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Socioeconomic inequalities in child growth failure in Ethiopia: findings from the 2000 and 2016 Demographic and Health Surveys

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ABSTRACT

Objective Socioeconomic inequalities in child growth failure (CGF) remain one of the main challenges in Ethiopia. This study examined socioeconomic inequalities in CGF and determinants that contributed to these inequalities in Ethiopia.

Methods The Ethiopia Demographic and Health Surveys 2000 and 2016 data were used in this study. A pooled unweighted sample of the two surveys yielded 21514 mother–child pairs (10873 in 2000 and 10641 in 2016). We assessed socioeconomic inequalities in CGF indicators using the concentration curve and concentration index (CI). We then decomposed the CI to identify percentage contribution of each determinant to inequalities.

Results Socioeconomic inequalities in CGF have increased in Ethiopia between 2000 and 2016. The CI increased from −0.072 and −0.139 for stunting, −0.088 and −0.131 for underweight and −0.015 and −0.050 for wasting between 2000 and 2016, respectively. Factors that mainly contributed to inequalities in stunting included geographical region (49.43%), number of antenatal care visits (31.40%) and child age in months (22.20%) in 2000. While in 2016, inequality in stunting was contributed mainly by wealth quintile (46.16%) and geographical region (−13.70%). The main contributors to inequality in underweight were geographical regions (82.21%) and wealth quintile (27.21%) in 2000, while in 2016, wealth quintile (29.18%), handwashing (18.59%) and access to improved water facilities (−17.55%) were the main contributors. Inequality in wasting was mainly contributed to by maternal body mass index (−66.07%), wealth quintile (−45.68%), geographical region (36.88%) and paternal education (33.55%) in 2000, while in 2016, wealth quintile (52.87%) and urban areas of residence (-17.81%) were the main driving factors.

Conclusions This study identified substantial socioeconomic inequalities in CGF, and factors that relatively contributed to the disparities. A plausible approach to tackling rising disparities may involve developing interventions on the identified predictors and prioritising actions for the most socioeconomically disadvantaged groups.

Strengths and limitations of this study

- ► The current study used large national representative data to help future intervention programmes to tackle child growth failure.
- ► The decomposition approach identified the contribution of various factors towards socioeconomic inequalities in child growth failure.
- ► Causality could not be shown due to the cross-sectional nature of the study design.
- ► Some relevant predictors may not have been considered in the analyses due to working within the constraints of an existing dataset from the Ethiopia Demographic and Health Surveys.

INTRODUCTION

Child undernutrition remains a major public health problem contributing to about 45% of child mortality cases and to about 3.1 million child deaths in low-income and middle-income countries.[1] Globally, in 2019, there were nearly 149 million children stunted while 50 million were wasted.[2] Again, in 2019, an estimated 82 and 59 million children were stunted in Asia and Africa, while 34 and 14 million children were wasted in Asia and Africa, respectively.[2]

Child growth failure (ie, under-5 stunting, underweight or wasting) is a subset of child undernutrition.[3] A child is stunted, underweight or wasted if his/her height-for-age z-score (HAZ), weight-for-age z-score (WAZ) or weight-for-height z-score (WHZ), respectively, falls more than two SD below the WHO's growth reference standards for a healthy population.[4] Estimations of stunting, being underweight and wasting can serve as a comprehensive assessment of CGF.[5] Stunting shows chronic undernutrition in children; wasting indicates acute undernutrition whereas being underweight represents chronic and/or acute undernutrition.[6] Inadequate growth during childhood can lead to poor health outcomes and increases the risk of premature death in adulthood.[7] Undernutrition affects child's cognitive and physical development, which can later lead to impaired school achievement and diminished economic productivity in adulthood.[8 9]

A global progress report during the period of 2000 to 2019 showed a steady decline in stunting, and only a modest non-significant decline in wasting.[2] In the face of such modest progress, global targets such as the WHO Global Nutrition Target (GTN) of reducing stunting by 40% and keeping wasting below 5% by 2025,[10] as well as the Sustainable Development Goal 2.2 to end all forms of malnutrition by 2030, seem unrealistic.[2] Several countries in Africa remain far away from achieving the ambitious WHO GTN to reduce the number of stunted and wasted children.[2 11] For instance, of 59 million stunted and 14 million wasted children in Africa in 2019, the East African region accounted for 41% of all cases of stunting and 29% of all cases of wasting.[2]

Multiple factors which impact CGF were identified in conceptual frameworks by the United Nations International Children's Emergency Fund as far back as in 1990[12] and reaffirmed by others studies more recently.[13 14] These underlying factors are found to be associated with the socioeconomic status of a household.[15 16] There have been persistent socioeconomic-related inequalities in CGF in developing countries and it is unclear how such inequalities are related with undernutrition rates.[17 18] For example, one study that estimated CGF levels in 51 African countries found decreased levels of CGF in 2015 compared with 2000, yet these countries were suffering disparities in CGF.[5]

Ethiopia is one of the East African countries with high levels of CGF. Despite reductions in levels of CGF over the past 15 years,[19] public health goals of ending CGF in Ethiopia has never been achieved. In 2016, the Ethiopia Demographic and Health Surveys (EDHS) showed nearly 38% of under-5 children were stunted while 10% were wasted at a national level.[19] There were substantial regional variations in CGF in Ethiopia. For example, stunting was 47% in the Amhara region, 43% in Benishangul-Gumuz, 41% in Dire Dawa and Afar, while being underweight was highest in Afar (36%), Benishangul-Gumuz (34%) and Amhara (29%) while wasting was highest in Somali (23%) and Afar (18%).[19]

To tackle CGF, Ethiopia implemented large-scale health and nutrition programmes in the years 2003–2014, such as the Health Extension Programme (HEP), the Enhanced Outreach Strategy, the Targeted Supplementary Food and Community Management of Acute Malnutrition (CMAM) programmes.[11] In 2008, these programmes were integrated into the HEP and the first National Nutrition Strategy was launched. The implementation of this strategy occurred in two phases from 2008 to 2013 and from 2013 to 2014.[11] In 2015, Ethiopia declared the Seqota Declaration to end child malnutrition by 2030 by launching the Multi-Sectoral National Nutrition Programme-II aimed to guide sectors.[20] Despite these programmes, the country is lagging behind the expected trajectory needed to achieve GTN by 2025 and to end undernutrition by 2030.

To our knowledge, there has been only limited published evidence on inequalities, successes and failures of these programmes at national and local levels. Also, disparities in CGF may have been inadvertently masked in previous prevalence estimates. Despite several studies having been conducted on CGF levels in Ethiopia,[21–25] little is known about the levels of socioeconomic-related inequalities in CGF. For instance, more recently, trend analyses in CGF at national and local levels have been reported elsewhere.[26] However, these analyses have not shown socioeconomic inequalities in CGF in Ethiopia. This evidence gap prevents both improved understanding of inequalities in CGF and informed priority-setting. It is important to examine the levels and underlying predictors behind these inequalities because it helps to reduce health inequalities as well as to amend policies and intervention programmes tailored to tackle CGF. This study aimed to assess socioeconomic-related inequalities in CGF and identify their driving predictors in Ethiopia between 2000 and 2016.

METHODS

Data type and sample size

Data for this study were taken from two rounds of EDHS: 2000 and 2016. The EDHS was financially sponsored by the US Agency for International Development. The survey was implemented in collaboration with the Ethiopian Ministry of Health, Central Statistical Agency and ICF International (previous Macro International). The population and health indicators were collected from nine regional states and two city administrative jurisdictions of the country. The sampling frame used for the 2000 EDHS was taken from the Population and Housing Census (PHC) in 1994, while the 2016 EDHS was taken from PHC 2007. The source population were all children aged 0–59 months as well as their mothers or caregivers in the enumeration areas (EA) of EDHS who slept in the selected households the night before the survey. We included all children under-5 years of age and women aged 15–49 years with valid anthropometric measurements in the selected households. The datasets were downloaded with permission from the Demographic and Health Survey (DHS) Programme website.[27] A pooled unweighted sample of the two surveys yielded 21 514 children, of which 17 880 had valid information for HAZ, 17 947 for WAZ and 18 148 for WHZ. Of 10 873 children 0 to 59 months of age in 2000, we found 8903 children had valid information on HAZ, 8903 on WAZ and 9085 for WHZ data. A total of 10 641 children had valid anthropometric indices in 2016, including 8855 for HAZ, 9033 for WAZ and 8919 for WHZ. Detailed sample size calculations are provided in the main publications of each survey.[19 28]

Sampling procedures and variables for EDHS

Two-stage stratified and cluster random sampling techniques were used in both EDHS. Each region was stratified into urban and rural areas. Stratification and proportional allocation to size were achieved at each of the lower administrative levels. In the first stage, EA or clusters were randomly selected with probability proportional to EA size from the list of EAs or clusters created during the 1994 and 2007 PHC. The selected EAs or clusters included 540 (139 from urban and 401 from rural) in 2000 and 645 (202 from urban and 443 from rural area) in the 2016 EDHS. Selected EAs were with a fixed number of households in each survey. A household listing operation (served as the sampling frame for household selection) was carried out in all selected EAs. In the second stage, 27 households per EA in the 2000 EDHS and 28 households per EA in the 2016 EDHS were selected. Detailed survey methods and sampling procedures are found in the respective EDHS reports.[19 28]

Variables

CGF was assessed according to WHO 2006 Child Growth standards.[4 29] Children's height/length, weight and age data were used to calculate the three CGF indicators (ie, stunting, underweight or wasting). Height was measured with a measuring board (Shorr Board) by lying down on the board (recumbent length) for children younger than age 24 months, while standing height was measured for older children. Each measure (index) provides different information about child growth and body composition. For example, stunting (low HAZ) is an indicator of chronic undernutrition which reflects inadequate nutrition over a long period and the effects of recurrent and chronic illness. Wasting (low WHZ) is a measure of acute undernutrition that shows inadequate food intake or recent episodes of illness which caused weight loss. Underweight is a composite index of WHZ and HAZ which includes both acute (wasting) and/or chronic (stunting) undernutrition.[19]

CGF is referred to as a specific subset of undernutrition characterised by inadequate height or weight for the specific age of a child on growth reference standards.[3 30] Previous studies[11 21 22 31 32] have identified factors associated with CGF. After reviewing these factors, the following variables were included in the analyses: sociodemographic characteristics of children, households and parents' characteristics such as place or residence (urban/rural), geographical region (nine regional states and two city administrative), maternal and paternal educational level, maternal age, child age, childbirth order, access to water, sanitation and handwashing (WASH) facilities.

We used the household wealth index as a main study variable because measuring socioeconomic-related inequalities in health outcomes requires information with which to rank households from the poorest to the richest. The DHS wealth index enables identification of disparities in health outcomes. The index also allows governments to evaluate whether public health services, vaccination campaigns, education and other crucial interventions are reaching the poorest households. The wealth index is particularly valuable in countries that lack reliable data on income and expenditure, which are proxy indicators of household economic status.[33] This index was calculated based on EDHS data on household ownership of selected assets such as major source of drinking water, type of toilet, sharing of toilet facilities, major type of cooking fuel, principal material of floors, walls and rooves, number of members per sleeping room, household services and possessions, such as electricity, television, radio, watch, telephone, computer, refrigerator, table, chair, bed with cotton/spring mattress, electric *mitad*, kerosene lamp/pressure lamp, mobile phone, bicycle, motorcycle or scooter, animal-drawn cart, car or truck, boat with a motor, *bagag*, domestic staff, a house and land. Using these assets, a wealth index was initially devised through the use of principal component analysis (PCA).[34] In conducting PCA, each of the above asset categorical items (such as type of water facility) were first categorised into binary indicator variables (ie, has/does not have), and together with continuous variables (such as number of members per sleeping room) were included in the PCA. In this case, the first principal component (ie, having the asset) was considered as the underlying index of wealth and each household's position on it was calculated using the PCA weights. The PCA approach produced an index that is 'normalised' which has a mean value of zero and SD of one. Dividing the position of households into five equal parts in the normal curve produced household wealth quintiles. Details of the DHS wealth index construction, including steps, is given elsewhere.[35]

Statistical analysis

We estimated socioeconomic-related inequalities in CGF using the concentration index (CI) following an approach described by Wagstaff *et al*[36] and O'Donnell *et al*.[37] The CI is a measure of relative inequality, capturing the extent to which CGF differs across households ranked by some indicator of living standards, and is directly related to the concentration curve.[38] The concentration curve plots the cumulative percentage of a health outcome (*y*-axis) vs the cumulative percentage of the population ranked by an indicator of socioeconomic status in ascending order (*x*-axis).[37] The CI is defined as twice the area between the concentration curve and the line of equality (45° line) and can be calculated as shown in equation one.[39] The Erreygers CI for stunting, underweight and wasting during 2000 and 2016 was calculated using the 'conindex' user written Stata command.[40] O'Donnell *et al*[37] has summarised CI formula as follows:

$CI = \frac{2}{\mu} cov\left(h, r\right)$equation (1)

Where, μ is the mean of the outcome variable (stunting, underweight and wasting), h is the value of the outcome variable for each observation and r is the rank of individual households in the wealth distribution. The values of CI range between −1 and +1. A negative CI value indicates that CGF is concentrated among lower ranked households and the concentration curve lies above the line of equality and vice versa. A CI with the value of 0, shows the absence of socioeconomic-related inequalities in CGF and the concentration curve coincides with the line of equality. When inequality is skewed towards the worse-off, for instance with the higher CGF level in the lower group, it can be referred to as a pro-poor inequality and vice versa.

We performed analyses to decompose CI so as to estimate the contribution of determinant variables to socioeconomic inequalities in the outcome variable.[36 37] For any continuous outcome variable, a linear regression model linking the outcome variable (y) to a set of k determinants (x_k), Wagstaff *et al*[36] suggested the following formula:

$y = \alpha + \sum_k \beta_k x_k$ +equation (2) where α is an intercept, β_k is a regression coefficient and ε is an error term. Equation 2 can be transformed to the CI of y, and it can also be rearranged as follows:

$CI = \sum_k (\beta_k \bar{x}_K / C_K + GC_\epsilon/\mu$ equation (3) where μ is the mean of y (outcome variable), $\bar{x}_K$ is the mean of x_k (for the k^{th} determinant), C_K is the CI of global x_k and GC_ϵ is the generalised CI for error term (ε). The term $(\beta_k \bar{x}_K / C_K$ represents an explained component of determinants to inequality, while the term GC_ϵ/μ or residual shows the part of inequality in outcome variables that cannot be explained by systematic variation in the determinants. The term $\beta_k \bar{x}_K/$ shows the sensitivity (elasticity) of each C_K on the sum of CI of outcome variable. Each absolute contribution is estimated by multiplying the sensitivity of the outcome variable with respect to the determinant and the degree of socioeconomic-related inequality in that determinant. Finally, the percentage contribution is obtained by dividing the absolute contribution by the total CI and multiplying by 100%.

We considered the complex sampling design in the DHS with utilising an appropriate sample weighting so that statistics in the current study could be generalised to the population. The survey-specific Stata command 'svy' was used to adjust for the sampling design. A p<0.05 was considered to indicate statistically significant estimates. All analyses were performed using Stata V.15.0. This paper followed the standard for reporting observational studies outlined in Strengthening the Reporting of Observational Studies in Epidemiology statement (online supplemental file 1).

Patient and public involvement

Patients and the public were not involved in the design and conduct of this research.

RESULTS

Trends in CGF by wealth quintiles

The overall proportion of CGF by socioeconomic status declined between 2000 and 2016 with an absolute reduction in stunting by 19.06%, underweight by 17.40% and wasting by 2.39%. These reductions occurred in almost all socioeconomic status categories in stunting and underweight, except for households in the lowest wealth quintile which showed a slight increase in wasting (table 1).

Inequalities in CGF

The CIs for 2000 and 2016 were −0.072 and −0.139 for stunting, −0.088 and −0.131 for being underweight and −0.015 and −0.050 for wasting, respectively. These results indicate that CGF was concentrated among poorest households in each year. The absolute values of the CI for all CGF indicators in 2016 were greater compared with 2000, showing that inequalities in CGF inequalities widened between 2000 and 2016. The difference in CI was statistically significant for all indicators (table 2). The concentration curve laid above the line of equality indicating that the concentration of CGF has taken higher values among lower ranked households (figure 1).

Table 1 Prevalence of child growth failure by wealth quintiles, EDHS 2000 and 2016

	Proportion of CGF by wealth quintile, % (SE)					
Year	**Poorest**	**Poorer**	**Middle**	**Richer**	**Richest**	**Total**
Stunting						
Year 2000	60.22 (1.81)	58.93 (1.69)	60.65 (1.63)	56.59 (1.71)	48.59 (2.38)	57.45 (0.93)
Year 2016	45.09 (1.48)	43.06 (2.05)	37.73 (2.26)	34.72 (1.96)	25.54 (2.05)	38.39 (1.00)
Difference	15.14 (0.02)	15.87 (0.03)	22.92 (0.03)	21.87 (0.03)	23.06 (0.03)	19.06 (0.01)
Underweight						
Year 2000	43.73 (1.76)	44.03 (1.80)	45.38 (1.64)	39.28 (1.67)	30.50 (2.02)	41.13 (0.93)
Year 2016	30.95 (1.63)	27.38 (1.51)	13.57 (1.65)	17.23 (1.38)	14.93 (1.68)	23.73 (0.80)
Difference	12.78 (0.02)	16.66 (0.02)	22.16 (0.02)	22.05 (0.02)	15.57 (0.03)	17.40 (0.01)
Wasting						
Year 2000	12.30 (1.13)	13.13 (0.91)	13.66 (1.11)	13.84 (1.20)	8.66 (1.01)	12.49 (0.60)
Year 2016	13.96 (1.29)	9.79 (1.08)	10.39 (1.19)	7.00 (0.97)	7.74 (1.09)	10.09 (0.51)
Difference	–1.66 (0.02)	3.33 (0.01)	3.26 (0.02)	6.85 (0.02)	0.91 (0.02)	2.39 (0.01)

% shows column proportion; difference (row 1-row 2) between 2000 and 2016.
EDHS, Ethiopia Demographic and Health Survey.

Table 2 Erreygers CIs of child growth failure among children under 5 years of age, EDHS 2000 and 2016

	Stunting	Underweight	Wasting
Year of survey	CI (SE)	CI (SE)	CI (SE)
Year 2000	−0.072*** (0.012)	−0.088*** (0.012)	−0.015 (0.008)
Year 2016	−0.139*** (0.012)	−0.131*** (0.010)	−0.050*** (0.007)
Difference	0.065** (0.025)	0.043* (0.022)	0.035* (0.016)

*P<0.05; **p<0.01; ***p<0.001.
CI, Concentration Index; ;EDHS, Ethiopia Demographic and Health Survey.

Decomposition analyses results

Table 3 presents results from decomposition analyses for stunting inequality. The columns under the heading 'absolute contribution' and 'percentage contributions' show adjusted contributions to inequalities of each predictor. For example, urban areas of residence contributed −5.64% to the socioeconomic-related inequality in stunting in 2000 and was calculated as: contribution of urban residence (0.004) divided by the total CI (−0.072) and multiplied by 100. In 2000, geographical region (49.43%) was the main component contributing to the increase in inequality in stunting (ie, percent shows subtotal from all regions). Specifically, the Amhara (23%) and Southern Nation, Nationalities and People's Region (SNNPR) (13.33%) were the main contributors to socioeconomic inequalities in CGF in 2000, respectively. In 2016, geographical region contributed negatively (−13.70%) to inequalities in CGF of which the Oromia (−5.58%) and SNNPR (−4.17%) contributed more than other regions. Antenatal care visits contributed 31.40% in 2000 and 10.57% in 2016 to the inequality in stunting, whereas household economic status as measured by wealth index contributed 13.87% in 2000 and 46.16% in 2016 to socioeconomic inequalities in stunting. Child age contributed 22.20% and 6.36% towards the total inequality in stunting in 2000 and 2016, respectively. About −17.21% in 2000 and −5.58% in 2016 inequalities in stunting were attributable to children being vaccinated. Living in urban areas, child's birth size, parental educational level, body mass index (BMI), preceding birth interval and access to improved WASH also showed substantial contributions to inequality in stunting in both 2000 and 2016. Maternal age, female child and childbirth order showed small contributions to the inequality in both years. Overall, 127.81% and 68.66% of the inequality in stunting was contributed to by the predictors included in the model in 2000 and 2016, respectively (table 3).

The main contributors to the widening of inequality in CGF measured by underweight in 2000 were geographical region (82.21%), wealth quintiles (27.21%), child's age (12.99%), ANC (12.89%) and maternal age (12.06%). However, maternal BMI (−21.67%) and being vaccinated (−7.08%) contributed to inequality in being underweight in 2000. Predictors such as child size at birth, access to improved water, childbirth order, paternal and maternal educational level also contributed significantly to the inequality in underweight in 2000. In 2016, the major positive contributors to the widening of inequality in being underweight were wealth quintiles (29.18%), handwashing (18.59%) and child size at birth (10.87%). Access to water facilities (−17.55%) and geographical region (−14.25%) contributed negatively to the total inequality in being underweight in 2016. Parental educational level and BMI also contributed to inequalities in being underweight in 2016. Other predictors such as urban residence, maternal age, female child, birth order, birth interval <24 months, ANC, being vaccinated and access to sanitation facilities showed minimal contribution to the inequality in being underweight. Overall, 152.97% and 59.83% of the inequality in being underweight was contributed to by the predictors included in the model in 2000 and 2016, respectively (table 4).

Table 5 shows the decomposition of CI for wasting during the period 2000 and 2016. The main positive contributors to total inequality in wasting in 2000 were geographical region (36.88%), ANC (34.56%), paternal educational status (33.55%), access to household sanitation (32%), living in urban area (26.40%) and childbirth order (23.64%). By contrast, maternal BMI (−66.07%), wealth quintiles (−45.68%), access to household water facilities (−22.03%) and child age (−13.58%) contributed negatively to inequality in wasting in 2000. In 2016, major contributors to inequality in wasting were wealth quintiles (52.87%) and childbirth order (12.75%). Living in an urban area (−17.81%) and geographical region (−11.53%) contributed to inequality in wasting in 2016. Overall, 55.48% and 36.33% of the inequality in wasting was contributed to by the determinants included in the model in 2000 and 2016, respectively (table 5).

Generally, any positive contribution in tables 3–5 means that socioeconomic-related disparities in CGF indicators favour the rich. Together these results provide important insights into the imbalance distribution of socioeconomic predictor between population subgroups.

DISCUSSION

Despite CGF prevalence declining in Ethiopia, this study showed evidence of socioeconomic inequalities in CGF which worsened between 2000 and 2016. The present findings seem to be consistent with DHS research which found a decreasing prevalence in stunting, yet with no consistent narrowing of inequalities in 16 African countries.[41] Overall, the observed increase in inequalities could be attributable to several factors such as lower parental educational status, inadequate dietary requirements

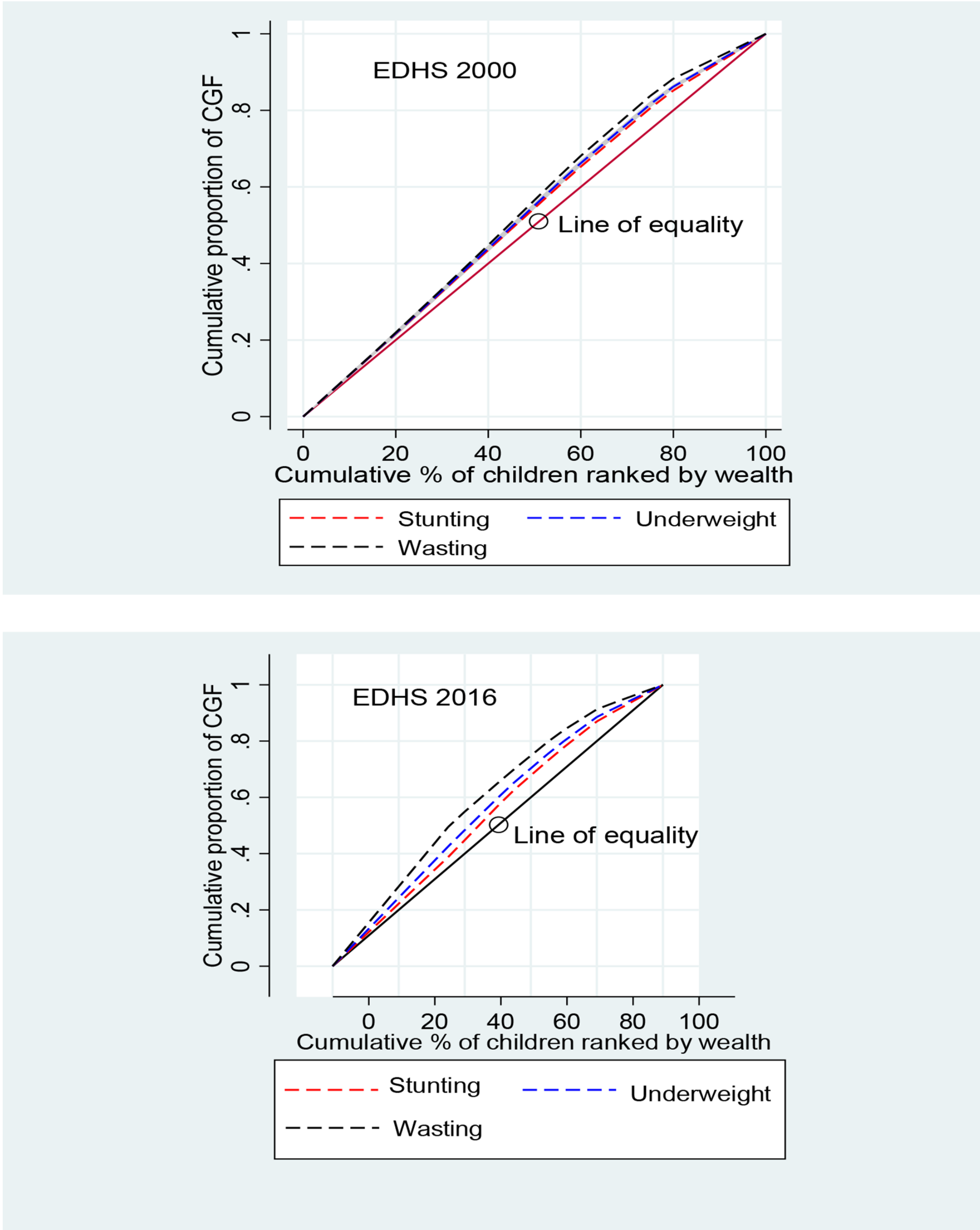

Figure 1 Concentration curve for CGF against cumulative percent of children ranked by wealth. CGF, child growth failure; EDHS, Ethiopia Demographic and Health Survey.

and poorer WASH practices among poorer households compared with wealthier households.[42 43] Also, drought that occurred in zones that were dependent on rain-fed agriculture[31 44] triggered food insecurity. In addition, internal displacement due to conflict[45] might be another driving factor that contributed to the increase in socioeconomic-related inequalities in CGF in the country. Similarly, in Nigeria a study found that undernutrition among poorer households increased over time, which the authors attributed to changes in income, education and lifestyle of the people.[46]

In the current study, the decomposition of CI showed that several determinants contributed to socioeconomic inequalities in CGF. Geographical region accounted for the largest share of contribution to the increase in socioeconomic-related inequalities in CGF in 2000. The observed largest share of the inequality in CGF in the different regions of the country could be attributed to

Table 3 Decomposition of the CI for stunting, EDHS 2000 and 2016

	Stunting							
	2000				2016			
Variables	Marginal effect	CI	Absolute contribution	Percentage contribution	Marginal effect	CI	Absolute contribution	Percentage contribution
Residence (rural (ref))	−0.012	0.474	0.004	−5.64	−0.040	0.503	0.005	−3.50
Region (Addis Ababa (ref)				**49.43†**				**−13.70†**
Tigray	0.053	−0.049	−0.001	2.03	0.073*	0.012	<0.0001	−0.25
Afar	−0.055	0.015	<0.0001	−0.01	0.03	−0.184	<0.0001	0.20
Amhara	0.071*	−0.117	−0.017	23.0	0.122***	0.026	0.003	−2.40
Oromia	0.009	−0.060	−0.008	10.9	0.031	0.057	0.008	−5.58
Somali	−0.016	−0.022	<0.0001	0.04	−0.093**	−0.161	0.002	−1.47
Benishangul Gumuz	−0.029	−0.012	<0.0001	0.03	0.095**	−0.027	<0.0001	0.11
SNNPR	0.073*	−0.078	−0.010	13.33	0.068*	0.058	0.006	−4.17
Gambela	−0.069	0.048	<0.0001	0.01	−0.069*	−0.046	<0.0001	−0.01
Harari	−0.055	0.065	<0.0001	0.01	0.029	0.077	<0.0001	−0.04
Dire Dawa	−0.106**	0.061	<0.0001	0.09	0.082*	0.050	<0.0001	−0.09
Paternal education (no schooling (ref)				**5.29†**				**6.04†**
Primary	−0.012	0.019	<0.0001	0.47	0.021	0.126	−0.006	4.11
Secondary	−0.081***	0.238	−0.003	4.50	−0.007	0.129	−0.001	0.63
Higher	−0.131**	0.055	<0.0001	0.32	0.001	0.140	−0.002	1.30
Maternal education (no schooling (ref)				**6.74†**				**5.62†**
Primary	0.008	0.123	−0.001	1.06	0.092**	0.188	−0.004	2.89
Secondary	−0.119***	0.176	−0.004	5.65	0.074*	0.133	−0.003	1.81
Higher	−0.240**	0.013	<0.0001	0.03	0.035	0.107	−0.001	0.92
Maternal age (15–24 (ref))				**−2.33†**				**3.07†**
25–34	0.001	0.016	<0.0001	0.19	0.006	−0.006	<0.0001	−0.04
35–44	0.006	0.009	<0.0001	−0.02	−0.013	−0.009	<0.0001	−0.05
45–49	−0.003	−0.109	0.002	−2.50	−0.021	0.034	−0.004	3.16
Maternal BMI (underweight(ref))				**−8.07†**				**2.37†**
Normal	−0.019	−0.063	0.006	−8.20	0.078***	−0.001	<0.0001	−0.03
Overweight	−0.079**	0.075	<0.0001	0.13	0.050**	0.151	−0.003	2.40
Wealth quintile (first(ref))				**13.87†**				**46.16†**

Continued

Table 3 Continued

	Stunting							
	2000				2016			
Variables	**Marginal effect**	**CI**	**Absolute contribution**	**Percentage contribution**	**Marginal effect**	**CI**	**Absolute contribution**	**Percentage contribution**
Second	0.009	−0.341	−0.001	1.93	0.002	−0.055	0.002	−1.12
Third	0.045**	−0.054	−0.002	2.73	−0.056**	0.123	−0.008	5.54
Fourth	0.007	0.302	<0.0001	−0.30	−0.072***	0.238	−0.015	10.76
Firth (richest)	0.009	0.670	−0.007	9.51	−0.094***	0.632	−0.043	30.98
Child gender (male (ref))	−0.029	0.011	<0.0001	1.38	−0.033**	0.008	−0.001	0.62
Child age (0–5 (ref))				**22.20†**				**6.36†**
6–23 months	0.304***	0.002	0.001	−0.81	0.179***	0.051	0.012	−8.44
24–59 months	0.481***	−0.017	−0.017	23.01	0.335***	−0.027	−0.021	14.80
Birth order (forth+ (ref)				**6.64†**				**1.15†**
First	−0.019	0.136	−0.004	4.95	−0.012	0.1235	−0.001	0.53
Second	−0.018	0.064	−0.001	1.89	−0.029	0.072	−0.001	0.43
Third	0.016	0.018	<0.0001	−0.20	−0.028	0.013	<0.0001	0.19
Birth interval (>24 months (ref))	0.058***	−0.014	−0.001	0.70	0.040**	−0.128	−0.004	3.18
Birth size (larger than average (ref))				**9.16†**				**7.87†**
Average	0.022	0.065	0.003	−4.44	0.038**	0.026	0.001	−0.87
Smaller than average	0.096***	−0.068	−0.010	13.60	0.099***	−0.124	−0.012	8.74
ANC (>4 visits (ref))	0.061***	−0.161	−0.023	31.40	0.047***	−0.182	−0.015	10.57
Vaccinated (no (ref))	0.011	0.267	0.012	−17.21	0.028*	0.261	0.008	−5.58
Water (unimproved (ref))	−0.015	0.314	−0.007	9.21	−0.021	0.408	0.010	−7.50
Sanitation (unimproved (ref)	−0.020	0.529	−0.004	5.04	0.027	0.384	−0.002	1.65
Handwashing (unimproved (ref)	n/a	n/a	n/a	n/a	0.017	0.366	−0.006	4.28
Residual				**−27.81**				**31.34**
Total				**127.81**				**68.66**

*P<0.05; **p<0.01; ***p<0.001.
†Subtotal for the categories of the predictor.
ANC, antenatal care; BMI, body mass index; CI, Concentration Index; EDHS, Ethiopia Demographic and Health Survey; n/a, not applicable; ref, reference group/base; SNNPR, Southern Nation, Nationalities and People's Region.

Table 4 Decomposition of the CI for underweight, EDHS 2000 and 2016

	Underweight							
	2000				2016			
Variables	**Marginal effect**	**CI**	**Absolute contribution**	**Percentage contribution**	**Marginal effect**	**CI**	**Absolute contribution**	**Percentage contribution**
Residence (rural (ref))	−0.001	0.474	0.0017	−1.93	0.030	0.503	−0.004	3.25
Region (Addis Ababa (ref)				**82.21†**				**−14.25†**
Tigray	0.085**	−0.049	−0.003	3.00	0.029	0.012	<0.0001	−0.30
Afar	0.069	0.015	<0.0001	−0.14	0.085**	−0.180	−0.001	0.92
Amhara	0.115***	−0.117	−0.030	34.02	0.080**	0.026	0.004	−2.83
Oromia	0.072*	−0.060	−0.020	22.80	0.022	0.057	0.013	−10.11
Somali	0.043	−0.022	<0.0001	0.22	0.025	−0.160	−0.004	3.35
Benishangul Gumuz	0.079*	−0.012	<0.0001	0.10	0.140***	−0.030	<0.0001	0.22
SNNPR	0.162***	−0.078	−0.020	22.46	0.035	0.058	0.007	−5.35
Gambela	0.059	0.048	<0.0001	−0.08	−0.017	−0.050	<0.0001	0.04
Harari	−0.028	0.065	<0.0001	−0.04	0.031	0.077	<0.0001	−0.07
Dire Dawa	0.045	0.061	<0.0001	−0.13	0.064*	0.050	<0.0001	−0.12
Paternal education (no schooling (ref)				**6.63†**				**6.07†**
Primary	−0.035**	0.019	−0.001	0.79	−0.035**	0.126	−0.006	4.32
Secondary	−0.070***	0.238	−0.005	5.32	−0.011	0.129	−0.001	0.56
Higher	−0.097*	0.055	−0.001	0.52	−0.027	0.140	−0.002	1.19
Maternal education (no schooling (ref)				**5.41†**				**9.49†**
Primary	−0.017	0.123	−0.002	2.43	−0.034**	0.188	−0.010	7.40
Secondary	−0.057*	0.176	−0.003	3.00	−0.046*	0.133	−0.002	1.62
Higher	−0.061	0.013	<0.0001	−0.02	−0.049	0.107	0.001	0.47
Maternal age (15–24 (ref))				**12.06†**				**0.73†**
25–34	0.024	0.016	<0.0001	−0.10	0.011	−0.010	<0.0001	−0.01
35–44	0.080**	0.009	<0.0001	−0.22	−0.021	−0.010	<0.0001	−0.03
45–49	0.040*	−0.109	−0.011	12.38	−0.015	0.034	−0.001	0.77
Maternal BMI (underweight(ref))				**−21.67†**				**4.48†**
Normal	−0.102***	−0.063	0.021	−23.42	−0.084***	−0.000	<0.0001	−0.15
Overweight	−0.180***	0.075	−0.002	1.75	−0.145***	0.151	−0.006	4.63
Wealth quintile (first (ref))				**27.21†**				**29.18†**

Continued

Table 4 Continued

	Underweight							
	2000				2016			
Variables	**Marginal effect**	**CI**	**Absolute contribution**	**Percentage contribution**	**Marginal effect**	**CI**	**Absolute contribution**	**Percentage contribution**
Second	0.008	−0.341	−0.006	7.12	0.000	−0.050	0.001	−0.67
Third	0.049**	−0.054	−0.003	2.88	−0.043**	0.123	−0.005	4.06
Fourth	−0.016	0.302	−0.002	2.51	−0.092***	0.238	−0.017	12.79
Firth (richest)	−0.055*	0.670	−0.013	14.70	−0.084***	0.632	−0.017	13.0
Child gender (male (ref))	−0.030**	0.011	−0.001	1.58	−0.031***	0.008	<0.0001	0.45
Child age (0–5 (ref))				**12.99†**				**2.97†**
6–23 months	0.234***	0.002	0.001	−0.64	0.105***	0.051	0.006	−4.76
24–59 months	0.285***	−0.017	−0.012	13.63	0.182***	−0.030	−0.010	7.73
Birth order (forth+ (ref)				**8.08†**				**0.29†**
First	−0.018	0.136	−0.005	5.92	−0.028	0.124	<0.0001	−0.12
Second	−0.031	0.064	−0.002	2.28	−0.025	0.072	<0.0001	0.34
Third	0.017	0.018	<0.0001	−0.12	−0.034*	0.013	<0.0001	0.07
Birth interval (>24 months (ref))	0.061***	−0.014	<0.0001	0.43	0.046***	−0.13	−0.002	1.81
Birth size (larger than average (ref))				**10.55†**				**10.87†**
Average	0.041**	0.065	0.005	−5.75	0.040***	0.026	0.002	−1.38
Smaller than average	0.134***	−0.068	−0.014	16.30	0.115***	−0.120	−0.016	12.25
ANC (>4 visits (ref))	0.049***	−0.161	−0.011	12.89	0.028**	−0.180	−0.003	2.64
Vaccinated (No (ref))	−0.007	0.267	0.006	−7.08	0.010	0.261	<0.0001	−0.28
Water (unimproved (ref))	−0.006	0.314	−0.007	8.13	0.024*	0.408	0.023	−17.55
Sanitation (unimproved (ref)	−0.001	0.529	0.004	−4.52	−0.034*	0.384	−0.001	1.09
Handwashing (unimproved (ref)	n/a	n/a	n/a	n/a	−0.039***	0.366	−0.024	18.59
Residual				**−52.97**				**40.17**
Total				**152.97**				**59.83**

*P<0.05; **p<0.01; ***p<0.001.
†Subtotal for the categories of the predictor.
ANC, antenatal care; CI, Concentration Index; EDHS, Ethiopia Demographic and Health Survey; n/a, not applicable; ref, reference group/base; SNNPR, Southern Nation, Nationalities and People's Region.

Table 5 Decomposition of the CI for wasting, EDHS 2000 and 2016

	Wasting							
	2000				2016			
Variables	Marginal effect	CI	Absolute contribution	Percentage contribution	Marginal effect	CI	Absolute contribution	Percentage contribution
Residence (rural (ref))	0.009	0.474	−0.004	26.40	0.046**	0.503	0.009	−17.81
Region (Addis Ababa (ref)				**36.88†**				**−11.53†**
Tigray	0.015	−0.049	<0.0001	1.52	0.037	0.012	<0.0001	−0.45
Afar	0.023	0.015	<0.0001	−0.10	0.072**	−0.18	−0.001	1.64
Amhara	0.007	−0.117	−0.001	4.55	0.022	0.026	0.001	−2.65
Oromia	0.013	−0.060	−0.001	7.93	0.031	0.057	0.008	−15.87
Somali	0.038	−0.022	<0.0001	0.34	0.119***	−0.160	−0.004	8.86
Benishangul Gumuz	0.068**	−0.012	<0.0001	0.15	0.033	−0.030	<0.0001	0.19
SNNPR	0.058*	−0.078	−0.003	23.0	0.000	0.058	0.003	−3.08
Gambela	0.092***	0.048	<0.0001	−0.28	0.047*	−0.050	<0.0001	0.08
Harari	−0.018	0.065	<0.0001	0.08	0.045	0.077	<0.0001	−0.13
Dire Dawa	0.045	0.061	<0.0001	−0.31	0.027	0.050	<0.0001	−0.12
Paternal education (no schooling (ref)				**33.55†**				**0.60†**
Primary	−0.032**	0.019	−0.001	4.23	−0.002	0.126	−0.001	2.15
Secondary	−0.032*	0.238	−0.004	28.55	0.033*	0.129	0.001	−1.33
Higher	−0.008	0.055	<0.0001	0.77	0.006	0.140	<0.0001	−0.22
Maternal education (no schooling (ref)				**3.50†**				**0.31†**
Primary	−0.006	0.123	−0.001	3.19	−0.008	0.188	<0.0001	−0.19
Secondary	−0.015	0.176	<0.0001	0.14	−0.021	0.133	<0.0001	0.54
Higher	−0.042	0.013	<0.0001	0.17	−0.012	0.107	<0.0001	−0.04
Maternal age (15–24 (ref))				**−2.59†**				**1.85†**
25–34	0.022	0.016	<0.0001	−0.71	−0.009	−0.010	<0.0001	−0.03
35–44	0.023	0.009	<0.0001	−0.17	−0.025	−0.010	<0.0001	−0.17
45–49	0.002	−0.109	<0.0001	−1.71	−0.012	0.034	−0.001	2.05
Maternal BMI (underweight(ref))				**−66.07†**				**7.07†**
Normal	−0.072***	−0.063	0.011	−74.52	−0.046***	−0.000	<0.0001	−0.25
Overweight	−0.105***	0.075	−0.001	8.45	−0.087***	0.151	−0.004	7.32
Wealth quintile (first(ref))				**−45.68†**				**52.87†**
Second	0.005	−0.341	−0.002	11.78	−0.019	−0.050	0.001	−1.92

Continued

Table 5 Continued

	Wasting							
	2000				2016			
Variables	Marginal effect	CI	Absolute contribution	Percentage contribution	Marginal effect	CI	Absolute contribution	Percentage contribution
Third	0.031**	−0.054	−0.001	4.54	−0.016	0.123	−0.001	2.66
Fourth	0.008	0.302	0.005	−35.29	−0.036**	0.238	−0.009	17.2
Firth (richest)	0.004	0.670	0.004	−26.71	−0.055**	0.632	−0.017	34.93
Child gender (male (ref))	−0.017*	0.011	−0.001	4.25	−0.028***	0.008	<0.0001	0.32
Child age (0–5 (ref))				**−13.58†**				**−5.89†**
6–23 months	0.036**	0.002	<0.0001	−0.51	−0.004	0.051	−0.001	2.17
24–59 months	−0.073***	−0.017	0.002	−13.07	−0.064***	−0.030	0.004	−8.06
Birth order (Forth+ (ref)				**23.64†**				**12.75†**
First	−0.012	0.136	−0.003	16.85	−0.023	0.124	−0.004	7.43
Second	−0.014	0.064	−0.001	6.46	−0.027*	0.072	−0.003	5.23
Third	0.001	0.018	<0.0001	0.33	−0.015	0.013	<0.0001	0.09
Birth interval (>24 months (ref))	0.012	−0.014	<0.0001	0.14	0.012	−0.130	0.001	−1.56
Birth size (larger than average (ref))				**11.28†**				**7.69†**
Average	0.020*	0.065	0.002	−15.02	0.015	0.026	0.001	−1.39
Smaller than average	0.042***	−0.068	−0.004	26.30	0.055***	−0.120	−0.005	9.08
ANC (>4 visits (ref))	0.013	−0.161	−0.005	34.56	0.010	−0.180	0.001	−1.13
Vaccinated (No (ref))	−0.007	0.267	<0.0001	−0.77	−0.011	0.261	0.002	−4.05
Water (unimproved (ref))	0.009	0.314	0.003	−22.03	0.001	0.408	<0.0001	0.64
Sanitation (unimproved (ref)	−0.024	0.529	−0.005	32.0	−0.009	0.384	0.001	−1.16
Handwashing (unimproved (ref)	n/a	n/a	n/a	n/a	−0.002	0.366	0.002	−4.64
Residual				44.52				63.67
Total				55.48				36.33

n/a because handwashing variable was not collected in EDHS 2000.
*P<0.05; **p<0.01; ***p<0.001.
†Subtotal for the categories of the predictor.
ANC, antenatal care; BMI, body mass index; CI, Concentration Index; EDHS, Ethiopia Demographic and Health Survey; Ref, reference group/base; SNNPR, Southern Nation, Nationalities and People's Region.

poverty and food insecurity. In Ethiopia, 23.5% of the total population (25.6% in rural and 14.8% in urban areas) were found to be living below the poverty line in 2015 while the Amhara region experienced 26.1% of the population living in poverty.[47] In 2010, over 35% of households in Amhara and 30% in Tigray were found to be below food poverty line.[48] In 2016, the national prevalence of stunting was 38%, while the Amhara region accounted for the largest share (47%).[49] A study showed that children in Amhara received the lowest minimum acceptable diet (measured by minimum dietary diversity and meal frequency) compared with other regions.[47] Also, climate variability increased the rate of stunting in zones that were dependent on rain-fed agriculture,[31 44 50 51] which is a crucial factor as it has an impact on household food security.

Our study found that household wealth status accounted for the largest contribution to inequalities in 2016. The increase in inequality appears to reflect a more rapid reduction in the prevalence of CGF in the wealthiest compared with the poorest households. This observed imbalance could be attributed to a disproportionate benefit from the economic growth and services in the country between the poorest and wealthiest households. This explanation is supported by previous studies which found that economic growth contributed to the reduction in CGF levels.[22 52] Wealthier households may spend more money on acquiring a balance of nutritious foods in their diet, which would have an impact on the health and nutritional status of children. Studies have suggested that redistributing income to the poorest families and most vulnerable people would have a positive impact on poverty and inequality[53] and would also increase access to healthcare, education and WASH services.[54 55] Another study found that supporting poor families and women-based investments in health and social development have contributed to equity gains in child survival.[56] Increasing the economy of disadvantaged women enables women to become better educated and hold more prominent roles in their communities. Also, there is much to learn from Brazil where equity-oriented public policy has accompanied substantial improvements in living conditions while reducing inequalities in undernutrition.[55]

Other factors that significantly increased pro-rich inequality in CGF included paternal education, low number of ANC contacts, elder child, access to improved handwashing and lower birth order. Factors that significantly contributed to the decease of socioeconomic-related inequalities in CGF included maternal BMI, access to improved water facilities, living in urban area and being vaccinated. Also, paternal educational level significantly contributed to inequality in wasting between 2000 and 2016. Previous studies have shown decreased odds of child under nutrition with increases in paternal education.[57–59] There are several ways through which paternal education promotes child nutrition. These include greater understanding of child nutrition and healthcare seeking behaviour for the family. For example, one study found that a higher education level among fathers was associated with greater health seeking behaviour in response to childhood febrile illness.[60]

Our study found that except for wealth quintiles, most other measured determinants showed a decreased contribution to socioeconomic-related inequalities in CGF in 2016. The current findings could be compared with previous studies which found wealth as a major contributor to inequalities in undernutrition.[61 62] The Ethiopian government implemented large-scale intervention programmes to curb undernutrition levels between 2003 and 2014.[11] The reductions in CGF levels in Ethiopia to date could be attributable to these programmes. However, it is not clear that the current multi-sectoral nutrition programmes in Ethiopia have set objectives to deal with the increasing inequalities. While inequalities appear to have increased over time in Ethiopia, this does not necessarily mean that those intervention programmes and policies have been ineffective. Yet, they may have contributed to the increase in inequality. For instance, the extent to which intervention programmes are reaching the lowest wealth status households in the population may be a missed target. Making matters worse, the lowest ranked groups in the population may have already been experiencing from inadequate infrastructure, limited access to education as well as health services, lower income and gender inequality.[63 64] Information generated from this study may help policy-makers to better outline interventions aimed at tackling present and future socioeconomic-related inequalities in CGF in Ethiopia.

The findings of the current study should be interpreted in the context of by considering the following limitations. First, causality could not be assumed due to the nature of the study design. Second, confounding factors (residuals) that were not included in this analysis may have had a substantial contribution to the worsening of inequality in CGF. Apart from these caveats the findings of this study are important for several reasons. First, the study has identified national levels of socioeconomic-related inequalities in CGF. Second, it used large national representative data to provide evidence to argue for changes in national policy priorities to tackle CGF. Third, the decomposition technique has examined the contribution of various factors towards socioeconomic-related inequalities in CGF.

CONCLUSIONS

Over the past 15 years, the Ethiopian government has taken various actions in health and other nutrition-specific interventions to tackle CGF. Despite years of these actions, CGF levels remain high in the country. This implies further work is required on nutrition-sensitive interventions such as economic strengthening, livelihoods, social protection as well as equal access to services. This study showed the rise of socioeconomic inequalities in CGF between 2000 and 2016. Our results shed light on the possible predictors of increasing socioeconomic inequalities in CGF in Ethiopia. Increased inequalities over time were accounted for largely by several factors such socioeconomic status, geographical region, ANC, WASH services and parental education.

Improving the socioeconomic status of the poorest households, prioritising regions with the highest needs, increasing ANC coverage, improving parental education levels and improving WASH facilities would most likely reduce these inequalities. Further research such as a systematic review of the literature is also suggested to examine any additional contributing determinants to inequalities in CGF that could not be identified in the current study due to the constraints of working with existing datasets from the EDHS.

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