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Socioeconomic inequalities in full vaccination coverage among children aged 12-23 months in Ethiopia, 2011-2016: A decomposition approach

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Abstract

Objectives: Monitoring and addressing unnecessary and avoidable differences in child vaccination is a critical global concern. This study aimed to assess socioeconomic inequalities in full vaccination coverage among children aged 12-23 months in Ethiopia.

Design, setting and participants: Secondary analyses of cross-sectional data from the two most recent (2011 and 2016) Ethiopia Demographic and Health Surveys were performed. This analysis included 1930 mother-child pairs in 2011 and 2004 mother-child pairs in 2016.

Outcome measures: Full vaccination status was defined based on whether a child received a single dose of Bacille Calmette Guerin (BCG), three doses diptheria, tetanus toxoids, and pertussis (DTP3), three doses of polio vaccine, and one dose of measles vaccine.

Methods: The concentration curve and concentration index (CCI) were used to estimate wealth related to inequalities. The concentration indices were also decomposed to examine the contributing factors to socioeconomic inequalities in childhood vaccination.

Results: From 2011 to 2016, the proportion of children who received full vaccination increased from 24.6% (95% confidence interval, CI: 21.4 to 28.0) to 38.6% (95% CI: 34.6 to 42.9). While coverage of BCG, DPT, and polio immunization increased during the study period, the uptake of measles vaccine decreased. The positive concentration index shows that full vaccination status was favourably concentrated among children from wealthier households CCI= 0.212 in 2011 and CCI= 0.212 in 2016. The decomposition analysis shows that maternal health services such as family planning and antenatal care, socioeconomic status, exposure to media, urban-rural residence, and maternal education explain inequalities in full vaccination coverage in Ethiopia.

Conclusions: Childhood vaccination coverage was low in Ethiopia. Vaccination was less likely in poorer than in richer households. Addressing wealth inequalities, enhancing education, and improving maternal health service coverage will reduce socioeconomic inequalities in full vaccination uptake in Ethiopia.

Keywords: Inequality, Immunization, Vaccination, Socioeconomic factors, Ethiopia

Strengths and limitations

- This study used two most recent (2011 and 2016) nationally representative Demographic and Health Surveys.
- The decomposition of the contributing factors that drive socioeconomic inequalities in vaccination status provided a rich set of analysis for policy interventions to address socioeconomic disparities in child vaccination in Ethiopia.
- Limitations of the current study may include recall bias related to vaccination status as not all children had vaccination cards, and measures had to depend on the mother's verbal report.
- The DHS is a cross-sectional survey; it was not possible to establish temporality between childhood vaccination and explanatory factors, precluding causal inference.

Introduction

Vaccination is an important public health intervention that helps prevent 2 to 3 million child deaths each year (1). With improved coverage, vaccines have the potential to save many more children, which is why it is necessary to ensure that all children receive full vaccination (2, 3).

In the last two decades, global basic vaccination coverage has improved remarkably (4, 5). However, there are inequalities in access to childhood vaccination and many children do not receive the basic vaccines worldwide (6, 7). These disparities in vaccination coverage exist within and between countries, and in some places; the difference is larger (6).

Many children in some regions of the world continue to receive lower coverage. The World Health Organization (WHO) report in 2019 shows that 19.4 million children under the age of one year did not receive basic vaccines; around 60% of these children live in 10 nations, including Nigeria, the Democratic Republic of the Congo and Ethiopia (1).

Complete lack or incomplete childhood vaccination remains the cause of millions of preventable child deaths each year in many countries (1). Previous studies in the area suggest that there exists a social gradient in child vaccination within countries (8-10). For example, increased vaccination coverage was favorably concentrated among children whose parents are well-educated, wealthy or living in urban areas.

Inequalities in access to health services need to be effectively assessed, monitored, and intervened to address systematically missed population groups (11, 12). Measuring inequalities in full vaccination coverage can reveal where gaps lie in routinely delivered vaccines and provide valuable information to introduce effective strategies and policies to address such inequalities.

Although there are previous studies (13-15) in Ethiopia that have addressed factors associated with childhood vaccination, there is no study that examined trends and socioeconomic inequalities in childhood vaccination. The objective of this study is to examine trends and socioeconomic inequalities in childhood vaccination. Moreover, the paper assesses factors that explain socioeconomic inequalities in childhood vaccination in the country using a decomposition approach.

Methods

Data

The most recent (2011 and 2016) Ethiopia Demographic and Health Surveys (EDHS) were analysed. The Ethiopian Central Statistical Agency (CSA) undertook the surveys in collaboration with the DHS program (16). The DHS surveys are nationally representative household surveys with large sample sizes and high response rates (17). The Demographic Health and Survey () uses a stratified, two-stage sampling technique to obtain the study participants (18). Standardised questionnaires are used across time and countries to ensure collected data are comparable (19). Sampling methods and design have been described elsewhere (20). For the purpose of this study, data collected on vaccination status of children aged 12-23 months were extracted and analyzed. The Ethiopia DHS included information on 11,872 births/women in 2011 and 11,023 births/women in 2016. The sample used for the current analysis was limited to children aged 12–23 months at the time of the survey, yielding a final sample of 1930 mother-child pairs in 2011, and 2004 mother-child pairs in 2016.

Measures

The dependent variable is a binary variable indicating whether a child received full vaccination that include eight recommended basic vaccines (21). The vaccines include one dose of Bacille Calmette Guerin (BCG) against tuberculosis, three doses of trivalent, tetravalent or pentavalent – vaccine against diptheria, tetanus toxoids and pertussis (DTP3), three doses of polio vaccine, and one dose of measles vaccine. Vaccination status of children was collected from two sources; primarily immunization record cards provided by mothers were considered. In the absence of vaccination cards, mothers' verbal reports of children's immunization status were collected.

Independent variables

The WHO Commission on Social Determinants of Health framework (22) was used to assess contributing factors of inequalities in vaccination status. In addition, factors identified in the current literature (8, 9, 23-25) on child vaccination that are available in the DHS surveys were included. The independent variables considered in the current study include 1) maternal and household factors: maternal parity, age, education levels, wealth status, and the use of maternal health services, 2) exposure to media, and 3) place of residence – urban/rural status.

The wealth index is a composite variable that measures the woman's household living standards. It is constructed by collecting and analysing information on ownership of selected materials and assets, such as radio, television, refrigerator, and vehicle; materials used for housing construction; and types of sanitation facilities and water access. Households were ranked into five quintiles (poorest, poorer, middle, richer and richest) depending on their level of wealth.

Education levels of the mothers were grouped in three categories (no education, primary, and secondary or higher). Exposure to media: frequency of listening to radio and watching television (TV): both categorised as (not at all, less than once a week, and once a week or more). Utilization of reproductive and maternal health services considered in the current study include use of contraceptive, antenatal care contacts, and delivery at the health facility.

Statistical analysis

Socioeconomic inequalities in the coverage of vaccination status were estimated using the concentration curve and concentration index (26). The concentration curve is a plot of the cumulative percentage of the population, ranked by wealth status, from the poorest to the richest (x-axis) against the cumulative percentage of the health variable (vaccination status) on the y-axis. If all children had an equal proportion of vaccination status regardless of their socioeconomic status, then the curve would coincide with the 45° line, which indicates the presence of equality in the coverage of vaccination. If the concentration curve falls below the 45° line of equality, it indicates that the uptake of vaccines is more concentrated among the rich. The opposite is true if the curve falls above the line of equality.

The concentration index is described as two times the area between the line of equality and the concentration curve. The index takes a value between −1 and +1; an index of 0 indicates the presence of equality in the uptake of vaccines. If wealth related inequalities exist, it can be seen in one of the two forms, the first is when there is uneven concentration of vaccine uptake among the rich, and in this case, the concertation index takes on a positive value. The second is negative value concentration index, which implies high concentration of vaccination status among the poor.

The concentration index (CCI) can be computed as follows:

$$CCI = \frac{2}{y}cov(h,r), \qquad (1)$$

where h is the healthcare outcome of interest (vaccination status), l is the mean of h and r is the fractional rank of an individual in the wealth distribution. 95% CIs will be used to assess statistical significance of the concentration index.

Decomposing inequality

The concentration curve and concentration index can only show and quantify the level of inequalities related to wealth in the use of health services. However, policymakers are also interested in the factors that contribute to socioeconomic inequalities in vaccination coverage. This can be done using an approach forwarded by Wagstaff and colleagues (27). The concentration index of a health variable can be decomposed into the contributions of individual factors to wealth-related health inequality. If we consider a linear regression model for the child vaccination status, v, is defined according to k explanatory factors, x_k as.

$$v = \alpha + \sum_k \beta_k x_k + \varepsilon\,, \qquad (2)$$

where α and β are parameters, and ε is the error term. The concentration index for child vaccination status can be decomposed as:

$$C = \sum_k \left(\frac{\beta_k \bar{x}_k}{\mu}\right) C_k + \frac{GC_\varepsilon}{\mu}, \qquad (3)$$

where μ is the mean of y, $\bar{x}_k$ is the mean of x_k, C_k is the concentration index for x_k, (defined analogously to C), and GC_ε is the generalized concentration index for the error term (ε). Equation 2 shows that C is equal to a weighted sum of the concentration indices of the k regressors, where the weight for x_k is the elasticity of y with respect to $x_k (\eta_k = \beta_k \frac{\bar{x}_k}{\mu})$. The residual component—captured by the last term $(\frac{GC_\varepsilon}{\mu})$ reflects the wealth-related inequality in health that is not explained by systematic variation in the regressors.

All analysis were performed after adjusting for sampling design (stratification and clustering) and sampling weights. STATA (version 14, StataCorp, College Station, Tex) and SPSS (version 26) software packages were used to perform data analysis.

Patient and public involvement

Patients/public were not involved in the design or implementation of this study.

Results

The sample used for the current analysis was limited to children aged 12–23 months at the time of the survey, yielding a final sample of 1930 mother-child pairs in 2011, and 2004 mother-child pairs in 2016. The majority (more than 85%) of respondents were from rural areas on both surveys, and more than 42% were from Oromia, which is the biggest region in the country. The percentage of mothers who had no education decreased from 68% in 2011 to 64% in 2016 while antenatal care contacts increased from 42% in 2011 to 60% in 2016 (Table 1).

Trends of vaccination coverage

Vaccination coverage showed improvements from 2011 to 2016; BCG vaccine uptake increased from 66% to 69%, DTP3 vaccine from 37% to 57%, Polio 3 vaccine from 45% to 57%, and full vaccination coverage from 24% in 2011 to 38% in 2016. However, measles vaccine coverage decreased from 56% in 2011 to 54% in 2016, while the proportion of children who received no vaccination increased from 14% in 2011 to 16% in 2016 (Figure 1).

The urban/rural differential in full vaccination coverage increased from almost 28% in 2011 to more than 29% in 2016 (Table 1). Coverage remained low but showed slight increases from 2011 to 2016 in regions such as Afar (8.5% to 15.2%), Somali (17.1% to 21.8%), and Oromia (15.6% to 24.7%). Full vaccination coverage also showed disparities between and within the regions of Ethiopia (Table 1). For example, in 2016, coverage was 89.2% (95% CI: 82.0%, 93.8%) and 67.3% (95% CI: 57.6%, 75.7%) among children living in Addis Ababa and Tigray regions respectively, whereas in Afar it was 15.2% (95% CI: 8.0%, 26.9%), and Somali 21.8% (95% CI: 13.8%, 32.7%).

Table 1 Full vaccination coverage by maternal and child characteristics in Ethiopia (DHS 2011 – 2016)

	2011				2016			
Study variables	**Number**	**Percent**	**Received full immunization (95% CI)**	**P-value**	**Number**	**Percent**	**Received full immunization (95% CI)**	**P-value**
Sex of child				**0.268**				**0.252**
Male	1010	52.3	23.1 (19.3, 27.5)		926	46.2	36.5 (31.2, 42.1)	
Female	920	47.7	26.1 (22.0, 30.7)		1078	53.8	40.5 (35.4, 45.8)	
Parity				**0.101**				**0.002**
1	358	18.6	30.1 (23.3, 37.9)		372	18.6	45.3 (37.7, 53.1)	
2	318	16.5	26.7 (20.7, 33.7)		322	16.0	47.1 (39.0, 55.3)	
3	306	15.9	22.8 (17.1, 29.8)		282	14.1	40.4 (31.9, 49.5)	
4	230	11.9	24.4 (18.1, 32.0)		243	12.1	39.5 (31.4, 48.2)	
5	220	11.4	15.3 (9.9, 22.8)		216	10.8	30.1 (21.5, 40.3)	
6	497	25.7	23.8 (17.5, 31.6)		569	28.4	28.7 (22.3, 36.2)	
Maternal age				**0.992**				**0.197**
15-24	518	26.8	24.6 (19.6, 30.4)		499	24.9	37.9 (31.6, 44.7)	
25-29	649	33.6	23.8 (19.3, 29.1)		596	29.7	44.1 (37.1, 51.4)	
30-34	386	20.0	24.7 (19.0, 31.5)		456	22.7	35.1 (28.7, 42.1)	
35-39	251	13.0	26.0 (18.9, 34.5)		295	14.7	33.5 (25.7, 42.4)	
40-49	127	6.6	24.8 (16.0, 36.2)		158	7.9	39.9 (29.3, 51.5)	
Contraceptive use				**<0.001**				**<0.001**
Never used	1106	57.3	17.9 (14.5, 21.8)		932	46.5	25.8 (21.3, 30.8)	
Using or used before	824	42.7	33.5 (28.8, 38.5)		1072	53.5	49.8 (44.3, 55.4)	
Antenatal care contact				**<0.001**				**<0.001**
No	1040	53.9	14.8 (11.6, 18.6)		711	35.5	18.6 (13.8, 24.4)	
Yes	815	42.2	37.3 (32.7, 42.1)		1194	59.6	50.8 (45.7, 55.8)	
Place child was delivered				**<0.001**				**<0.001**
Home	1694	87.8	20.6 (17.5, 24.1)		1309	65.3	30.6 (25.9, 35.6)	
Health facility	236	12.2	52.7 (43.3, 62.0)		695	34.7	53.8 (47.6, 60.0)	

Maternal educational levels			**<0.001**				**<0.001**
No education	1307	67.7	20.4 (16.9, 24.5)		1257	62.7	30.9 (26.6, 35.6)	
Primary	522	27.0	28.5 (23.6, 33.9		577	28.8	46.1 (39.8, 52.5)	
Secondary or higher	102	5.3	57.3 (44.7, 69.0)		170	8.5	70.5 (55.9, 81.8)	
Household wealth index in quintiles				**<0.001**				**<0.001**
Poorest	441	22.9	16.8 (12.0, 23.0)		504	25.2	22.2 (16.1, 29.8)	
Poorer	419	21.7	18.7 (13.9, 24.7)		396	19.8	38.1 (30.7, 46.1)	
Middle	394	20.4	18.7 (13.8, 24.7)		450	22.4	37.1 (30.1, 44.7)	
Richer	369	19.1	25.1 (18.7, 32.7)		366	18.3	44.6 (36.4, 53.0)	
Richest	307	15.9	50.7 (41.5, 59.8)		288	14.4	63.0 (52.0, 72.8)	
Place of residence				**<0.001**				**<0.001**
Urban	274	14.2	48.2 (38.8, 57.8)		232	11.6	64.6 (51.1, 76.2)	
Rural	1656	85.8	20.6 (17.4, 24.3)		1772	88.4	35.2 (31.1, 39.6)	
Regions				**<0.001**				**<0.001**
Tigray	129	6.7	59.3 (50.7, 67.5)		152	7.6	67.3 (57.6, 75.7)	
Afar	18	0.9	8.6 (4.9, 14.6)		20	1.0	15.2 (8.0, 26.9)	
Amhara	446	23.1	27.1 (20.0, 35.6)		364	18.2	46.4 (36.7, 56.4)	
Oromia	811	42.0	15.6 (11.1, 21.3)		881	44.0	24.7 (18.9, 31.6)	
Somali	51	2.6	17.1 (10.2, 27.2)		76	3.8	21.8 (13.8, 32.7)	
Benishangul-Gumuz	23	1.2	24.2 (16.8, 33.5)		21	1.0	57.4 (47.1, 67.2)	
Southern Nations, Nationalities and People	391	20.2	24.1 (18.0, 31.4)		419	20.9	46.9 (38.5, 55.5)	
Gambela	8	0.4	17.4 (8.7, 31.8)		5	0.3	41.1 (30.3, 52.9)	
Harari	5	0.3	36.1 (27.3, 46.0)		5	0.2	42.2 (31.1, 54.0)	
Addis Ababa	43	2.2	78.7 (69.1, 85.9)		52	2.6	89.2 (82.0, 93.8)	
Dire Dawa	7	0.4	59.4 (49.3, 68.8)		9	0.5	75.9 (64.2, 84.6)	

Inequalities in vaccination coverage

Inequalities in child vaccination persisted during 2011 and 2016: full vaccination status was favourably concentrated among children from wealthier households while the distribution of those who received no vaccination remained pro-poor (Figure 2). The uptake of BCG, DTP3, Polio 3, measles, and full vaccination were disproportionately concentrated among children from wealthy households during 2011 and 2016 (Figure 3). DTP3 and full vaccination status had lower coverage and showed the highest inequalities during 2011 and 2016; for example, in 2016, DPT3 had concentration index of (CCI= 0.175) and full vaccination (CCI= 0.172). The estimate for the distribution of children who received no vaccination in 2011 was (CCI= -0.092), this increased to (CCI= -0.184) in 2016 (Figure 3). The negative values for children who received no vaccination confirms pro-poor distributions. Increased vaccination coverage decreased inequalities as vaccinations such as BCG, Polio 3, and measles that had higher coverage showed lower inequalities (Figure 3).

The decomposition results in Table 2 and Figure 4 show that the significant contributors to socioeconomic inequality in full vaccination status included, wealth, maternal education, contraceptive use, antenatal care contacts, exposure to media that include radio and television, and place of residence (rural).

The decomposition analysis showed similar patterns in factors that explain socioeconomic inequalities in child vaccination status on both surveys. The use of maternal health services had the highest significant contributions to socioeconomic inequalities in child vaccination. Antenatal care contacts had 45.4% contribution in 2011 and 50.4% in 2016. Wealth status is the other significant contributor, 23.9% in 2011 and 21.2% in 2016. On the other hand, rural residence had negative contribution to socioeconomic inequalities in child vaccination on both surveys.

The overall concentration index for full child vaccination was positive, any significant positive contributor in Table 2 and Figure 4 means that socioeconomic inequality in full vaccination would have been less pro-rich if: (i) the contributing variables (e.g. antenatal care contacts or wealth) were to be evenly distributed among the rich and poor. Negative contributing variables (e.g. rural

residence) would cause the opposite effect. The residual or unexplained contributing factors to socioeconomic inequalities in full vaccination account for 34.5% in 2011 and -12% in 2016.

Table 2 Decomposition of socioeconomic inequalities in full vaccination coverage in Ethiopia, (DHS 2011, 2016)

Study variables	2011				2016			
	Marginal effect	Concentration index	Absolute contribution	Percentage contribution	Marginal effect	Concentration index	Absolute contribution	Percentage contribution
Sex of child								
Male	(Base)	(Base)	(Base)	(Base)	(Base)	(Base)	(Base)	(Base)
Female	0.022	0.035	0.001	0.4	0.043	0.034	0.001	0.6
Maternal age								
15-24	(Base)	(Base)	(Base)	(Base)	(Base)	(Base)	(Base)	(Base)
25-29	0.052	0.049	0.003	1.2	0.562	0.073	0.006	2.2
30-34	0.072	-0.006	0.000	-0.2	0.058	-0.030	-0.002	-0.7
35-39	0.060	-0.052	-0.003	-1.5	0.052	0.006	0.000	0.1
40-49	0.023	0.019	0.000	0.2	0.057	-0.009	-0.001	-0.2
Maternal parity								
1	(Base)	(Base)	(Base)	(Base)	(Base)	(Base)	(Base)	(Base)
2	-0.004	-0.042	0.000	0.1	0.037	0.066	0.002	0.9
3	-0.033	0.020	-0.001	-0.3	0.014	-0.009	0.000	0.0
4	-0.021	-0.015	0.000	0.1	0.016	-0.034	-0.001	-0.2
5	-0.068	-0.012	0.001	0.4	-0.030	0.008	0.000	-0.1
6	-0.034	-0.048	0.002	0.8	-0.070	-0.123	0.009	3.2
Pattern of contraceptive use								
Never	(Base)	(Base)	(Base)	(Base)	(Base)	(Base)	(Base)	(Base)
Using or used before	0.091	0.348	0.032	15.2	0.235	0.322	0.076	28.5
Antenatal care contact								
No	(Base)	(Base)	(Base)	(Base)	(Base)	(Base)	(Base)	(Base)
Yes	0.242	0.390	0.094	45.4	0.566	0.237	0.134	50.4
Place child was delivered								
Home	(Base)	(Base)	(Base)	(Base)	(Base)	(Base)	(Base)	(Base)
Health facility	0.030	0.323	0.010	4.6	0.027	0.371	0.010	3.7

Frequency of listening to radio								
Not at all	(Base)	(Base)	(Base)	(Base)	(Base)	(Base)	(Base)	(Base)
Less than once a week	-0.031	0.104	-0.003	-1.6	0.049	0.127	0.006	2.3
At least once a week	0.026	0.232	0.006	2.9	0.045	0.219	0.010	3.7
Frequency of watching television								
Not at all	(Base)	(Base)	(Base)	(Base)	(Base)	(Base)	(Base)	(Base)
Less than once a week	-0.035	0.066	-0.002	-1.1	-0.008	0.120	-0.001	-0.3
At least once a week	0.042	0.223	0.009	4.5	0.007	0.286	0.002	0.7
Education levels								
No education	(Base)	(Base)	(Base)	(Base)	(Base)	(Base)	(Base)	(Base)
Primary	-0.005	0.182	-0.001	-0.4	0.070	0.127	0.009	3.3
Secondary or higher	-0.001	0.152	0.000	0.0	0.028	0.235	0.007	2.5
Place of residence								
Urban	(Base)	(Base)	(Base)	(Base)	(Base)	(Base)	(Base)	(Base)
Rural	0.143	-0.426	-0.061	-29.2	0.080	-0.323	-0.026	-9.8
Household wealth index in quintiles								
Poorest	(Base)	(Base)	(Base)	(Base)	(Base)	(Base)	(Base)	(Base)
Poorer	0.005	-0.283	-0.001	-0.7	0.094	-0.236	-0.022	-8.3
Middle	-0.015	0.078	-0.001	-0.6	0.061	0.110	0.007	2.5
Richer	0.032	0.375	0.012	5.8	0.070	0.387	0.027	10.2
Richest	0.076	0.535	0.040	19.4	0.091	0.492	0.045	16.8
Residual				34.6				-12.1
Total				65.4				112.1

Discussion

This study examined inequalities in full vaccination coverage among children aged 12-23 months in Ethiopia. The uptake of full vaccination increased from 24.6% in 2011 to 38.6% in 2016. Coverage improvements from 2011 to 2016 were observed in BCG vaccine uptake by 3%, DTP3 by 16.2%, Polio 3 by 11.5%, and full vaccination by 14%. However, Ethiopia remains one of the top ten high priority countries in the world where children remain unvaccinated (1).

The uptake of BCG, DTP3, Polio 3, measles, and full vaccination were disproportionately concentrated among children from wealthier households. The coverage of DPT3 and full vaccination showed the highest inequalities favouring children from wealthy households. More than 14% of children received none of the vaccines during 2011 and 2016. These children were mainly from disadvantaged households; for example, children who remained unvaccinated in 2016 were 8.3% among the richest quantile, while 24% were from the poorest quantile. Full vaccination coverage also showed significant variations across regions of the country; this ranged from 15% in Afar, and 21% in Somali, to 67.3% in Tigray, and 89.2% in Addis Ababa. Afar and Somali regions are predominantly nomadic pastoralist areas, with relatively weaker health systems compared to Tigray, and Addis Ababa that have improved healthcare coverage (28).

Ensuring access to all recommended vaccines for all children, regardless of sociodemographic or socioeconomic status, saves more lives and facilitates progress towards achieving sustainable development goals (SDGs) (29). SDG target for child mortality aims to reduce neonatal mortality to lower than 12 deaths per 1,000 live births and under-5 mortality to lower than 25 deaths per 1,000 live births across all countries (29). In 2016, the infant mortality rate was 48 deaths per 1,000 live births, and the under-5 mortality rate was 67 deaths per 1,000 live births in Ethiopia (16).

Findings of the current study revealed that the use of maternal health services, maternal education, exposure to media, and wealth had positive contributions to full vaccination uptake. These findings align with other similar studies (10, 24, 30). Maternal knowledge about vaccinations has been identified as a determinant for vaccination status, which may be associated with increased knowledge about benefits of child vaccination because of counselling during

family planning, and antenatal care contacts (31, 32). Moreover, based on findings related to the impact of residence and access to health facilities on vaccination, it may be that a mother with regular access to family planning and antenatal care is also more likely to seek out postnatal care where vaccination of her child can be more readily provided (33).

In the present study, maternal education had contributions to vaccine uptake in 2016, but this was not the case in 2011. Education helps to create improved awareness and knowledge about childhood vaccination (32). Previous studies have also indicated that educated women are more likely to take their child for vaccination (8, 32). Exposure to media can also be a useful tool to reach population at different socioeconomic levels. The findings of this study showed that access to mass media (radio and TV) favourably influences vaccine uptake. Transmitting information about the importance of childhood vaccination is vital to reach not only mothers but also their partners and community leaders (34). Information dissemination that targets mother's partner and community leaders can help to create a conducive environment that can favourably influence mothers to vaccinate their children.

In the present study, the socioeconomic well-being of mothers was associated with higher vaccination uptake. While vaccinations are provided free of charge in many developing countries, mothers sometimes incur indirect costs, for example, transportation costs, which often limit their uptake of these services (4). Mothers at the lower wealth categories are more likely to experience challenges in accessing healthcare facilities and transportation barriers as such less likely to take their child for vaccination (24).

Children from rural areas had lower vaccination coverage compared to children from urban areas. In 2011, full vaccination coverage was 48.2% in urban areas while it was 20.6% in rural areas. This pattern continued in 2016, as 64.6% of children from urban areas had full vaccination, but only 35.2% in rural areas. This finding is consistent with those of similar studies (24, 35). This could partly be explained by challenges faced in rural areas due to less developed health infrastructure and fewer skilled providers (36). In rural areas, long-distance to health facilities is another reason for low full vaccination coverage. People live far away from health facilities and

the long-distance, and lack of transportation poses a critical challenge for mothers to take their child for vaccination (36).

Vaccines require cold chain management as it is sensitive to high temperatures (37). Health facilities in rural areas face a shortage of electric power supply to keep the cold chain equipment working, which could lead to cancellation of services as lack of cold chain equipment may result in the stock-out of vaccines (10). One study from Nigeria found that 47% of solar fridges for vaccine storage in eight states were broken (38).

Conclusions

The coverage of full vaccination improved by 14 % from 2011 to 2016, but the overall coverage remained low. Increased vaccine coverage was disproportionately concentrated among children from wealthy households, while the majority of children who had no vaccination were from disadvantaged households. Utilisation of reproductive and maternal health services, household income status, and maternal education had significant positive contributions to improved vaccination status. Therefore, continued efforts at improving coverage of family planning, antenatal care contacts, institutional delivery, maternal education, and socioeconomic well-being are required to improve vaccination status. Moreover, regions such as Afar, Somali, and Oromia, and rural areas of the country at large require targeting.

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Ethics approval:

The Ethiopian Ministry of Science and Technology and Institutional Review Board of ICF International approved the original survey. Survey participants were informed about the objective and duration of the interviews. They were also notified that participation was voluntary, and that they could withdraw from the study at any time if they wished to do so.

Contributors

FTB is the single author of the paper

Data availability statement: The dataset was made available for public use after de-identification (data are available online at: https://www.idhsdata.org/idhs/)

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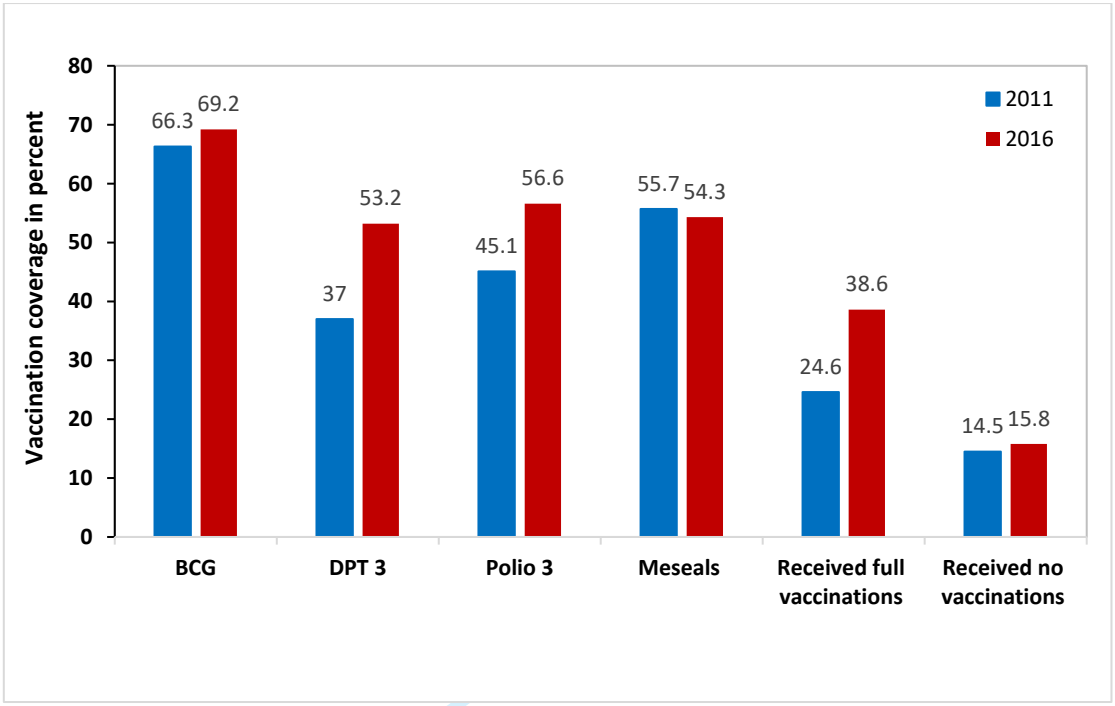

Figure 1 Vaccination coverage among children aged 12-23 months in Ethiopia (DHS 2011, 2016).

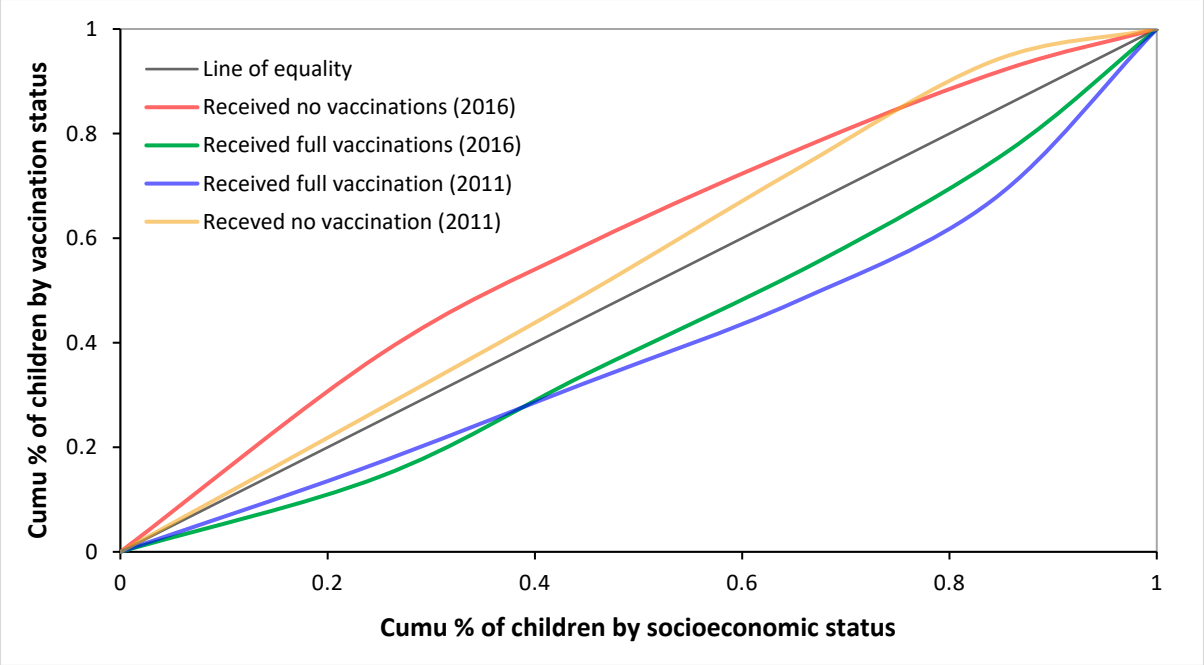

Figure 2 Concentration curves for child vaccination status, Ethiopia (DHS 2011, 2016)

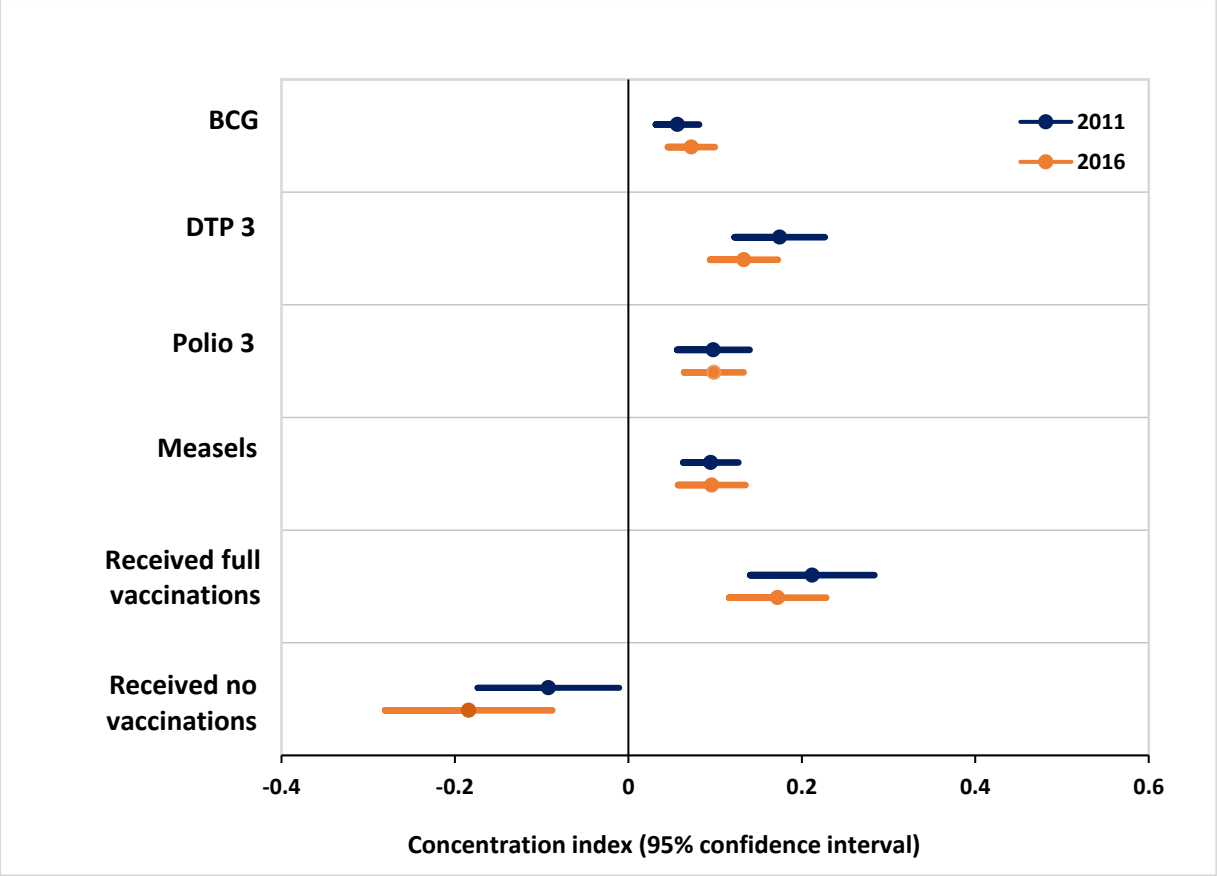

Figure 3 Concentration indecies that shows socioeconomic inequalities in child vaccinations, Ethiopia (DHS 2011, 2016)

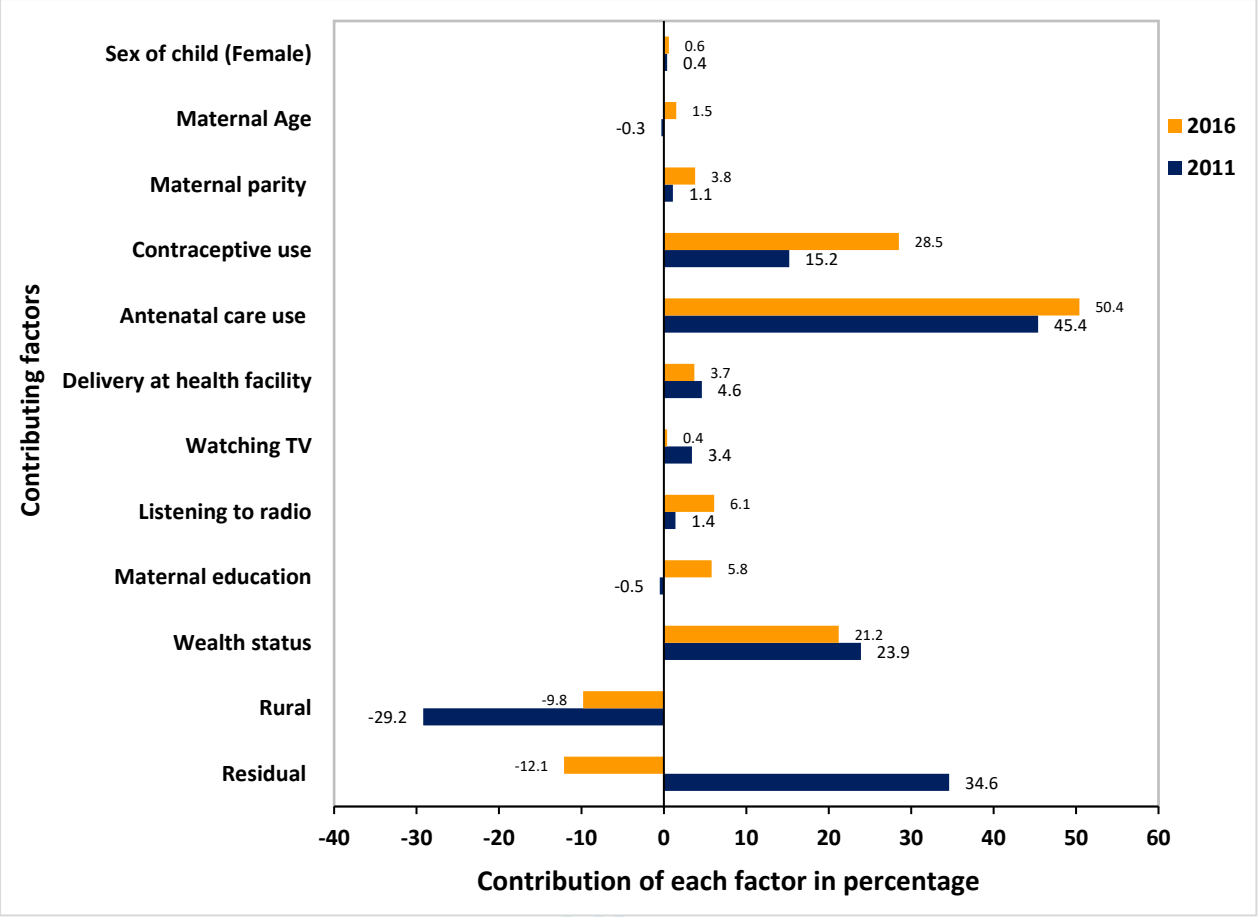

Figure 4 Percentage contributions of factors explaining socioeconomic inequalities in full vaccination coverage, Ethiopia (DHS 2011, 2016)

Health Insurance Coverage and Associated Factors among Women in Ethiopia: A Secondary Analysis of Ethiopia Demographic and Health Survey Data 2016 – STROBE checklist

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

		(*c*) If relevant, consider translating estimates of relative risk into absolute risk for a meaningful time period
Other analyses	N/A	Report other analyses done—eg analyses of subgroups and interactions, and sensitivity analyses
Discussion		
Key results	13-17	Summarise key results with reference to study objectives
Limitations	3	Discuss limitations of the study, taking into account sources of potential bias or
Interpretation	13-17	Give a cautious overall interpretation of results considering objectives, limitations, multiplicity of analyses, results from similar studies, and other relevant evidence
Generalisability	3	Discuss the generalisability (external validity) of the study results
Other information Funding	N/A	Give the source of funding and the role of the funders for the present study and, if applicable, for the original study on which the present article is based

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Socioeconomic inequalities in child vaccination coverage in Ethiopia: A decomposition approach

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Socioeconomic inequalities in child vaccination coverage in Ethiopia: A decomposition approach

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Abstract

Objectives: Monitoring and addressing unnecessary and avoidable differences in child vaccination is a critical global concern. This study aimed to assess socioeconomic inequalities in basic vaccination coverage among children aged 12-23 months in Ethiopia.

Design, setting and participants: Secondary analyses of cross-sectional data from the two most recent (2011 and 2016) Ethiopia Demographic and Health Surveys were performed. This analysis included 1930 mother-child pairs in 2011 and 2004 mother-child pairs in 2016.

Outcome measures: Completion of basic vaccinations was defined based on whether a child received a single dose of Bacille Calmette Guerin (BCG), three doses of diptheria, tetanus toxoids, and pertussis (DTP), three doses of polio vaccine (OPV), and one dose of measles vaccine.

Methods: The concentration curve and concentration index (CCI) were used to estimate wealth related to inequalities. The concentration indices were also decomposed to examine the contributing factors to socioeconomic inequalities in childhood vaccination.

Results: From 2011 to 2016, the proportion of children who received basic vaccination increased from 24.6% (95% confidence interval, CI: 21.4 to 28.0) to 38.6% (95% CI: 34.6 to 42.9). While coverage of BCG, DPT, and polio immunization increased during the study period, the uptake of measles vaccine decreased. The positive concentration index shows that basic vaccination status was favourably concentrated among children from wealthier households CCI= 0.212 in 2011 and CCI= 0.212 in 2016. The decomposition analysis shows that maternal health services such as family planning and antenatal care, socioeconomic status, exposure to media, urban-rural residence, and maternal education explain inequalities in basic vaccination coverage in Ethiopia.

Conclusions: Childhood vaccination coverage was low in Ethiopia. Vaccination was less likely in poorer than in richer households. Addressing wealth inequalities, enhancing education, and improving maternal health service coverage will reduce socioeconomic inequalities in basic vaccination uptake in Ethiopia.

Keywords: Inequality, Immunization, Vaccination, Socioeconomic factors, Ethiopia

Strengths and limitations

- This study used two most recent (2011 and 2016) nationally representative Demographic and Health Surveys (DHS).
- The decomposition of the contributing factors that drive socioeconomic inequalities in vaccination status provided a rich set of analysis for policy interventions to address socioeconomic disparities in child vaccination in Ethiopia.
- Limitations of the current study may include recall bias related to vaccination status as not all children had vaccination cards, and measures had to depend on the mother's verbal report.
- The DHS is a cross-sectional survey; it was not possible to establish temporality between childhood vaccination and explanatory factors, precluding causal inference.

Introduction

Vaccination is an important public health intervention that helps prevent 2 to 3 million child deaths each year. [1] With improved coverage, vaccines have the potential to save many more children, which is why it is necessary to ensure that all children receive all recommended vaccines. [2,3]

In Ethiopia, a child is said to have received full vaccinations if they receive one dose of the Bacille Calmette-Guérin vaccine (BCG, for tuberculosis), three doses of the pentavalent vaccine (penta includes diphtheria, tetanus, pertussis [DTP], hepatitis B [HBV], and Haemophilus influenzae type b [Hib]), three doses of the oral polio vaccine (OPV), three doses of the pneumococcal conjugate vaccine (PCV), and two doses of the rotavirus vaccine (rota), and one dose of measles-containing vaccine (MCV). [4,5] Basic vaccination is defined as access to a single dose of BCG, three doses of DTP, three doses of OPV, and one dose of measles vaccine by the age of 12 months. [4]

In the last two decades, global basic vaccination coverage has improved remarkably. [6,7] In 2018, the proportion of the world's children who received three doses of the combined diphtheria, tetanus toxoid, and pertussis-containing vaccine (DTP3) reached 86% worldwide. [1] However, there are inequalities in access to childhood vaccination and many children do not receive the basic vaccines worldwide. [8,9]

Many regions of the world continue to have low coverage. The World Health Organization (WHO) report in 2019 shows that 19.4 million children under the age of one year did not receive basic vaccines; around 60% of these children live in 10 nations, including Nigeria, the Democratic Republic of the Congo and Ethiopia. [1] Disparities in vaccination coverage exist within and between countries, and in some places; the difference is more significant. [8] Within countries, inequalities in child vaccination data show that richer subgroups tend to have higher coverage whereas the coverage among poorer subgroups varies across countries. For example, studies in India [10], Nigeria [11] and Brazil [12] indicated that children of mothers who had higher education levels and household wealth status are more likely receive higher vaccination coverage.

Complete lack or incomplete childhood vaccination remains the cause of millions of preventable child deaths each year in many countries. [1] Previous studies in the area suggest that there exists a social gradient in child vaccination within countries. [13-15] For example, increased vaccination

coverage was favorably concentrated among children whose parents are well-educated, wealthy or living in urban areas. Inequalities in access to child vaccination need to be effectively assessed, monitored, and intervened to address systematically missed population groups. [16,17] In 2019, only 43% of children received all recommended vaccines while 19% received none of the vaccines [18]. This is way below WHO's 2020 goal of 90% coverage in every country [19]. Addressing these gaps requires measuring inequalities in basic vaccination coverage and identifying where gaps exist in routinely delivered vaccines and provide valuable information to introduce effective strategies and policies to address such inequalities. It is equally important those children who receive incomplete or no vaccines be identified to devise equity-oriented immunisation programs to reach disadvantaged populations and reduce Ethiopia's high levels of vaccine preventable childhood morbidity and mortality.

Although there are previous studies [20-22] in Ethiopia that have addressed factors associated with childhood vaccination, there is no study that examined trends and socioeconomic inequalities in childhood vaccination. The objective of this study is to examine trends and socioeconomic inequalities in childhood vaccination. Moreover, the paper assesses factors that explain socioeconomic inequalities in childhood vaccination in the country using a decomposition approach.

Methods

Data

We analysed the most recent (2011 and 2016) Ethiopia Demographic and Health Surveys . The Ethiopian Central Statistical Agency (CSA) undertook the surveys in collaboration with the DHS program. [23] The DHS are nationally representative household surveys with large sample sizes and high response rates. [24] The DHS uses a stratified, two-stage sampling technique to obtain the study participants. [25] Standardised questionnaires are used across time and countries to ensure collected data are comparable. [26] Sampling methods and design have been described elsewhere. [27] For the purpose of this study, data collected on vaccination status of children aged 12-23 months were extracted and analyzed. The Ethiopia DHS included information on 11,872 births/women in 2011 and 11,023 births/women in 2016. The sample used for the current analysis was limited to children aged 12–23 months at the time of the survey, yielding a final sample of 1930 mother-child pairs in 2011, and 2004 mother-child pairs in 2016.

Measures

The dependent variable is whether a child received all basic vaccinations, that is the ight recommended basic vaccines. [28] The vaccines included one dose of Bacille Calmette Guerin (BCG) against tuberculosis, three doses of diptheria, tetanus toxoids, and pertussis vaccine (DTP), three doses of oral polio vaccine (OPV), and one dose of measles vaccine. Table 1 shows immunization schedule for children under 12 months in Ethiopia. [4] The DHS determined the vaccination status of children from two sources. First, thet considred the primary immunization record cards provided by mothers, but if these were absent,The DHS data collectors used mothers' verbal reports of children's immunization status.

Table 1 Basic vaccination schedule for children under 12 months in Ethiopia

Vaccine	Diseases	Age
BCG	Tuberculosis	At birth
DPT	Diphteria, Pertussis, Tetanus	6, 10, 14 weeks
OPV	Polio	At birth, 6, 10, 14 weeks
Measles	Measles	9 months

The WHO Commission on Social Determinants of Health framework [29] was used to explain contributing factors of inequalities in vaccination status. In addition, factors identified in the

current literature [11,13,14,30,31] on child vaccination that are available in the DHS surveys were included. The independent variables considered in the current study include 1) maternal and household factors: maternal parity, age, education levels, wealth status, and the use of maternal health services, 2) exposure to media, and 3) place of residence – urban/rural status.

The wealth index is a composite variable that measures the woman's household living standards. It is constructed by collecting and analysing information on ownership of selected materials and assets, such as radio, television, refrigerator, and vehicle; materials used for housing construction; and types of sanitation facilities and water access. Households were ranked into five quintiles (poorest, poorer, middle, richer and richest) depending on their level of wealth.

We grouped education levels of the mothers in to three categories (no education, primary, and secondary or higher). Exposure to media: frequency of listening to radio and watching television (TV): both categorised as (not at all, less than once a week, and once a week or more). Utilization of reproductive and maternal health services considered in the current study include use of contraceptive, antenatal care contacts, and delivery at the health facility.

Statistical analysis

Socioeconomic inequalities in the coverage of vaccination status were estimated using the concentration curve and concentration index. [32] The concentration curve is a plot of the cumulative percentage of the population, ranked by wealth status, from the poorest to the richest (x-axis) against the cumulative percentage of the health variable (vaccination status) on the y-axis. If all children had an equal proportion of vaccination status regardless of their socioeconomic status, then the curve would coincide with the 45° line, which indicates the presence of equality in the coverage of vaccination. If the concentration curve falls below the 45° line of equality, it indicates that the uptake of vaccines is more concentrated among the rich. The opposite is true if the curve falls above the line of equality.

The concentration index is described as two times the area between the line of equality and the concentration curve. The index takes a value between −1 and +1; an index of 0 indicates the presence of equality in the uptake of vaccines. If wealth related inequalities exist, it can be seen

in one of the two forms, the first is when there is uneven concentration of vaccine uptake among the rich, and in this case, the concertation index takes on a positive value. The second is negative value concentration index, which implies high concentration of vaccination status among the poor.

The concentration index (CCI) can be computed as follows:

$$CCI = \frac{2}{y}cov(h,r), \qquad (1)$$

where h is the healthcare outcome of interest (i.e. vaccination status), y is the mean of h and r is the fractional rank of an individual in the wealth distribution. We also computed 95% CIs for the concentration index.

Decomposing inequality

The concentration curve and concentration index can only show and quantify the level of inequalities related to wealth in the use of health services. However, policymakers are also interested in the factors that contribute to socioeconomic inequalities in vaccination coverage. This can be done using an approach developed by Wagstaff and colleagues. [33] The concentration index of a health variable can be decomposed into the contributions of individual factors to wealth-related health inequality. If we consider a linear regression model for the child's vaccination status, v, is defined according to k explanatory factors, x_k as.

$$v = \alpha + \sum_k \beta_k x_k + \varepsilon\,, \qquad (2)$$

where α and β are parameters, and ε is the error term. The concentration index for child vaccination status can be decomposed as:

$$C = \sum_k \left(\frac{\beta_k \bar{x}_k}{\mu}\right) C_k + \frac{GC_\varepsilon}{\mu}, \qquad (3)$$

where μ is the mean of y, $\bar{x}_k$ is the mean of x_k, C_k is the concentration index for x_k, (defined analogously to C), and GC_ε is the generalized concentration index for the error term (ε). Equation 3 shows that C is equal to a weighted sum of the concentration indices of the k regressors, where

the weight for x_k is the elasticity of y with respect to $x_k(\eta_k = \beta_k \frac{\overline{x}_k}{\mu})$. The residual component—captured by the last term $(\frac{GC_\varepsilon}{\mu})$ reflects the wealth-related inequality in health that is not explained by systematic variation in the regressors. We used the bootstrap method with 1000 replications to estimate standard errors . All analysis were performed after adjusting for sampling design (stratification and clustering) and sampling weights. STATA (version 14, StataCorp, College Station, Tex) and SPSS (version 26) software packages were used to perform data analysis.

Patient and public involvement

Patients/public were not involved in the design or implementation of this study.

Results

The sample used for the current analysis was limited to children aged 12–23 months at the time of the survey, yielding a final sample of 1930 mother-child pairs in 2011, and 2004 mother-child pairs in 2016. The majority (85.8% and 88.4%) of respondents were from rural areas in 2011 and 2016 surveys respectively, and more than 42% were from Oromia, which is the biggest region in the country. The percentage of mothers who had no education decreased from 68% in 2011 to 64% in 2016 while antenatal care contacts increased from 42% in 2011 to 60% in 2016 (Table 2).

Trends of vaccination coverage

Vaccination coverage showed improvements from 2011 to 2016; BCG vaccine uptake increased from 66% to 69%, DTP3 vaccine from 37% to 57%, OPV3 vaccine from 45% to 57%, and basic vaccination coverage from 24% in 2011 to 38% in 2016. The proportion of children who received all basic vaccinations that include BCG, DPT3, OPV3, and measles increased by 14% from 2011 to 2016. However, measles vaccine coverage decreased from 56% in 2011 to 54% in 2016, while the proportion of children who received no vaccination increased from 14% in 2011 to 16% in 2016 (Figure 1).

The urban/rural differential in basic vaccination coverage increased from almost 28% in 2011 to more than 29% in 2016 (Table 2). Coverage remained low but showed slight increases from 2011 to 2016 in regions such as Afar (8.5% to 15.2%), Somali (17.1% to 21.8%), and Oromia (15.6% to 24.7%). Basic vaccination coverage also showed disparities between and within the regions of Ethiopia (Table 2). For example, in 2016, coverage was 89.2% (95% CI: 82.0%, 93.8%) and 67.3% (95% CI: 57.6%, 75.7%) among children living in Addis Ababa and Tigray regions respectively, whereas in Afar it was 15.2% (95% CI: 8.0%, 26.9%), and Somali 21.8% (95% CI: 13.8%, 32.7%).

Table 2 Basic vaccination coverage by maternal and child characteristics in Ethiopia (DHS 2011 – 2016)

	2011				2016			
Study variables	**Number**	**Percent**	**Received all basic immunization (95% CI)**	**P-value**	**Number**	**Percent**	**Received all basic immunization (95% CI)**	**P-value**
Sex of child				**0.268**				**0.252**
Male	1010	52.3	23.1 (19.3, 27.5)		926	46.2	36.5 (31.2, 42.1)	
Female	920	47.7	26.1 (22.0, 30.7)		1078	53.8	40.5 (35.4, 45.8)	
Parity				**0.101**				**0.002**
1	358	18.6	30.1 (23.3, 37.9)		372	18.6	45.3 (37.7, 53.1)	
2	318	16.5	26.7 (20.7, 33.7)		322	16.0	47.1 (39.0, 55.3)	
3	306	15.9	22.8 (17.1, 29.8)		282	14.1	40.4 (31.9, 49.5)	
4	230	11.9	24.4 (18.1, 32.0)		243	12.1	39.5 (31.4, 48.2)	
5	220	11.4	15.3 (9.9, 22.8)		216	10.8	30.1 (21.5, 40.3)	
6	497	25.7	23.8 (17.5, 31.6)		569	28.4	28.7 (22.3, 36.2)	
Maternal age				**0.992**				**0.197**
15-24	518	26.8	24.6 (19.6, 30.4)		499	24.9	37.9 (31.6, 44.7)	
25-29	649	33.6	23.8 (19.3, 29.1)		596	29.7	44.1 (37.1, 51.4)	
30-34	386	20.0	24.7 (19.0, 31.5)		456	22.7	35.1 (28.7, 42.1)	
35-39	251	13.0	26.0 (18.9, 34.5)		295	14.7	33.5 (25.7, 42.4)	
40-49	127	6.6	24.8 (16.0, 36.2)		158	7.9	39.9 (29.3, 51.5)	
Contraceptive use				**<0.001**				**<0.001**
Never used	1106	57.3	17.9 (14.5, 21.8)		932	46.5	25.8 (21.3, 30.8)	
Using or used before	824	42.7	33.5 (28.8, 38.5)		1072	53.5	49.8 (44.3, 55.4)	
Antenatal care contact				**<0.001**				**<0.001**
No	1040	53.9	14.8 (11.6, 18.6)		711	35.5	18.6 (13.8, 24.4)	
Yes	815	42.2	37.3 (32.7, 42.1)		1194	59.6	50.8 (45.7, 55.8)	
Place child was delivered				**<0.001**				**<0.001**
Home	1694	87.8	20.6 (17.5, 24.1)		1309	65.3	30.6 (25.9, 35.6)	
Health facility	236	12.2	52.7 (43.3, 62.0)		695	34.7	53.8 (47.6, 60.0)	

Maternal educational levels				**<0.001**				**<0.001**
No education	1307	67.7	20.4 (16.9, 24.5)		1257	62.7	30.9 (26.6, 35.6)	
Primary	522	27.0	28.5 (23.6, 33.9		577	28.8	46.1 (39.8, 52.5)	
Secondary or higher	102	5.3	57.3 (44.7, 69.0)		170	8.5	70.5 (55.9, 81.8)	
Household wealth index in quintiles				**<0.001**				**<0.001**
Poorest	441	22.9	16.8 (12.0, 23.0)		504	25.2	22.2 (16.1, 29.8)	
Poorer	419	21.7	18.7 (13.9, 24.7)		396	19.8	38.1 (30.7, 46.1)	
Middle	394	20.4	18.7 (13.8, 24.7)		450	22.4	37.1 (30.1, 44.7)	
Richer	369	19.1	25.1 (18.7, 32.7)		366	18.3	44.6 (36.4, 53.0)	
Richest	307	15.9	50.7 (41.5, 59.8)		288	14.4	63.0 (52.0, 72.8)	
Place of residence				**<0.001**				**<0.001**
Urban	274	14.2	48.2 (38.8, 57.8)		232	11.6	64.6 (51.1, 76.2)	
Rural	1656	85.8	20.6 (17.4, 24.3)		1772	88.4	35.2 (31.1, 39.6)	
Regions				**<0.001**				**<0.001**
Tigray	129	6.7	59.3 (50.7, 67.5)		152	7.6	67.3 (57.6, 75.7)	
Afar	18	0.9	8.6 (4.9, 14.6)		20	1.0	15.2 (8.0, 26.9)	
Amhara	446	23.1	27.1 (20.0, 35.6)		364	18.2	46.4 (36.7, 56.4)	
Oromia	811	42.0	15.6 (11.1, 21.3)		881	44.0	24.7 (18.9, 31.6)	
Somali	51	2.6	17.1 (10.2, 27.2)		76	3.8	21.8 (13.8, 32.7)	
Benishangul-Gumuz	23	1.2	24.2 (16.8, 33.5)		21	1.0	57.4 (47.1, 67.2)	
Southern Nations, Nationalities and People	391	20.2	24.1 (18.0, 31.4)		419	20.9	46.9 (38.5, 55.5)	
Gambela	8	0.4	17.4 (8.7, 31.8)		5	0.3	41.1 (30.3, 52.9)	
Harari	5	0.3	36.1 (27.3, 46.0)		5	0.2	42.2 (31.1, 54.0)	
Addis Ababa	43	2.2	78.7 (69.1, 85.9)		52	2.6	89.2 (82.0, 93.8)	
Dire Dawa	7	0.4	59.4 (49.3, 68.8)		9	0.5	75.9 (64.2, 84.6)	

Inequalities in vaccination coverage

Inequalities in child vaccination persisted during 2011 and 2016: basic vaccination status was favourably concentrated among children from wealthier households while the distribution of those who received no vaccination remained disproportionately concentrated among poor (Figure 2). The uptake of BCG, DTP3, OPV3, measles, and basic vaccination were disproportionately concentrated among children from wealthy households during 2011 and 2016 (Figure 3). DTP3 and basic vaccination status had lower coverage and showed the highest inequalities during 2011 and 2016; for example, in 2016, DPT3 had concentration index of (CCI= 0.175) and basic vaccination (CCI= 0.172). The estimate for the distribution of children who received no vaccination in 2011 was (CCI= -0.092), this increased to (CCI= -0.184) in 2016 (Figure 3). The negative values for children who received no vaccination confirms pro-poor distributions. Increased vaccination coverage decreased inequalities as vaccinations such as BCG, OPV3, and measles that had higher coverage showed lower inequalities (Figure 3).

The decomposition results in (Table 3) and (Figure 4) show that the significant contributors to socioeconomic inequality in basic vaccination status included, wealth, maternal education, contraceptive use, antenatal care contacts, exposure to media that include radio and television, and place of residence (rural).

The decomposition analysis showed similar patterns in factors that explain socioeconomic inequalities in child vaccination status on both surveys. The use of maternal health services had the highest significant contributions to socioeconomic inequalities in child vaccination. Antenatal care contacts had 45.4% contribution in 2011 and 50.4% in 2016. Wealth status is the other significant contributor, 23.9% in 2011 and 21.2% in 2016. On the other hand, rural residence had a negative contribution to socioeconomic inequalities in child vaccination on both surveys.

The overall concentration index for basic child vaccination was positive. Any significant positive contributor in (Table 3) and (Figure 4) means that socioeconomic inequality in basic vaccination would have been less pro-rich if: (i) the contributing variables (e.g. antenatal care contacts or wealth) were to be evenly distributed among the rich and poor. Negative contributing variables (e.g. rural residence) would cause the opposite effect. The residual or unexplained contributing

factors to socioeconomic inequalities in basic vaccination account for 34.5% in 2011 and -12% in 2016.

Table 3 Decomposition of socioeconomic inequalities in basic vaccination coverage in Ethiopia, (DHS 2011, 2016)

Study variables	2011				2016			
	Marginal effect	Concentration index	Absolute contribution	Percentage contribution	Marginal effect	Concentration index	Absolute contribution	Percentage contribution
Sex of child								
Male	(Base)	(Base)	(Base)	(Base)	(Base)	(Base)	(Base)	(Base)
Female	0.022	0.035	0.001	0.4	0.043	0.034	0.001	0.6
Maternal age								
15-24	(Base)	(Base)	(Base)	(Base)	(Base)	(Base)	(Base)	(Base)
25-29	0.052*	0.049	0.003	1.2	0.562	0.073	0.006	2.2
30-34	0.072*	-0.006	0.000	-0.2	0.058	-0.030	-0.002	-0.7
35-39	0.060*	-0.052	-0.003	-1.5	0.052	0.006	0.000	0.1
40-49	0.023	0.019	0.000	0.2	0.057*	-0.009	-0.001	-0.2
Maternal parity								
1	(Base)	(Base)	(Base)	(Base)	(Base)	(Base)	(Base)	(Base)
2	-0.004	-0.042	0.000	0.1	0.037	0.066	0.002	0.9
3	-0.033	0.020	-0.001	-0.3	0.014	-0.009	0.000	0.0
4	-0.021	-0.015	0.000	0.1	0.016	-0.034	-0.001	-0.2
5	-0.068	-0.012	0.001	0.4	-0.030	0.008	0.000	-0.1
6	-0.034	-0.048	0.002	0.8	-0.070	-0.123	0.009	3.2
Pattern of contraceptive use								
Never	(Base)	(Base)	(Base)	(Base)	(Base)	(Base)	(Base)	(Base)
Using or used before	0.091**	0.348	0.032	15.2	0.235***	0.322	0.076	28.5
Antenatal care contact								
No	(Base)	(Base)	(Base)	(Base)	(Base)	(Base)	(Base)	(Base)
Yes	0.242***	0.390	0.094	45.4	0.566***	0.237	0.134	50.4
Place child was delivered								
Home	(Base)	(Base)	(Base)	(Base)	(Base)	(Base)	(Base)	(Base)
Health facility	0.030*	0.323	0.010	4.6	0.027*	0.371	0.010	3.7

Frequency of listening to radio								
Not at all	(Base)	(Base)	(Base)	(Base)	(Base)	(Base)	(Base)	(Base)
Less than once a week	-0.031	0.104	-0.003	-1.6	0.049	0.127	0.006	2.3
At least once a week	0.026*	0.232	0.006	2.9	0.045	0.219	0.010	3.7
Frequency of watching television								
Not at all	(Base)	(Base)	(Base)	(Base)	(Base)	(Base)	(Base)	(Base)
Less than once a week	-0.035	0.066	-0.002	-1.1	-0.008	0.120	-0.001	-0.3
At least once a week	0.042	0.223	0.009	4.5	0.007	0.286	0.002	0.7
Education levels								
No education	(Base)	(Base)	(Base)	(Base)	(Base)	(Base)	(Base)	(Base)
Primary	-0.005	0.182	-0.001	-0.4	0.070**	0.127	0.009	3.3
Secondary or higher	-0.001	0.152	0.000	0.0	0.028**	0.235	0.007	2.5
Place of residence								
Urban	(Base)	(Base)	(Base)	(Base)	(Base)	(Base)	(Base)	(Base)
Rural	0.143	-0.426	-0.061	-29.2	0.080	-0.323	-0.026	-9.8
Household wealth index in quintiles								
Poorest	(Base)	(Base)	(Base)	(Base)	(Base)	(Base)	(Base)	(Base)
Poorer	0.005	-0.283	-0.001	-0.7	0.094**	-0.236	-0.022	-8.3
Middle	-0.015*	0.078	-0.001	-0.6	0.061**	0.110	0.007	2.5
Richer	0.032**	0.375	0.012	5.8	0.070**	0.387	0.027	10.2
Richest	0.076***	0.535	0.040	19.4	0.091**	0.492	0.045	16.8
Residual				34.6				-12.1
Total				65.4				112.1

* indicates <p 0.05; ** indicates p < 0.01; *** indicates p < 0.001

Discussion

This study examined inequalities in vaccination coverage among children aged 12-23 months in Ethiopia. The uptake of all basic vaccinations increased from 24.6% in 2011 to 38.6% in 2016. Coverage improvements from 2011 to 2016 were observed in BCG vaccine uptake by 3%, DTP3 by 16.2%, OPV3 by 11.5%, and all basic vaccinations by 14%. While there were improvements in vaccination coverage from 2011 to 2016, issues that need to be address include a lack of awareness about vaccination, facilities' limited operating hours, maternal time constraints, and the distance to facilities [34,35].

Ethiopia remains one of the top ten high priority countries in the world where children remain unvaccinated [1]. In the current study, more than 15% of children received none of the vaccines, while incomplete vaccinations were 62% in 2011 and 46% in 2016. Possible explanations for under vaccination or no vaccination may include vaccine hesitancy or refusal, lack of access to vaccination services, or missed opportunities [5]. Vaccine hesitancy refers to concerns about real or perceived vaccine adverse events among parents that may lead to delayed vaccination schedules or refusal of vaccinations altogether [36]. Missed opportunities present another explanation in which children may not receive one or all of recommended vaccines even if they are vaccine-eligible and can attend health facilities, which is commonly refers to missed opportunities [5,36].

The uptake of BCG, DTP3, OPV3, measles, and receipt of all basic vaccinations were disproportionately concentrated among children from wealthier households. This finding is consistent with multi country studies across low-middle income countries.[9,37] However, a study across three countries [14] that include Gambia, Kyrgyz Republic, and Namibia showed that receipt of all basic vaccinations was disproportionately concentrated among children from poor households. The coverage of DPT3 and basic vaccination showed the highest inequalities favouring children from wealthy households. More than 14% of children received none of the vaccines during 2011 and 2016. These children were mainly from disadvantaged households; for example, children who remained unvaccinated in 2016 were 8.3% among the richest quantile, while 24% were from the poorest quantile. Basic vaccination coverage also showed significant

variations across regions of the country; this ranged from 15% in Afar, and 21% in Somali, to 67.3% in Tigray, and 89.2% in Addis Ababa. Afar and Somali regions are predominantly nomadic pastoralist areas, with relatively weaker health systems compared to Tigray, and Addis Ababa that have improved healthcare coverage [38].

Ensuring access to all recommended vaccines for all children, regardless of sociodemographic or socioeconomic status, saves more lives and facilitates progress towards achieving sustainable development goals (SDGs) [39]. SDG target for child mortality aims to reduce neonatal mortality to lower than 12 deaths per 1,000 live births and under-5 mortality to lower than 25 deaths per 1,000 live births across all countries [39]. In 2016, the infant mortality rate was 48 deaths per 1,000 live births, and the under-5 mortality rate was 67 deaths per 1,000 live births in Ethiopia [23].

Findings of the current study revealed that the use of maternal health services, maternal education, exposure to media, and wealth had positive contributions to basic vaccination uptake. These findings align with other similar studies [11,15,40]. Maternal knowledge about vaccinations is a determinant for vaccination status, which may be associated with increased knowledge about benefits of child vaccination because of counselling during family planning, and antenatal care contacts [41-43]. Moreover, based on findings related to the impact of residence and access to health facilities on vaccination, it may be that a mother with regular access to family planning and antenatal care is also more likely to seek out postnatal care where vaccination of her child can be more readily provided [44].

In the present study, maternal education had contributions to vaccine uptake in 2016, but this was not the case in 2011. Education helps to create improved awareness and knowledge about childhood vaccination [42]. Previous studies have also indicated that educated women are more likely to take their child for vaccination [13,42]. Exposure to media can also be a useful tool to reach population at different socioeconomic levels. The findings of this study showed that access to mass media (radio and TV) favourably influences vaccine uptake. Transmitting information about the importance of childhood vaccination is vital to reach not only mothers but also their partners and community leaders [45]. Information dissemination that targets mother's partner and

community leaders can help to create a conducive environment that can favourably influence mothers to vaccinate their children.

In the present study, the socioeconomic well-being of mothers was associated with higher vaccination uptake. While vaccinations are provided free of charge in many developing countries, mothers sometimes incur indirect costs, for example, transportation costs, which often limit their uptake of these services [6]. Mothers at the lower wealth categories are more likely to experience challenges in accessing healthcare facilities as such less likely to take their child for vaccination [11].

Children from rural areas had lower vaccination coverage compared to children from urban areas. In 2011, basic vaccination coverage was 48.2% in urban areas while it was 20.6% in rural areas. This pattern continued in 2016, as 64.6% of children from urban areas had basic vaccination, but only 35.2% in rural areas. This finding is consistent with those of similar studies [11,46]. This could partly be explained by challenges faced in rural areas due to less developed health infrastructure and fewer skilled providers [47]. In rural areas, long-distance to health facilities is another reason for low basic vaccination coverage. People live far away from health facilities and the long-distance, and lack of transportation poses a critical challenge for mothers to take their child for vaccination [47].Vaccines require cold chain management as it is sensitive to high temperatures [48]. Health facilities in rural areas face a shortage of electric power supply to keep the cold chain equipment working, which could lead to cancellation of services as lack of cold chain equipment may result in the stock-out of vaccines [15]. One study from Nigeria found that 47% of solar fridges for vaccine storage in eight states were broken [49].

The strengths of this study include the use of a nationally representative survey from the two most recent DHS surveys. The decomposition of the contributing factors that drive socioeconomic inequalities in vaccination status provided a rich set of analysis for policy interventions to address socioeconomic disparities in access to basic vaccinations in Ethiopia. Limitations of the current study may include recall bias related to vaccination status as not all children had vaccination cards, and measures had to depend on the mother's verbal report. The

DHS is a cross-sectional survey; it was not possible to establish temporality between childhood vaccination and explanatory factors..

Conclusions

The coverage of basic vaccination improved by 14 % from 2011 to 2016, but the overall coverage remained low. Increased vaccine coverage was disproportionately concentrated among children from wealthy households, while the majority of children who had no vaccination were from disadvantaged households. Utilisation of reproductive and maternal health services, household income status, and maternal education had significant positive contributions to improved vaccination status. Therefore, continued efforts at improving coverage of family planning, antenatal care contacts, institutional delivery, maternal education, and socioeconomic well-being are required to improve vaccination status. Moreover, regions such as Afar, Somali, and Oromia, and rural areas of the country at large require targeting.

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Ethics approval was not required for the current analysis, as the data were from publicly available DHS data. The MEASURE DHS /ICF International, Rockville, Maryland, USA – granted access to data upon request.

Contributors

FTB designed the study, worked on the analysis and drafted the manuscript. AH helped revise the study design, and supervised the data analysis. All authors read and approved the final manuscript.

Data availability statement:

The dataset was made available for public use after de-identification (data are available online at: https://www.idhsdata.org/idhs/)

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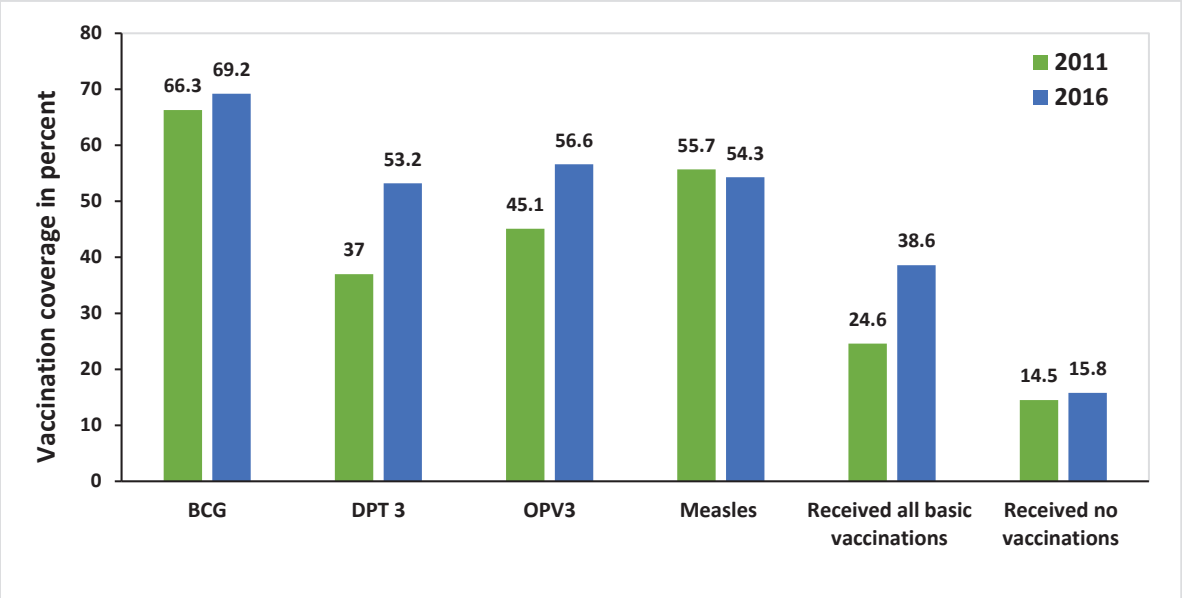
Figures

Fig. 1 Vaccination coverage among children aged 12-23 months in Ethiopia (DHS 2011, 2016).

Fig. 2 Concentration curves for child vaccination status, Ethiopia (DHS 2011, 2016)

Fig. 3 Concentration indecies that shows socioeconomic inequalities in child vaccinations, Ethiopia (DHS 2011, 2016)

2Fig. 4 Percentage contributions of factors explaining socioeconomic inequalities in full vaccination coverage, Ethiopia (DHS 2011, 2016)



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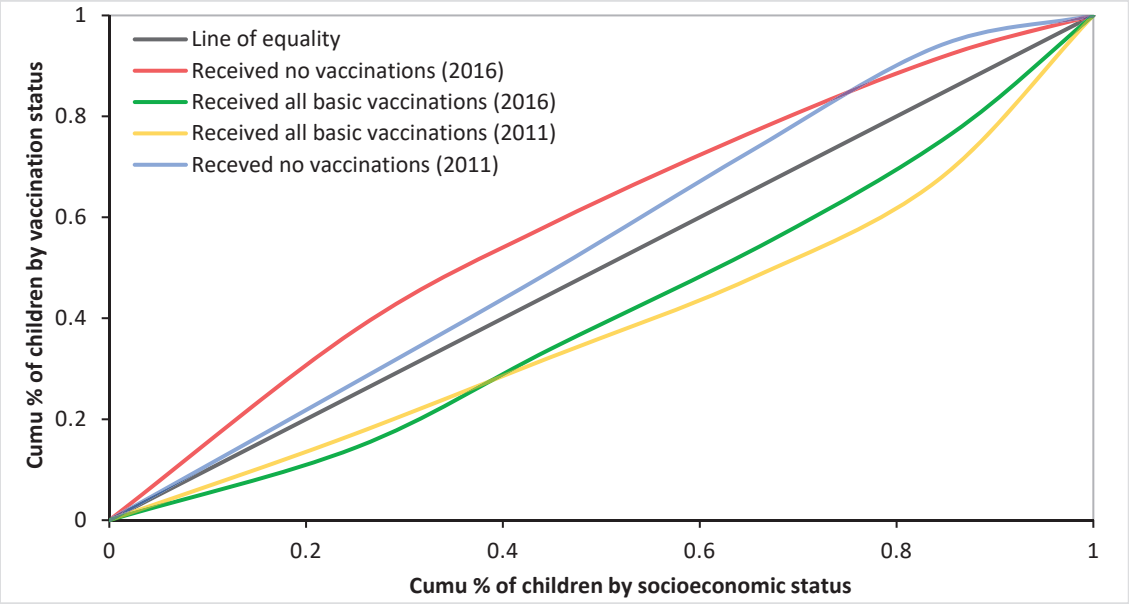

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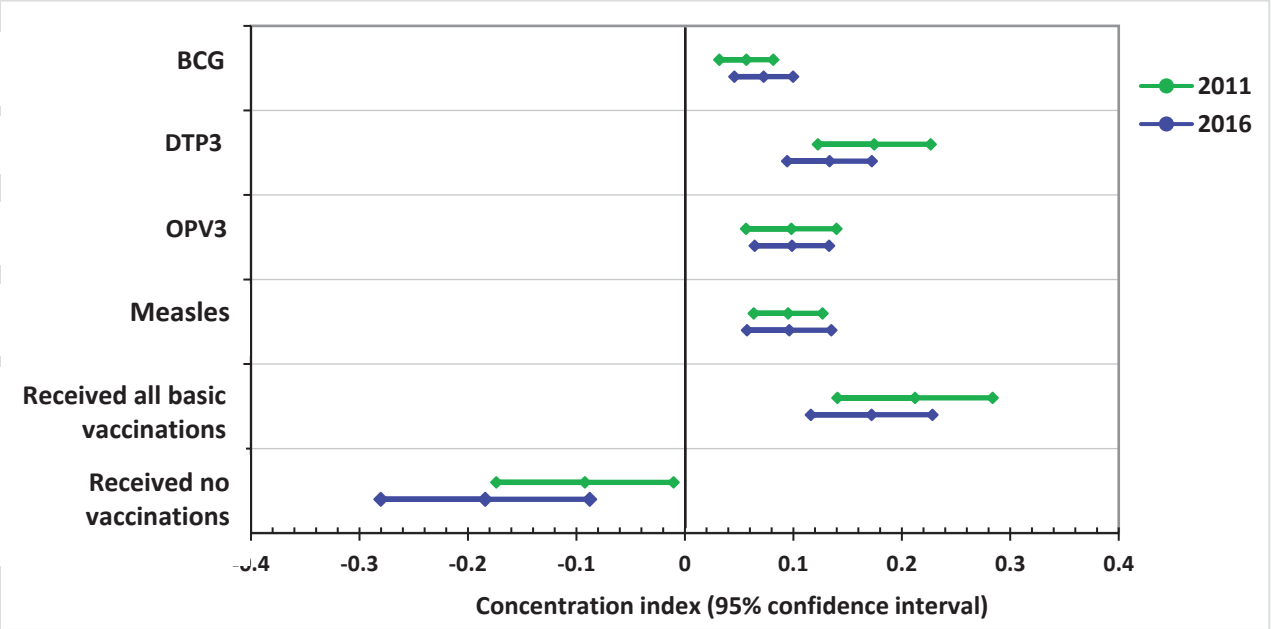

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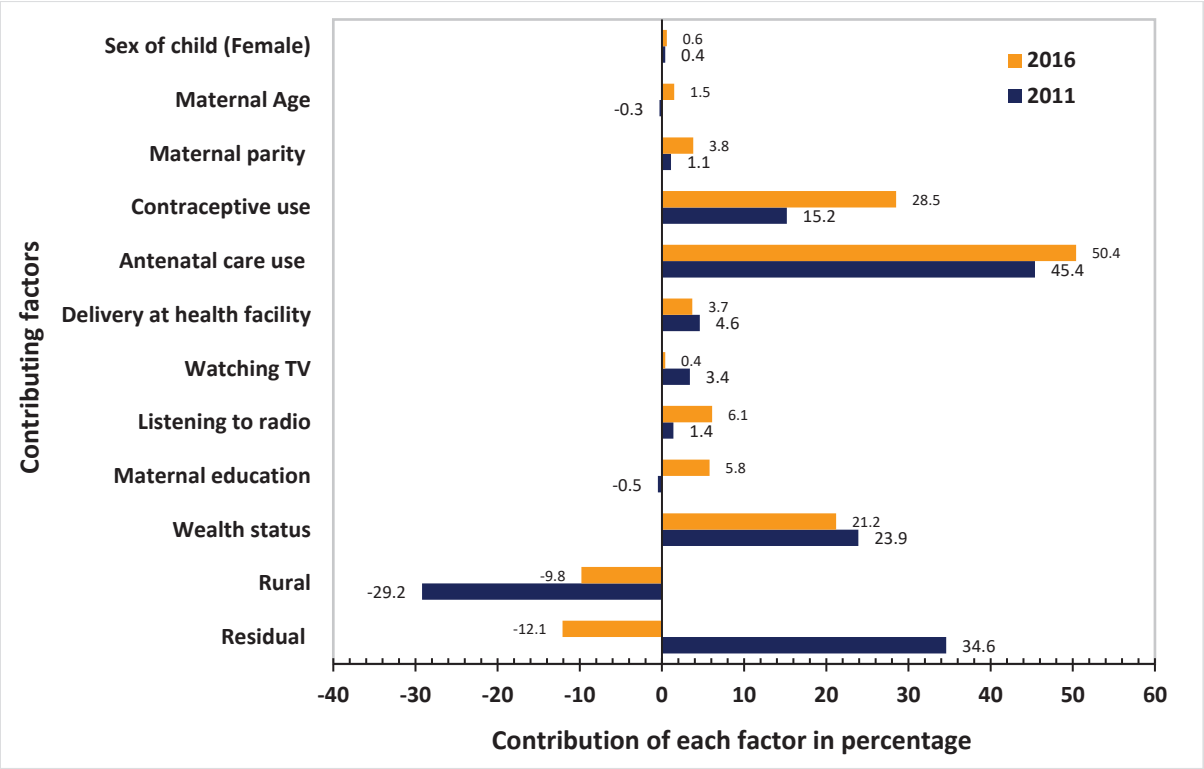

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Health Insurance Coverage and Associated Factors among Women in Ethiopia: A Secondary Analysis of Ethiopia Demographic and Health Survey Data 2016 – STROBE checklist

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

		(*c*) If relevant, consider translating estimates of relative risk into absolute risk for a meaningful time period
Other analyses	N/A	Report other analyses done—eg analyses of subgroups and interactions, and sensitivity analyses
Discussion		
Key results	13-17	Summarise key results with reference to study objectives
Limitations	3	Discuss limitations of the study, taking into account sources of potential bias or
Interpretation	13-17	Give a cautious overall interpretation of results considering objectives, limitations, multiplicity of analyses, results from similar studies, and other relevant evidence
Generalisability	3	Discuss the generalisability (external validity) of the study results
Other information Funding	N/A	Give the source of funding and the role of the funders for the present study and, if applicable, for the original study on which the present article is based

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Decomposition of socioeconomic inequalities in child vaccination in Ethiopia: Results from the 2011-2016 demographic and health survey data

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Abstract

Objectives: Monitoring and addressing unnecessary and avoidable differences in child vaccination is a critical global concern. This study aimed to assess socioeconomic inequalities in basic vaccination coverage among children aged 12-23 months in Ethiopia.

Design, setting and participants: Secondary analyses of cross-sectional data from the two most recent (2011 and 2016) Ethiopia Demographic and Health Surveys were performed. This analysis included 1930 mother-child pairs in 2011 and 2004 mother-child pairs in 2016.

Outcome measures: Completion of basic vaccinations was defined based on whether a child received a single dose of Bacille Calmette Guerin (BCG), three doses of diptheria, tetanus toxoids, and pertussis (DTP), three doses of polio vaccine (OPV), and one dose of measles vaccine.

Methods: The concentration curve and concentration index (CCI) were used to estimate wealth related to inequalities. The concentration indices were also decomposed to examine the contributing factors to socioeconomic inequalities in childhood vaccination.

Results: From 2011 to 2016, the proportion of children who received basic vaccination increased from 24.6% (95% confidence interval, CI: 21.4 to 28.0) to 38.6% (95% CI: 34.6 to 42.9). While coverage of BCG, DPT, and polio immunization increased during the study period, the uptake of measles vaccine decreased. The positive concentration index shows that basic vaccination status was favourably concentrated among children from wealthier households CCI= 0.212 in 2011 and CCI= 0.212 in 2016. The decomposition analysis shows that use of maternal health services such as family planning and antenatal care, socioeconomic status, exposure to media, urban-rural residence, and maternal education explain inequalities in basic vaccination coverage in Ethiopia.

Conclusions: Childhood vaccination coverage was low in Ethiopia. Vaccination was less likely in poorer than in richer households. Addressing wealth inequalities, enhancing education, and improving maternal health service coverage will reduce socioeconomic inequalities in basic vaccination uptake in Ethiopia.

Keywords: Inequality, Immunization, Vaccination, Socioeconomic factors, Ethiopia

Strengths and limitations

- This study used two most recent (2011 and 2016) nationally representative Demographic and Health Surveys (DHS).
- The decomposition of the contributing factors that drive socioeconomic inequalities in vaccination status provided a rich set of analysis for policy interventions to address socioeconomic disparities in child vaccination in Ethiopia.
- Limitations of the current study may include recall bias related to vaccination status as not all children had vaccination cards, and measures had to depend on the mother's verbal report.
- The DHS is a cross-sectional survey; it was not possible to establish temporality between childhood vaccination and explanatory factors, precluding causal inference.

Introduction

Vaccination is an important public health intervention that helps prevent 2 to 3 million child deaths each year. [1] With improved coverage, vaccines have the potential to save many more children, which is why it is necessary to ensure that all children receive all recommended vaccines. [2,3]

In Ethiopia, a child is said to have received full vaccinations if they receive one dose of the Bacille Calmette-Guérin vaccine (BCG, for tuberculosis), three doses of the pentavalent vaccine (penta includes diphtheria, tetanus, pertussis [DTP], hepatitis B [HBV], and Haemophilus influenzae type b [Hib]), three doses of the oral polio vaccine (OPV), three doses of the pneumococcal conjugate vaccine (PCV), and two doses of the rotavirus vaccine (rota), and one dose of measles-containing vaccine (MCV). [4,5] Basic vaccination is defined as access to a single dose of BCG, three doses of DTP, three doses of OPV, and one dose of measles vaccine by the age of 12 months. [4]

In the past decades, global basic vaccination coverage has improved remarkably. [6,7] In 2018, the proportion of the world's children who received three doses of the combined diphtheria, tetanus toxoid, and pertussis-containing vaccine (DTP3) reached 86% worldwide. [1] However, there are inequalities in access to childhood vaccination and many children do not receive the basic vaccines worldwide. [8,9]

Many regions of the world continue to have low coverage. The World Health Organization (WHO) report in 2019 shows that 19.4 million children under the age of one year did not receive basic vaccines; around 60% of these children live in 10 nations, including Nigeria, the Democratic Republic of the Congo and Ethiopia. [1] Disparities in vaccination coverage exist within and between countries, and in some places; the difference is more significant. [8] Within countries, inequalities in child vaccination data show that richer subgroups tend to have higher coverage whereas the coverage among poorer subgroups varies across countries. For example, studies in India [10], Nigeria [11] and Brazil [12] indicated that children of mothers who had higher education levels and household wealth status are more likely receive higher vaccination coverage.

Complete lack or incomplete childhood vaccination remains the cause of millions of preventable child deaths each year in many countries. [1] Previous studies in the area suggest that there exists a social gradient in child vaccination within countries. [13-15] For example, increased vaccination

coverage was favorably concentrated among children whose parents are well-educated, wealthy or living in urban areas. Inequalities in access to child vaccination need to be effectively assessed, monitored, and intervened to address systematically missed population groups. [16,17] In 2019, only 43% of children received all recommended vaccines while 19% received none of the vaccines [18]. This is way below WHO's 2020 goal of 90% coverage in every country [19]. Addressing these gaps requires measuring inequalities in basic vaccination coverage and identifying where gaps exist in routinely delivered vaccines and provide valuable information to introduce effective strategies and policies to address such inequalities. It is equally important those children who receive incomplete or no vaccines be identified to devise equity-oriented immunisation programs to reach disadvantaged populations and reduce Ethiopia's high levels of vaccine preventable childhood morbidity and mortality.

Although there are previous studies [20-22] in Ethiopia that have addressed factors associated with childhood vaccination, there is a need to examine trends and socioeconomic inequalities in childhood vaccination. The objective of this study is to examine trends and socioeconomic inequalities in childhood vaccination. Moreover, the paper assesses factors that explain socioeconomic inequalities in childhood vaccination in the country using a decomposition approach.

Methods

Data

We analysed the most recent (2011 and 2016) Ethiopia Demographic and Health Surveys. The Ethiopian Central Statistical Agency (CSA) undertook the surveys in collaboration with the DHS program. [23] The DHS are nationally representative household surveys with large sample sizes and high response rates. [24] The DHS uses a stratified, two-stage sampling technique to obtain the study participants. [25] Standardised questionnaires are used across time and countries to ensure collected data are comparable. [26] Sampling methods and design have been described elsewhere. [27] For the purpose of this study, data collected on vaccination status of children aged 12-23 months were extracted and analyzed. The Ethiopia DHS included information on 11,872 births/women in 2011 and 11,023 births/women in 2016. The sample used for the current analysis was limited to children aged 12–23 months at the time of the survey, yielding a final sample of 1930 mother-child pairs in 2011, and 2004 mother-child pairs in 2016.

Measures

The dependent variable is whether a child received all basic vaccinations that is the eight recommended basic vaccines. [28] The vaccines included one dose of Bacille Calmette Guerin (BCG) against tuberculosis, three doses of diptheria, tetanus toxoids, and pertussis vaccine (DTP), three doses of oral polio vaccine (OPV), and one dose of measles vaccine. Table 1 shows immunization schedule for children under 12 months in Ethiopia. [4] The DHS determined the vaccination status of children from two sources. Primarily immunization record cards provided by mothers, but if these were absent the DHS data collectors used mothers' verbal reports of children's immunization status.

Table 1 Basic vaccination schedule for children under 12 months in Ethiopia

Vaccine	Diseases	Age
BCG	Tuberculosis	At birth
DPT	Diphteria, Pertussis, Tetanus	6, 10, 14 weeks
OPV	Polio	At birth, 6, 10, 14 weeks
Measles	Measles	9 months

The WHO Commission on Social Determinants of Health framework [29] was used to explain contributing factors of inequalities in vaccination status. In addition, factors identified in the

current literature [11,13,14,30,31] on child vaccination that are available in the DHS surveys were included. The independent variables considered in the current study include 1) maternal and household factors: maternal parity, age, education levels, wealth status, and the use of maternal health services, 2) exposure to media, and 3) place of residence – urban/rural status.

The wealth index is a composite variable that measures the woman's household living standards. It is constructed by collecting and analysing information on ownership of selected materials and assets, such as radio, television, refrigerator, and vehicle; materials used for housing construction; and types of sanitation facilities and water access. Households were ranked into five quintiles (poorest, poorer, middle, richer and richest) depending on their level of wealth.

We grouped education levels of the mothers in to three categories (no education, primary, and secondary or higher). Exposure to media: frequency of listening to radio and watching television (TV): both categorised as (not at all, less than once a week, and once a week or more). Utilization of reproductive and maternal health services considered in the current study include use of contraceptive, antenatal care contacts, and delivery at the health facility.

Statistical analysis

Socioeconomic inequalities in the coverage of vaccination status were estimated using the concentration curve and concentration index. [32] The concentration curve is a plot of the cumulative percentage of the population, ranked by wealth status, from the poorest to the richest (x-axis) against the cumulative percentage of the health variable (vaccination status) on the y-axis. If all children had an equal proportion of vaccination status regardless of their socioeconomic status, then the curve would coincide with the 45° line, which indicates the presence of equality in the coverage of vaccination. If the concentration curve falls below the 45° line of equality, it indicates that the uptake of vaccines is more concentrated among the rich. The opposite is true if the curve falls above the line of equality.

The concentration index is described as two times the area between the line of equality and the concentration curve. The index takes a value between −1 and +1; an index of 0 indicates the presence of equality in the uptake of vaccines. If wealth related inequalities exist, it can be seen

in one of the two forms, the first is when there is uneven concentration of vaccine uptake among the rich, and in this case, the concertation index takes on a positive value. The second is negative value concentration index, which implies high concentration of vaccination status among the poor.

The concentration index (CCI) can be computed as follows:

$$CCI = \frac{2}{y}cov(h,r), \qquad (1)$$

where h is the healthcare outcome of interest (i.e. vaccination status), y is the mean of h and r is the fractional rank of an individual in the wealth distribution. We also computed 95% CIs for the concentration index.

Decomposing inequality

The concentration curve and concentration index can only show and quantify the level of inequalities related to wealth in the use of health services. However, policymakers are also interested in the factors that contribute to socioeconomic inequalities in vaccination coverage. This can be done using an approach developed by Wagstaff and colleagues. [33] The concentration index of a health variable can be decomposed into the contributions of individual factors to wealth-related health inequality. If we consider a linear regression model for the child's vaccination status, v, is defined according to k explanatory factors, x_k as.

$$v = \alpha + \sum_k \beta_k x_k + \varepsilon\,, \qquad (2)$$

where α and β are parameters, and ε is the error term. The concentration index for child vaccination status can be decomposed as:

$$C = \sum_k \left(\frac{\beta_k \bar{x}_k}{\mu}\right) C_k + \frac{GC_\varepsilon}{\mu}, \qquad (3)$$

where μ is the mean of y, $\bar{x}_k$ is the mean of x_k, C_k is the concentration index for x_k, (defined analogously to C), and GC_ε is the generalized concentration index for the error term (ε). Equation 3 shows that C is equal to a weighted sum of the concentration indices of the k regressors, where

the weight for x_k is the elasticity of y with respect to $x_k(\eta_k = \beta_k \frac{\overline{x}_k}{\mu})$. The residual component—captured by the last term $(\frac{GC_\varepsilon}{\mu})$ reflects the wealth-related inequality in health that is not explained by systematic variation in the regressors. We used the bootstrap method with 1000 replications to estimate standard errors . All analysis were performed after adjusting for sampling design (stratification and clustering) and sampling weights. STATA (version 14, StataCorp, College Station, Tex) and SPSS (version 26) software packages were used to perform data analysis.

Patient and public involvement

Patients/public were not involved in the design or implementation of this study.

Results

The sample used for the current analysis was limited to children aged 12–23 months at the time of the survey, yielding a final sample of 1930 mother-child pairs in 2011, and 2004 mother-child pairs in 2016. The majority (85.8% and 88.4%) of respondents were from rural areas in 2011 and 2016 surveys respectively, and more than 42% were from Oromia, which is the biggest region in the country. The percentage of mothers who had no education decreased from 68% in 2011 to 64% in 2016 while antenatal care contacts increased from 42% in 2011 to 60% in 2016 (Table 2).

Trends of vaccination coverage

Vaccination coverage showed improvements from 2011 to 2016; BCG vaccine uptake increased from 66% to 69%, DTP3 vaccine from 37% to 57%, OPV3 vaccine from 45% to 57%, and basic vaccination coverage from 24% in 2011 to 38% in 2016. The proportion of children who received all basic vaccinations that include BCG, DPT3, OPV3, and measles increased by 14% from 2011 to 2016. However, measles vaccine coverage decreased from 56% in 2011 to 54% in 2016, while the proportion of children who received no vaccination increased from 14% in 2011 to 16% in 2016 (Figure 1).

The urban/rural differential in basic vaccination coverage increased from almost 28% in 2011 to more than 29% in 2016 (Table 2). Coverage remained low but showed slight increases from 2011

to 2016 in regions such as Afar (8.5% to 15.2%), Somali (17.1% to 21.8%), and Oromia (15.6% to 24.7%). Basic vaccination coverage also showed disparities between and within the regions of Ethiopia (Table 2). For example, in 2016, coverage was 89.2% (95% CI: 82.0%, 93.8%) and 67.3% (95% CI: 57.6%, 75.7%) among children living in Addis Ababa and Tigray regions respectively, whereas in Afar it was 15.2% (95% CI: 8.0%, 26.9%), and Somali 21.8% (95% CI: 13.8%, 32.7%).

Table 2 Basic vaccination coverage by maternal and child characteristics in Ethiopia (DHS 2011 – 2016)

	2011				2016			
Study variables	**Number**	**Percent**	**Received all basic immunization (95% CI)**	**P-value**	**Number**	**Percent**	**Received all basic immunization (95% CI)**	**P-value**
Sex of child				**0.268**				**0.252**
Male	1010	52.3	23.1 (19.3, 27.5)		926	46.2	36.5 (31.2, 42.1)	
Female	920	47.7	26.1 (22.0, 30.7)		1078	53.8	40.5 (35.4, 45.8)	
Parity				**0.101**				**0.002**
1	358	18.6	30.1 (23.3, 37.9)		372	18.6	45.3 (37.7, 53.1)	
2	318	16.5	26.7 (20.7, 33.7)		322	16.0	47.1 (39.0, 55.3)	
3	306	15.9	22.8 (17.1, 29.8)		282	14.1	40.4 (31.9, 49.5)	
4	230	11.9	24.4 (18.1, 32.0)		243	12.1	39.5 (31.4, 48.2)	
5	220	11.4	15.3 (9.9, 22.8)		216	10.8	30.1 (21.5, 40.3)	
6	497	25.7	23.8 (17.5, 31.6)		569	28.4	28.7 (22.3, 36.2)	
Maternal age				**0.992**				**0.197**
15-24	518	26.8	24.6 (19.6, 30.4)		499	24.9	37.9 (31.6, 44.7)	
25-29	649	33.6	23.8 (19.3, 29.1)		596	29.7	44.1 (37.1, 51.4)	
30-34	386	20.0	24.7 (19.0, 31.5)		456	22.7	35.1 (28.7, 42.1)	
35-39	251	13.0	26.0 (18.9, 34.5)		295	14.7	33.5 (25.7, 42.4)	
40-49	127	6.6	24.8 (16.0, 36.2)		158	7.9	39.9 (29.3, 51.5)	
Contraceptive use				**<0.001**				**<0.001**
Never used	1106	57.3	17.9 (14.5, 21.8)		932	46.5	25.8 (21.3, 30.8)	
Using or used before	824	42.7	33.5 (28.8, 38.5)		1072	53.5	49.8 (44.3, 55.4)	
Antenatal care contact				**<0.001**				**<0.001**
No	1040	53.9	14.8 (11.6, 18.6)		711	35.5	18.6 (13.8, 24.4)	
Yes	815	42.2	37.3 (32.7, 42.1)		1194	59.6	50.8 (45.7, 55.8)	
Place child was delivered				**<0.001**				**<0.001**
Home	1694	87.8	20.6 (17.5, 24.1)		1309	65.3	30.6 (25.9, 35.6)	
Health facility	236	12.2	52.7 (43.3, 62.0)		695	34.7	53.8 (47.6, 60.0)	

Maternal educational levels				**<0.001**				**<0.001**
No education	1307	67.7	20.4 (16.9, 24.5)		1257	62.7	30.9 (26.6, 35.6)	
Primary	522	27.0	28.5 (23.6, 33.9		577	28.8	46.1 (39.8, 52.5)	
Secondary or higher	102	5.3	57.3 (44.7, 69.0)		170	8.5	70.5 (55.9, 81.8)	
Household wealth index in quintiles				**<0.001**				**<0.001**
Poorest	441	22.9	16.8 (12.0, 23.0)		504	25.2	22.2 (16.1, 29.8)	
Poorer	419	21.7	18.7 (13.9, 24.7)		396	19.8	38.1 (30.7, 46.1)	
Middle	394	20.4	18.7 (13.8, 24.7)		450	22.4	37.1 (30.1, 44.7)	
Richer	369	19.1	25.1 (18.7, 32.7)		366	18.3	44.6 (36.4, 53.0)	
Richest	307	15.9	50.7 (41.5, 59.8)		288	14.4	63.0 (52.0, 72.8)	
Place of residence				**<0.001**				**<0.001**
Urban	274	14.2	48.2 (38.8, 57.8)		232	11.6	64.6 (51.1, 76.2)	
Rural	1656	85.8	20.6 (17.4, 24.3)		1772	88.4	35.2 (31.1, 39.6)	
Regions				**<0.001**				**<0.001**
Tigray	129	6.7	59.3 (50.7, 67.5)		152	7.6	67.3 (57.6, 75.7)	
Afar	18	0.9	8.6 (4.9, 14.6)		20	1.0	15.2 (8.0, 26.9)	
Amhara	446	23.1	27.1 (20.0, 35.6)		364	18.2	46.4 (36.7, 56.4)	
Oromia	811	42.0	15.6 (11.1, 21.3)		881	44.0	24.7 (18.9, 31.6)	
Somali	51	2.6	17.1 (10.2, 27.2)		76	3.8	21.8 (13.8, 32.7)	
Benishangul-Gumuz	23	1.2	24.2 (16.8, 33.5)		21	1.0	57.4 (47.1, 67.2)	
Southern Nations, Nationalities and People	391	20.2	24.1 (18.0, 31.4)		419	20.9	46.9 (38.5, 55.5)	
Gambela	8	0.4	17.4 (8.7, 31.8)		5	0.3	41.1 (30.3, 52.9)	
Harari	5	0.3	36.1 (27.3, 46.0)		5	0.2	42.2 (31.1, 54.0)	
Addis Ababa	43	2.2	78.7 (69.1, 85.9)		52	2.6	89.2 (82.0, 93.8)	
Dire Dawa	7	0.4	59.4 (49.3, 68.8)		9	0.5	75.9 (64.2, 84.6)	

Inequalities in vaccination coverage

Inequalities in child vaccination persisted during 2011 and 2016: basic vaccination status was favourably concentrated among children from wealthier households while the distribution of those who received no vaccination remained disproportionately concentrated among poor (Figure 2). The uptake of BCG, DTP3, OPV3, measles, and basic vaccination were disproportionately concentrated among children from wealthy households during 2011 and 2016 (Figure 3). DTP3 and basic vaccination status had lower coverage and showed the highest inequalities during 2011 and 2016; for example, in 2016, DPT3 had concentration index of (CCI= 0.175) and basic vaccination (CCI= 0.172). The estimate for the distribution of children who received no vaccination in 2011 was (CCI= -0.092), this increased to (CCI= -0.184) in 2016 (Figure 3). The negative values for children who received no vaccination confirms pro-poor distributions. Increased vaccination coverage decreased inequalities as vaccinations such as BCG, OPV3, and measles that had higher coverage showed lower inequalities (Figure 3).

The decomposition results in (Table 3) and (Figure 4) show that the significant contributors to socioeconomic inequality in basic vaccination status included, wealth, maternal education, contraceptive use, antenatal care contacts, exposure to media that include radio and television, and place of residence (rural).

The decomposition analysis showed similar patterns in factors that explain socioeconomic inequalities in child vaccination status on both surveys. The use of maternal health services had the highest significant contributions to socioeconomic inequalities in child vaccination. Antenatal care contacts had 45.4% contribution in 2011 and 50.4% in 2016. Wealth status is the other significant contributor, 23.9% in 2011 and 21.2% in 2016. On the other hand, rural residence had a negative contribution to socioeconomic inequalities in child vaccination on both surveys.

The overall concentration index for basic child vaccination was positive. Any significant positive contributor in (Table 3) and (Figure 4) means that socioeconomic inequality in basic vaccination would have been less pro-rich if: (i) the contributing variables (e.g. antenatal care contacts or wealth) were to be evenly distributed among the rich and poor. Negative contributing variables (e.g. rural residence) would cause the opposite effect. The residual or unexplained contributing

factors to socioeconomic inequalities in basic vaccination account for 34.5% in 2011 and -12% in 2016.

Table 3 Decomposition of socioeconomic inequalities in basic vaccination coverage in Ethiopia, (DHS 2011, 2016)

Study variables	2011				2016			
	Marginal effect	Concentration index	Absolute contribution	Percentage contribution	Marginal effect	Concentration index	Absolute contribution	Percentage contribution
Sex of child								
Male	(Base)	(Base)	(Base)	(Base)	(Base)	(Base)	(Base)	(Base)
Female	0.022	0.035	0.001	0.4	0.043	0.034	0.001	0.6
Maternal age								
15-24	(Base)	(Base)	(Base)	(Base)	(Base)	(Base)	(Base)	(Base)
25-29	0.052*	0.049	0.003	1.2	0.562	0.073	0.006	2.2
30-34	0.072*	-0.006	0.000	-0.2	0.058	-0.030	-0.002	-0.7
35-39	0.060*	-0.052	-0.003	-1.5	0.052	0.006	0.000	0.1
40-49	0.023	0.019	0.000	0.2	0.057*	-0.009	-0.001	-0.2
Maternal parity								
1	(Base)	(Base)	(Base)	(Base)	(Base)	(Base)	(Base)	(Base)
2	-0.004	-0.042	0.000	0.1	0.037	0.066	0.002	0.9
3	-0.033	0.020	-0.001	-0.3	0.014	-0.009	0.000	0.0
4	-0.021	-0.015	0.000	0.1	0.016	-0.034	-0.001	-0.2
5	-0.068	-0.012	0.001	0.4	-0.030	0.008	0.000	-0.1
6	-0.034	-0.048	0.002	0.8	-0.070	-0.123	0.009	3.2
Pattern of contraceptive use								
Never	(Base)	(Base)	(Base)	(Base)	(Base)	(Base)	(Base)	(Base)
Using or used before	0.091**	0.348	0.032	15.2	0.235***	0.322	0.076	28.5
Antenatal care contact								
No	(Base)	(Base)	(Base)	(Base)	(Base)	(Base)	(Base)	(Base)
Yes	0.242***	0.390	0.094	45.4	0.566***	0.237	0.134	50.4
Place child was delivered								
Home	(Base)	(Base)	(Base)	(Base)	(Base)	(Base)	(Base)	(Base)
Health facility	0.030*	0.323	0.010	4.6	0.027*	0.371	0.010	3.7

Frequency of listening to radio								
Not at all	(Base)	(Base)	(Base)	(Base)	(Base)	(Base)	(Base)	(Base)
Less than once a week	-0.031	0.104	-0.003	-1.6	0.049	0.127	0.006	2.3
At least once a week	0.026*	0.232	0.006	2.9	0.045	0.219	0.010	3.7
Frequency of watching television								
Not at all	(Base)	(Base)	(Base)	(Base)	(Base)	(Base)	(Base)	(Base)
Less than once a week	-0.035	0.066	-0.002	-1.1	-0.008	0.120	-0.001	-0.3
At least once a week	0.042	0.223	0.009	4.5	0.007	0.286	0.002	0.7
Education levels								
No education	(Base)	(Base)	(Base)	(Base)	(Base)	(Base)	(Base)	(Base)
Primary	-0.005	0.182	-0.001	-0.4	0.070**	0.127	0.009	3.3
Secondary or higher	-0.001	0.152	0.000	0.0	0.028**	0.235	0.007	2.5
Place of residence								
Urban	(Base)	(Base)	(Base)	(Base)	(Base)	(Base)	(Base)	(Base)
Rural	0.143	-0.426	-0.061	-29.2	0.080	-0.323	-0.026	-9.8
Household wealth index in quintiles								
Poorest	(Base)	(Base)	(Base)	(Base)	(Base)	(Base)	(Base)	(Base)
Poorer	0.005	-0.283	-0.001	-0.7	0.094**	-0.236	-0.022	-8.3
Middle	-0.015*	0.078	-0.001	-0.6	0.061**	0.110	0.007	2.5
Richer	0.032**	0.375	0.012	5.8	0.070**	0.387	0.027	10.2
Richest	0.076***	0.535	0.040	19.4	0.091**	0.492	0.045	16.8
Residual				34.6				-12.1
Total				65.4				112.1

* indicates <p 0.05; ** indicates p < 0.01; *** indicates p < 0.001

Discussion

This study examined inequalities in vaccination coverage among children aged 12-23 months in Ethiopia. The uptake of all basic vaccinations increased from 24.6% in 2011 to 38.6% in 2016. Coverage improvements from 2011 to 2016 were observed in BCG vaccine uptake by 3%, DTP3 by 16.2%, OPV3 by 11.5%, and all basic vaccinations by 14%. While there were improvements in vaccination coverage from 2011 to 2016, issues that need to be address include a lack of awareness about vaccination, facilities' limited operating hours, maternal time constraints, and the distance to facilities [34,35].

Ethiopia remains one of the top ten high priority countries in the world where children remain unvaccinated [1]. In the current study, more than 15% of children received none of the vaccines, while incomplete vaccinations were 62% in 2011 and 46% in 2016. Possible explanations for under vaccination or no vaccination may include vaccine hesitancy or refusal, lack of access to vaccination services, or missed opportunities [5]. Vaccine hesitancy refers to concerns about real or perceived vaccine adverse events among parents that may lead to delayed vaccination schedules or refusal of vaccinations altogether [36]. Missed opportunities present another explanation in which children may not receive one or all of recommended vaccines even if they are vaccine-eligible and can attend health facilities, which is commonly refers to missed opportunities [5,36].

The uptake of BCG, DTP3, OPV3, measles, and receipt of all basic vaccinations were disproportionately concentrated among children from wealthier households. This finding is consistent with multi country studies across low-middle income countries.[9,37] However, a study across three countries [14] that include Gambia, Kyrgyz Republic, and Namibia showed that receipt of all basic vaccinations was disproportionately concentrated among children from poor households. The coverage of DPT3 and basic vaccination showed the highest inequalities favouring children from wealthy households. More than 14% of children received none of the vaccines during 2011 and 2016. These children were mainly from disadvantaged households; for example, children who remained unvaccinated in 2016 were 8.3% among the richest quantile, while 24% were from the poorest quantile. Basic vaccination coverage also showed significant

variations across regions of the country; this ranged from 15% in Afar, and 21% in Somali, to 67.3% in Tigray, and 89.2% in Addis Ababa. Afar and Somali regions are predominantly nomadic pastoralist areas, with relatively weaker health systems compared to Tigray, and Addis Ababa that have improved healthcare coverage [38].

Ensuring access to all recommended vaccines for all children, regardless of sociodemographic or socioeconomic status, saves more lives and facilitates progress towards achieving sustainable development goals (SDGs) [39]. SDG target for child mortality aims to reduce neonatal mortality to lower than 12 deaths per 1,000 live births and under-5 mortality to lower than 25 deaths per 1,000 live births across all countries [39]. In 2016, the infant mortality rate was 48 deaths per 1,000 live births, and the under-5 mortality rate was 67 deaths per 1,000 live births in Ethiopia [23].

Findings of the current study revealed that the use of maternal health services, maternal education, exposure to media, and wealth had positive contributions to basic vaccination uptake. These findings align with other similar studies [11,15,40]. Maternal knowledge about vaccinations is a determinant for vaccination status, which may be associated with increased knowledge about benefits of child vaccination because of counselling during family planning, and antenatal care contacts [41-43]. Moreover, based on findings related to the impact of residence and access to health facilities on vaccination, it may be that a mother with regular access to family planning and antenatal care is also more likely to seek out postnatal care where vaccination of her child can be more readily provided [44].

In the present study, maternal education had contributions to vaccine uptake in 2016, but this was not the case in 2011. Education helps to create improved awareness and knowledge about childhood vaccination [42]. Previous studies have also indicated that educated women are more likely to take their child for vaccination [13,42]. Exposure to media can also be a useful tool to reach population at different socioeconomic levels. The findings of this study showed that access to mass media (radio and TV) favourably influences vaccine uptake. Transmitting information about the importance of childhood vaccination is vital to reach not only mothers but also their partners and community leaders [45]. Information dissemination that targets mother's partner and

community leaders can help to create a conducive environment that can favourably influence mothers to vaccinate their children.

In the present study, the socioeconomic well-being of mothers was associated with higher vaccination uptake. While vaccinations are provided free of charge in many developing countries, mothers sometimes incur indirect costs, for example, transportation costs, which often limit their uptake of these services [6]. Mothers at the lower wealth categories are more likely to experience challenges in accessing healthcare facilities as such less likely to take their child for vaccination [11].

Children from rural areas had lower vaccination coverage compared to children from urban areas. In 2011, basic vaccination coverage was 48.2% in urban areas while it was 20.6% in rural areas. This pattern continued in 2016, as 64.6% of children from urban areas had basic vaccination, but only 35.2% in rural areas. This finding is consistent with those of similar studies [11,46]. This could partly be explained by challenges faced in rural areas due to less developed health infrastructure and fewer skilled providers [47]. In rural areas, long-distance to health facilities is another reason for low basic vaccination coverage. People live far away from health facilities and the long-distance, and lack of transportation poses a critical challenge for mothers to take their child for vaccination [47].Vaccines require cold chain management as it is sensitive to high temperatures [48]. Health facilities in rural areas face a shortage of electric power supply to keep the cold chain equipment working, which could lead to cancellation of services as lack of cold chain equipment may result in the stock-out of vaccines [15]. One study from Nigeria found that 47% of solar fridges for vaccine storage in eight states were broken [49].

The strengths of this study include the use of a nationally representative survey from the two most recent DHS surveys. The decomposition of the contributing factors that drive socioeconomic inequalities in vaccination status provided a rich set of analysis for policy interventions to address socioeconomic disparities in access to basic vaccinations in Ethiopia. Limitations of the current study may include recall bias related to vaccination status as not all children had vaccination cards, and measures had to depend on the mother's verbal report. The

DHS is a cross-sectional survey; it was not possible to establish temporality between childhood vaccination and explanatory factors..

Conclusions

The coverage of basic vaccination improved by 14 % from 2011 to 2016, but the overall coverage remained low. Increased vaccine coverage was disproportionately concentrated among children from wealthy households, while the majority of children who had no vaccination were from disadvantaged households. Utilisation of reproductive and maternal health services, household income status, and maternal education had significant positive contributions to improved vaccination status. Therefore, continued efforts at improving coverage of family planning, antenatal care contacts, institutional delivery, maternal education, and socioeconomic well-being are required to improve vaccination status. Moreover, regions such as Afar, Somali, and Oromia, and rural areas of the country at large require targeting.

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Competing interests:

None declared

Patient consent for publication:

Not required

Ethics approval:

Ethics approval was not required for the current analysis, as the data were from publicly available DHS data. The MEASURE DHS /ICF International, Rockville, Maryland, USA – granted access to data upon request.

Contributors

FTB designed the study, analysed and drafted the manuscript. AH helped revise the study design, and supervised the data analysis. All authors read and approved the final manuscript.

Data availability statement:

The dataset was made available for public use after de-identification (data are available online at: https://www.idhsdata.org/idhs/)

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Figures

Fig. 1 Vaccination coverage among children aged 12-23 months in Ethiopia (DHS 2011, 2016).

Fig. 2 Concentration curves for child vaccination status, Ethiopia (DHS 2011, 2016)

Fig. 3 Concentration indecies that shows socioeconomic inequalities in child vaccinations, Ethiopia (DHS 2011, 2016)

2Fig. 4 Percentage contributions of factors explaining socioeconomic inequalities in full vaccination coverage, Ethiopia (DHS 2011, 2016)

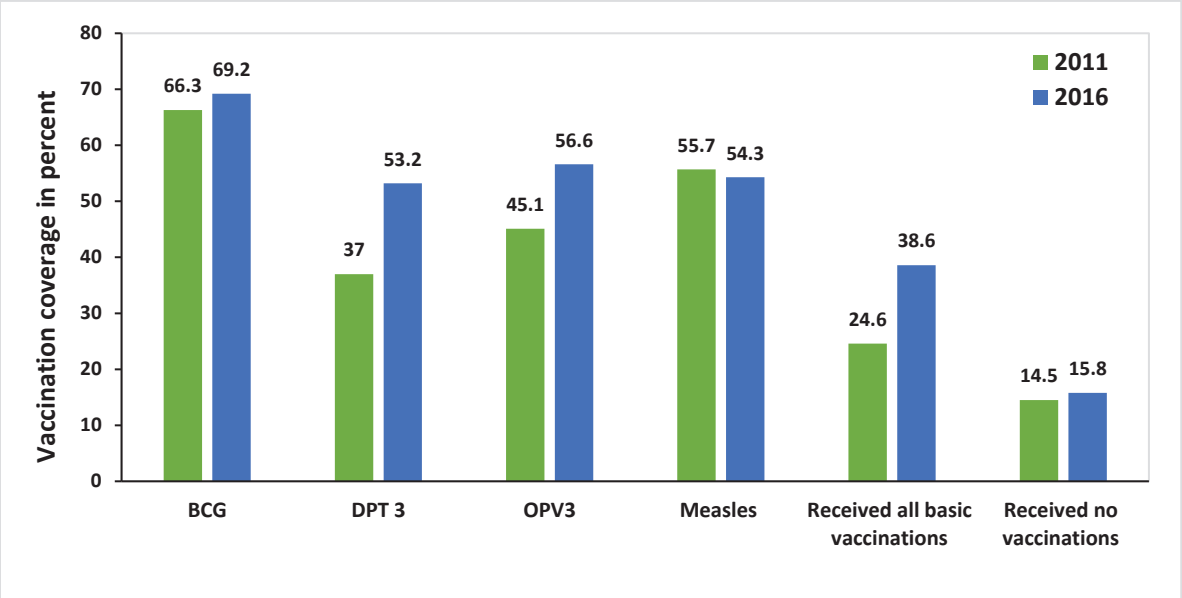

Fig. 1 Vaccination coverage among children aged 12-23 months in Ethiopia (DHS 2011, 2016).

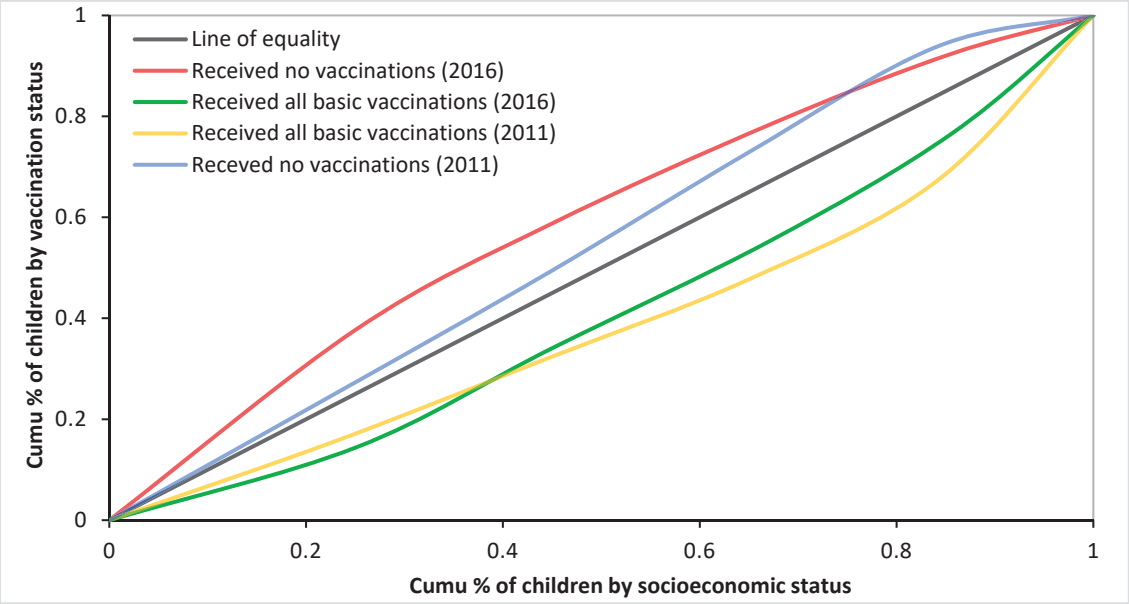

Fig. 2 Concentration curves for child vaccination status, Ethiopia (DHS 2011, 2016)

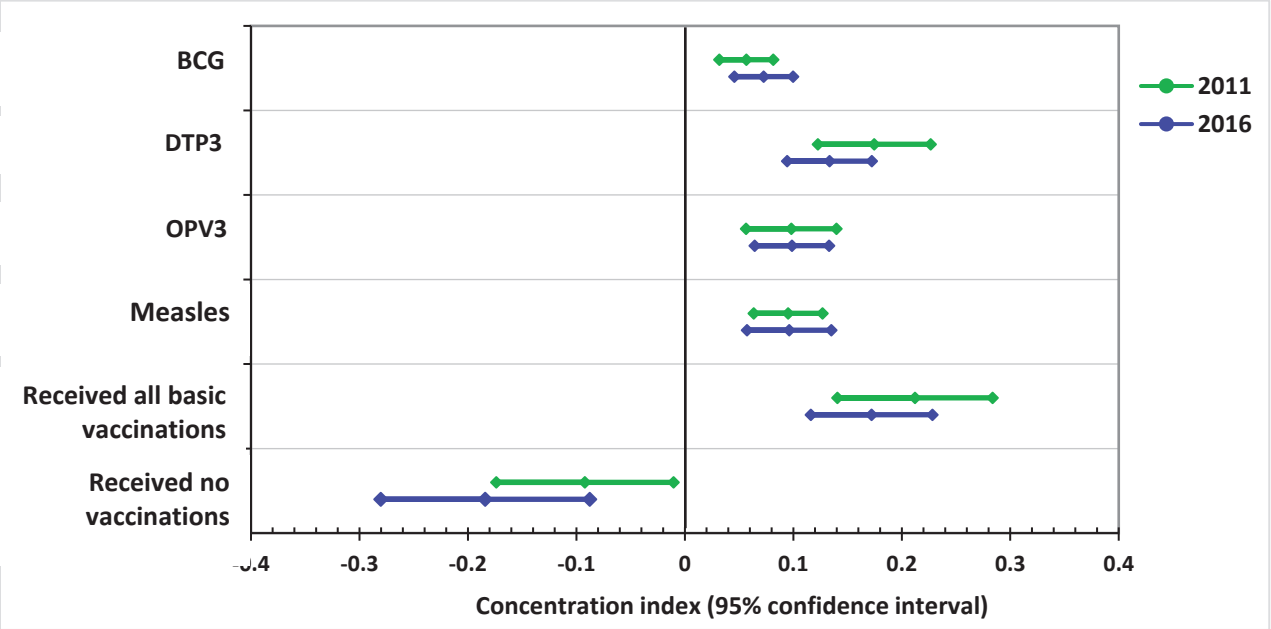

Fig. 3 Concentration indecies that shows socioeconomic inequalities in child vaccinations, Ethiopia (DHS 2011, 2016)

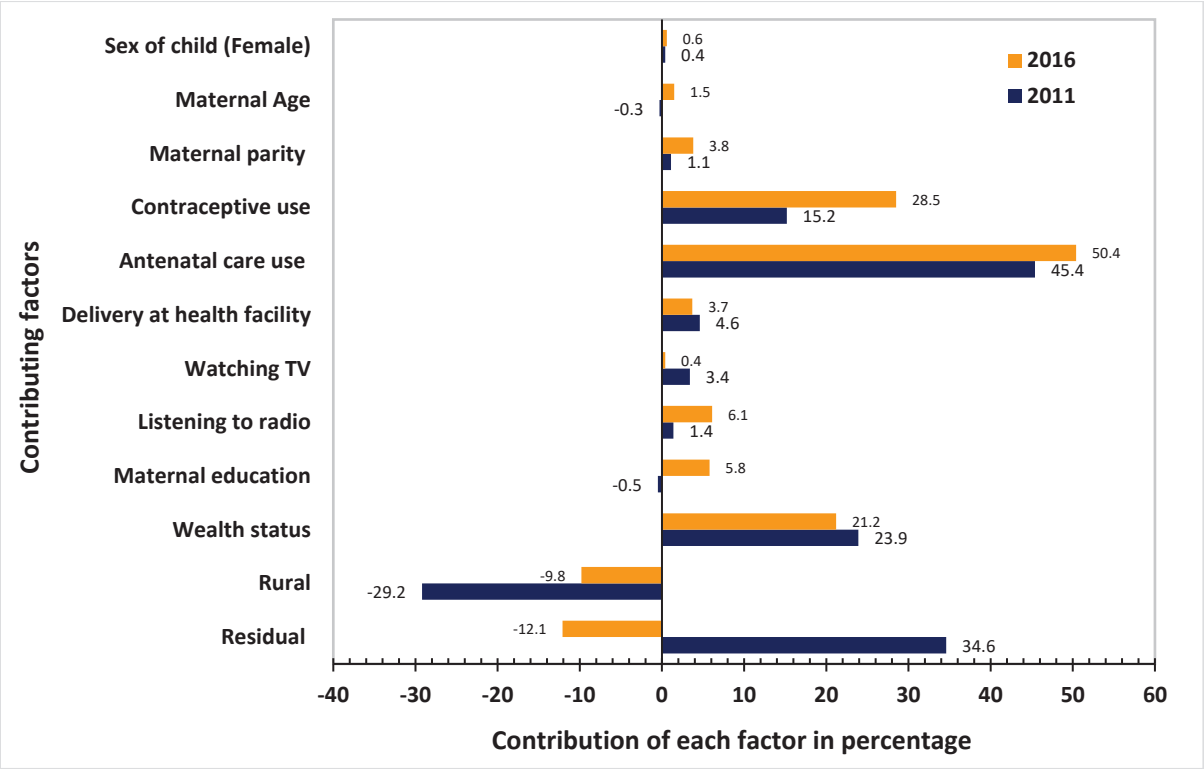

Fig. 4 Percentage contributions of factors explaining socioeconomic inequalities in full vaccination coverage, Ethiopia (DHS 2011, 2016)

Health Insurance Coverage and Associated Factors among Women in Ethiopia: A Secondary Analysis of Ethiopia Demographic and Health Survey Data 2016 – STROBE checklist

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

		(*c*) If relevant, consider translating estimates of relative risk into absolute risk for a meaningful time period
Other analyses	N/A	Report other analyses done—eg analyses of subgroups and interactions, and sensitivity analyses
Discussion		
Key results	13-17	Summarise key results with reference to study objectives
Limitations	3	Discuss limitations of the study, taking into account sources of potential bias or
Interpretation	13-17	Give a cautious overall interpretation of results considering objectives, limitations, multiplicity of analyses, results from similar studies, and other relevant evidence
Generalisability	3	Discuss the generalisability (external validity) of the study results
Other information Funding	N/A	Give the source of funding and the role of the funders for the present study and, if applicable, for the original study on which the present article is based