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Less than one-fifth of Ethiopian children were vaccinated for measles second dose; evidence from the Ethiopian mini demographic and health survey 2019

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ABSTRACT

Ethiopia introduced the measles second dose vaccine from the routine expanded immunization program in 2018. Shreds of evidence are scarce on the measles second dose vaccination coverage and its associated factors in Ethiopia. We aimed to assess the measles second dose vaccination coverage and associated factors in Ethiopia using the recent Ethiopian Mini Demographic and Health Survey (EMDHS) 2019 data. An in-depth secondary data analysis was conducted based on the Ethiopian mini demographic and health survey 2019 data; which was a cross-sectional survey targeted on key indicators of maternal and child health. A weighted sample of 965 children was included in the analysis. A multi-level mixed effect logistics regression model was fitted. Adjusted Odds Ratio (AOR) with 95 %CI was reported for statistically significant variables. The measles second dose coverage was 12.36 % (95 %CI = 10.89, 15.44). Not vaccinated for the third dose of pentavalent vaccine (Penta 3) (AOR = 0.60, 95 %CI: 0.37, 0.95), age of the child [13 to 23 months (AOR = 2.14, 95 %CI: 1.05, 4.36), 24 to 36 months (AOR = 2.58, 95 %CI: 1.32, 5.05)], household head educational status [no education (AOR = 0.51,95 %CI: 0.26, 0.99), primary (AOR = 0.44, 95 %CI: 0.23, 0.85)], and living in south nation, nationalities and peoples region (SNNPR) (AOR = 2.83,95 %CI: 1.12, 7.11) were significantly associated with measles second dose vaccination coverage. Measles second dose vaccination coverage was low in Ethiopia. Age of the child, being vaccinated for the Penta 3, educational status of the household head, and region of residence were significant determinants of measles second dose vaccination coverage.

Background

Measles is a serious and highly pathogenic viral infectious disease manifested by fever, cough, rash, and other symptoms [1,2]. The world is struggling to find a globe free of measles infection by 2030 and beyond [3]. The introduction of the measles vaccine prevents nearly 25 million deaths since 2010 [1]. The United States of America declared as they eliminated measles by 2016 but reports noted frequent measles outbreaks in 2018[3,4]. In Europe, high measles vaccination coverage (93 % to 96 % for 1st dose, and 88 % to 92 % for the second dose) [5], but tiple times higher cases(800,000) in 2019 compared with 23,927 cases in 2017/18 were reported with high variations among countries [6,7].

As measles cases have surged, the world health organization calls for emergency action on measles control [8]. The measles second dose was started in a different year among countries, delivered in different forms either in combination with other vaccines like rubella or independently and the coverage remains varied [9–18]. As reported by the WHO, the second dose of measles-containing vaccine (MCV2) coverage was 73 % in 2019 with significant regional variations [3]. Measles-rubella vaccine coverage varies across districts: ranging from 75 to 91 % in Japan and Switzerland [19,20]. The measles second dose vaccination coverage was less

Abbreviations: AOR, adjusted odds ratio; EMDHS, Ethiopian Mini demographic and health survey; AIC, Akaike information criterion; ICC, intraclass correlation; DIC, deviance information criteria; MOR, Median Odds Ratio; PCV, percentage change invariance.

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than 50 % in Kenya [21], and 62 % in Burkina Faso[22]. As evidenced by the joint report of WHO, and UNICEF the second-dose measles-containing vaccine coverage in Ethiopia was 71, and 70.56 % in 2020, and 2021 respectively [23].

Federal Ministry of health-Ethiopia believes that vaccines are cost-effective public health interventions. As a result, Ethiopia introduced a measles second dose vaccine to be administered at the age of 15 months from birth [13] in the routine expanded immunization program schedules to boost immunity and halt repeated measles outbreaks.

Different factors determine the coverage of measles' second dose. A study in Switzerland reported that the sex of the child and maternal educational status significantly affects the second dose measles-rubella vaccine coverage [20]. Based on the evidence of the 2012 study finding, Non-Muslim religious followers have 1.62 times higher odds of measles vaccination coverage in Indonesia [24]. Another study in China pointed out that the low educational status and the fixed-job of the mother, children delivered at home, low household income, and younger age of the mother [15] are associated with decreased measles second dose vaccination coverage. Higher maternal education, the high number of birth orders, and high socioeconomic development were significantly associated with measles second dose vaccination coverage [25]. Mothers' knowledge of the second dose measles-containing vaccine, and waiting time for the minimum number of children to open the vaccine vial are related to the measles-containing second dose vaccination [12]. Moreover, wastage rates, parents, and healthcare providers' knowledge, and attitudes towards the introduction of the measles second dose vaccine have a paramount on vaccine coverage rates [26].

Several strategies for measles elimination, and repeated outbreaks in Ethiopia and beyond are a paradox that request evidence to overcome [2,27–35]. Hence assessing the coverage of the newly introduced vaccine (Measles second dose), and associated factors are very critical to informing scholars and policymakers using the 1st national data containing the measles second dose vaccine.

Methods

Study area and setting: The 2019 Ethiopian Mini Demographic and Health Survey (EMDHS) was conducted from 21, March to 28 June 2019 in Ethiopia. Ethiopia is found in the horn of East Africa with ten regions and two city administrations. It is the second-most populous country in Africa with a high number of under-five children. The country introduces new vaccinations like measles second dose and others in the Expanded Program on Immunization (*EPI*) schedule as routine service since 2018.

Study design and population: The 2019 EMDHS is a nation-wide community-based cross-sectional study. We undertake an in-depth secondary data analysis using the EMDHS data set. The EMDHS was based on 305 enumeration areas of which 212 were rural, and 93 were rural enumeration areas. Details of the EMDHS methodology are found somewhere else [36]. A total weighted sample size of 965 children aged less than 36 months was included in the final analysis.

Variables: The dependent variable of this study was measles second dose vaccination status (reported as received/not received measles second dose). Individual-level variables were age, marital status, occupation, and educational status of the respondent; birth order, age, sex, nutritional status, being vaccinated for Penta 3 of the child; the number of living children in the household, preceding birth interval, sex, and religion of the household head. Community-level variables were region and types of place of residence (urban/rural).

Data analysis

Descriptive analysis: As per the recommendation of the survey methodology, and different none response rates, we weighed the data before actual analysis. Proportions and frequencies were used to describe the characteristics of the study subjects including figures and narratives.

Multivariable multilevel analysis: a two-stage multilevel logistic regression model was used to determine the individual and community level factors' effect on measles second dose vaccine coverage, and to quantify the between cluster variability in the odds of measles second dose coverage. We fitted four models; the null model (Model I), an empty model without any independent variable to estimate the Intra-Cluster Correlation (ICC) showing the extent of intra-cluster variation in measles second dose vaccination. The Individual level model (Model II) was only individual-level variables included; the community-level model (Model III) was only community-level factors like region, and types of places of residence considered, and the final model (Model IV) was where individual and community-level variables fitted simultaneously. The Adjusted Odds Ratio (AOR) with 95 %CI was reported for significant variables after adjusting for individual and community-level variables. The chi-square and multicollinearity assumptions were tested. A P-value less than 0.2, and 0.05 were used to declare the level of significance at the bi-variable and multivariable multilevel logistic regressions respectively.

Random effect analysis: The random effects were measured by the intra-class correlation coefficient (ICC), Median Odds Ratio (MOR), and proportional change in variance (PCV) [37]. The ICC was calculated to evaluate whether the variation in measles second dose vaccination is primarily within or between communities. In our article, MOR shows the extent to which the individual probability of measles second dose vaccination contributed by the residential area. The PCV was used to quantify the cumulative effect of individual and community-level factors on measles second dose vaccination coverage [38].

Results

Characteristics of the study participants

More than half 545(56.48 %) of the children were male. Four hundred fifteen (43.04 %) of them were in 24–36 months old. More than a quarter 261 (27.04 %) of the children were underweight (weight/age < -2sd). On top of this more than a third 381 (39.52 %) of the children were not vaccinated for the third dose of pentavalent (Penta 3). Nearly half 478 (49.49 %) of the women had no formal education, and 802 (83.12 %) were rural residents. Among 965 weighted participants, 120 (12.36 %, 95 %CI: 10.89, 15.41) of the respondents were vaccinated for measles second dose (Table 1).

Determinant factors of measles second dose coverage

In the bi-variable multi-level analysis: The age and sex of the child, being vaccinated for the Penta 3 vaccine, households wealth index, nutritional status of the child, religion, and educational status of the household head was significant. After adjusting for wealth index, sex of the child, religion, child's nutritional status; the age of the child, educational status of the household head, being vaccinated for Penta 3, and region of residence were significantly associated with measles second dose vaccination among under-five children. A child aged 12–23, and 24–36 months had 2.14, and 2.58 times higher odds of receiving measles second dose vaccine respectively as compared to those less than a year-old

Table 1
Characteristics of the study participants.

Variable	Category	Weighted Frequency	Weighted Proportion (%)
Individual-level variables			
Age of the child in months	≤12	252	26.17
	12–23	297	30.80
	24–36	415	43.03
Sex of the child	Male	545	56.48
	Female	420	43.52
Birth order	1st	234	24.22
	2-4th	390	40.41
	>4th	341	35.37
Vaccinated for Penta 3	Yes	584	60.84
	No	381	39.52
Number of living children in the household	1	212	21.97
	2to4	435	45.04
	Above 4	318	32.99
Sex of HH head	Male	852	88.27
	Female	113	11.73
Age of respondent	15to20	148	15.29
	21 to 25	278	28.86
	26 to 35	422	43.69
	>35	117	12.17
The religion of the household head	Orthodox	304	31.55
	Protestant	323	33.45
	Muslim	325	33.68
	Other*	13	1.32
Women Highest education	No education	478	49.49
	Primary	372	38.53
	Secondary and above	116	11.97
Marital status	Not married	57	5.87
	Married	909	94.13
Wealth index	Poorest	221	22.86
	Poorer	247	25.56
	Middle	222	23.06
	Richer	167	17.37
	Richest	107	11.14
Preceding birth interval	Normal	289	29.97
	Short	317	32.86
	Long	125	12.93
	Primary child	234	24.24
Weight for age	z-score < -2 underweight	261	27.04
	−2 to + 2 normal	659	68.25
	>+2 overweight	45	4.71
Community-level variables			
Region	South nations and nationalities	175	18.18
	Amhara	218	22.61
	Oromia	451	46.71
	Diredawa and Addis Ababa	14	1.43
	Others**	107	11.06
Place of residence	Urban	163	16.88
	Rural	802	83.12

* *others =.catholic, and traditional religion followers.*
** *Others = Somali, Afar, Gambela, Benishangul Gumuz, and Tigray region.*

child's. Moreover, children who were not vaccinated for the third dose of the pentavalent vaccine had 40 % lower odds of receiving the measles second dose vaccine as compared to their counterparts (Table 2).

Random effect analysis

As evidenced from the empty model, 13.46 % (ICC = 0.1346) of variation of the odds of measles second dose vaccination was accounted for by variations of the between cluster characteristics. The between-cluster variability decline successively from 13.46 % in the empty model to 13.03, 6.12, and 3.97 % in the individual, community level, and final combined models respectively. We found that there is an increased proportion of explained variation in measles second dose vaccination as depicted by the PCV.i.e nearly 50 % increase from the empty model. This implies that 48.61 % of the variance in measles second dose vaccination was explained by the individual and community level factors together. On top of this measles, second dose vaccination coverage was significantly affected by community-level characteristics. Based on the empty model, the variations between communities were nearly-two times (MOR = 1.98) higher than the reference. The unexplained variation in the community decreased to 1.44 in the final model when individual and community-level variables were added from the empty model. We compared the model fitness using the deviance, and the final model is the better model (Table 3).

Discussions

This study was based on the 1st (that incorporates measles second dose vaccination status) national representative and population-based data to assess the new vaccination (measles second dose) coverage and associated factors. We found that the measles second dose vaccination coverage was low where only 12.36 % of the children were vaccinated. The measles second dose coverage was higher among children older than 1 year, those vaccinated for the third dose of the pentavalent vaccine, and born from women with better education.

In Ethiopia, nearly a tenth of the children were vaccinated for the second dose of the measles vaccine. Accordingly, the coverage of the second dose of the measles vaccine was low as compared to the global report [3], and other studies were conducted in Switzerland where more than three-fourths of the young population was vaccinated for the second dose [20]. This might be due to variations in the population, and socioeconomic characteristics. As the countries have introduced the vaccine at different times, living in different set-ups where developed nations like Switzerland and others have better access, early introduction of the vaccine [39,40], while Ethiopia introduced the vaccine in 2018; which may have challenges in perceptions, women knowledge and willingness to take the vaccine. Moreover, less frequent vaccination services and short service time reduces the measles second dose vaccination [25] affects the coverage in china and may work in Ethiopia. Children who reside in places where there are institutions that provide the immunization service more frequently, and in the morning and afternoon sessions have low missed opportunity rates.

The odds of receiving the second dose of the measles vaccine doubles for children aged 13–23, and 24 to 36 months old as compared to those children aged less than 13 months. This was supported by findings from Pakistan where the child's age significantly affects the timing of the measles vaccination [41]. In our scenario, the ideal recommended time to receive a measles second dose is 15 months, but we found that some children were early vaccinated/before 15 months.

Additionally, children living in southern nations and nationalities and peoples region had more than double the odds of receiving measles second dose vaccine as compared to the Amhara region. This holds for other vaccines too as reported from different studies the vaccination coverage has significant variation among regions of Ethiopia [36]. Other studies reported that living in different geographic areas had a significant effect on measles vaccination coverage [15,25]. This might be due to variations in the access to vaccines that have a significant effect on vaccination coverage [42].

Regarding previous vaccination status for other vaccines, children who were not vaccinated for the third dose of Pentavalent had 40 % fewer odds of receiving the measles second dose compared to their counterparts. This might be because those children

Table 2
Determinant factors of measles second dose vaccine coverage among children using multilevel logistic regression, Evidence from Ethiopian Mini Demographic and Health Survey 2019 data.

Variable	category	Model I (AOR, 95 % CI)	Model II (AOR, 95 % CI)	Model III (AOR, 95 % CI)	Model IV (AOR, 95 % CI)
Empty	Null model	0.13(0.09,0.17)			
Age of the child in months	≤12		Ref		Ref
	12–23		2.44(1.19, 5.01)		2.14(1.05, 4.36) *
	24–36		2.85 (1.44, 5.64)		2.58 (1.32, 5.05) *
Wealth index	Poorest		0.57(0.24, 1.33)		0.71(0.30, 1.66)
	Poorer		1.03(0.46, 2.29)		1.24 (0.56, 2.77)
	Middle		1.47 (0.67, 3.23)		1.98 (0.89, 4.40)
	Richer		1.71 (0.81, 3.74)		2.09 (0.94, 4.60)
	Richest		Ref		Ref
Weight for age	z-score < -2 underweight		Ref		Ref
	−2 to + 2 normal		0.87(0.53, 1.44)		0.82(0.50,1.34)
	>+2 overweight		0.37 (0.10, 1.36)		0.32 (0.10, 1.14)
Sex of the child	Male		Ref		Ref
	Female		0.71(0.45, 1.12)		0.68 (0.44, 1.06)
Highest education	No education		0.46 (0.23, 0.91)		0.51 (0.26,1.00)
	Primary		0.38 (0.20, 0.74)		0.44 (0.23, 0.85) *
	Secondary and above		Ref		Ref
Vaccinated for Penta 3	Yes		Ref		Ref
	No		0.61 (0.37,0.99)		0.60 (0.37, 0.95) *
The religion of the household head	Orthodox		1.60 (0.90, 2.85)		1.70 (0.92, 3.12)
	Protestant		1.85 (0.97, 3.53)		1.45(0.72, 2.92)
	Muslim		Ref		Ref
	Other		1.74 (0.29, 10.31)		1.44 (0.26, 7.93)
Region	South nations and nationalities		______	2.32(1.09, 4.94)	2.83(1.12, 7.11) *
	Amhara		______	Ref	Ref
	Oromia		______	0.48 (0.20, 1.18)	0.64(0.23, 1.79)
	Diredawa and Addis Ababa		______	1.38 (0.61, 3.10)	2.62(0.96, 7.18)
	Others		______	0.73 (0.37, 1.45)	1.13 (0.53, 2.42)

* statistically significant factors; Ref, reference; Penta 3: 3rd dose of Pentavalent vaccine.

Table 3
Random effect model.

Random effects (a measure of variations for measles second dose coverage)	Model I	Model II	Model III	Model IV
Community variance(SE)	0.72(0.22)	0.70(0.23)	0.46(0.27)	0.37(0.35)
ICC (%)	13.46	13.03	6.12	3.97
Explained variation (PCV%)	Reference	2.8	36.11	48.61
MOR	1.98	1.95	1.55	1.42
Model fit statistics				
Deviances	655.64	600	636.22	583.72
AIC	659.64	634.38	648	625

Footnotes:
AIC: Akakie information criterion; ICC: intraclass correlation, DIC: deviance information criteria; MOR; Median Odds Ratio; PCV: percentage change invariance.
Model I: Null model, baseline model without any covariates.
Model II: is adjusted for individual-level factors.
Model III: is adjusted for community-level factors.
Model IV: is the final model adjusted for both individual and community-level factors.

who are not vaccinated for the third dose of the pentavalent vaccine may have less access, and their parents may have poor knowledge about the schedule and importance of the measles second dose vaccine [43]. Women who don't know the routine schedule and the appropriate age for measles second dose vaccination reduce the vaccination status of their child [44]. Children of women with no, and primary education had>50 % fewer odds of receiving measles second dose vaccine compared to women with secondary and above education. This is supported by other evidence reported from Congo finds that children from more educated mothers have better measles second dose coverage [45]. This might be because mothers with better education may have better knowledge, and perceptions about vaccination benefits, and get their infants vaccinated [42].

Strengths and limitations

We are confident that using nationwide data and the first study on the topic may have its role for policymakers will make our research strong but we faced the limitations of secondary data. We missed some important predictors like health services availability, and other socio-cultural and vaccine-related issues as we rely on the available variables only.

Conclusions

The measles second dose vaccine coverage was low in Ethiopia. Children's age and being vaccinated for 3rd dose of pentavalent, educational status of the women, and region of residence were significant predictors. Therefore, empowering women and creating public awareness about the need for a second-dose measles vaccine may help to halt repeated measles outbreaks in the country and achieve the measles elimination target in the long run.

Declarations

Ethics approval and consent to participate

Ethical clearance was obtained from an institutional ethical review committee of the Institute of Public Health, College of Medicine and Health Science, University of Gondar, Ethiopia. Permission for data access was obtained from the Major DHS program after registering as an authorized user. All the data used in this manuscript are publicly available and confidentiality was maintained anonymously.

Consent for publication

Not applicable.

Availability of data and material

The data used for the preparation of this manuscript are available from https://www.dhsprogram.com and anyone can access it through an online request as an authorized user. The authors prepared the data that was used for the preparation of this manuscript can be shared if required.

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Authors' contributions

AGM selects the title, develops the proposal, extracts the data, analysis the data, interpreted the results, and prepared the manuscript. MWM, BT, YA, MGF, and GMK assist the design, commenting, approving the proposal, and preparing the manuscript. All authors read and approve the final manuscript before submission.

Data availability

Data will be made available on request.

Declaration of Competing Interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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