Trends in inequality in the coverage of vitamin A supplementation among children 6–59 months of age over two decades in Ethiopia: Evidence from demographic and health surveys

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Abstract

Objectives: There is a dearth of evidence on inequalities in vitamin A supplementation in Ethiopia. The goal of this study was to assess the magnitude and overtime changes of inequalities in vitamin A supplementation among children aged 6–59 months in Ethiopia.

Methods: We extracted data from four waves of the Ethiopia Demographic and Health Surveys (2000, 2005, 2011, and 2016). The analysis was carried out using the 2019 updated World Health Organization’s Health Equity Assessment Toolkit software that facilitates the use of stored data from World Health Organization’s Health Equity Monitor Database. We conducted analysis of inequality in vitamin A supplementation by five equity stratifiers: household economic status, educational status, place of residence, child’s sex, and subnational region. Four summary measures—population attributable fraction, ratio, difference, and population attributable risk—were assessed. We computed 95% uncertainty intervals for each point estimate to ascertain statistical significance of the observed vitamin A supplementation inequalities and overtime disparities.

Results: The findings suggest marked absolute and relative pro-rich (population attributable fraction = 29.51, 95% uncertainty interval; 25.49–33.53, population attributable risk = 13.18, 95% uncertainty intervals; 11.38–14.98) and pro-urban (difference = 16.55, 95% uncertainty intervals; 11.23–21.87, population attributable fraction = 32.95, 95% uncertainty intervals; 32.12–33.78) inequalities. In addition, we found education-related (population attributable risk = 18.95, 95% uncertainty intervals; 18.22–19.67, ratio = 1.54, 95% uncertainty intervals; 1.37–1.71), and subnational regional (difference = 38.56, 95% uncertainty intervals; 29.57–47.54, ratio = 2.10, 95% uncertainty intervals; 1.66–2.54) inequalities that favored children from educated subgroups and those living in some regions such as Tigray. However, no sex-based inequalities were observed. While constant pattern was observed in subnational regional disparities, mixed but increasing patterns of socioeconomic and urban–rural inequalities were observed in the most recent surveys (2011–2016).

Conclusion: In this study, we found extensive socioeconomic and geographic-based disparities that favored children from advantaged subgroups such as those whose mothers were educated, lived in the richest/richer households, resided in urban areas, and from regions like Tigray. Government policies and programs should prioritize underprivileged subpopulations and empower women as a means to increase national coverage and achieve universal accessibility of vitamin A supplementation.

Keywords

Vitamin A supplementation, health inequalities, global health, demographic and health surveys, Ethiopia

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Introduction

Vitamins are crucial micronutrients, which are necessary for good health. Vitamin A is one of the essential vitamins that is vital for enhancing reproduction and vision, as well as for preventing blindness and infection. Vitamin A has numerous important functions such as preserving the intestinal, respiratory, and urinary tracts and the surface of the eyes, as well as for proper functioning of the immune system. Vitamin A is indispensable for adequate fetal growth during the embryonic phase. On the other hand, absence of sufficient vitamin A, especially in children, increases the risk of illnesses such as blindness, measles, diarrhea, and death.

Vitamin A deficiency (VAD) is a major public issue in low- and middle-income countries (LMICs). Measles- and diarrhea-related childhood mortality is mainly associated with a deficiency of Vitamin A, and in LMICs, its deficiency is one of the major causes of preventable childhood blindness. Insufficient intake of vitamin A is considered as the key cause of VAD. Children require optimal intake of vitamin A, especially during infections, for reducing VAD-related complications.

Worldwide, nearly 190 million young children are affected by VAD, in which Africa accounts for 56.4% of this global burden. VAD significantly contributes to under-five morbidity and mortality. Recent studies in LMICs showed that VAD accounts for 1.7% of the overall under-five mortality in those countries, of which 95% occurs in South Asia and sub-Saharan Africa.

In Ethiopia, based on the 2016 Ethiopia Demographic and Health Survey (EDHS), child mortality is still high. For instance, 48 children per 1000 live births are dying before celebrating their fifth birthday. VAD caused 80,000 deaths in a year and affected 61% of under-five children. Approximately, 23% of all causes of child mortality can be averted by adequately supplementing vitamin A, especially for children with VAD, since it can increase their immunity and resistance to diseases.

Assuring optimal supplementation coverage is extremely vital, not only for preventing VAD but because it is also one of the utmost cost-effective approaches and fundamental components of the child survival program. A recent study in Ethiopia shows that vitamin A supplementation (VAS) has saved between 167,563 to 376,030 child lives between 2005 and 2019.

Hence, many LMICs including Ethiopia have implemented interventions that include routine VAS for children aged 6–59 months. These interventions are constituents of the Integrated Management of Childhood Illness (IMCI) package and provide vitamin supplementation two times per year mainly at the primary health facility level and during other designated campaigns such as the maternal, newborn, and child health (MNCH) weeks and national immunization days. VAS is being pragmatic in many LMICs. Although few countries have reported that the coverage of VAS is up to 85%, in many LMICs like Ethiopia, it is below this target.

Based on the recent 2016 EDHS, the coverage of VAS among 6–59 months aged children was 45%. Extant literature showed geographic and socioeconomic variations in VAS coverage. However, there is a dearth of evidence on comprehensive assessments of inequalities in VAS in Ethiopia. Thus, the purpose of the present study was to answer two key questions: (1) What is the magnitude of VAS coverage across socioeconomic and geographic subpopulations from 2000 to 2016 in Ethiopia? (2) What are the trends in socioeconomic, demographic and geographic inequalities in vitamin A coverage in Ethiopia from 2000 to 2016?

Recognizing the magnitude of these disparities will uncover some of the underlying risk factors for poor population health outcomes and contribute to policies and programs/interventions to promote health for all. The reduction of these inequalities is also crucial for the achievement of universal health coverage. Ongoing monitoring of the magnitude of health inequalities is essential to assure the disadvantaged population groups are prioritized in policy and program interventions.

Methods

Data source

It is a descriptive cross-sectional study and we used data from four waves of EDHSs (2000, 2005, 2011, and 2016). The EDHS is conducted with the financial support of the United State Agency for International Development (USAID) and technical assistance of United Nation International Children’s Emergency Fund (UNICEF). The EDHS is a nationally representative survey designed to collect data on various health topics such as nutrition, domestic violence and female genital mutilation, access to mass media, fertility, young child development, breastfeeding and food intake, vaccinations, and treatment of diseases. By providing the government of Ethiopia with valid and up-to-date health indicators on reproductive-aged women (15–49 years of age), men 15–59 years old, and children under 5, the survey aims to monitor and assess the health situation of the population.

Sample size determination

The sample for all the four EDHS was designed to provide population and health indicators at national (urban and rural) and regional levels. The sample design permitted for specific indicators, such as VAS, to be calculated for each of Ethiopia’s 11 geographic/administrative regions (the nine regional states and two city administrations). The 1994 population and housing census, conducted by the Central Statistical Agency (CSA), was provided the sampling frame for the 2000 and 2005 EDHSs, while the 2007
population and housing census used for the 2011 and 2016 EDHSs. Administratively, regions in Ethiopia are divided into zones, and zones into administrative units called weredas. Each wereda is further subdivided into the lowest administrative unit, called kebele. Each kebele was subdivided into census enumeration areas (EAs), which were convenient for the implementation of the census. An EA is a geographic area that covers an average of 181 households. All four EDHS samples used a stratified, two-stage cluster sampling design, and EAs were the sampling units for the first stage. Thus, 2348 clusters (672 urban and 1676 rural) were selected from the list of EA using proportional probability sampling (PPS) technique. In the second stage, households from each cluster were then systematically selected for participation in the survey. In all four surveys, a total of 65,112 households were selected for the sample, of which 62,180 were occupied. Of the occupied households, 61,145 were successfully interviewed. A total of 37,625 children aged 6–59 months were included. Detailed description of the sampling design and overall methodology of EDHSs is explained elsewhere.1,24–26

Instruments

The EDHS data are collected usually every 5 years with the use of pretested validated quantitative tools and structured methodologies. Specifically for this study, data were collected using a questionnaire that included information on children’s identity (age, sex, and relationship to the main caregiver) and VAS coverage during the preceding 6 months. Caregivers were shown samples of VA capsules and were asked about their sociodemographic characteristics and their sources of information on vitamin A. The information is based on mother’s recall, health facility information (where available), and the vaccination card (where available). In case of missing information on the day of the supplementation date, we imputed 15 as the probable day. The rationale for selection of day 15 refers to its position in the middle of the month; therefore, it would minimize potential bias referring to the child’s age in the date of the supplementation.1,24–26

Variables and their measurements

We measured inequality in VAS coverage, which is the primary outcome variable of interest for the study. VAS was assessed among living children aged 6–59 months who received vitamin A capsule or supplement 6 months before the interview.27 In the EDHS, the mothers or caregivers are questioned on whether their child had received vitamin A capsule or not. If the child received the supplement, we coded the variable as “yes” and if not, we coded it as “no.”27

We measured inequality in VAS coverage using five equity stratifiers, namely, household’s economic status, educational status, child’s sex, place of residence, and subnational region. Household economic status was measured using the Demographic and Health Survey (DHS) wealth index, which is customarily calculated by considering the possession of durable goods, household characteristics and availability of basic household facilities following the methodology explained elsewhere.28 For all the surveys, the commonly used variables took account of possession of a car, motorcycle, bicycle, electricity, television, radio, and material used for constructing wall, roof and floor of household house, water and hygiene and sanitation facilities.28,29 The constructed wealth index is then divided into five quintiles, namely, wealth quintile 1 (poorest), wealth quintile 2 (poorer), wealth quintile 3 (middle), wealth quintile 4 (richer), and wealth quintile 5 (richest). The other equity stratifiers are maternal education (coded as no education, primary school, secondary school and above), place of residence (coded as rural and urban), child’s sex (coded as male and female), and subnational region (coded into nine regions and two city administration: Tigray, Afar, Amhara, Oromiya, Somali, Benishangul-Gumuz, South Nation and Nationalities People (SNNP), Gambela, Harari, Addis Ababa, and Dire Dawa).

Statistical analysis

The analysis was done using HEAT software that is recommended by World Health Organization (WHO) for investigation of health inequalities and it is available offline after installation. The detailed description of the software is available elsewhere.30,31 In brief, the HEAT is software that enables the examination and analysis of health inequalities across and within countries. The software is valuable for exploring the health disparity situation in a systematic manner. The HEAT software application comprises the WHO Health Equity Monitor (HEM) database.32 The database has large sets of data from Multiple Indicator Cluster Survey (MICS) and DHS which are carried out in several LMICs including Ethiopia. Currently, the HEM database comprises more than 30 maternal, neonatal, child and reproductive health indicators.

The analysis included two key steps. First, disaggregation of VAS was made using the above-mentioned five equity stratifiers. Following the disaggregation, VAS inequality was further analyzed using the four summary measures, namely, population attributable fraction (PAF), population attributable risk (PAR), difference (D), and ratio (R). The selection of the summary measures for an inequality study should be based on the fact that, the selected summary measures need to be of simple and complex measures.33 At the same time, summary measures need to be relative and absolute measures to be able to examine inequality from different angles. For our study, we selected measures of inequality by these recommendations. PAF and PAR are complex measures, whereas R and D are simple measures.33 In addition, PAF and R are relative summary measures, whereas PAR and D are absolute summary measures.
Simple measures make pairwise comparisons of health between two subgroups, such as the most and least wealthy.  

Simple pairwise comparisons have historically been the dominant type of measurement used in inequality monitoring, as their simplicity makes them intuitive and easily understood. Complex measurements, on the contrary, make use of data from all subgroups to assess inequality. When describing the inequality in a health indicator by region, for instance, pairwise comparisons can be used to describe the inequality between two selected regions—such as worst versus best—whereas complex measures could describe the inequality that exists among all regions. While pairwise comparisons of inequality have certain limitations that complex measures overcome, they will be described here at length as they play an important role in inequality monitoring. Because they are straightforward, and they are preferable over complex measures in situations where complex measures do not present a substantially improved picture of inequality. Detailed description of the calculation of each of the summary measures used in this study is explained elsewhere, but we have highlighted here a summary. D is calculated by subtracting two subgroups \( D = Y_{\text{high}} - Y_{\text{low}} \), where \( Y_{\text{high}} \) represents richest, secondary school and above, female, and urban and \( Y_{\text{low}} \) represents poorest, no education, male, and rural. Similar calculation was applied for subregions (region with highest VAS coverage minus lowest VAS coverage). The calculation of R in all five dimensions of inequalities is similar with D except that R is dividing subgroups with highest VAS coverage with subgroups with lowest VAS coverage as follows: R is calculated by dividing two subgroups \( R = Y_{\text{high}} / Y_{\text{low}} \), where \( Y_{\text{high}} \) represents richest, secondary school and above, female, and urban and \( Y_{\text{low}} \) represents poorest, no education, male, and rural for economic, education, sex, and place of residence dimensions, respectively. Similar calculation was applied for subregions (region with highest VAS coverage minus lowest VAS coverage). The calculation of R in all five dimensions of inequalities is similar with D except that R is dividing subgroups with highest VAS coverage with subgroups with lowest VAS coverage as follows: R is calculated by dividing two subgroups \( R = Y_{\text{high}} / Y_{\text{low}} \), where \( Y_{\text{high}} \) represents richest, secondary school and above, female, and urban and \( Y_{\text{low}} \) represents poorest, no education, male, and rural for economic, education, sex, and place of residence dimensions, respectively. 

PAR was calculated by subtracting the national average of VAS coverage from the reference subgroups. The reference subgroups for economic, education, sex, and place of residence are richest, secondary school and above, female, and urban, respectively. For subnational, the reference subgroups are region with the highest VAS coverage in each survey. PAF is computed by dividing the PAR with the national average of VAS coverage (\( \mu \)) and multiplied by 100. An inequality in VAS coverage is nonexistent if the D included zero and R included 1. PAF and PAR take the value of zero if no inequalities or same levels are recorded across subgroups. The greater the value of PAF and PAR from zero, the higher the inequality. The value of PAF and PAR indicates the potential improvement in the national coverage of VAS coverage if the VAS coverage reached the same level across subgroups or no inequality across subgroups. A positive value of PAR and PAF indicates higher concentration of coverage of VAS coverage among advantaged subpopulations such as richest, secondary school and above, female children and urban residents as well as regions with the highest VAS coverage. Inequality trends were assessed in caution and by referring to the uncertainty intervals (UI) of each summary measure of different surveys. That means if the UIs did not overlap, there were increasing or decreasing changes, but the overlapping of UIs was considered a constant pattern. However, the small and large overlapping was not treated equally and authors considered this important concept during interpretations of trends. For enabling this study’s quality of evidence, we followed the guideline indicated in strengthening Reporting of Observational Studies in Epidemiology (STROBE).

**Ethical considerations**

For the analysis of this study, ethical approval was not sought for the present study because authors utilized already existing secondary data. All ethical procedures that were followed by the custodians of the data have been reported in the manuscript. In addition, the University of Ottawa’s Office of Research Ethics and Integrity stated that “no ethics review is required for the use of previously collected, publicly available, anonymously collected data” (https://research.ottawa.ca/ethics/submission-and-review/types-review).

**Results**

**Sociodemographic characteristics of study participants**

In the present study, 37,625 children below 5 years are included. Of them, 18,458 (49%) were females and 33,616 (89.3%) were rural residents. Approximately three-fourth (27,889 (74.1%)) of the respondents (their mothers) had no formal education, while 7851 (20.9%) and 1883 (5.0%) of the respondents attended primary and secondary school, respectively (Table 1).

**Coverage of VAS among children 6–59 months of age**

The findings show the overall national coverage rates of VAS in 2000, 2005, 2011 and 2016 were 59.9%, 46%, 53.1% and 44.7% respectively. This study also shows marked differences in the coverage of VAS across wealth quintiles, especially between quintile 1 (poorest) and quintile 5 (richest) from 2000 to 2016 survey period. In addition to variation, the coverage of VAS was mixed across economic subpopulations (Figure 1). For instance, among wealth quintile 1 and wealth quintile 5, VAS coverage decreased from 2000 to 2005 and then remained constant until 2016. Among wealth quintile 2, VAS coverage decreased from 2000 to 2005; however, it rose from 2005 to 2011 and decreased from 2011 to 2016.

In this study, we found variations in VAS coverage based on educational status, with higher coverage among secondary
Table 1. Sociodemographic characteristics of study participants: evidence from Ethiopia Demographic and Health Surveys.

| Dimension of inequality | Subpopulation                  | Sampled population |
|-------------------------|--------------------------------|--------------------|
|                         |                                | 2000   | 2005   | 2011   | 2016   | Total   |
| Economic status         | Quintile 1 (poorest)           | 2108   | 1989   | 2191   | 2206   | 8494    |
|                         | Quintile 2                     | 2048   | 1892   | 2165   | 2106   | 8211    |
|                         | Quintile 3                     | 2005   | 1953   | 1989   | 1938   | 7885    |
|                         | Quintile 4                     | 1937   | 1743   | 1935   | 1642   | 7257    |
|                         | Quintile 5 (richest)           | 1576   | 1377   | 1495   | 1323   | 5771    |
| Educational level       | No education                   | 7892   | 7052   | 6793   | 6152   | 27,889  |
|                         | Primary school                 | 1287   | 1501   | 2629   | 2434   | 7851    |
|                         | Secondary school+              | 497    | 403    | 353    | 630    | 1883    |
| Place of residence      | Rural                          | 8638   | 8284   | 8498   | 8196   | 33,616  |
|                         | Urban                          | 1038   | 672    | 1278   | 1021   | 4009    |
| Sex of child            | Female                         | 4775   | 4450   | 4775   | 4458   | 18,458  |
|                         | Male                           | 4902   | 4507   | 5001   | 4759   | 19,169  |
| Subnational region      | Tigray                         | 639    | 590    | 639    | 604    | 2472    |
|                         | Afar                           | 97     | 85     | 97     | 93     | 372     |
|                         | Amhara                         | 2516   | 2025   | 2219   | 1745   | 8505    |
|                         | Oromia                         | 3937   | 3598   | 4082   | 4015   | 15,632  |
|                         | Somali                         | 114    | 383    | 293    | 420    | 1210    |
|                         | Benshangul-gumz                | 93     | 83     | 113    | 100    | 389     |
| South nation Nationality People | 2056 | 1986   | 2048   | 1944   | 8034    |
|                         | Gambela                        | 22     | 26     | 33     | 22     | 103     |
|                         | Harari                         | 20     | 18     | 24     | 21     | 83      |
|                         | Addis Ababa                     | 147    | 130    | 191    | 209    | 677     |
|                         | Dire Dawa                      | 31     | 30     | 32     | 39     | 132     |

Figure 1. Coverage of vitamin A supplementation among children 6–59 months of age in Ethiopia by household economic status: Evidence from EDHS 2000–2016.
school subgroups in all four surveys compared with no education subgroups. The pattern in the coverage of VASs also varied across education subgroups from 2000 to 2016. For instance, among no education subgroups, the VAS decreased from 2000 to 2005, then increased from 2005 to 2011, and again decreased from 2011 to 2016. Among secondary school and above subgroups, the VAS coverage decreased from 2000 to 2005 and then remained constant until 2016 (Figure 2).

This study revealed urban–rural variation in the coverage of VAS, with higher coverage among urban subpopulation especially in three surveys (2000, 2005, and 2016). Generally, the coverage decreased in both subpopulations approximately at a similar rate, which is 1.04 percentage points (pp) and 0.95 pp per year among urban and rural subgroups, respectively (Figure 3).

Regarding sex-based distribution, the coverage of VAS was not varied among male and female children in all four surveys as illustrated in Figure 4.

Another finding from this study is profound variation in the coverage of VAS coverage across subnational regions from 2000 to 2016. Except in Afar and SNNP regions, the coverage decreased from 2000 to 2005 across all regions. Again, except, Somali and SNNP regions, the coverage increased from 2005 to 2011. When we see the first and last surveys, the coverage roughly decreased in most regions, but an increment was seen in Benshangul-Gumuz and Afar regions. The coverage was approximately constant in Tigray, SNNP, and Gambela regions (Figure 5).

For more details about the magnitude and trends in the coverage of VAS coverage, with the corresponding 95% UI,
among children 6–59 months of age across various subpopulation groups, please refer to Table 2.

**Magnitude of and trends in inequality**

Table 3 shows the magnitude and trends in socioeconomic and geographic related inequalities in VAS among children 6–59 months by four summary measures. We found significant absolute and relative wealth-driven inequalities between the 2000 and 2016 period both by simple (D, R) and complex (PAR, PAF) measures. For instance, in the 2016 survey, based on D measure, the coverage among children in the richest subgroups was higher by 17.1 pp (95% UI: 10.77–23.32) compared with children in the poorest subpopulation. Significant absolute and relative education-related inequalities in VAS coverage were observed both by simple and complex measures. The simple measures indicated constant pattern of inequality over the 16-year survey period. The patterns of both wealth-driven and education-related inequality were constant using the simple measures over the 16 years while mixed using the complex measures.

Except absence of inequality in 2011 by R measure, we found substantial relative and absolute place of residence inequalities in VAS coverage over the 2000 survey period. No sex-based inequality was seen over the 16 years while mixed using the complex measures. Except absence of inequality in 2011 by R measure, we found substantial relative and absolute place of residence inequalities in VAS coverage over the 16-year survey period. The possible justification for the reduction of coverage of VAS coverage from 2000 to 2016 might be due to inequality in maternal healthcare service utilization. Recent studies in Ethiopia shows that compared with 2000, the likelihood of maternal health service utilization significantly increased in 2016 among economically advantaged subpopulation than those who are poor. This widened inequality might be due to fast population growth from 2000 to 2017, which again results to increase healthcare demand.

**Discussion**

In this study, we examined trends in absolute and relative inequalities in VAS among children 6–59 months using five commonly used inequality dimensions. The findings show the overall national coverage rates of VAS coverage in 2000, 2005, 2011 and 2016 were 59.9%, 46%, 53.1%, and 44.7%, respectively. Our finding is lower compared with other African countries such as Senegal (88.4%), Rwanda (86.4%), Sierra Leone (83.2%), and Togo (81.7), respectively. The differences for coverage across countries could partly be due to variations in women’s literacy level, place of residence and media exposure. Significant socioeconomic and geographic-based inequalities in VAS were observed in Ethiopia from 2000 to 2016. The patterns of inequalities varied based on the respective summary measures. The possible justification for the reduction of coverage of VAS coverage from 2000 to 2016 might be due to inequality in maternal healthcare service utilization. Recent studies in Ethiopia shows that compared with 2000, the likelihood of maternal health service utilization significantly increased in 2016 among economically advantaged subpopulation than those who are poor. This widened inequality might be due to fast population growth from 2000 to 2017, which again results to increase healthcare demand.
Table 2. Coverage of vitamin A supplementation across different subpopulations in Ethiopia from 2000 to 2016: Evidence from Ethiopia Demographic and Health Surveys.

| Dimension of inequality | Subpopulation         | 2000     | 2005     | 2011     | 2016     |
|-------------------------|-----------------------|----------|----------|----------|----------|
|                         |                       | % (95% UI)| Popn     | % (95% UI)| Popn     | % (95% UI)| Popn     | % (95% UI)| Popn     |
| Economic status         | Quintile 1 (poorest)  | 56.42 (51.59–61.14) | 2108 | 39.73 (35.69–43.91) | 1989 | 45.21 (41.59–48.89) | 2191 | 40.80 (35.93–45.86) | 2206 |
|                         | Quintile 2             | 58.65 (54.04–63.11) | 2048 | 42.29 (38.06–46.64) | 1892 | 53.16 (48.90–57.38) | 2165 | 41.29 (37.54–45.16) | 2106 |
|                         | Quintile 3             | 55.69 (51.36–59.95) | 2005 | 45.75 (41.75–49.82) | 1953 | 51.39 (47.08–55.68) | 1989 | 42.37 (38.26–46.59) | 1938 |
|                         | Quintile 4             | 59.21 (54.77–63.50) | 1937 | 49.92 (44.94–54.89) | 1743 | 59.63 (55.03–64.07) | 1935 | 46.29 (41.57–51.06) | 1642 |
|                         | Quintile 5 (richest)   | 72.28 (67.67–76.46) | 1576 | 55.95 (50.77–61.01) | 1377 | 58.07 (51.98–63.93) | 1495 | 57.85 (53.97–61.64) | 1323 |
| Educational level       | No education           | 57.90 (55.28–60.47) | 7892 | 44.68 (41.96–47.45) | 8284 | 52.48 (49.88–55.07) | 8498 | 42.83 (40.22–45.49) | 8196 |
|                         | Primary school         | 64.12 (58.47–69.40) | 1287 | 50.77 (45.99–55.55) | 1501 | 57.43 (53.55–61.22) | 2629 | 48.42 (44.64–52.22) | 2343 |
|                         | Secondary school +     | 80.44 (73.90–85.66) | 497  | 64.27 (58.11–69.99) | 403  | 67.27 (59.54–74.17) | 353  | 63.62 (58.27–68.65) | 360  |
| Place of residence      | Rural                  | 57.95 (55.30–60.56) | 8638 | 44.68 (41.96–47.45) | 8284 | 52.48 (49.88–55.07) | 8498 | 42.83 (40.22–45.49) | 8196 |
|                         | Urban                  | 75.96 (69.57–81.37) | 1038 | 63.03 (56.41–69.19) | 672  | 56.83 (50.17–63.25) | 1278 | 59.39 (54.69–63.93) | 1021 |
| Sex of child            | Female                 | 59.78 (56.87–62.62) | 4775 | 46.28 (43.32–49.27) | 4450 | 53.93 (51.19–56.64) | 4775 | 44.41 (41.47–47.39) | 4458 |
|                         | Male                   | 59.99 (57.22–62.69) | 4902 | 45.85 (43.03–48.69) | 4507 | 52.21 (49.29–55.11) | 5001 | 49.41 (46.22–47.62) | 4759 |
| Subnational region      | Tigray                 | 71.95 (67.77–75.79) | 639  | 65.33 (59.56–70.68) | 590  | 82.78 (78.11–86.62) | 639  | 73.54 (67.20–79.04) | 604  |
|                         | Afar                   | 27.61 (18.77–38.62) | 97   | 33.32 (25.88–41.69) | 85   | 35.32 (29.03–42.17) | 97   | 34.98 (28.54–42.01) | 93   |
|                         | Amhara                 | 71.08 (66.93–74.91) | 2516 | 43.31 (36.75–50.12) | 2025 | 63.76 (57.86–69.28) | 2219 | 47.82 (43.12–52.56) | 1745 |
|                         | Oromia                 | 58.14 (53.49–62.66) | 3937 | 43.43 (38.92–48.06) | 3598 | 48.68 (44.36–53.02) | 4082 | 37.64 (33.18–42.33) | 4015 |
|                         | Somali                 | 49.16 (35.43–63.02) | 114  | 38.82 (31.88–46.24) | 383  | 26.32 (21.05–32.37) | 293  | 36.26 (30.62–42.31) | 420  |
|                         | Benshangul-Gumuz       | 54.21 (46.12–62.08) | 93   | 27.40 (20.33–35.81) | 83   | 59.89 (51.02–68.16) | 113  | 63.67 (58.35–68.68) | 100  |
|                         | South Nation Nationality People | 45.65 (40.70–50.68) | 2056 | 50.19 (46.32–54.07) | 1986 | 43.92 (39.85–48.06) | 2048 | 47.06 (42.93–51.23) | 1944 |
|                         | Gambela                | 57.31 (46.62–67.35) | 22   | 39.06 (31.91–46.72) | 26   | 55.58 (48.95–62.01) | 33   | 56.77 (49.50–63.75) | 22   |
|                         | Harari                 | 82.99 (78.68–86.58) | 20   | 36.33 (30.07–43.09) | 18   | 62.57 (56.40–68.36) | 24   | 39.63 (32.06–47.74) | 21   |
|                         | Addis Ababa            | 85.77 (80.83–89.59) | 147  | 54.91 (48.45–61.22) | 130  | 62.34 (55.70–68.56) | 191  | 53.90 (47.78–59.91) | 209  |
|                         | Dire Dawa              | 88.48 (85.25–91.07) | 31   | 48.18 (43.54–52.86) | 30   | 67.56 (60.54–73.87) | 32   | 71.22 (63.23–78.07) | 39   |
| National average        |                       | 59.88     | 46.06    | 53.05     | 44.67     |
and imbalanced population to health facility ratio and due to low healthcare forces. A recent study in Ethiopia shows that related to individual, household, and community-level factors, women in Ethiopia are still changing in accessing healthcare services, especially those who are disadvantaged subpopulations. The finding shows more than 71% of married women in Ethiopia encountered at least one type of barrier (i.e. money, distance to a health facility, getting permission to go to a health facility, and going alone) to accessing healthcare services.

Some husbands still do not allow their spouses and children to access and use healthcare services, and this is partly linked to their religious view. As an example, a study in Northeast Ethiopia indicates that healing, as well as illness and health, is given by God. The healing system takes place through searching for the help of the divine via supplication and scripture-based healing procedures and through nature spirit actors which include “woliy,” “wodaja,” and “tsebel”/holy water. Every nature spirit agent performs numerous key roles on this process affecting non-secular, mental, and bodily health.

Healthcare utilization can be affected by cultural backgrounds, ideals, norms and values of particular ethnic organizations and faith. Ethnicity and faith are frequent concepts linked to beliefs, norms, and values on the subject of pregnancy, childbirth, and usage of services. A previous inquiry on Ethiopia’s maternal health services utilization suggests that Christian and Muslim women had been more likely to apply maternal health services than conventional and other religions. This result is steady with other studies. This may be because women with traditional religion can be much less modern and greater inclined to standard beliefs. Regarding ethnicity, Wolaita ethnic groups were less probably to use skilled antenatal care and transport care than other ethnic agencies. The reason for the low maternal health service usage by the Wolaita ethnic group can be because of the fact that those ethnic groups culturally might not assist facility delivery due to their cultural ideals and values on maternal healthcare.

Geographic related and socioeconomic inequalities remained high in accessing health services more prevalently in rural settings. More precisely, we found pro-rich inequalities, which were comparable with findings of studies in India, Philippines, Cambodia, Bangladesh, Guinea and Ethiopia. In Ethiopia, the report from 2016 EDHS confirmed recent findings of about 17% variation in VAS coverage between children in the poorest households (41%) and children in the richest households (58%). Higher uptake of VAS among children from the wealthier households might partly be due to the fact that better economic status increases healthcare seeking behaviors and access to health information.
Within the Ethiopian health system, a few public health services had been provided to all residents freed from charge irrespective of level of earnings. This has taken place because of the nature of these activities and due to the desire to promote the utilization of certain healthcare services. Although exemption services were extra standardized across regions, some services needed standardization by means of authorities. Services that have been supplied free of price in a few public health centers have been not unfastened in others. Furthermore, there was no clear distinction among the financing and service provision. Health centers were providing free services without budgetary/funding support for these sports.54

Ethiopia institutionalized mechanisms for supplying offerings to the bad free of price through a fee-waiver system, as well as through free provision of selected public health services (via exemption) consisting of health education and treatment of tuberculosis patients and through services targeting selected corporations (e.g. immunization of children under the age of 5). However, a sturdy want existed to systematize and standardize those services. For instance, local authorities had been issuing (and continues to be issuing in some areas) price waiver certificates to the negative as verified through local social justice structures at the time of sickness. This led to cumbersome processes that brought on delays in the poor’s capability to get entry to care. This changed into now not the case for people in better income classes, and the system therefore created healthcare inequities.54,55

We found education-related disparities in VAS coverage that favored children from educated mothers as compared with children from mothers who had no formal education. Similar findings are reported in several previous studies in India,19 Philippines,48 Cambodia,49 Bangladesh,50 Guinea,51 Nigeria,20 Ghana,18 and Ethiopia.52 The observed association between VAS coverage and mother’s education is not surprising; this relationship has also been reported in association with other child health services such as immunization and nutrition.56 Better utilization of maternal and child health services has been reported among educated women, likely because education enhances access to opportunities as well as communication capacities with healthcare providers. These could potentially lead to improved understanding of the benefits and schedules of health promotion services.57–59 Furthermore, disparities in access to health information between educated and non-educated mothers could be reduced through strategies tailored to the local context and suited to non-educated women within communities, as reported in Mali.60

A previous study in Sierra Leone showed that extensive and contextual cluster-based social mobilization resulted in increased VAS coverage from 86.7% to 97.8%. This finding suggests that designing contextual-based awareness creation strategies for the improvement of VAS coverage and other child health services is an effective solution to promote healthcare utilization among the poorest individuals, especially within communities with low female literacy rates.61

In this study, significant pro-rich disparities in VAS coverage were observed in all four surveys. A study conducted in Kenya also reported comparable findings.62 One possible justification for poor uptake of VAS coverage among rural residents might be a far distance to health facilities.52 Unlike children living close to health facilities, poor uptake of VAS coverage is usually seen among children living far from the facilities.62 This may be explained partly by transport costs needed to reach the health facilities.62 The other reason might be due to factors such as women’s autonomy, societal way of life and perceptions interconnected with the use of maternal and child health services on every occasion they want care. This could be associated with other variables like with schooling of women and urban residence, both of which are factors that boom the chance of the use of maternal and child health services.46 Our study showed no sex-based disparities in VAS coverage in Ethiopia in all four surveys. No sex-based variation in VAS coverage was reported in several previous studies elsewhere.19,20,30,63 Furthermore, we found substantial regional disparities in VAS coverage in Ethiopia from 2000 to 2016. The PAF and PAR measures in the 2016 survey, for example, indicated that, if the country avoided relative and absolute disparities in VAS across regions, it was possible to increase the 2016 national VAS coverage approximately by 64.6 pp and 28.8 pp, respectively. The finding showed that the VAS coverage in regions such as Afar and Somali was approximately two times lower than Tigray region. Similar findings are reported in Ethiopia,44 Nigeria,50,65,66 Guinea51 and India.19 In Afar and Somali regions of Ethiopia, majority of the population are Muslim,1 and in those communities’ religious beliefs and cultural practices are believed to influence the uptake of maternal and child health interventions, similar to findings reported in Nigeria.20,67,68 Evidence shows fathers’ consent in such communities is significantly related to utilization of maternal and child health services including immunization and VAS coverage.69,70 However, other factors such as unequal distribution of healthcare services across regions within the country may also be possible reasons for the observed disparities.47

A previous study in Ethiopia reported inequalities in access and availability, across subnational regions, related to health center–based healthcare services.47 This may be partly explained by unequal distribution of healthcare providers across regions.24 A typical example of this is that a previous study in Ethiopia has revealed poor accessibility of health services in Afar region related to a shortage of healthcare providers, in addition to the difficult climate conditions and pastoral life of the communities.71

Another study by WHO also confirmed inequalities in the distribution of healthcare providers across regions.72 Therefore, ensuring equal distribution of human and other resources across regions may reduce disparities in the
uptake of health services, including VAS. In addition, regional differences in culture, socioeconomic status, supply or availability, and accessibility of immunization and VAS services might be another possible reason for the disparities assessed. For example, a study conducted on regional economic inequality in Ethiopia shows that though little increment is seen especially after 1994, the dominantly pastoral regions of the country (Afar and Somali) have the lowest socioeconomic status. These regions are not only the most disadvantaged regions in the country in terms of average economic status but also have the lowest intergenerational mobility. Another recent study by Zegeye et al. on barriers of healthcare access in Ethiopia shows huge variations in barriers to accessing healthcare services across regions with more barriers among Oromia, Benshangul-Gumuz, and SNNP regions, respectively. Therefore, all the above-mentioned contexts need to be considered in policies and programs aimed at enhancing VAS coverage in Ethiopia.

**Strengths and limitations of the study**

The first strength of this study is the use of nationally representative EDHSs to investigate wide-ranging inequalities in VAS coverage through a standardized analytic approach. In addition, incorporating simple and complex as well as absolute and relative summary measures of inequalities has highlighted significant types of inequalities in the coverage of VAS coverage as a first step toward reducing and eliminating these disparities. Despite these strengths, a notable limitation of the current study is that due to the emphasis on the five equality stratifiers included in the WHO’s Health Equity Monitor Database, we were not able to include other sociocultural and demographic covariates in the analysis. Therefore, we recommend future studies to address this gap. Finally, since the data in the software are available as 0–59 months, we were unable to use age as a dimension of inequality.

**Conclusion and policy implication**

In this study, notable socioeconomic, urban–rural, and sub-national region inequalities in VAS were observed from 2000 to 2016 in Ethiopia. These disparities favored children from advantaged subpopulations such as those with educated mothers, richest/richer household wealth quintiles, urban residence and regions such as Tigray. However, we did not find sex-based disparities in VAS across all four surveys. The findings suggest mixed patterns of socioeconomic and urban–rural disparities, with overall increases in the recent two surveys (2011–2016). Regional disparities remained constant over the 16 years of surveys. Therefore, prioritizing underprivileged subpopulations could be a temporary solution to the observed disparities in VAS. In the long-term, equitable allocation of national economic and development benefits across regions and subpopulations as well as empowering women through education and economic resources may ensure universal health coverage and sustainable health development.

Monitoring health inequality fosters accountability and continuous improvement within health systems. Underprivileged population subgroups can hold back a country’s national VAS figures as outliers. Addressing health inequalities such as inequalities in VAS can thus lead to a better national health system, enhancing national coverage of VAS like that of other African countries that have relatively better coverage of VAS, which included Senegal (88.4%), Rwanda (86.4%), Sierra Leone (83.2%) and Togo (81.7). Moreover, it can ensure the principle of health for all.

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**Author contributions**

S.Y. and B.Z. contributed to the conception and design of the study, interpreted the data, and prepared the first draft manuscript. C.O.Z., B.O.A., E.K.A., A.S., and E.G. helped with data interpretation and critically reviewed the manuscript for its intellectual content. S.Y. had the final responsibility to submit the manuscript for publication. All authors read and revised drafts of the paper and approved the final version.

**Data availability**

The datasets generated and/or analyzed during the current study are available in the WHO’s HEAT version 3.1 [(https://www.who.int/gho/health_equity/assessment_toolkit/en/)].

**Declaration of conflicting interests**

The author(s) declared no potential conflicts of interest with respect to the research, authorship, and/or publication of this article.

**Ethical approval**

Ethical approval was not sought for the present study because authors utilized already existing secondary data. All ethical procedures that were followed by the custodians of the data have been reported in the manuscript. In addition, the University of Ottawa’s Office of Research Ethics and Integrity stated that “no ethics review is required for the use of previously collected, publicly available, anonymously collected data” [(https://research.uottawa.ca/ethics/submission-and-review/types-review)].

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**Informed consent**

Informed consent was obtained from all subjects before the study. The DHS Program maintains strict standards for protecting the privacy of respondents and household members in all DHSs. Before
each interview or biomarker test is conducted, an informed consent statement is read to the respondent, who may accept or decline to participate. A parent or guardian must provide consent prior to participation by a child or adolescent.

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