identify significant 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.

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 mortality.

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

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.

Objectives

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

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

Methods

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 otherwise classified 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].

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_{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, $\text{logit}[E(y_{ij})] = \text{logit}(p_{ij}) = \alpha_0 + X_{ij}\beta + Z_j\gamma + u_j$ [30].

Where α0 is the regular intercept, Xijβ is the product of individual-level predictors and the corresponding unknown parameters, and Zjγ 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) = σ^2 ε/(σ^2 ε +σ^2 μ); $\sigma^2\mu=\pi^2/3$[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 √2 x VA x 0.6745 = exp (0.95xVA) [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.**

Random effect	Null model	Model I	Model II	**Model III**
Variance	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 likelihood	-1950	-1904	-1920	**-1889**
AIC	3905	3826	3848	**3801**

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	184	5.7
Religion	Orthodox	929	29
	Catholic	18	0.6
	Protestant	588	18.3
	Muslim	1633	50.9
	Traditional	32	1
	Other	8	0.2
Region	Tigray	261	8.1
	Afar	371	11.6
	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
	≥ 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 section	No	3001	93.5
	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 children in Ethiopia

The prevalence of zero dose children among children aged 12-35 months old was 16.3% (95%CI, 15%–17.6%) **(Fig-1).**

Fig-1: Prevalence of zero dose children in Ethiopia using mini-EDHS 2019.

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	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, 5.53)	**2.29 (1.53, 3.42)***	0.004
Urban				Reference	

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

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].

[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

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

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

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.

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.

Ethical declaration

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 anonymized before we accessed informed consent from DHS international.

Consent for publication

Not required.

Data availability statement

All relevant data is available in the manuscript.

Conflict of interest

The author declares no conflict of interest

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Author Contributions

Conceptualization: Muluken Chanie Agimas

Formal analysis: Muluken Chanie Agimas, Meron Asmamaw Alemayewhu, Tigabu Kidie Tesfie, Werkneh Melkie Tilahun

Investigation: Muluken Chanie Agimas and Meron Asmamaw Alemayewhu

Methodology: Muluken Chanie Agimas, Worku Necho Asferie, Mekuriaw Nibret Aweke, Moges Tadesse Abebe, Anteneh Kassa yalew, Tigabu Kidie Tesfie

Software: Muluken Chanie Agimas, Werkneh Melkie Tilahun, Worku Necho Asferie, Mekuriaw Nibret Aweke, Moges Tadesse Abebe, Anteneh Kassa yalew, Tigabu Kidie Tesfie

Supervision: Muluken Chanie Agimas, Anteneh Kassa yalew

Validation: Muluken Chanie Agimas, Worku Necho Asferie, Mekuriaw Nibret Aweke, Moges Tadesse Abebe, Anteneh Kassa yalew, Tigabu Kidie Tesfie

Visualization: Muluken Chanie Agimas, Worku Necho Asferie, Mekuriaw Nibret Aweke, Moges Tadesse Abebe, Anteneh Kassa yalew

Writing – review & editing: Muluken Chanie Agimas, Worku Necho Asferie, Mekuriaw Nibret Aweke, Moges Tadesse Abebe, Anteneh Kassa yalew, Meron Asmamaw Alemayewhu, Tigabu Kidie Tesfie

Muluken chanie Agimas (MCA) is guarantor of this article.

Abbreviation and acronym

AIC……Akaike information criteria

ANC……Antenatal Care

DHS…..Demographic Health Survey

EAs-……Enumeration Areas

EDHS……Ethiopian Demographic Health Survey

LLR……Log Likelihood Ratio

SNNPR……South Nation and Nationality of People Representative

VPDs……..Vaccine Preventable Diseases

Reference

1. Ozigbu, C.E., et al., *Correlates of Zero-Dose Vaccination Status among Children Aged 12–59 Months in Sub-Saharan Africa: A Multilevel Analysis of Individual and Contextual Factors.* 2022. **10**(7): p. 1052.
2. Antai, D.J.B.i.d., *Inequitable childhood immunization uptake in Nigeria: a multilevel analysis of individual and contextual determinants.* 2009. **9**: p. 1-10.
3. Wiysonge, C.S., et al., *Individual and contextual factors associated with low childhood immunisation coverage in sub-Saharan Africa: a multilevel analysis.* 2012. **7**(5): p. e37905.
4. Bobo, F.T., et al., *Child vaccination in sub-Saharan Africa: Increasing coverage addresses inequalities.* 2022. **40**(1): p. 141-150.
5. Fokoun, C.J.H.V. and Immunotherapeutics, *Strategies implemented to address vaccine hesitancy in France: a review article.* 2018. **14**(7): p. 1580-1590.
6. Nathanson, N. and O.M.J.A.j.o.e. Kew, *From emergence to eradication: the epidemiology of poliomyelitis deconstructed.* 2010. **172**(11): p. 1213-1229.
7. Kretsinger, K., et al., *Polio eradication in the World Health Organization African Region, 2008–2012.* 2014. **210**(suppl_1): p. S23-S39.
8. Waziri, N.E., et al., *Polio eradication in Nigeria and the role of the National Stop Transmission of Polio program, 2012–2013.* 2014. **210**(suppl_1): p. S111-S117.
9. Brownwright, T.K., Z.M. Dodson, and W.G.J.B.p.h. van Panhuis, *Spatial clustering of measles vaccination coverage among children in sub-Saharan Africa.* 2017. **17**(1): p. 1-7.
10. Wobudeya, E., et al., *Epidemiology of tuberculosis in children in Kampala district, Uganda, 2009–2010; a retrospective cross-sectional study.* 2015. **15**: p. 1-8.
11. Mihigo, R., et al., *Routine immunization in the WHO African region: progress, challenges and way forward.* 2015. **19**(2): p. 2-7.
12. Organization, W.H., *WHO UNICEF coverage estimates WHO World Health Organization: Immunization, Vaccines and Biologicals. Vaccine preventable diseases Vaccines monitoring system 2019 Global Summary Reference Time Series: DTP3.[Cited 2020 Feb 12]*. 2012.
13. Rachlin, A., et al., *Routine vaccination coverage—worldwide, 2021.* 2022. **71**(44): p. 1396.
14. Jheeta, M. and J.J.B.o.t.W.H.O. Newell, *Childhood vaccination in Africa and Asia: the effects of parents' knowledge and attitudes*. 2008, SciELO Public Health. p. 419-419A.
15. *WHO/UNICEF Estimates of National Immunization Coverage (WUENIC), progress and challenges with Achieving Universal Immunization Coverage, URL: https://www.who.int/publications/m/item/progress-and-challenges*

2022.
16. Chido-Amajuoyi, O.G., et al., *Prevalence and correlates of never vaccinated Nigerian children, aged 1–5 years.* 2018. **36**(46): p. 6953-6960.
17. Cata-Preta, B.O., et al., *Zero-dose children and the immunisation cascade: understanding immunisation pathways in low and middle-income countries.* 2021. **39**(32): p. 4564-4570.
18. Arambepola, R., et al., *Using geospatial models to map zero-dose children: Factors associated with zero-dose vaccination status before and after a mass measles and rubella vaccination campaign in Southern province, Zambia.* 2021. **6**(12): p. e007479.
19. Galles, N.C., et al., *Measuring routine childhood vaccination coverage in 204 countries and territories, 1980–2019: a systematic analysis for the Global Burden of Disease Study 2020, Release 1.* 2021. **398**(10299): p. 503-521.
20. Murhekar, M.V. and M.S.J.T.L.G.H. Kumar, *Reaching zero-dose children in India: Progress and challenges ahead.* 2021. **9**(12): p. e1630-e1631.

21. Johri, M., S. Rajpal, and S.J.T.L.G.H. Subramanian, *Progress in reaching unvaccinated (zero-dose) children in India, 1992–2016: a multilevel, geospatial analysis of repeated cross-sectional surveys.* 2021. **9**(12): p. e1697-e1706.
22. VanderEnde, K., et al., *Global routine vaccination coverage—2017.* 2018. **67**(45): p. 1261.
23. García-Moreno, C., et al., *Global and regional estimates of violence against women: prevalence and health effects of intimate partner violence and non-partner sexual violence*. 2013: World Health Organization.
24. Nour, T.Y., et al., *Predictors of immunization coverage among 12–23 month old children in Ethiopia: systematic review and meta-analysis.* 2020. **20**(1): p. 1-19.
25. Alfaro-Murillo, J.A., et al., *The case for replacing live oral polio vaccine with inactivated vaccine in the Americas.* 2020. **395**(10230): p. 1163-1166.
26. Kanté, A.M., et al., *Factors associated with compliance with the recommended frequency of postnatal care services in three rural districts of Tanzania.* 2015. **15**: p. 1-10.
27. Azie, J.I., et al., *Reaching zero-dose children.* 2024. **8**(85): p. 85.
28. Fetene, S.M., T.J.B.P. Gebremedhin, and Childbirth, *Uptake of postnatal care and its determinants in Ethiopia: a positive deviance approach.* 2022. **22**(1): p. 601.
29. Indicators, K.J.E. and ICF, *Mini demographic and health survey.* 2019.
30. H., A., *A new look at the statistical model identification. IEEE transactions on automatic control. ;19(6):716-23.* 1974 Dec.
31. H., G., *Multilevel statistical models. John Wiley & Sons; 2011 Jul 8.*
32. Merlo, J., et al., *A brief conceptual tutorial of multilevel analysis in social epidemiology: using measures of clustering in multilevel logistic regression to investigate contextual phenomena.* 2006. **60**(4): p. 290-297.
33. Mangbassim, N.T., et al., *Prevalence and factors associated with "zero-dose" in children 12 to 23 months in Togo.* 2023. **9**: p. 12.
34. *WHO/UNICEF. national immunization estimate.* 2021.
35. Nchinjoh, S.C., et al., *Factors Associated with Zero-Dose Childhood Vaccination Status in a Remote Fishing Community in Cameroon: A Cross-Sectional Analytical Study.* 2022. **10**(12): p. 2052.
36. Berhanel, Y., A. Bekele, and F.J.E.M.J. Tesfaye,, *Immunization (EPI) in Ethiopia: acceptance, coverage, and sustainability. 2000. 38: p. 1-60.*
37. Moyer, C.A., et al., *The relationship between facility delivery and infant immunization in Ethiopia.* 2013. **123**(3): p. 217-220.
38. Hajizadeh, M.J.J.E.C.H., *Socioeconomic inequalities in child vaccination in low/middle-income countries: what accounts for the differences?* 2018.
39. Glewwe, P.J.J.o.h.r., *Why does mother's schooling raise child health in developing countries? Evidence from Morocco.* 1999: p. 124-159.
40. Krishnamoorthy, Y. and T.J.F.P. Rehman, *Impact of antenatal care visits on childhood immunization: a propensity score-matched analysis using nationally representative survey.* 2022. **39**(4): p. 603-609.
41. Farrenkopf, B.A., et al., *Understanding household-level risk factors for zero dose immunization in 82 low-and middle-income countries.* 2023. **18**(12): p. e0287459.
42. Machmud, P.B., et al., *Mother's Media Use and Children's Vaccination Status in Indonesia: A Community-Based Cross-Sectional Study.* 2022. **9**: p. 2333794X221092740.
43. Sato, R.J.V., *Geospatial and Time Trend of Prevalence and Characteristics of Zero-Dose Children in Nigeria from 2003 to 2018.* 2022. **10**(9): p. 1556.
44. Forshaw, J., et al., *The global effect of maternal education on complete childhood vaccination: a systematic review and meta-analysis.* 2017. **17**(1): p. 1-16.

45. Douthit, N., et al., *Exposing some important barriers to health care access in the rural USA.* 2015. **129**(6): p. 611-620.
46. Grant, R., et al., *Transportation barriers to child health care access remain after health reform.* 2014. **168**(4): p. 385-386.
47. Weigel, P.A., et al., *Variation in primary care service patterns by rural-urban location.* 2016. **32**(2): p. 196-203.

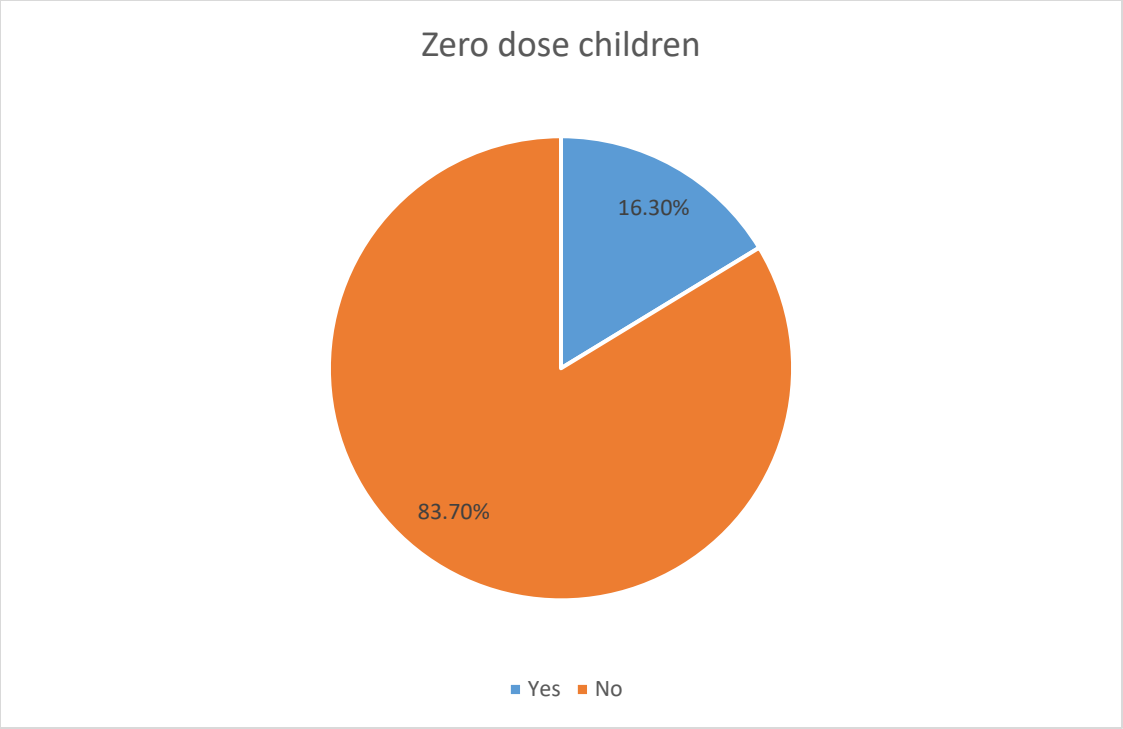

Fig-1: Prevalence of zero dose children in Ethiopia using EDHS 2019.

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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 Agimas[1], Meron Asmamaw Alemayehu[1], Tigabu Kidie Tesfie[1], Werkneh Melkie Tilahun[2], Worku Necho Asferie[4], Mekuriaw Nibret Aweke[6], Moges Tadesse Abebe[3], Anteneh Kassa yalew[5]

[1]Department of Epidemiology and Biostatistics, institute of public health, college of medicine and health science, university of Gondar, Gondar, Ethiopia.

[2]Department of Public Health, College of Medicine and Health Sciences, Debre Markos University, Debre Markos, Ethiopia.

[3]Department of Nursing, College of Health Science, Debark University, Debark, Ethiopia.

[4]Departments of pediatric and neonatal Nursing, College of Health Science, Debre Tabor University, Debre Tabor, Ethiopia

[5]Department of Public health, college of medicine and Health science, Wolkite University, Wolkite, Ethiopia.

[6]Department 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

Abstract

Introduction: Zero-dose children refer to a child who has not yet received any childhood vaccines. Globally, zero-dose children are the major public health problem. In sub-Saharan African countries, among five children, one did not access the vaccines. But the efforts to identify the factors contributing to the zero-dose child are not well addressed in Ethiopia.

Objectives: To assess individual and community-level maternal factors of zero-dose children in Ethiopia using mini-EDHS 2019.

Methods: A secondary analysis of a cross-sectional study was used among a total of 3208 participants. The STATA-14 was used for descriptive and multilevel binary logistic regression (mixed effect model) analysis. Model selection was conducted using AIC. To identify significant 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.

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 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.

Objectives

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

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

Methods

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 otherwise classified 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].

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, $\text{logit}[E(y_{ij})] = \text{logit}(p_{ij}) = \alpha_0 + X_{ij}\beta + Z_j\gamma + u_j$ [30].

Where α0 is the regular intercept, Xijβ is the product of individual-level predictors and the corresponding unknown parameters, and Zjγ 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) = σ^2 ε/(σ^2 ε +σ^2 μ); $\sigma^2\mu=\pi^2/3$[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 √2 x VA x 0.6745 = exp (0.95xVA) [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.**

Random effect	Null model	Model I	Model II	**Model III**
Variance	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 likelihood	-1950	-1904	-1920	**-1889**
AIC	3905	3826	3848	**3801**

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	184	5.7
Religion	Orthodox	929	29
	Catholic	18	0.6
	Protestant	588	18.3
	Muslim	1633	50.9
	Traditional	32	1
	Other	8	0.2
Region	Tigray	261	8.1
	Afar	371	11.6
	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
	≥ 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 section	No	3001	93.5
	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 children in Ethiopia

The prevalence of zero dose children among children aged 12-35 months old was 16.3% (95%CI, 15%–17.6%) **(Fig-1).**

Fig-1: Prevalence of zero dose children in Ethiopia using mini-EDHS 2019.

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

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

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].

[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

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

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.

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.

Ethical declaration

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 anonymized before we accessed informed consent from DHS international.

Consent for publication

Not required.

Data availability statement

All relevant data is available in the manuscript.

Conflict of interest

The author declares no conflict of interest

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Author Contributions

Conceptualization: Muluken Chanie Agimas

Formal analysis: Muluken Chanie Agimas, Meron Asmamaw Alemayewhu, Tigabu Kidie Tesfie, Werkneh Melkie Tilahun

Investigation: Muluken Chanie Agimas and Meron Asmamaw Alemayewhu

Methodology: Muluken Chanie Agimas, Worku Necho Asferie, Mekuriaw Nibret Aweke, Moges Tadesse Abebe, Anteneh Kassa yalew, Tigabu Kidie Tesfie

Software: Muluken Chanie Agimas, Werkneh Melkie Tilahun, Worku Necho Asferie, Mekuriaw Nibret Aweke, Moges Tadesse Abebe, Anteneh Kassa yalew, Tigabu Kidie Tesfie

Supervision: Muluken Chanie Agimas, Anteneh Kassa yalew

Validation: Muluken Chanie Agimas, Worku Necho Asferie, Mekuriaw Nibret Aweke, Moges Tadesse Abebe, Anteneh Kassa yalew, Tigabu Kidie Tesfie

Visualization: Muluken Chanie Agimas, Worku Necho Asferie, Mekuriaw Nibret Aweke, Moges Tadesse Abebe, Anteneh Kassa yalew

Writing – review & editing: Muluken Chanie Agimas, Worku Necho Asferie, Mekuriaw Nibret Aweke, Moges Tadesse Abebe, Anteneh Kassa yalew, Meron Asmamaw Alemayewhu, Tigabu Kidie Tesfie

Muluken chanie Agimas (MCA) is guarantor of this article.

Abbreviation and acronym

AIC……Akaike information criteria

ANC……Antenatal Care

DHS…..Demographic Health Survey

EAs-……Enumeration Areas

EDHS……Ethiopian Demographic Health Survey

LLR……Log Likelihood Ratio

SNNPR……South Nation and Nationality of People Representative

VPDs……..Vaccine Preventable Diseases

Reference

1. Ozigbu, C.E., et al., *Correlates of Zero-Dose Vaccination Status among Children Aged 12–59 Months in Sub-Saharan Africa: A Multilevel Analysis of Individual and Contextual Factors.* 2022. **10**(7): p. 1052.
2. Antai, D.J.B.i.d., *Inequitable childhood immunization uptake in Nigeria: a multilevel analysis of individual and contextual determinants.* 2009. **9**: p. 1-10.
3. Wiysonge, C.S., et al., *Individual and contextual factors associated with low childhood immunisation coverage in sub-Saharan Africa: a multilevel analysis.* 2012. **7**(5): p. e37905.
4. Bobo, F.T., et al., *Child vaccination in sub-Saharan Africa: Increasing coverage addresses inequalities.* 2022. **40**(1): p. 141-150.

5. Fokoun, C.J.H.V. and Immunotherapeutics, *Strategies implemented to address vaccine hesitancy in France: a review article.* 2018. **14**(7): p. 1580-1590.
6. Nathanson, N. and O.M.J.A.j.o.e. Kew, *From emergence to eradication: the epidemiology of poliomyelitis deconstructed.* 2010. **172**(11): p. 1213-1229.
7. Kretsinger, K., et al., *Polio eradication in the World Health Organization African Region, 2008–2012.* 2014. **210**(suppl_1): p. S23-S39.
8. Waziri, N.E., et al., *Polio eradication in Nigeria and the role of the National Stop Transmission of Polio program, 2012–2013.* 2014. **210**(suppl_1): p. S111-S117.
9. Brownwright, T.K., Z.M. Dodson, and W.G.J.B.p.h. van Panhuis, *Spatial clustering of measles vaccination coverage among children in sub-Saharan Africa.* 2017. **17**(1): p. 1-7.
10. Wobudeya, E., et al., *Epidemiology of tuberculosis in children in Kampala district, Uganda, 2009–2010; a retrospective cross-sectional study.* 2015. **15**: p. 1-8.
11. Mihigo, R., et al., *Routine immunization in the WHO African region: progress, challenges and way forward.* 2015. **19**(2): p. 2-7.
12. Organization, W.H., *WHO UNICEF coverage estimates WHO World Health Organization: Immunization, Vaccines and Biologicals. Vaccine preventable diseases Vaccines monitoring system 2019 Global Summary Reference Time Series: DTP3.[Cited 2020 Feb 12]*. 2012.
13. Rachlin, A., et al., *Routine vaccination coverage—worldwide, 2021.* 2022. **71**(44): p. 1396.
14. Jheeta, M. and J.J.B.o.t.W.H.O. Newell, *Childhood vaccination in Africa and Asia: the effects of parents' knowledge and attitudes*. 2008, SciELO Public Health. p. 419-419A.
15. *WHO/UNICEF Estimates of National Immunization Coverage (WUENIC), progress and challenges with Achieving Universal Immunization Coverage, URL: https://www.who.int/publications/m/item/progress-and-challenges* 2022.
16. Chido-Amajuoyi, O.G., et al., *Prevalence and correlates of never vaccinated Nigerian children, aged 1–5 years.* 2018. **36**(46): p. 6953-6960.
17. Cata-Preta, B.O., et al., *Zero-dose children and the immunisation cascade: understanding immunisation pathways in low and middle-income countries.* 2021. **39**(32): p. 4564-4570.
18. Arambepola, R., et al., *Using geospatial models to map zero-dose children: Factors associated with zero-dose vaccination status before and after a mass measles and rubella vaccination campaign in Southern province, Zambia.* 2021. **6**(12): p. e007479.
19. Galles, N.C., et al., *Measuring routine childhood vaccination coverage in 204 countries and territories, 1980–2019: a systematic analysis for the Global Burden of Disease Study 2020, Release 1.* 2021. **398**(10299): p. 503-521.
20. Murhekar, M.V. and M.S.J.T.L.G.H. Kumar, *Reaching zero-dose children in India: Progress and challenges ahead.* 2021. **9**(12): p. e1630-e1631.
21. Johri, M., S. Rajpal, and S.J.T.L.G.H. Subramanian, *Progress in reaching unvaccinated (zero-dose) children in India, 1992–2016: a multilevel, geospatial analysis of repeated cross-sectional surveys.* 2021. **9**(12): p. e1697-e1706.
22. VanderEnde, K., et al., *Global routine vaccination coverage—2017.* 2018. **67**(45): p. 1261.
23. García-Moreno, C., et al., *Global and regional estimates of violence against women: prevalence and health effects of intimate partner violence and non-partner sexual violence*. 2013: World Health Organization.
24. Nour, T.Y., et al., *Predictors of immunization coverage among 12–23 month old children in Ethiopia: systematic review and meta-analysis.* 2020. **20**(1): p. 1-19.
25. Alfaro-Murillo, J.A., et al., *The case for replacing live oral polio vaccine with inactivated vaccine in the Americas.* 2020. **395**(10230): p. 1163-1166.

26. Kanté, A.M., et al., *Factors associated with compliance with the recommended frequency of postnatal care services in three rural districts of Tanzania.* 2015. **15**: p. 1-10.
27. Azie, J.I., et al., *Reaching zero-dose children.* 2024. **8**(85): p. 85.
28. Fetene, S.M., T.J.B.P. Gebremedhin, and Childbirth, *Uptake of postnatal care and its determinants in Ethiopia: a positive deviance approach.* 2022. **22**(1): p. 601.
29. Indicators, K.J.E. and ICF, *Mini demographic and health survey.* 2019.
30. H., A., *A new look at the statistical model identification. IEEE transactions on automatic control. ;19(6):716-23.* 1974 Dec.
31. H., G., *Multilevel statistical models. John Wiley & Sons; 2011 Jul 8.*
32. Merlo, J., et al., *A brief conceptual tutorial of multilevel analysis in social epidemiology: using measures of clustering in multilevel logistic regression to investigate contextual phenomena.* 2006. **60**(4): p. 290-297.
33. Mangbassim, N.T., et al., *Prevalence and factors associated with "zero-dose" in children 12 to 23 months in Togo.* 2023. **9**: p. 12.
34. *WHO/UNICEF. national immunization estimate.* 2021.
35. Nchinjoh, S.C., et al., *Factors Associated with Zero-Dose Childhood Vaccination Status in a Remote Fishing Community in Cameroon: A Cross-Sectional Analytical Study.* 2022. **10**(12): p. 2052.
36. Berhanel, Y., A. Bekele, and F.J.E.M.J. Tesfaye,, *Immunization (EPI) in Ethiopia: acceptance, coverage, and sustainability. 2000. 38: p. 1-60.*
37. Moyer, C.A., et al., *The relationship between facility delivery and infant immunization in Ethiopia.* 2013. **123**(3): p. 217-220.
38. Hajizadeh, M.J.J.E.C.H., *Socioeconomic inequalities in child vaccination in low/middle-income countries: what accounts for the differences?* 2018.
39. Glewwe, P.J.J.o.h.r., *Why does mother's schooling raise child health in developing countries? Evidence from Morocco.* 1999: p. 124-159.
40. Krishnamoorthy, Y. and T.J.F.P. Rehman, *Impact of antenatal care visits on childhood immunization: a propensity score-matched analysis using nationally representative survey.* 2022. **39**(4): p. 603-609.
41. Farrenkopf, B.A., et al., *Understanding household-level risk factors for zero dose immunization in 82 low-and middle-income countries.* 2023. **18**(12): p. e0287459.
42. Machmud, P.B., et al., *Mother's Media Use and Children's Vaccination Status in Indonesia: A Community-Based Cross-Sectional Study.* 2022. **9**: p. 2333794X221092740.
43. Sato, R.J.V., *Geospatial and Time Trend of Prevalence and Characteristics of Zero-Dose Children in Nigeria from 2003 to 2018.* 2022. **10**(9): p. 1556.
44. Forshaw, J., et al., *The global effect of maternal education on complete childhood vaccination: a systematic review and meta-analysis.* 2017. **17**(1): p. 1-16.
45. Douthit, N., et al., *Exposing some important barriers to health care access in the rural USA.* 2015. **129**(6): p. 611-620.
46. Grant, R., et al., *Transportation barriers to child health care access remain after health reform.* 2014. **168**(4): p. 385-386.
47. Weigel, P.A., et al., *Variation in primary care service patterns by rural-urban location.* 2016. **32**(2): p. 196-203.

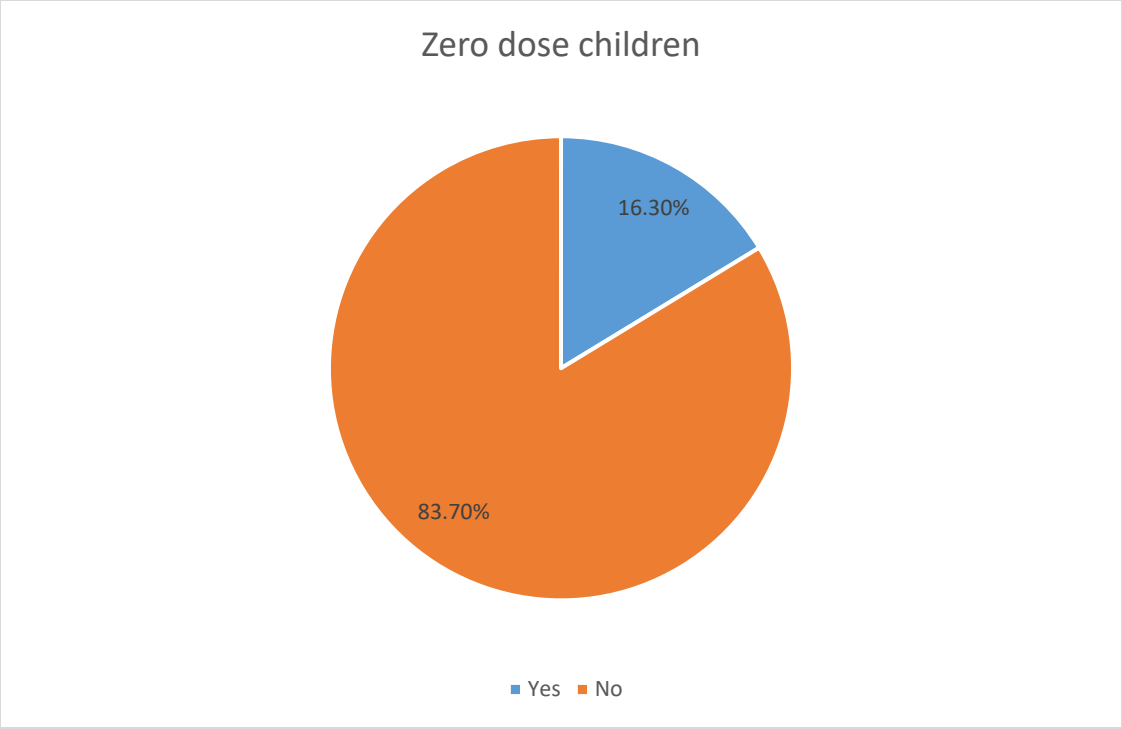

Fig-1: Prevalence of zero dose children in Ethiopia using EDHS 2019.

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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 Agimas[1], Meron Asmamaw Alemayehu[1], Tigabu Kidie Tesfie[1], Werkneh Melkie Tilahun[2], Worku Necho Asferie[4], Mekuriaw Nibret Aweke[6], Moges Tadesse Abebe[3], Anteneh Kassa yalew[5]

[1]Department of Epidemiology and Biostatistics, institute of public health, college of medicine and health science, university of Gondar, Gondar, Ethiopia.

[2]Department of Public Health, College of Medicine and Health Sciences, Debre Markos University, Debre Markos, Ethiopia.

[3]Department of Nursing, College of Health Science, Debark University, Debark, Ethiopia.

[4]Departments of pediatric and neonatal Nursing, College of Health Science, Debre Tabor University, Debre Tabor, Ethiopia

[5]Department of Public health, college of medicine and Health science, Wolkite University, Wolkite, Ethiopia.

[6]Department 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

Abstract

Introduction: Zero-dose children refer to a child who has not yet received any childhood vaccines. Globally, zero-dose children are the major public health problem. In sub-Saharan African countries, among five children, one did not access the vaccines. But the efforts to identify the factors contributing to the zero-dose child are not well addressed in Ethiopia.

Objectives: To assess individual and community-level maternal factors of zero-dose children in Ethiopia using mini-EDHS 2019.

Methods: A secondary analysis of a cross-sectional study was used among a total of 3208 participants. The STATA-14 was used for descriptive and multilevel binary logistic regression (mixed effect model) analysis. Model selection was conducted using AIC. To identify significant 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.

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 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.
- Recall bias was also the limitation of the 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.

Objectives

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

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

Methods

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 otherwise classified 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].

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, $\text{logit}[E(y_{ij})] = \text{logit}(p_{ij}) = \alpha_0 + X_{ij}\beta + Z_j\gamma + u_j$ [30].

Where α0 is the regular intercept, Xijβ is the product of individual-level predictors and the corresponding unknown parameters, and Zjγ 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) = σ^2 ε/(σ^2 ε +σ^2 μ); $\sigma^2\mu=\pi^2/3$[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 √2 x VA x 0.6745 = exp (0.95xVA) [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.**

Random effect	Null model	Model I	Model II	**Model III**
Variance	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 likelihood	-1950	-1904	-1920	**-1889**
AIC	3905	3826	3848	**3801**

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	184	5.7
Religion	Orthodox	929	29
	Catholic	18	0.6
	Protestant	588	18.3
	Muslim	1633	50.9
	Traditional	32	1
	Other	8	0.2
Region	Tigray	261	8.1
	Afar	371	11.6
	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
	≥ 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 section	No	3001	93.5
	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 children in Ethiopia

The prevalence of zero dose children among children aged 12-35 months old was 16.3% (95%CI, 15%–17.6%) **(Fig-1).**

Fig-1: Prevalence of zero dose children in Ethiopia using mini-EDHS 2019.

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

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

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].

[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

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

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]. 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.

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.

Ethical declaration

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 anonymized before we accessed informed consent from DHS international.

Consent for publication

Not required.

Data availability statement

All relevant data is available in the manuscript.

Conflict of interest

The author declares no conflict of interest

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Author Contributions

Conceptualization: Muluken Chanie Agimas

Formal analysis: Muluken Chanie Agimas, Meron Asmamaw Alemayewhu, Tigabu Kidie Tesfie, Werkneh Melkie Tilahun

Investigation: Muluken Chanie Agimas and Meron Asmamaw Alemayewhu

Methodology: Muluken Chanie Agimas, Worku Necho Asferie, Mekuriaw Nibret Aweke, Moges Tadesse Abebe, Anteneh Kassa yalew, Tigabu Kidie Tesfie

Software: Muluken Chanie Agimas, Werkneh Melkie Tilahun, Worku Necho Asferie, Mekuriaw Nibret Aweke, Moges Tadesse Abebe, Anteneh Kassa yalew, Tigabu Kidie Tesfie

Supervision: Muluken Chanie Agimas, Anteneh Kassa yalew

Validation: Muluken Chanie Agimas, Worku Necho Asferie, Mekuriaw Nibret Aweke, Moges Tadesse Abebe, Anteneh Kassa yalew, Tigabu Kidie Tesfie

Visualization: Muluken Chanie Agimas, Worku Necho Asferie, Mekuriaw Nibret Aweke, Moges Tadesse Abebe, Anteneh Kassa yalew

Writing – review & editing: Muluken Chanie Agimas, Worku Necho Asferie, Mekuriaw Nibret Aweke, Moges Tadesse Abebe, Anteneh Kassa yalew, Meron Asmamaw Alemayewhu, Tigabu Kidie Tesfie

Muluken chanie Agimas (MCA) is guarantor of this article.

Abbreviation and acronym

AIC……Akaike information criteria

ANC……Antenatal Care

DHS…..Demographic Health Survey

EAs-……Enumeration Areas

EDHS……Ethiopian Demographic Health Survey

LLR……Log Likelihood Ratio

SNNPR……South Nation and Nationality of People Representative

VPDs……..Vaccine Preventable Diseases

Reference

1. Ozigbu, C.E., et al., *Correlates of Zero-Dose Vaccination Status among Children Aged 12–59 Months in Sub-Saharan Africa: A Multilevel Analysis of Individual and Contextual Factors.* 2022. **10**(7): p. 1052.
2. Antai, D.J.B.i.d., *Inequitable childhood immunization uptake in Nigeria: a multilevel analysis of individual and contextual determinants.* 2009. **9**: p. 1-10.
3. Wiysonge, C.S., et al., *Individual and contextual factors associated with low childhood immunisation coverage in sub-Saharan Africa: a multilevel analysis.* 2012. **7**(5): p. e37905.
4. Bobo, F.T., et al., *Child vaccination in sub-Saharan Africa: Increasing coverage addresses inequalities.* 2022. **40**(1): p. 141-150.
5. Fokoun, C.J.H.V. and Immunotherapeutics, *Strategies implemented to address vaccine hesitancy in France: a review article.* 2018. **14**(7): p. 1580-1590.
6. Nathanson, N. and O.M.J.A.j.o.e. Kew, *From emergence to eradication: the epidemiology of poliomyelitis deconstructed.* 2010. **172**(11): p. 1213-1229.
7. Kretsinger, K., et al., *Polio eradication in the World Health Organization African Region, 2008–2012.* 2014. **210**(suppl_1): p. S23-S39.
8. Waziri, N.E., et al., *Polio eradication in Nigeria and the role of the National Stop Transmission of Polio program, 2012–2013.* 2014. **210**(suppl_1): p. S111-S117.
9. Brownwright, T.K., Z.M. Dodson, and W.G.J.B.p.h. van Panhuis, *Spatial clustering of measles vaccination coverage among children in sub-Saharan Africa.* 2017. **17**(1): p. 1-7.
10. Wobudeya, E., et al., *Epidemiology of tuberculosis in children in Kampala district, Uganda, 2009–2010; a retrospective cross-sectional study.* 2015. **15**: p. 1-8.
11. Mihigo, R., et al., *Routine immunization in the WHO African region: progress, challenges and way forward.* 2015. **19**(2): p. 2-7.
12. Organization, W.H., *WHO UNICEF coverage estimates WHO World Health Organization: Immunization, Vaccines and Biologicals. Vaccine preventable diseases Vaccines monitoring system 2019 Global Summary Reference Time Series: DTP3.[Cited 2020 Feb 12]*. 2012.
13. Rachlin, A., et al., *Routine vaccination coverage—worldwide, 2021.* 2022. **71**(44): p. 1396.
14. Jheeta, M. and J.J.B.o.t.W.H.O. Newell, *Childhood vaccination in Africa and Asia: the effects of parents' knowledge and attitudes*. 2008, SciELO Public Health. p. 419-419A.
15. *WHO/UNICEF Estimates of National Immunization Coverage (WUENIC), progress and challenges with Achieving Universal Immunization Coverage, URL: https://www.who.int/publications/m/item/progress-and-challenges*

2022.
16. Chido-Amajuoyi, O.G., et al., *Prevalence and correlates of never vaccinated Nigerian children, aged 1–5 years.* 2018. **36**(46): p. 6953-6960.
17. Cata-Preta, B.O., et al., *Zero-dose children and the immunisation cascade: understanding immunisation pathways in low and middle-income countries.* 2021. **39**(32): p. 4564-4570.
18. Arambepola, R., et al., *Using geospatial models to map zero-dose children: Factors associated with zero-dose vaccination status before and after a mass measles and rubella vaccination campaign in Southern province, Zambia.* 2021. **6**(12): p. e007479.
19. Galles, N.C., et al., *Measuring routine childhood vaccination coverage in 204 countries and territories, 1980–2019: a systematic analysis for the Global Burden of Disease Study 2020, Release 1.* 2021. **398**(10299): p. 503-521.
20. Murhekar, M.V. and M.S.J.T.L.G.H. Kumar, *Reaching zero-dose children in India: Progress and challenges ahead.* 2021. **9**(12): p. e1630-e1631.

21. Johri, M., S. Rajpal, and S.J.T.L.G.H. Subramanian, *Progress in reaching unvaccinated (zero-dose) children in India, 1992–2016: a multilevel, geospatial analysis of repeated cross-sectional surveys.* 2021. **9**(12): p. e1697-e1706.
22. VanderEnde, K., et al., *Global routine vaccination coverage—2017.* 2018. **67**(45): p. 1261.
23. García-Moreno, C., et al., *Global and regional estimates of violence against women: prevalence and health effects of intimate partner violence and non-partner sexual violence*. 2013: World Health Organization.
24. Nour, T.Y., et al., *Predictors of immunization coverage among 12–23 month old children in Ethiopia: systematic review and meta-analysis.* 2020. **20**(1): p. 1-19.
25. Alfaro-Murillo, J.A., et al., *The case for replacing live oral polio vaccine with inactivated vaccine in the Americas.* 2020. **395**(10230): p. 1163-1166.
26. Kanté, A.M., et al., *Factors associated with compliance with the recommended frequency of postnatal care services in three rural districts of Tanzania.* 2015. **15**: p. 1-10.
27. Azie, J.I., et al., *Reaching zero-dose children.* 2024. **8**(85): p. 85.
28. Fetene, S.M., T.J.B.P. Gebremedhin, and Childbirth, *Uptake of postnatal care and its determinants in Ethiopia: a positive deviance approach.* 2022. **22**(1): p. 601.
29. Indicators, K.J.E. and ICF, *Mini demographic and health survey.* 2019.
30. H., A., *A new look at the statistical model identification. IEEE transactions on automatic control. ;19(6):716-23.* 1974 Dec.
31. H., G., *Multilevel statistical models. John Wiley & Sons; 2011 Jul 8.*
32. Merlo, J., et al., *A brief conceptual tutorial of multilevel analysis in social epidemiology: using measures of clustering in multilevel logistic regression to investigate contextual phenomena.* 2006. **60**(4): p. 290-297.
33. Mangbassim, N.T., et al., *Prevalence and factors associated with "zero-dose" in children 12 to 23 months in Togo.* 2023. **9**: p. 12.
34. *WHO/UNICEF. national immunization estimate.* 2021.
35. Nchinjoh, S.C., et al., *Factors Associated with Zero-Dose Childhood Vaccination Status in a Remote Fishing Community in Cameroon: A Cross-Sectional Analytical Study.* 2022. **10**(12): p. 2052.
36. Berhanel, Y., A. Bekele, and F.J.E.M.J. Tesfaye,, *Immunization (EPI) in Ethiopia: acceptance, coverage, and sustainability. 2000. 38: p. 1-60.*
37. Moyer, C.A., et al., *The relationship between facility delivery and infant immunization in Ethiopia.* 2013. **123**(3): p. 217-220.
38. Hajizadeh, M.J.J.E.C.H., *Socioeconomic inequalities in child vaccination in low/middle-income countries: what accounts for the differences?* 2018.
39. Glewwe, P.J.J.o.h.r., *Why does mother's schooling raise child health in developing countries? Evidence from Morocco.* 1999: p. 124-159.
40. Krishnamoorthy, Y. and T.J.F.P. Rehman, *Impact of antenatal care visits on childhood immunization: a propensity score-matched analysis using nationally representative survey.* 2022. **39**(4): p. 603-609.
41. Farrenkopf, B.A., et al., *Understanding household-level risk factors for zero dose immunization in 82 low-and middle-income countries.* 2023. **18**(12): p. e0287459.
42. Machmud, P.B., et al., *Mother's Media Use and Children's Vaccination Status in Indonesia: A Community-Based Cross-Sectional Study.* 2022. **9**: p. 2333794X221092740.
43. Sato, R.J.V., *Geospatial and Time Trend of Prevalence and Characteristics of Zero-Dose Children in Nigeria from 2003 to 2018.* 2022. **10**(9): p. 1556.
44. Forshaw, J., et al., *The global effect of maternal education on complete childhood vaccination: a systematic review and meta-analysis.* 2017. **17**(1): p. 1-16.

45. Douthit, N., et al., *Exposing some important barriers to health care access in the rural USA.* 2015. **129**(6): p. 611-620.
46. Grant, R., et al., *Transportation barriers to child health care access remain after health reform.* 2014. **168**(4): p. 385-386.
47. Weigel, P.A., et al., *Variation in primary care service patterns by rural-urban location.* 2016. **32**(2): p. 196-203.

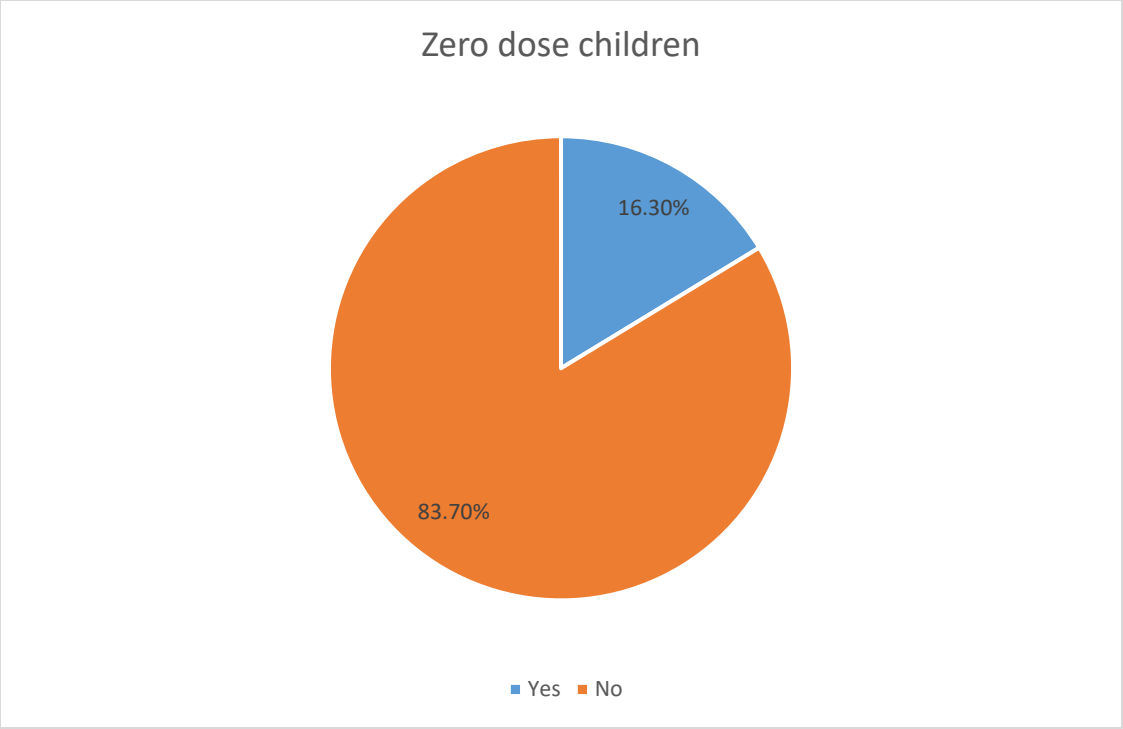

Fig-1: Prevalence of zero dose children in Ethiopia using EDHS 2019.

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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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Complete List of Authors:	Agimas, Muluken Chanie; University of Gondar College of Medicine and Health Sciences, epidemiology; University of Gondar College of Medicine and Health Sciences, epidemiology Alemayehu, Meron Asmamaw; University of Gondar, Epidemiology Tesfie, Tigabu Kidie; University of Gondar, Department of Epidemiology and Biostatistics Tilahun, Werkneh Melkie ; Debre Markos University, Department of Public Health Asferie, Worku; Debre Tabor University, Departments of pediatric and neonatal Nursing Aweke, Mekuriaw Nibret; University of Gondar, Department of Nutrition ABEBE, MOGES; Debark University, Department of Nursing Yalew, Anteneh; Wolkite University, Department of Public health
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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 Agimas[1], Meron Asmamaw Alemayehu[1], Tigabu Kidie Tesfie[1], Werkneh Melkie Tilahun[2], Worku Necho Asferie[4], Mekuriaw Nibret Aweke[6], Moges Tadesse Abebe[3], Anteneh Kassa yalew[5]

[1]Department of Epidemiology and Biostatistics, institute of public health, college of medicine and health science, university of Gondar, Gondar, Ethiopia.

[2]Department of Public Health, College of Medicine and Health Sciences, Debre Markos University, Debre Markos, Ethiopia.

[3]Department of Nursing, College of Health Science, Debark University, Debark, Ethiopia.

[4]Departments of pediatric and neonatal Nursing, College of Health Science, Debre Tabor University, Debre Tabor, Ethiopia

[5]Department of Public health, college of medicine and Health science, Wolkite University, Wolkite, Ethiopia.

[6]Department 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

Abstract

Introduction: Zero-dose children refer to a child who has not yet received any childhood vaccines. Globally, zero-dose children are the major public health problem. In sub-Saharan African countries, among five children, one did not access the vaccines. But the efforts to identify the factors contributing to the zero-dose child are not well addressed in Ethiopia.

Objectives: To assess individual and community-level maternal factors of zero-dose children in Ethiopia using mini-EDHS 2019.

Methods: A secondary analysis of a cross-sectional study was used among a total of 3208 participants. The STATA-14 was used for descriptive and multilevel binary logistic regression (mixed effect model) analysis. Model selection was conducted using AIC. To identify significant 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.

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 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.
- Recall bias was also the limitation of the 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.

Objectives

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

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

Methods

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 otherwise classified 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].

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, $\text{logit}[E(y_{ij})] = \text{logit}(p_{ij}) = \alpha_0 + X_{ij}\beta + Z_j\gamma + u_j$ [30].

Where α0 is the regular intercept, Xijβ is the product of individual-level predictors and the corresponding unknown parameters, and Zjγ 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) = σ^2 ε/(σ^2 ε +σ^2 μ); $\sigma^2\mu=\pi^2/3$[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 √2 x VA x 0.6745 = exp (0.95xVA) [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.**

Random effect	Null model	Model I	Model II	**Model III**
Variance	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 likelihood	-1950	-1904	-1920	**-1889**
AIC	3905	3826	3848	**3801**

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	184	5.7
Religion	Orthodox	929	29
	Catholic	18	0.6
	Protestant	588	18.3
	Muslim	1633	50.9
	Traditional	32	1
	Other	8	0.2
Region	Tigray	261	8.1
	Afar	371	11.6
	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
	≥ 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 section	No	3001	93.5
	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 children in Ethiopia

The prevalence of zero dose children among children aged 12-35 months old was 16.3% (95%CI, 15%–17.6%) **(Fig-1).**

Fig-1: Prevalence of zero dose children in Ethiopia using mini-EDHS 2019.

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

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

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].

[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

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

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]. 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.

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.

Ethical declaration

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 anonymized before we accessed informed consent from DHS international.

Consent for publication

Not required.

Data availability statement

All relevant data is available in the manuscript.

Conflict of interest

The author declares no conflict of interest

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Author Contributions

Conceptualization: Muluken Chanie Agimas

Formal analysis: Muluken Chanie Agimas, Meron Asmamaw Alemayewhu, Tigabu Kidie Tesfie, Werkneh Melkie Tilahun

Investigation: Muluken Chanie Agimas and Meron Asmamaw Alemayewhu

Methodology: Muluken Chanie Agimas, Worku Necho Asferie, Mekuriaw Nibret Aweke, Moges Tadesse Abebe, Anteneh Kassa yalew, Tigabu Kidie Tesfie

Software: Muluken Chanie Agimas, Werkneh Melkie Tilahun, Worku Necho Asferie, Mekuriaw Nibret Aweke, Moges Tadesse Abebe, Anteneh Kassa yalew, Tigabu Kidie Tesfie

Supervision: Muluken Chanie Agimas, Anteneh Kassa yalew

Validation: Muluken Chanie Agimas, Worku Necho Asferie, Mekuriaw Nibret Aweke, Moges Tadesse Abebe, Anteneh Kassa yalew, Tigabu Kidie Tesfie

Visualization: Muluken Chanie Agimas, Worku Necho Asferie, Mekuriaw Nibret Aweke, Moges Tadesse Abebe, Anteneh Kassa yalew

Writing – review & editing: Muluken Chanie Agimas, Worku Necho Asferie, Mekuriaw Nibret Aweke, Moges Tadesse Abebe, Anteneh Kassa yalew, Meron Asmamaw Alemayewhu, Tigabu Kidie Tesfie

Muluken chanie Agimas (MCA) is guarantor of this article.

Abbreviation and acronym

AIC……Akaike information criteria

ANC……Antenatal Care

DHS…..Demographic Health Survey

EAs-……Enumeration Areas

EDHS……Ethiopian Demographic Health Survey

LLR……Log Likelihood Ratio

SNNPR……South Nation and Nationality of People Representative

VPDs……..Vaccine Preventable Diseases

Reference

1. Ozigbu, C.E., et al., *Correlates of Zero-Dose Vaccination Status among Children Aged 12–59 Months in Sub-Saharan Africa: A Multilevel Analysis of Individual and Contextual Factors.* 2022. **10**(7): p. 1052.
2. Antai, D.J.B.i.d., *Inequitable childhood immunization uptake in Nigeria: a multilevel analysis of individual and contextual determinants.* 2009. **9**: p. 1-10.
3. Wiysonge, C.S., et al., *Individual and contextual factors associated with low childhood immunisation coverage in sub-Saharan Africa: a multilevel analysis.* 2012. **7**(5): p. e37905.

4. Bobo, F.T., et al., *Child vaccination in sub-Saharan Africa: Increasing coverage addresses inequalities.* 2022. **40**(1): p. 141-150.
5. Fokoun, C.J.H.V. and Immunotherapeutics, *Strategies implemented to address vaccine hesitancy in France: a review article.* 2018. **14**(7): p. 1580-1590.
6. Nathanson, N. and O.M.J.A.j.o.e. Kew, *From emergence to eradication: the epidemiology of poliomyelitis deconstructed.* 2010. **172**(11): p. 1213-1229.
7. Kretsinger, K., et al., *Polio eradication in the World Health Organization African Region, 2008–2012.* 2014. **210**(suppl_1): p. S23-S39.
8. Waziri, N.E., et al., *Polio eradication in Nigeria and the role of the National Stop Transmission of Polio program, 2012–2013.* 2014. **210**(suppl_1): p. S111-S117.
9. Brownwright, T.K., Z.M. Dodson, and W.G.J.B.p.h. van Panhuis, *Spatial clustering of measles vaccination coverage among children in sub-Saharan Africa.* 2017. **17**(1): p. 1-7.
10. Wobudeya, E., et al., *Epidemiology of tuberculosis in children in Kampala district, Uganda, 2009–2010; a retrospective cross-sectional study.* 2015. **15**: p. 1-8.
11. Mihigo, R., et al., *Routine immunization in the WHO African region: progress, challenges and way forward.* 2015. **19**(2): p. 2-7.
12. Organization, W.H., *WHO UNICEF coverage estimates WHO World Health Organization: Immunization, Vaccines and Biologicals. Vaccine preventable diseases Vaccines monitoring system 2019 Global Summary Reference Time Series: DTP3.[Cited 2020 Feb 12]*. 2012.
13. Rachlin, A., et al., *Routine vaccination coverage—worldwide, 2021.* 2022. **71**(44): p. 1396.
14. Jheeta, M. and J.J.B.o.t.W.H.O. Newell, *Childhood vaccination in Africa and Asia: the effects of parents' knowledge and attitudes*. 2008, SciELO Public Health. p. 419-419A.
15. *WHO/UNICEF Estimates of National Immunization Coverage (WUENIC), progress and challenges with Achieving Universal Immunization Coverage, URL: https://www.who.int/publications/m/item/progress-and-challenges* 2022.
16. Chido-Amajuoyi, O.G., et al., *Prevalence and correlates of never vaccinated Nigerian children, aged 1–5 years.* 2018. **36**(46): p. 6953-6960.
17. Cata-Preta, B.O., et al., *Zero-dose children and the immunisation cascade: understanding immunisation pathways in low and middle-income countries.* 2021. **39**(32): p. 4564-4570.
18. Arambepola, R., et al., *Using geospatial models to map zero-dose children: Factors associated with zero-dose vaccination status before and after a mass measles and rubella vaccination campaign in Southern province, Zambia.* 2021. **6**(12): p. e007479.
19. Galles, N.C., et al., *Measuring routine childhood vaccination coverage in 204 countries and territories, 1980–2019: a systematic analysis for the Global Burden of Disease Study 2020, Release 1.* 2021. **398**(10299): p. 503-521.
20. Murhekar, M.V. and M.S.J.T.L.G.H. Kumar, *Reaching zero-dose children in India: Progress and challenges ahead.* 2021. **9**(12): p. e1630-e1631.
21. Johri, M., S. Rajpal, and S.J.T.L.G.H. Subramanian, *Progress in reaching unvaccinated (zero-dose) children in India, 1992–2016: a multilevel, geospatial analysis of repeated cross-sectional surveys.* 2021. **9**(12): p. e1697-e1706.
22. VanderEnde, K., et al., *Global routine vaccination coverage—2017.* 2018. **67**(45): p. 1261.
23. García-Moreno, C., et al., *Global and regional estimates of violence against women: prevalence and health effects of intimate partner violence and non-partner sexual violence*. 2013: World Health Organization.
24. Nour, T.Y., et al., *Predictors of immunization coverage among 12–23 month old children in Ethiopia: systematic review and meta-analysis.* 2020. **20**(1): p. 1-19.

25. Alfaro-Murillo, J.A., et al., *The case for replacing live oral polio vaccine with inactivated vaccine in the Americas.* 2020. **395**(10230): p. 1163-1166.
26. Kanté, A.M., et al., *Factors associated with compliance with the recommended frequency of postnatal care services in three rural districts of Tanzania.* 2015. **15**: p. 1-10.
27. Azie, J.I., et al., *Reaching zero-dose children.* 2024. **8**(85): p. 85.
28. Fetene, S.M., T.J.B.P. Gebremedhin, and Childbirth, *Uptake of postnatal care and its determinants in Ethiopia: a positive deviance approach.* 2022. **22**(1): p. 601.
29. Indicators, K.J.E. and ICF, *Mini demographic and health survey.* 2019.
30. H., A., *A new look at the statistical model identification. IEEE transactions on automatic control. ;19(6):716-23.* 1974 Dec.
31. H., G., *Multilevel statistical models. John Wiley & Sons; 2011 Jul 8.*
32. Merlo, J., et al., *A brief conceptual tutorial of multilevel analysis in social epidemiology: using measures of clustering in multilevel logistic regression to investigate contextual phenomena.* 2006. **60**(4): p. 290-297.
33. Mangbassim, N.T., et al., *Prevalence and factors associated with "zero-dose" in children 12 to 23 months in Togo.* 2023. **9**: p. 12.
34. *WHO/UNICEF. national immunization estimate.* 2021.
35. Nchinjoh, S.C., et al., *Factors Associated with Zero-Dose Childhood Vaccination Status in a Remote Fishing Community in Cameroon: A Cross-Sectional Analytical Study.* 2022. **10**(12): p. 2052.
36. Berhanel, Y., A. Bekele, and F.J.E.M.J. Tesfaye,, *Immunization (EPI) in Ethiopia: acceptance, coverage, and sustainability. 2000. 38: p. 1-60.*
37. Moyer, C.A., et al., *The relationship between facility delivery and infant immunization in Ethiopia.* 2013. **123**(3): p. 217-220.
38. Hajizadeh, M.J.J.E.C.H., *Socioeconomic inequalities in child vaccination in low/middle-income countries: what accounts for the differences?* 2018.
39. Glewwe, P.J.J.o.h.r., *Why does mother's schooling raise child health in developing countries? Evidence from Morocco.* 1999: p. 124-159.
40. Krishnamoorthy, Y. and T.J.F.P. Rehman, *Impact of antenatal care visits on childhood immunization: a propensity score-matched analysis using nationally representative survey.* 2022. **39**(4): p. 603-609.
41. Farrenkopf, B.A., et al., *Understanding household-level risk factors for zero dose immunization in 82 low-and middle-income countries.* 2023. **18**(12): p. e0287459.
42. Machmud, P.B., et al., *Mother's Media Use and Children's Vaccination Status in Indonesia: A Community-Based Cross-Sectional Study.* 2022. **9**: p. 2333794X221092740.
43. Sato, R.J.V., *Geospatial and Time Trend of Prevalence and Characteristics of Zero-Dose Children in Nigeria from 2003 to 2018.* 2022. **10**(9): p. 1556.
44. Forshaw, J., et al., *The global effect of maternal education on complete childhood vaccination: a systematic review and meta-analysis.* 2017. **17**(1): p. 1-16.
45. Douthit, N., et al., *Exposing some important barriers to health care access in the rural USA.* 2015. **129**(6): p. 611-620.
46. Grant, R., et al., *Transportation barriers to child health care access remain after health reform.* 2014. **168**(4): p. 385-386.
47. Weigel, P.A., et al., *Variation in primary care service patterns by rural-urban location.* 2016. **32**(2): p. 196-203.

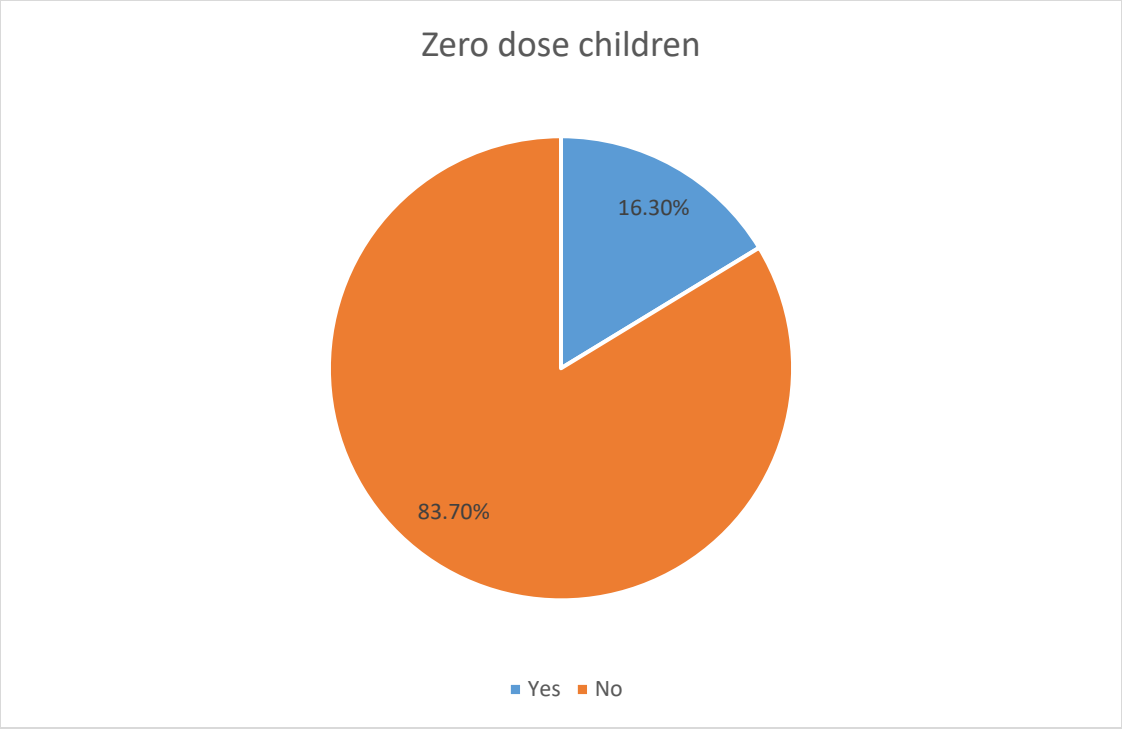

Fig-1: Prevalence of zero dose children in Ethiopia using EDHS 2019.