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Inequality in child immunization coverage in Ethiopia: evidence from Expanded Program for Immunization coverage survey

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Abstract. Background: Immunization is one of the cost-effective public health interventions, and can be used to prevent life-threatening childhood illnesses. This study aimed to assess disparities in child immunization coverage in Ethiopia. **Method:** Data from the 2012 Ethiopian Expanded Program for Immunization coverage survey was used. In this study, absolute and relative equity analysis was employed based on socioeconomic variables **Result:** Equity analysis was conducted in 3,748 subjects out of 3,762 child caregivers' data. The concentration index among the poorest and richest group for BCG immunization coverage was 11%, OPV 3 was 13.3%, Pneumococcal 3 was 38.6%, Pentavalent 3 was 21.5%, Measles was 12.9%, Vitamin A supplementation was 8.9%, and full immunization was 38.6%. **Conclusion:** Inequalities were observed in child immunization coverage across the socioeconomic groups, with the better-off wealth status, urban residents, and children from an educated mother being more likely to be vaccinated.

Keywords. Equity, Immunization, Ethiopia

Introduction

According to the Sustainable Development Goal (SDG) by 2030, all countries aiming to reduce neonatal mortality to 12 per 1000 live births and under-5 mortality to 25 per 1000 live births (1).

A large proportion of deaths are occurring in sub-Saharan Africa(2). Immunization is one of the cost-effective public health interventions and can be used to reduce or eliminate life-threatening diseases (3). Globally, immunization reduces 2–3 million deaths yearly, but vaccine-preventable diseases still account for over 2 million under-five mortality annually(4). Successful vaccination programs generally result from high vaccine efficacy and proper vaccination(5).

In Ethiopia routine immunization was started in 1980 to reduce child morbidity and death (6). There are limited evidences which indicate child immunization inequality at national level. A recent study conducted in four regions of Ethiopia showed that an inequitable child immunization

coverage between poorest and better-off wealth status (7). To achieve and sustain high rate of vaccine coverage, access to vaccination is a community for financial and technical support or strengthening of programs and introduction of vaccines in low-income environments, acceptance and demand for vaccinations(8). The Ethiopian National Expanded Program on Immunization had planned to achieve 96% at the national level and at least 80% DTP-HepB-Hib3/OPV3 coverage in all districts by 2015(9). However, still most studies conducted in Ethiopia showed inequality based on the wealth of the household. However, this analysis tends to assess equity in child immunization service at the national level as well as disparities based on multiple socio-economic variables such as maternal education status, resident, and wealth status of the household. Despite an increasing trend of immunization coverage in the last decades, understanding the disparities is important for designing strategies that can reduce the burden of vaccine-preventable diseases.

Methods

Data source

National Expanded Program for Immunization (EPI) coverage data, conducted in 2012, was used in this analysis. This study was a community based cross-sectional survey. The study was conducted at national level in nine regions and two city administrations of Ethiopia. Details of the survey was presented elsewhere (10).

Measurements

During analysis, source of immunization was classified into three groups for each antigen: card plus history, register only, and history only. Card plus history refers to individuals who had a card, where some doses were included as a dose by history when the caregiver reported doses not recorded on the card (10).

Socioeconomic indicators were used to assess equity in child immunization services. The inequality was measured for fourteen child vaccinations and based on three socio-economic stratifying indicators namely; wealth index, resident of a child, and education status of mother/caregiver. The wealth index was calculated in the same manner as in the DHS reports. Accordingly, wealth index was calculated using a principal component analysis (PCA) weights for each asset variable, an aggregated score was calculated for each of the surveyed households, which was grouped into quintiles 1 (Q1) representing the poorest 20% of households in the sample and quintile 5 (Q5) representing 20% of the better-off (10). In addition, education status of the mother/caregiver and residence type was also considered as a stratifying variable to measure equity.

Data Analysis

In this study, absolute (slope index) and relative equity analysis (concentration index) were employed based on three socio-economic indicators. A total of 3,762 mothers/caregivers of eligible child data were analyzed for childhood immunization. However, 14 child data had a missing value of education status and wealth index, therefore the equity analysis for these variables excluded them from the analysis. The analysis was conducted using statistical software (STATA), version 14. Coverage estimates were generated using weighted analysis.

Results

Background characteristics

A total of 3,748 mothers/caregivers of eligible child data were analysed for childhood immunization. Out of total caregivers, 40.7% of respondents were Orthodox, followed by Muslim (35.6%), and Protestant (22%). Most of the respondents were residing in urban areas (85.7%). One in five households were categorized in poorest (22.4%), poor (22.8%), and middle (21.8%) quintile. While, 13.7% of households were in richest quintile. Two-third of the caregivers (66.3%) had no formal education and few (2.3%) caregivers attended higher education (Table 1)

Table 1. Background characteristics of study participants by residence and religion (n=3,748)

Variables	category	Percent
Residence	Rural	85.7
	Urban	14.3
Wealth status	Poorest	22.4
	Poorer	22.5
	Middle	21.8
	Richer	19.7
	Richest	13.7
Maternal education	No education	66.3
	Pre-school	9.0
	Primary	17.8
	Secondary	4.6
	Higher	2.3

Child Immunization coverage inequality

The slope index of inequity based on wealth status for the basic immunizations: BCG (39.6%), Polio 3 (48.8%), Pentavalent 3 (29.68%), and measles (20.4%) showed statistically significant differences in the coverage of the four basic immunizations. The slope index of inequity based on residence for the basic immunizations: BCG (55.3%), Polio 3(54.6%), Pentavalent 3 (58.9%), Pneumococcal 3(38.7%), Measles (46.3%), in Vitamin A supplementation (37.2%) and in full immunization (60.0%). There is a significant difference in immunization utilization among urban and rural residents. The slope index of inequity based on maternal education for the basic immunizations: BCG (46.2%), Polio 3 (44.8%), Pentavalent 3 (53.0%), Pneumococcal 3 (30.5%), Measles (43.6%), Vitamin A supplementation (31.8%) and Full immunization (53.3%). There is a significant difference in utilization of the all-child immunization types among education status of child-mother (Table 2).

The concentration index of inequity based on wealth status for the basic immunizations: (BCG) immunization (11.1%), Polio vaccine 3(13.4%), Pentavalent vaccine 3(21.5%), Pneumococcal Vaccine 3(45.7%), Measles (12.9%), Vitamin A supplementation (9.20%) and full immunization (25.2%) Concentration index of inequity based on residence for the basic immunizations: BCG immunization (8.50%), Polio 3(10.7%), Pentavalent 3(15.01%), Pneumococcal Vaccine 3(36.41%), Measles (9.7%), Vitamin A supplementation (8.4%) and full

immunization (18.4%) have found statistically significant differences in the utilization of all immunizations service. Concentration index of inequity based on maternal education for the basic immunizations: BCG (7.0%), Polio 3(8.2%), Pentavalent 3(12.3%), Pneumococcal 3(28.3%), Measles (8.2%), Vitamin A supplementation (6.7%) and full immunization (15.0%). There are statistically significant differences in the utilization of all immunization services among child-mother/care giver education (Table 2).

Table 2. Absolute and relative equity analysis of child immunization coverage by background (n=3,748)

Type of vaccine	Wealth Quintile				Residence				Mother's Education			
	SII		CIX		SII		CIX		SII		CIX	
	%	SE	%	SE	%	SE	%	SE	%	SE	%	SE
BCG	54.6*	0.02	11.1*	0.01	55.3*	0.03	8.5*	0.01	46.2*	0.00	7.0*	0.00
OPV 0	70*	0.02	42.2*	0.01	76.2*	0.02	41.2*	0.01	55.1*	0.00	29.4*	0.00
OPV 1	33*	0.02	5.5*	0.00	32.7*	0.04	4.1*	0.00	24.4*	0.00	3.8*	0.00
OPV 2	42.2*	0.02	8.2*	0.00	44.4*	0.03	6.7*	0.00	33.2*	0.00	6.0*	0.00
OPV 3	57.5*	0.02	13.4*	0.01	54.6*	0.03	10.7*	0.01	45.6*	0.00	8.2*	0.00
PVV 1	55.2*	0.02	11.6*	0.01	47.2*	0.03	8.0*	0.01	43.6*	0.00	8.0*	0.00
PVV 2	64.4*	0.02	15.9*	0.01	55.1*	0.03	11.0*	0.01	49.5*	0.00	10.6*	0.00
PVV 3	71.1*	0.02	21.5*	0.01	58.9*	0.03	15.0*	0.01	53.3*	0.00	12.3*	0.00
PCV 1	46.9*	0.02	28.9*	0.02	45*	0.02	22.0*	0.02	34.4*	0.00	17.9*	0.00
PCV 2	44.6*	0.02	32.6*	0.02	42.3*	0.02	25.2*	0.02	33.8*	0.00	21.9*	0.00
PCV 3	43.2*	0.02	42.7*	0.02	38.7*	0.02	36.4*	0.02	30.5*	0.00	28.4*	0.00
Measles	51.4*	0.02	12.9*	0.01	46.3*	0.03	9.7*	0.01	44.3*	0.00	8.2*	0.00
Vitamin A	35*	0.03	9.2*	0.01	37.2*	0.03	8.4*	0.01	32.2*	0.00	6.7*	0.00
Full immunization	70.3*	0.02	25.2*	0.01	60*	0.02	18.4*	0.01	53.7*	0.00	15.0*	0.00

CIX: Concentration Index, SII: Slope index, SE: Standard Error and *: significant at 95% confidence interval.

Moreover, Figure 1., illustrates the concentration of cumulative proportion of immunization coverage by stratifying variables. The concentration curve for full immunization coverage lies below the diagonal line, an equity line, indicating disparities among wealth quintiles, resident, and maternal education.

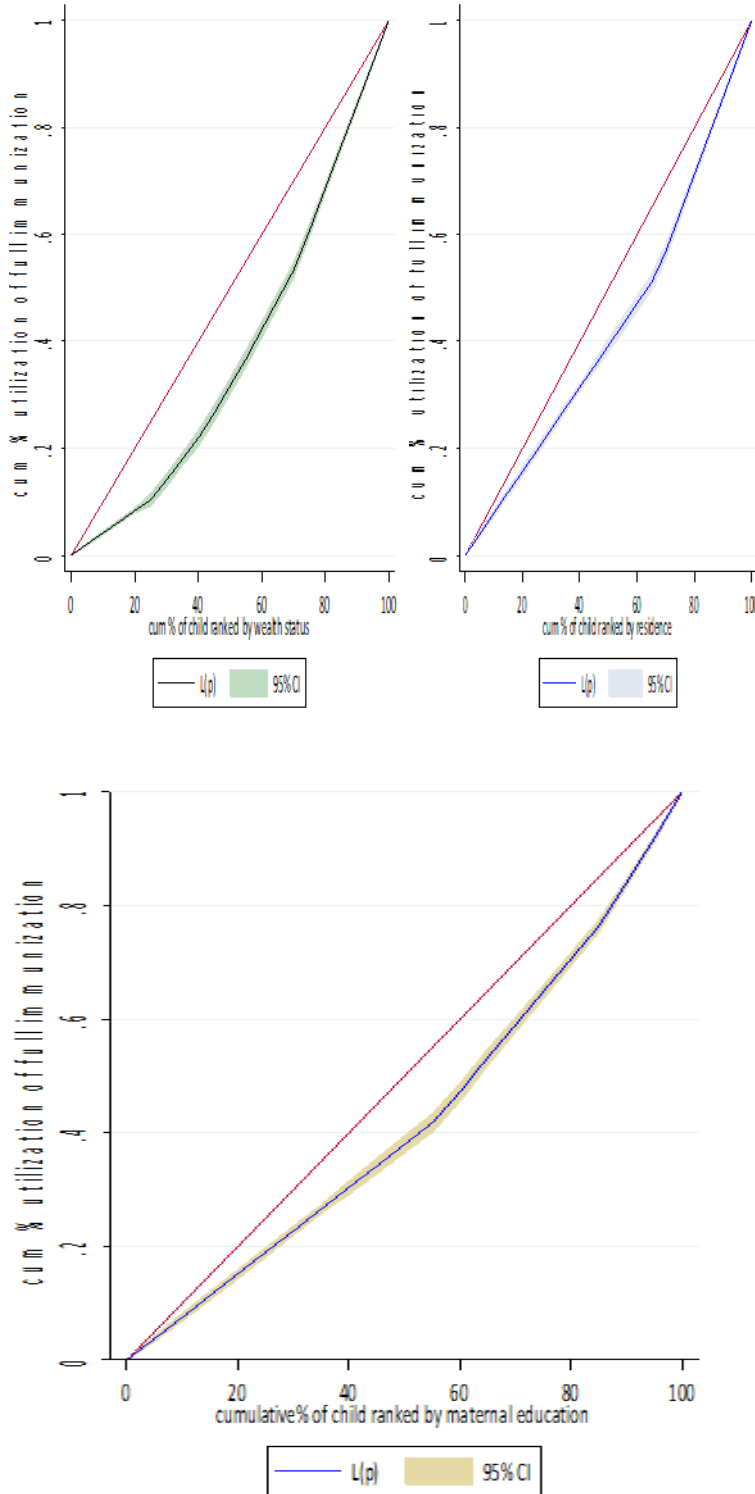


Figure 1. Concentration Curve for child immunization coverage by wealth quintiles, residence and maternal education

Figure 2., Illustrate the percent utilization and distribution of child immunization coverage by wealth quintiles and residence. The absolute differences explained by equiplot indicate that there is a disparity in all child immunization coverage by wealth quintile and residence type.

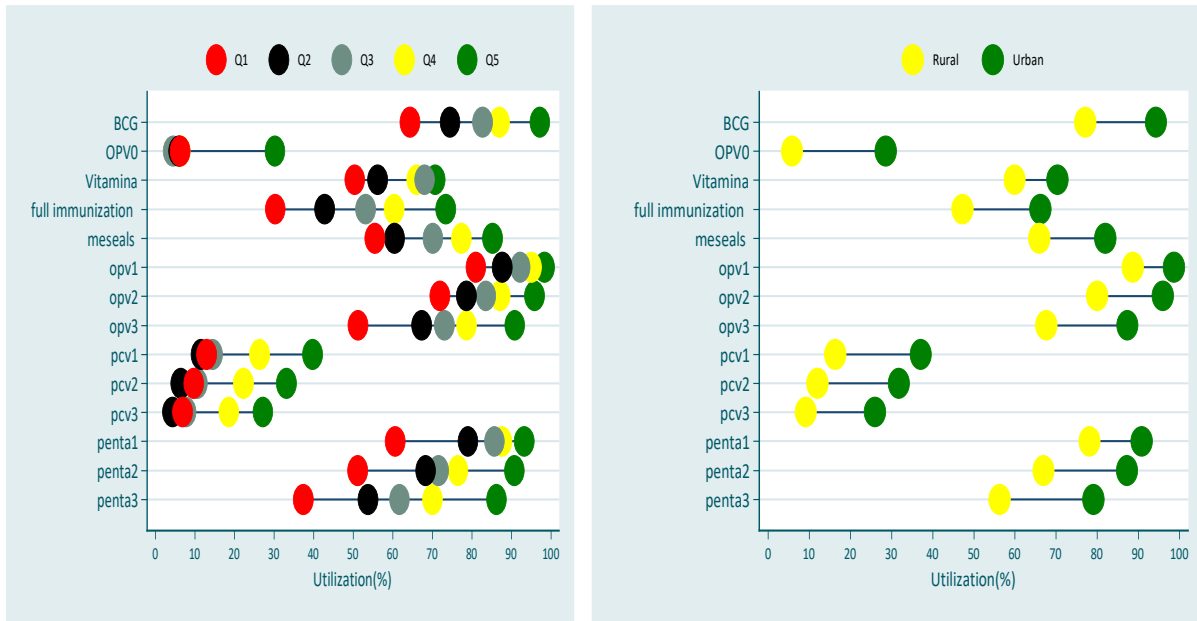


Figure 2 Equiplot of child immunization coverage by wealth quintiles and residence

Discussion

Child immunization coverage in Ethiopia had a significant inequality in both absolute and relative measures of equity based on three geographic and socioeconomic variables. In general, this study indicates child immunization coverage was inequitably distributed with the better-off wealth status, urban residents, and child of the educated mother being more likely to use these services.

The reliability and comparability of the National Expanded program for immunization coverage survey dataset were highly trusted compared to other childhood immunization survey estimates. Its primary aim was to address the coverage of immunization at population but for the other surveys did not aim to have direct immunization survey this might lead to lack of accuracy in data collection. Hence, EPI coverage survey was reliable in providing a truly robust and accurate estimation of immunization coverage (11). Therefore, in this study equity analysis was conducted by using reliable, trusted, and comparable dataset rather than using other administrative, other surveys, and other international/national estimates of coverage.

Some national and international studies have investigated the inequality of child vaccination, consequently, our result contradicted with a study conducted on wealth-based equity in child health services utilization implying that child health service utilization were equitable among poorest and richest (7,12–14). Our finding for full vaccination coverage consistent with the report of other low-and middle-income countries (15,16), shown immunization coverage better-off wealth status more likely in vaccine use. Furthermore, our study is national estimate of immunization coverage and the previous studies was conducted in four regions of Ethiopia.

Our finding on Measles antigen inequality was consistent with a study conducted in Ethiopia using the demographic and health surveys 2000–2016, implying that in measles immunization coverage urban residents were significant more likely to vaccine compared to rural resident(17).

Residence-based inequality was observed in our study for all immunization service. This indicates that children in rural areas had lower vaccination coverage compared with children in urban areas. The finding was consistent with a study conducted by in Ethiopia using demographic and health surveys 2011– 2016 (2,18)

Another main finding from this study is the presence of significant absolute and relative inequality in Ethiopia in all immunization service on the educational status of mother as the finding indicates that there was inequality of child immunization between a child-mother educational status. The finding indicates child immunization services utilization tended to be inequitably distributed favoring children from mothers' education status increased. Our finding is consistent with a study conducted in Nepal using four recent demographic and health surveys(19). Reflecting that child vaccine coverage inequality by household wealth quintile and maternal education status was narrowed over time. The finding of the study was found similar to the finding of Childhood vaccination coverage and equity impact in Ethiopia through socioeconomic, geographic, and child characteristics inferring that children in the richest wealth status were 3 times more likely to have full vaccination coverage compared to children in the poorest wealth status (20).

When interpreting the results of this study, some of the following limitations should be considered. A national vaccination survey was conducted nine years ago. This may not reflect the current state of immunization equity for children.

We suggest that targeted programs to reach unvaccinated children (illiterate mothers, rural residence, and poor households) in these populations improve child vaccination equity in Ethiopia and would help to achieve sustainable development goals regarding child health improvement. An awareness program to increase the need for childhood vaccination in rural and uneducated communities improves equity of childhood vaccination, and special monitoring program of child vaccination targeting poorest, rural, and uneducated populations improve the equity of child vaccination in Ethiopia.

Conclusion

The inequality observed in the quintile of wealth indicate unfair use of the child vaccine between the poorest and the richest. In Ethiopia, all immunization services are provided for free. Therefore, we expect all individuals could access the service regardless of wealth. We also observed inequality of child immunization between rural and urban residents, and among mothers' education status, which implies that vaccine utilization was found low in the uneducated community.

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Abbreviation

BCG: Bacilium Calmette Guerin; EPI: Ethiopian Population Immunization; DPT: Diphtheria/Pertussis/Tetanus; OPV: Oral Polio Vaccine; PV: Pentavalent Vaccine; PCV: Pneumococcal Vaccine; SDG: Sustainable Development Goal; VPDs: Vaccine-Preventable Diseases; CSA: Central statistics agency; SII: slope index inequality; EPHI: Ethiopian public health institute

Conflict of interest

The authors declare that there was no competing interest.

Availability of data

The complete dataset will be available from the data repository of EPHI upon request.

Authors' contributions

DY participated in conception and design of the study, data curation, data analysis and interpretation, draft write up. TG participated in conception and design of the study, data curation, interpretation, and review the write up. MG, TT, GT, AT, AZ, AD and FG participated in review of the manuscript. All authors read and approved the final version of the manuscript.

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