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Change in stunting and its associated factors among children aged less than 5 years in Ethiopia using Ethiopia Demographic and Health Survey data from 2005 to 2019: a multivariate decomposition analysis

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ABSTRACT

Objective The aim of this study is to assess change in stunting and its associated factors among children aged less than 5 years in Ethiopia using Ethiopia Demographic and Health Survey data from 2005 to 2019.

Design A community-based cross-sectional study was conducted.

Setting The study was conducted in Ethiopia.

Participants In 2005, 4586 individuals were examined, followed by 10 282 in 2011, 9462 in 2016 and 4937 in 2019.

Primary and secondary outcomes The primary outcome of the study was stunting, and the secondary outcome was factors associated with stunting and its change. A multilevel logistic regression model was fitted to identify individual and community-level factors associated with stunting among children aged less than 5 years. Multivariate decomposition analysis was also carried out to assess the role of compositional characteristics and behavioural change for decline in stunting among children aged less than 5 years in Ethiopia.

Results Over the study period, the prevalence rate of stunting in children aged less than 5 years decreased from 47% to 37% in 2019. Differences in behavioural change among children under the age of 5 years account for 76.69% of the overall decline in stunting prevalence rate in the years 2005–2011, 86.53% in the years 2005–2016, 98.9% in the years 2005–2019, 70.34% in the years 2011–2016 and 73.77% in the years 2011–2019. Behavioural adjustments among breastfed children, diet diversity, place of delivery, ANC follow-up and region have all had a major effect on stunting prevalence rate. The wealth index, parenteral education, child's age in months, length of breast feeding and area were among the compositional change factors.

Conclusion A large percentage of children aged less than 5 years remains stunted in Ethiopia. Stunting was associated with alterations in the compositional and behavioural characteristics of children. Stimulating existing nutritional measures and improving the wealth index will make a significant difference in reducing stunting among Ethiopian children aged less than 5 years.

STRENGTHS AND LIMITATIONS OF THE STUDY

⇒ This is the first study in Ethiopia to address factors associated with changes in stunting, according to our search strategy.
⇒ The use of data that span the entire country is also another strength of the study.
⇒ The identification of behavioural and decompositional elements connected to altering stunting gives good understanding into each factor's role.
⇒ The stunting data in this study are only considered once every 5 years, making it unlikely that many up and down trends would not be identified over a 5-year period.
⇒ For 2019, we used the mini DHS data, which would have minimum amount of inconsistency when compared with other standard survey years' data.

INTRODUCTION

The foundation of a child's existence, health and development is a nutritious, and well-balanced diet. Children who are well fed are more likely to grow up to be healthy, hard-working and eager to learn. Undernutrition is similarly disastrous, potentially reducing brainpower and productivity,[1 2] and slowing economic downturn, which can perpetuate a cycle of poverty and illness.[3] Stunting is characterised by a decline in height relative to a child's age, which is frequently caused by malnutrition, recurring illnesses and/or a lack of social stimulation.[4] Children who are stunted typically have stunted growth and development as a result of poor nutrition, frequent infections and a lack of psychosocial stimulation. Stunted children are those whose height-for-age is >2 SD below the WHO Child Growth Standards median.[5 6]

Linear growth failure is the most common type of malnutrition worldwide,[7] affecting an estimated 165 million children aged less than 5 years. Stunting has been designated as a major public health issue, with aggressive objectives set to eliminate stunting prevalence by 40% between 2010 and 2025.[7 8] The global target translates to a 4% annual reduction, with 171 million stunted children in 2010 falling to approximately 100 million by 2025. However, if current improvement rates continue, there will be 127 million stunted children by 2025, which is 27 million more than the target and only a 26% decrease.[9]

Stunted children may never reach their full height potential, and their brains may never fully develop cognitively. These children have a significant disadvantage in life: they struggle in school, earn less as adults and face barriers to community participation.[10 11] Stunting, along with other concomitant nutrition issues such as fetal growth restriction, wasting, vitamin A and zinc deficiencies, and suboptimal nursing, was estimated to be the cause of 3.1 million child fatalities (45% of all child deaths) in 2011.[12] According to more recent estimates, stunting and severe wasting account for a third of all deaths among children aged less than 5 years.[13]

Stunting is caused by inadequate nutrition and repeated bouts of infection during the first 1000 days of a child's life, and it is often permanent. Long-term consequences for individuals and societies include impaired cognitive and physical development, reduced productive capacity, poor health, and an increased risk of degenerative diseases such as diabetes.[14] One million children die each year as a result of stunting. Stunting in infancy and early childhood has long-term consequences for survivors, including impaired cognition and school performance, reduced physical development, poor health, lost productivity and low adult wages for those who survive.[15 16]

Despite the fact that stunting is on the decline in Ethiopia, the prevalence remains high.[17] Ethiopia has one of the world's highest rates of stunted children aged less than 5 years.[18 19] The government has signed various global initiatives and set national commitments to eradicate child malnutrition, including stunting.[20 21] It was discovered that the patterns of stunting and severe stunting are not random. Amhara, Benishangul-Gumuz, Afar, Tigray and Oromia are among the country's stunted regions.[22]

Stunting trends over the last two decades can be attributed to a variety of factors, including increased total consumable agricultural output, an increase in the number of health professionals, parental education, maternal nutrition, economic progress and lower diarrhoea incidence. A mother of high stature, living in a city, having a large child size, a mother without anaemia, having a large child weight, higher agricultural productivity, and improved sanitation and childcare practices all contribute to stunting reduction.[23–25] Due to a lack of attention paid to these factors, existing investment levels are insufficient to sustain the progress required to accomplish these goals.[26]

Effective nutrition strategies in Ethiopia, as elsewhere, necessitate targeting based on factors for change in order to maximise stunting reduction. However, because Ethiopia is a developing country, it will be difficult to implement this programme due to a lack of data on the pattern of stunting over time and the determinant factors that influence stunting prevalence change among children. Apart from detecting stunting reduction, there is a lack of epidemiological data to determine whether the reduction was caused by the intervention or by a change in community composition. To close this visible gap in the literature, it is necessary to estimate the impact of nutritional interventions and other factors on stunting, carefully monitor the intervention, and provide reliable data to national policymakers. Therefore, the current study aimed to assess change in stunting and its associated factors among children aged less than 5 years in Ethiopia. The current study's contribution will be in line with Ethiopia's 2030 sustainable development objective, according to the Federal Ministry of Health, and will expand our understanding of factors that cause stunting change in Ethiopia.

METHODS
Study settings and period
The Ethiopia Demographic and Health Survey (EDHS) data from the years 2005, 2011, 2016, and 2019 were used in this study. A global effort supported by the US Agency for International Development to collect nationally representative demographic and health data. Ethiopia is structured into 11 administrative regions, each of which is subdivided into zones, with each zone further subdivided into districts. The districts are subdivided further into kebeles. Every 5 years, the EDHS conducts a national and subnational representative household survey. Ethiopia is Africa's second most populated country, situated between 3° and 15° north latitude and 33° and 48° east longitude in the Horn of Africa.[27]

Study design and population
Cross-sectional data from the four consecutive (2005–2019) EDHS, which are collected every 5 years, were used to assess change in stunting and associated factors among children aged 0–5 years. Children whose data were incomplete, flagged cases and de facto residents were not included in this study.

Sample size and sampling procedure
The current study's sample size was calculated using data from a demographic health survey. The EDHS data set was accessed after asking measure of DHS for permission through the project title 'factors associated with change in stunting among under five children in Ethiopia using Ethiopian demographic health survey data from 2005 to 2019'. In 2005, 4586 individuals were examined, followed by 10 282 in 2011, 9462 in 2016 and 4937 in 2019. After exclusion criteria were applied, the final analysis included
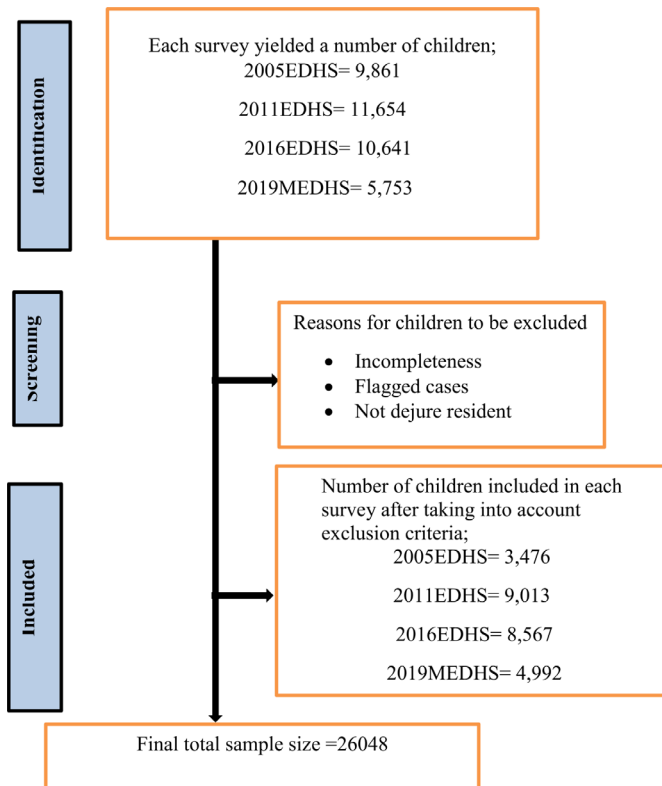
Figure 1 Flow diagram shows the technique for selecting study participants for the final analysis; EDHS, 2005–2019, Ethiopia. EDHS, Ethiopia Demographic and Health Survey.

3476 participants from the 2005 EDHS, 9013 from 2016, 8567 from 2017, and 4992 from the 2019 Mini Ethiopia Demographic and Health Survey (MEDHS) (figure 1). A stratified, two-stage cluster sampling technique was used in all four DHS (2005, 2011, 2016 and 2019). Children 0–59 months in the selected households were measured for height-for-age. To achieve stratification, each region was divided into urban and rural areas. The Somali region was separated into two parts, the first of which consisted of the first three zones, and the second consisted of the three additional zones that were added later. Because the Addis Ababa region is fully urban, 23 sampling strata were constructed. In addition, the 2019 EMDHS sample was stratified and selected in two stages. There were 21 sampling strata in each region, which were divided into urban and rural areas. In two steps, Enumeration Areas (EA) samples were selected independently in each stratum. At each of the lower administrative levels, implicit stratification and proportionate allocation were used by sorting the sampling frame within each sampling stratum before sample selection. Participants were chosen based on administrative units at various levels and a probability proportional to the size selection method at the first stage of the sampling study. In all DHS reports, the sampling technique is described in detail.[28–31]

Data source and extraction
EDHS data sets from 2005 to 2019 were requested and downloaded from the Measure DHS programme website,

which are freely available at (https://dhsprogram.com/data/dataset_admin/login_main.cfm) to all registered users. The recommended data set type for children aged less than 5 years was chosen after analysing and examining the details of the EDHS data structure and data set types. Stunting data and potential independent variables were extracted in this manner.

Patient and public involvement statement
Patients or the public were not involved in the study design, conduct, reporting or distribution strategies of the research.

Study variables and measurement
The primary outcome of the study was the study of stunting, and the secondary outcome was factors associated with stunting and its change. Stunting was defined as the highest for age being less than 2.0 SD height-for-age z-score (HAZ) from the WHO reference population's median for age, as defined by the WHO height-for-age z-scores as Child Growth Standards.[32] Sociodemographic and economic factors such as residence, region, wealth index, source of drinking water, toilet facilities, parent education and occupation, head of household and maternal characteristics, and child morbidity such as diarrhoeal diseases, respiratory tract infection and anaemia are the independent variables.

Data management and statistical analysis
The outcome variable was coded as a binary variable ('stunting' = 1 and 'not stunting' = 0), similar to a prior study,[33] and the data analysis was executed using STATA V.15. To account for the uneven probability of selection between the strata that were geographically specified, sample weights were used. The methodology of EDHS final reports contains a full explanation of the weighting procedure.[28–31] First, descriptive statistics and trends in stunting were examined across all surveys using recoded background variables. Second, multilevel logistic regression models were fitted to find predictors of stunting at individual and community levels, taking into account the hierarchical nature of the 4-year EDHS data, which included 26 048 children aged 0–5 years nested inside each year's enumeration areas. Four models were fitted to compare and choose the best fit model: the first model (model I), also known as the null model, was fitted as a baseline model without any predictor variables, the second model (model II) was fitted with individual-level variables, the third model (model III) was fitted with community-level (region and residence) variables, and the final model (model IV) was fitted with both individual-level and community-level variables. Then the models were compared using deviance information criteria (DIC), and the final best fit model (model IV) was selected as the model with the smallest DIC value.[34] For measures of association (fixed effect), adjusted ORs with 95% CIs were used to declare statistical significance. For measures of variation (random effects), the intraclass

correlation coefficient were used. Akaike's information criterion and Bayesian information criterion were also used to assess how well the model fits the data (online supplemental appendix 1). Lower scores in both criteria were considered to choose the best model. The SE was used to identify multicollinearity, and equal proportions of the total change in each covariate were assumed to occur at the same time.

Third, multivariate decomposition analysis was used to determine the contribution of each covariate to the observed change in stunting prevalence. The influence of changes in population structure in terms of children's characteristics on percentage of stunting over time was investigated using random-effects generalised least square regression. At a value of p<0.05, any statistical test will be judged significant. The decomposition approach divides the total drop in stunting into two parts: the endowments component, which can be attributed to changes in the composition or prevalence of a set of indicators, and the effect portion, which can be assigned to changes in the effect of these indicators (referred to as the coefficient portion).[35] The formula is given by

$\Delta Y^{i-j} = (X^i - X^j)^{\beta i} + X^j (\beta^i - \beta^j)$, i≠j,

where i,j=2005, 2011, 2016 and 2019,

ΔY is the difference in mean prediction of stunting between year i and year j, of the different characteristics of X,

β is the estimated regression coefficient,

$(X^i - X^j) \beta^i$ represents the difference due to endowment between the ith and jth years,

$X^j (\beta^i - \beta^j)$ represents the difference due to coefficients between the ith and jth years.

RESULTS
Sociodemographic and socioeconomic characteristics
Data from 3476 children aged less than 5 years in 2005, 9013 in 2011, 8567 in 2016 and 4992 in the 2019 EDHS were used in this analysis. Girls made up about 51% of children aged less than 5 years. The majority of the children were under the age of 2 years in all of the surveys included in the analysis. The vast majority of those polled (68%) reside in rural areas. The Oromia region had the highest number of children (12%–20%), followed by Amhara (9%–13%) and Southern Nations, Nationalities, and People's Region(SNNPR), (11.80–18.79%). Open defecation was used by 41.55%–65.54% of the individuals who responded. Antenatal care follow-up has increased from 33.79% in 2005 to 74.64% in the 2019 EDHS. Over the course of the study, the percentage of children in the poorest wealth index category increased over the survey period, and the proportion has become larger than in other categories (see online supplemental appendix 2).

Trend of stunting
Over the study period (2005–2019), the prevalence of stunting fell from 47% in 2005 to 37% in 2019. The difference was statistically significant, with a beta coefficient

of −0.767184 and 95% CI −1.23 to −0.30 with a value of p=0.019. With a 6% decline, the survey period 2011–2016 saw the highest decline. From 2005 to 2019, the rate of reduction in stunting varies depending on the child's attributes. Girls had the largest decrease (12.4%) in the specified period, compared with boys who had the lowest (7 %). Despite the fact that stunting was relatively low among urban residents, the decline was higher (7%) among children from rural settlements across the study period. Breastfed children had a decreased trend by 11.85% during the study period, which was higher than the other groups. Over the study period, the Amhara region has shown the largest reduction in stunting (15.88%), followed by SNNPR (15.41%). In the Benishangul-Gumuz region, however, the percentage of stunted children has increased over time (table 1).

Multilevel logistic regression analysis to identify factors associated with stunting
Wealth index, source of drinking water, toilet facilities, parent education, occupation, mother's age, number of children aged less than 5 years in the house, living status of the child, age of mother at first childbirth, mother's height, child's age in months, antenatal care visit, place of delivery, early initiation of breast feeding, exclusive breast feeding, duration of breast feeding, bottle feeding, diversity feeding, sex of child, age of mother, birth order, birth type, diarrhoeal diseases, cough, short rapid breathing, anaemia and body max index of respondents were fitted in model II as individual-level factors. Model III has been fitted with residence and region as second-level variables. The final model showed that in the 2016 EDHS, women with higher education had a reduced risk of stunting than mothers with no education (AOR=0.42, 95% CI 0.22 to 0.85). In both the 2011 and 2019 EDHS data sets, the number of children aged less than 5 years demonstrated a statistically significant association with stunting. The risk of stunting increased by 1.2 and 1.40 times, respectively, in the 2011 and 2016 EDHS when the number of children aged less than 5 years in the home increased by 1, with AOR=1.2, 95% CI 1.02 to 1.4 and AOR=1.40, 95% CI 1.11 to 1.69. The respondent's height was a statistically significant factor in stunting in two of the studies that were looked at. AOR=0.994, 95% CI 0.992 to 0.996 and AOR=0.994, 95% CI 0.992 to 0.995 for the 2005 and 2016 EDHS, respectively, show that a centimetre increase in respondent height reduces stunting by 0.6% (table 2).

With the exception of the 2019 EDHS, breastfeeding length was a statistically significant factor. In the 2005 EDHS, children who were still breast fed had a 2.57 (AOR=2.57, 95% CI 1.86 to 3.56) times higher chance of being stunted than children who were ever breast fed but not during the data collection period. In the 2011 and 2016 EDHS, children who were still breast fed were 2.29 and 1.7 times more likely to be stunted than children who were ever breast fed, with (AOR=2.29, 95% CI 1.72 to 3.07) and (AOR=1.7, 95% CI 1.34 to 2.16), respectively. In all surveys, the likelihood of being stunted increased

Table 1 Trends in stunting among under-five-year-old children by child characteristics from 2005 to 2019,Ethiopia (weighted).

Characteristics		2005 (n=3476) Percentage	2011 (n=9013) Percentage	2016 (n=8567) Percentage	2019 (n=4992) Percentage
Prevalence of stunting		47.35	44	38.09	37
Sex	Male	47.2	46.13	40.65	40.2
	Female	46	42.5	35.40	33.6
Age of child, years	≤2	42	38.51	34.05	33.81
	>2	55	52.16	44.38	42.53
Residence	Urban	30	31.5	26.52	25.8
	Rural	48	46.2	39.50	41
Region	Tigray	41	51	39	49
	Affar	41.14	50.2	41	43.4
	Amhara	57.20	52	46	41.32
	Oromia	41.2	41	37	36
	Somali	45.2	33	27.1	30.7
	Benishangul-Gumuz	39.7	48.6	42.80	41
	SNNPR	51.61	44	39	36.2
	Gambela	29.3	27.3	23.73	18
	Harari	38.6	30	31.62	35
	Addis Ababa	18.12	22.26	15 .2	14
	Dire Dawa	31.36	36	40.21	25
Mother's education	No education	49.1	46.6	41.15	42
	Primary	39.8	42	35.35	35.41
	Secondary	26.59	20.02	21.46	18.68
	Higher	15.81	17.62	17.37	17.0
Water source	Improved	47.41	42.29	36.61	37.23
	Unimproved	46.94	46.13	40.06	37.54
Type of toilet facility	Open defecation	48.28	47.26	43.22	42.50
	Unimproved	46.12	44.28	36.56	36.45
	Improved	42.85	34.13	27.56	30.74
	Others	78.54	71.59	28.14	18.52
Duration of breast feeding	Ever breast fed, not currently	50.59	49.81	41.65	41.54
	Never breast fed	39.52	36.83	42.94	38.88
	Still breast feeding	44.44	38.72	34.09	32.59
ANC follow-up	No	47.56	46.14	34.19	35.50
	Yes	40.80	36.56	39.36	34.50
Place of delivery	Home	48.56	45.91	40.84	40.16
	Health institution	24.10	29.16	30.54	34.80
	Others	36.79	61.06	41.65	16.2
Wealth index	Poorest	48	49	43.96	42
	Poorer	54.0	47	42.85	42
	Middle	46	46.34	37.42	40
	Richer	46	45	35.03	35
	Richest	35	29	25.57	23.6

EDHS, Ethiopia Demographic and Health Survey; SNNPR, Southern Nations, Nationalities, and People's Region.

Table 2 Parameter estimates of household, maternal and child characteristics: EDHS of 2005, 2011, 2016 and 2019 (weighted)

		AOR			
		2005	**2011**	**2016**	**2019**
Characteristics		**Model IV AOR (95% CI)**	**Model IV AOR (95% CI)**	**Model IV AOR (95% CI)**	**Model IV AOR (95% CI)**
Highest educational level	No education	1	1	1	1
	Primary	0.90 (0.68 to 1.2)	1.1 (0.88 to 1.30)	0.93 (0.77 to 1.14)	1.02 (0.71 to 1.48)
	Secondary	0.51 (0.24 to 1.08)	0.79 (0.41 to 1.54)	0.78 (0.51 to 1.20)	0.71 (0.34 to 1.48)
	Higher	0.39 (0.12 to 1.3)	0.91 (0.37 to 2.25)	0.42 (0.22 to 0.85)**	2 (0.38 to 10.54)
Toilet	Open defecation	0.77 (0.16 to 3.68)	1.11 (0.80 to 1.54)	1.18 (0.86 to 1.62)	0.75(0.35 to 1.61)
	Unimproved	0.63 (0.13 to 3.06)	1.03 (0.65 to 1.25)	0.98 (0.73 to 1.32)	0.75(0.35 to 1.61)
	Improved	1	1	1	1
Number of children aged less than 5 years		1.06 (0.90 to 1.26)	1.2 (1.02 to 1.41)*	1.1 (0.96 to 1.26)	1.40 (1.11 to 1.69)*
Height of respondent		0.994 (0.992 to 0.996)***	1 (1 to 1.01)	0.994 (0.992 to 0.995)***	–
Duration of breast feeding	Ever breast fed, not currently	1	1	1	1
	Never breast fed	1.66 (0.47 to 5.94)	1.6 (0.43 to 5.77)	1.45 (0.81 to 2.60)	1.34 (0.57 to 3.16)
	Still breast feeding	2.57 (1.86 to 3.56)***	2.29 (1.72 to 3.07)***	1.7 (1.34 to 2.16)***	0.98 (0.66 to 1.47)
ANC follow-up	Yes	1	1	1	1
	No	1.21 (0.95 to 1.53)	1.18 (0.99 to 1.40)	1.03 (0.84 to 1.25)	0.75 (0.46 to 1.22)
Place of delivery	Home	1	1	1	1
	Health institution	0.54 (0.24 to 1.23)	0.73 (0.41 to 1.3)	0.83 (0.61 to 1.14)	1.17 (0.78 to 1.75)
	Others	0.8 (0.25 to 2.54)	2.13 (0.51 to 8.71)	1.51 (0.78 to 2.91)	0.20 (0.031 to 1.26)
Diarrhoea	No	1			–
	Yes	1.40 (1.06 to 1.82)**	1.4 (1.1 to 1.8)**	1.27 (0.94 to 1.70)	–
Bottle feeding (yes)		1.33 (0.85, 2.09)	0.92 (0.67 to 1.26)	0.70 (0.53 to 0.92)*	0.92 (0.66 to 1.28)
Wealth index	Poorest	1.73 (1.13 to 2.64)*	2.3 (1.4 to 3. 5)**	1.54 (1.03 to 2.32)*	4.85 (1.44 to 16.36)*
	Poorer	1.79 (1.19 to 2.70)***	2.29 (1.48 to 3.60) ***	1.35 (0.97 to 1.90)	3.37 (1.10 to 10.37)*
	Middle	1.48 (1.01 to 2.18)*	2.24 (1.42 to 3.53) **	1.03 (0.72 to 1.47)	3.16 (0.996 to 10.00)
	Richer	1.68 (1.16 to 2.51)*	1.9 (1.20 to 2.93)**	1.17 (0.85 to 1.61)	2.39 (0.84 to 6.80)
	Richest	1	1	1	1
Age of child in months		1.05 (1.03 to 1.06)***	1.06 (1.05 to 1.07)***	1.03 (1.02 to 1.04)***	1.07 (1.04 to 1.09)***
Sex of child	Male	–	1	1	1
	Female	0.83 (0.67 to 1.04)	0.77 (0.65 to 0.92)**	0.84 (0.71 to 0.999)*	0.67 (0.49 to 0.92)**
Birth order		0.97 (0.94 to 1.01)	0.93 (0.90 to 0.96)***	0.97 (0.94 to 1.01)	0.93 (0.87 to 0.998)**
Dietary diversity	Yes	–	1	1	1
	No	–	1.63 (1.20 to 2.23)**	1.53 (1.10 to 2.14)*	0.72 (0.41 to 1.26)
Region	Tigray	1	1	1	1
	Affar	1.24 (0.75 to 2.06)	0.84 (0.59 to 1.19)	0.99 (0.69 to 1.42)	0.70 (0.42 to 1.19)
	Amhara	1.78 (1.15 to 2.77)*	0.71 (0.52 to 0.96)*	1.31 (0.98 to 1.75)	0.73 (0.39 to 1.38)
	Oromiya	1.07 (0.76 to 1.5)	0.50 (0.36 to 0.70)***	0.98 (0.72 to 1.34)	0.43 (0.23 to 0.79)**
	Somali	1.28 (0.8 to 2.04)	0.46 (0.30 to 0.72)**	1.03 (0.73 to 1.45)	0.29 (0.14 to 0.54)***
	Benishangul-Gumuz	0.99 (0.6 to 1.63)	0.68 (0.48 to 0.97)*	1.08 (0.78 to 1.51)	0.6 (0.31 to 1.15)
	SNNP	1.55 (0.98 to 2.45)	0.51 (0.37 to 0. 70)***	1.06 (0.78 to 1.44)	0.43 (0.24 to 0.78)**
	Gambela	0.96 (0.51 to 1.81)	0.25 (0.16 to 0.39)***	0.70 (0.47 to 1.04)	0.27 (0.15 to 0.50)***
	Harari	1.55 (0.86 to 2.79)	0.40 (0.26 to 0.62)***	1.08 (0.76 to 1.53)	0.89 (0.44 to 1.80)
	Addis Ababa	1.02 (0.47 to 2.24)	0.44 (0.25 to 0.76)***	0.71 (0.42 to 1.19)	0.35 (0.23 to 0.68)*
	Dire Dawa	0.73 (0.42 to 1.25)	0.56 (0.37 to 0.84)*	1.44 (0. 90 to 2.33)	0.61 (0.33 to 1.12)

AOR, adjusted OR; EDHS, Ethiopia Demographic and Health Survey; SNNP, Southern Nations, Nationalities, and People.

by about 5% as children's age grew by 1 month. In the 2005 and 2011 EDHS, diarrhoea increased the likelihood of stunting by 1.4 times, with AOR=1.4, 95% CI 1.06 to 1.82 and AOR=1.495, % CI 1.10 to 1.80, respectively. In the 2016 EDHS, bottle feeding was the sole significant factor, and when comparing children who were bottle fed to children who were not bottle fed, the probability of becoming stunted fell by 30% (AOR=0.70, 95% CI 0.53 to 0.92) (table 2).

In this study, there is a strong correlation between the wealth index and stunting. According to a multilevel logistic analysis of the 2005 EDHS, children from the poorest and poorer categories were 1.73 and 1.79 times more likely to be stunted than children from the richest households, with AOR=1.73, 95% CI 1.13 to 2.64 and AOR=1.79, 95% CI 1.19 to 2.70, respectively. Similarly, according to the 2011 EDHS, children from the poorest and poorer families were 2.3 and 2.29 times more likely to be stunted than children from the richest families, with AOR=2.3, 95% CI 1.4 to 3. 5 and AOR=2.29, 95 % CI 1.48 to 3.60, respectively. Girls were less likely than boys to be stunted, according to the 2011 and 2019 EDHS (AOR=0.77, 95% CI 0.65 to 0.92 and AOR=0.67, 95 % CI 0.49 to 0.92, respectively). In the 2011 and 2019 EDHS, we found that increasing the birth order by one unit reduced the risk of stunting by 7% (AOR=0.93, 95% CI 0.90 to 0.96 and AOR=0.93, 95% CI 0.87 to 0.998, respectively) (table 2).

Only one variable, region, has a significant association with stunting when considering community-level determinants. In the 2005 EDHS, children from the Amhara region had a significantly higher risk of stunting than children from Tigray (AOR=1.68, 95% CI 1.16 to 2.43). Children from the Amhara region, on the other hand, had a lower risk of stunting in 2011 than children from Tigray (AOR=0.71, 95 % CI 0.52 to 0.96). The two survey analyses (2011 and 2019) revealed that children from Oromia region have a lower risk of stunting than children from Tigray (AOR=0.50, 95% CI 0.36 to 0.70 and 0.43, 95% CI 0.23 to 0.79, respectively) (table 2).

Children from the Somali region have a lower risk of stunting than children from Tigray region, according to the analysis of 2011 and 2019 EDHS (AOR=0.46, 95% CI 0.30 to 0.72 and AOR=0.29, 95% CI 0.14 to 0.54), respectively. Only the analysis of the 2011 EDHS showed a strong link between residing in the Benishangul-Gumuz regions and stunting. When compared with children in the Tigray region, living in Benishangul-Gumuz reduces the risk of stunting by 32% (AOR=0.68, 95% CI 0.48 to 0.97). There are two types of findings in the current study for children aged less than 5 years in SNNPR. In 2005, children aged less than 5 years in SNNPR had a 50% higher likelihood of being stunted than children aged less than 5 years in the Tigray region. Children aged less than 5 years from SNNPR, on the other hand, were 0.51 and 0.45 times less likely to be stunted in the 2011 and 2019 EDHS data analyses (AOR=0.51, 95 % CI 0.37 to 0.70 and AOR=0.43, 95% CI 0.24 to 0.78), respectively. Children from Gambela,

Harari, Addis Ababa and Dire Dawa had a lower risk of stunting than children from Tigray (AOR=0.25, 95% CI 0.16 to 0.39, AOR=0.40, 95% CI 0.26 to 0.62, AOR=0.44, 95% CI 0.25 to 0.76 and AOR=0.56, 95% CI 0.37 to 0.84), respectively. Similarly, according to the 2019 EDHS data, children aged less than 5 years in the Gambela and Addis Ababa regions had a lower risk of stunting than children aged less than 5 years in Tigray (AOR=0.27, 95% CI 0.15 to 0.50 and AOR=0.35, 95% CI 0.23 to 0.68), respectively (table 2).

Multivariate decomposition analysis of 2005–2011 and 2005–2016 EDHS

The overall change in the prevalence rate of stunting between 2005 and 2011 was 3%, according to a multivariate decomposed logistic regression analysis. Differences in the compositional characteristics of children accounted for 25.31% of the overall change in in the prevalence rate of stunting. According to the multivariate decomposition logistic regression study from 2005 to 2016, 13.47% of the overall change was related to change in child compositional characteristics. In multivariate decomposed logistic regression analysis of the 2005–2011 and 2005–2016 EDHS data sets, among the compositional change factors the wealth index, parenteral education, child's age in months, duration of breast feeding and region all had a statistically significant contribution to change in the prevalence rate of stunting (table 3).

Children from families with no or limited education were more likely to be stunted than those from families with higher education. Parents primary school coverage grew from 16.60% in 2005 to 25.3% in 2011 and 25.73% in 2016 (online supplemental appendix 2), resulting in a negative significant compositional contribution to a 14.80% and 8.78% reduction in stunting prevalence rate, respectively. From the 2005–2011 and 2016 EDHS, the proportion of women with no education decreased from 76.41% to 69.87% and 64.01%, respectively (online supplemental appendix 2), resulting in a 14.95% and 9.25% increased change in the prevalence rate of stunting. The likelihood of becoming stunted decreased as respondents' height increased. Between 2005 and the two most recent EDHS surveys (2011 and 2016), community compositional changes in respondent height had a positive contribution to change in stunting prevalence rate by 43.41% and 21.86 %, respectively (table 3).

During the data collection period, children aged less than 5 years who were breast feeding were more likely to be stunted than children who were ever breast fed but not during the study period. As a result, the drop in the number of breastfed children between the surveys contributed to a positive improvement in the prevalence rate of stunting of 2.26% between the 2005 and 2011, and 1.88% between the 2005 and 2016 EDHS. Children aged less than 5 years in the poorest household wealth index category were more likely to be stunted than children in the highest household wealth index category. Between 2005 and 2011, increasing the proportion of children in

Table 3 A multivariate decomposition analysis of different features in the 2005–2011 EDHS and 2005–2016 EDHS

Characteristics		2005–2011 EDHS				2005–2016 EDHS			
		Endowments		Coefficients		Endowments		Coefficients	
		Coef with 95% CI	Per cent	Coef with 95% CI	Per cent	Coef with 95% CI	Per cent	Coef with 95% CI	Per cent
Highest educational level	No education	−0.011 (−0.0214 to 0.0004)*	14.95	0.100 (−0.1713 to 0.371)	−136.92	−0.012 (−0.024 to 0.00053)*	9.25	0.038 (−0.217 to 0.294)	−28.90
	Primary	0.011 (0.0002 to 0.0214)*	−14.80	0.0242 (−0.0362 to 0.08453)	−33.16	0.012 (0.0005 to 0.023)*	−8.78	0.009 (−0.047 to 0.066)	−7.11
	Secondary	0.0005 (−0.00012 to 0.00114)	−0.70	0.00813 (−0.009 to 0.025)	−11.16	0.001 (−0.0002 to 0.002)	−0.57	0.0036 (−0.010 to 0.018)	−2.73
	Higher	1	1	1	1	1	1	1	1
Height of respondent		−0.032 (−0.0524 to 0.011)**	43.41	0.0358 (−0.799 to 0.871)	−49.12	−0.029 (−0.048 to 0.01)**	21.86	−0.148 (−0.924 to 0.627)	111.84
Duration of breast feeding	Ever breast fed, not currently	1	1	1	1	1	1	1	1
	Never breast fed	0.0006 (−0.0002, 0.00133)	−0.79	0.0003 (−0.00262, 0.00311)	−0.34	0.0005 (−0.0003, 0.0012)	−0.35	−0.0004 (−0.0033, 0.0024)	0.31
	Still breast feeding	−0.0017 (−0.003 to 0.00034)*	2.26	−0.130 (−0.2046 to 0.0552)*	178.19	−0.003 (−0.005 to 0.001)*	1.88	−0.084 (−0.151 to 0.0167)*	62.98
Wealth index	Poorest	0.00023 (0.00001 to 0.00044)*	−0.31	−0.0022 (−0.032 to 0.028)	3.01	−0.00001 (−0.0001 to 0.0001)	0.0001	−0.006 (−0.034 to 0.023)	4.31
	Poorer	0.00051 (−0.0001 to 0.0011)	−0.69	−0.0107 (−0.040 to 0.019)	14.61	0.0006 (−0.0002 to 0.0013)	−0.43	−0.011 (−0.038 to 0.016)	8.29
	Middle	0.00013 (−0.0006 to 0.00083)	−0.18	−0.00833 (−0.035 to 0.0185)	11.43	0.00003 (−0.0002 to 0.0003)	−0.02	−0.017 (−0.043 to 0.010)	12.62
	Richer	−0.0001 (−0.0003 to 0.00014)	0.11	−0.014 (−0.041 to 0.013)	19.23	−0.0001 (−0.00031 to 0.0002)	0.06	−0.015 (−0.040 to 0.010)	11.47
	Richest	1	1	1	1	1	1	1	1
Age of child in months		0.004 (0.0015 to 0.0063)*	−5.31	−0.154 (−0.223 to 0.085)***	211.32	0.007 (0.003 to 0.011)**	−5.30	−0.044 (−0.10 to 0.011)	33.36
Region	Tigray	0.0002 (−0.00004 to 0.00045)	−0.28	0.0042 (−0.01083 to 0.01918)	−5.73	0.0003 (−0.0001 to 0.001)	−0.23	0.008 (−0.005 to 0.021)	−6.29
	Affar	0.00003 (−0.00002 to 0.00008)	−0.05	0.0001 (−0.0018 to 0.002)	−0.07	−0.0000 (−0.0001 to 0.001)	0.00	0.0003 (−0.002 to 0.002)	−0.19
	Amhara	−0.00004 (−0.00007 to 0.00001)*	0.05	−0.002 (−0.0487 to 0.04501)	2.54	−0.001 (−0.0012 to 0.0001)*	0.46	0.009 (−0.034 to 0.052)	−6.79
	Addis Ababa	1	0.00	1	1	1	1	1	0.00
	Dire Dawa	0.00005 (0.00001 to 0.0001)*	−0.07	0.00025 (−0.00043 to 0.00093)	−0.35	0.0001 (0.00001 to 0.00014)*	−0.06	0.0005 (−0.00003 to 0.0011)	−0.40
Anaemia	Severe	0.00001 (−0.00004 to 0.00005)	0.809	0.00323 (−0.00024 to 0.00670)	−4.43	−0.00001 (−0.00005 to 0.00002)	0.01	0.0021 (−0.0015 to 0.006)	−1.59
	Moderate	−0.00102 (−0.0023 to 0.00021)	0.104	0.00927 (−0.00091 to 0.0195)	−12.72	−0.0013 (−0.0025 to 0.00003)	0.95	0.011 (0.0011 to 0.021)*	−8.13
	Mild anaemia	0.0008 (0.00001 to 0.0015)	0.049	0.0155 (0.00063 to 0.0304)	−21.27	0.0006 (−0.00003 to 0.0012)	−0.44	0.014 (0.00001 to 0.027)*	−10.32
	Not anaemic	1	1	1	1	1	1	1	1

*pvalue<0.05; **pvalue<0.01; ***pvalue<0.001
EDHS, Ethiopia Demographic and Health Survey.

the poorest wealth index group reduced change in prevalence rate of stunting by 0.31%. The present study relates a 5.31% drop change in the prevalence rate of stunting between 2005 and 2011 and a 5.30% decline between 2005 and 2016 to mean age compositional differences among children aged less than 5 years. Between 2005 and 2011, change in the composition of children aged less than 5 years in the Amhara region and Dire Dawa city contributed to a 0.05% increase and a 0.07% decrease change in the prevalence rate of stunting, respectively. In addition, between 2005 and 2016, changes in the composition of children in the Amhara region and Dire Dawa city contributed to a 0.46% increase and a 0.06% reduction in the prevalence of stunting, respectively. Note that other regions in the combined survey data did not significantly contribute to the change (table 3).

Controlling the effects of change in compositional features, behavioural changes among children aged less than 5 years who were breast feeding during the survey time increased change in the prevalence rate of stunting by 178.2%, according to a multivariate decomposed logistic regression analysis conducted between 2005 and 2011. Change in the prevalence rate of stunting progressed by 211.32% as a result of age-related behavioural changes in children from young to old. According to a multivariate decomposed logistic regression analysis conducted between 2005 and 2016, the change in stunting prevalence rate increased by 62.98% with behavioural changes among children who were breast feeding during the survey period (table 3).

Multivariate decomposition analysis of the 2005–2019 and 2011–2016 EDHS

From 2005 to 2019, a multivariate decomposition logistic regression analysis revealed that 98.9% of the overall reduction in stunting prevalence rate was due to children's behavioural changes. None of the compositional variables have a significant relationship with stunting prevalence rate change. However, a multivariate decomposition logistic regression analysis of 2011–2016 revealed that alterations in compositional characteristics of children aged less than 5 years accounted for 29.66% of the entire change. Among the compositional change factors, parent's education, height of mothers, children's age, sex of children in month, anemiaanaemia and region had a statistically significant contribution on change in stunting. Children from a family that had primary education were more likely to be stunted than children from a family that had higher education. The coverage of parents' primary education was increased from 25.53% in the year 2011 to 25.73% in 2016 (online supplemental appendix 2) that had a negative significant compositional contribution to the decline in the prevalence rate of stunting by 10.05 (table 4).

The likelihood of becoming stunted decreased as respondents' height increased. Between the 2011 and 2016 EDHS, community compositional changes in respondents' height (increased mean height) had increased

reduction in the prevalence rate of stunting by 13.23%. In a multilevel logistic analysis, female children were less likely than male children to be stunted. Between 2005 and 2016, the proportion of female children included in the study increased by 0.1%. Stunting decreased by 4.28% as a result of this compositional alteration. Changes in the composition of children in the Amhara region between surveys contributed to a 4.71% reduction in the prevalence rate of stunting between 2011 and 2016. However, raising the proportion of children with moderate anaemia from 16.81% to 23.51% (online supplemental appendix 2) had a negative impact on stunting prevalence rate reduction by 7.26% (table 4).

Controlling the roles of change in compositional characteristics, behavioural changes among women towards Antenatal care (ANC) follow-up enhanced decline in the prevalence rate of stunting by 49.94 %, according to a multivariate decomposed logistic regression analysis from 2005 to 2019. Also, changing the behaviour of children who were breast fed during the study period resulted in a 72.9% increased change in the prevalence rate of stunting. Stunting had been decreased by 37.7% as a result of age-related behavioural changes in children aged less than 5 years from young to old. Stunting increased by 8.34% as a result of behavioural changes among children in the Tigray region as compared with Addis Ababa. Stunting could have been decreased by 119.3% with behavioural changes among children from middle-income families, according to a multivariate decomposition logistic regression analysis conducted between 2011 and 2016. Change in the prevalence rate of stunting was reduced by 233.14% and 109.63%, respectively, due to behavioural modifications among children in the Oromia and SNNP regions. A good practice of eating solid, semisolid, or soft foods one or more times on the day before data collection time resulted in a 119.97% increase in stunting prevalence rate change (table 4).

Multivariate decomposition analysis of the 2011–2019 EDHS

Difference due to characteristics (endowment); 2011–2019 EDHS

The multivariate decomposition logistic regression analysis of 2011–2019 found that decomposition changes in children's characteristics account for 26.23% of the overall change in the prevalence rate of stunting. The remaining 73.77% was attributed to children's behavioural changes. Wealth index, parenteral education, home water source, child's age in months, child's sex, place of delivery and region all exhibited a statistically significant compositional influence on change in the prevalence rate of stunting when variables were decomposed. Keeping all other behavioural variables equal, children from families with no education were more likely to be stunted than children from families with a higher level of education. Between the surveys, a reduction in the share of mothers with no education (online supplemental appendix 2) contributed to a 31% increased change in the prevalence

Table 4 A multivariate decomposition analysis of different features in the 2005–2019 EDHS and 2011–2016 EDHS

Characteristics	2005–2019 EDHS				2011–2016 EDHS			
	Endowments		Coefficients		Endowments		Coefficients	
	Coef with 95% CI	Per cent	Coef with 95% CI	Per cent	Coef with 95% CI	Per cent	Coef with 95% CI	Per cent
ANC (no as ref) — Yes	0.002 (−0.034 to 0.037)	−1.19	−0.078 (−0.137 to 0.019)*	49.94	0.0063 (−0.004 to 0.016)	−13.49	−0.0313 (−0.077 to 0.015)	66.90
Highest educational level — No education	−0.0024 (−0.051 to 0.046)	1.56	0.016 (−0.214 to 0.245)	−10.05	−0.0094 (−0.0193 to 0.0005)	20.17	0.128 (−0.120 to 0.376)	−274.51
Primary	0.002 (−0.030 to 0.034)	−1.04	0.0023 (−0.048 to 0.052)	−1.45	0.005 (0.00052 to 0.0093)*	−10.47	0.065 (−0.037 to 0.169)	−139.87
Secondary	−0.0001 (−0.0024 to 0.002)	0.07	−0.003 (−0.016 to 0.011)	1.78	0.0037 (−0.0005 to 0.008)	−7.91	0.0048 (−0.007 to 0.017)	−10.28
Higher	1		1		1	1	1	1
Height of respondent					−0.0062 (−0.009 to 0.0032)***	13.23	0.277 (−0.730 to 1.284)	−593.33
Duration of breast feeding — Ever breast fed, not currently	1		1		1	1	1	1
Still breast feeding	−0.0003 (−0.0067 to 0.006)	0.20	−0.112 (−0.185 to 0.039)**	72.09	−0.0016 (−0.0051 to 0.0020)	3.33	−0.10 (−0.250 to 0.051)	213.12
Wealth index — Poorest	−0.0001 (−0.0017 to 0.0015)	0.05	0.017 (−0.016 to 0.050)	−10.83	−0.0001 (−0.0002 to 0.0001)	0.19	−0.031 (−0.075 to 0.013)	66.06
Poorer	0.0001 (−0.0014 to 0.0016)	−0.05	0.0025 (−0.029 to 0.037)	−1.60	−0.0001 (−0.0005 to 0.00033)	0.14	−0.039 (−0.0822 to 0.0034)	84.26
Middle	−0.00003 (−0.0007 to 0.00061)	0.02	0.014 (−0.016 to 0.044)	−8.95	−0.0002 (−0.0005 to 0.0002)	0.34	−0.056 (−0.100 to 0.013)*	119.33
Richer	−0.0001 (−0.0017 to 0.0016)	0.05	−0.001 (−0.029 to 0.028)	0.41	−0.00003 (−0.001 to, 0.0010)	0.06	−0.027 (−0.060 to 0.005)	57.42
Richest	1		1		1	1	1	1
Age of child in months	0.0013 (−0.025 to 0.028)	−0.85	−0.059 (−0.118 to 0.00002)*	37.70	0.0041 (0.0031 to 0.0052)***	−8.86	0.044 (−0.023 to 0.111)	−94.28
Sex of child (male as ref)	−0.0001 (−0.0018 to 0.0016)	0.05	−0.022 (−0.053 to 0.010)	13.96	−0.002 (−0.0036 to 0.0004)*	4.28	−0.005 (−0.038 to 0.027)	9.75
Region — Tigray	0.00014 (−0.0026 to 0.0028)	−0.09	0.013 (0.0003 to 0.026)*	−8.34	0.0006 (−0.0005 to 0.0020)	−1.25	0.003 (−0.0101 to 0.017)	−6.92
Amhara	−0.0001 (−0.002 to 0.002)	0.06	−0.005 (−0.049 to 0.040)	2.88	−0.002 (−0.004 to 0.00042)*	4.71	0.026 (−0.019 to 0.071)	−55.20
Oromiya	0.0001 (−0.001, 0.001)	−0.03	0.0036 (−0.065, 0.073)	−2.32	0.0004 (−0.0001 to 0.001)	−0.76	0.110 (0.004 to 0.214)*	−233.14
SNNP	−0.0001 (−0.002 to 0.002)	0.06	−0.0018 (−0.046 to 0.043)	1.12	−0.0008 (−0.002 to 0.00022)	1.80	0.051 (0.0014 to 0.101)*	−109.63
Addis Ababa	1		1		1	1	1	1
Dire Dawa	0.00001 (−0.00003 to 0.00003)	−0.00	0.0002 (−0.0004 to 0.001)	−0.12	−0.00001 (−0.00002 to 0.00001)	0.01	0.0004 (−0.00033 to 0.001)	−0.86
Anaemia — Severe	–	–	–	–	0.0007 (−0.0011 to 0.0024)	−1.38	−0.0003 (−0.0025 to 0.002)	0.68
Moderate	–	–	–	–	0.0034 (0.0011 to 0.0057)**	−7.26	0.003 (−0.003 to 0.008)	−5.61
Not anaemic	–	–	–	–	1	1	1	1
Number of times ate solid, semisolid or soft food yesterday — None	–	–	–	–	1	0.00	0.00000	0.00
≥1	–	–	–	–	−0.0024 (−0.004 to 0.001)	5.19	−0.056 (−0.110 to 0.002)*	119.97

*pvalue<0.05; **pvalue<0.01; ***pvalue<0.001
EDHS, Ethiopia Demographic and Health Survey.

Table 5 A multivariate decomposition analysis of different features in the 2011–2016 EDHS

| Characteristics | | **2011–2019 EDHS** | | | |
| | | **Endowments** | | **Coefficients** | |
		Coef with 95% CI	**Per cent**	Coef with 95% CI	**Per cent**
Residence (urban as ref) Rural		−0.005 (−0.013 to 0.003)	7.07	0.026 (−0.080 to 0.132)	−37.18
Highest educational level	No education	−0.022 (−0.039 to 0.0041)*	31.00	−0.002 (−0.160 to 0.160)	2.35
	Primary	0.010 (0.001 to 0.020)*	−13.97	−0.0092 (−0.070 to 0.052)	13.32
	Secondary	−0.001 (−0.007 to 0.005)	1.31	−0.002 (−0.006 to 0.003)	2.94
	Higher				
Duration of breast feeding	Ever breast fed, not currently	1	1	1	1
	Never breast fed	0.0001 (−0.003 to 0.003)	−0.07	0.0012 (−0.0013 to 0.004)	−1.77
	Still breast feeding	−0.001 (−0.002 to 0.001)	0.74	−0.040 (−0.079 to 0.001)*	57.20
Water source (improved as ref) unimproved		0.006 (0.00001 to 0.012)*	−8.57	−0.024 (−0.055 to 0.007)	34.64
Wealth index	Poorest	0.001 (0.00033 to 0.00122)**	−1.12	0.001 (−0.030 to 0.032)	−1.41
	Poorer	−0.0001 (−0.0002 to 0.00001)*	0.13	−0.008 (−0.040 to 0.022)	12.16
	Middle	−0.0022 (−0.004 to 0.001)*	3.11	−0.001 (−0.030 to 0.027)	1.05
	Richer	−0.0016 (−0.0031 to 0.00001)*	2.28	−0.007 (−0.033 to 0.020)	9.51
	Richest	1	1		
Age of child in months		−0.001 (−0.0044 to 0.0015)***	4.23	−0.093 (−0.170 to 0.020)*	134.53
Sex of child (male as ref)		−0.00022 (−0.0004 to 0.0001)**	0.32	−0.013 (−0.040 to 0.012)	18.97
Region	Tigray	0.0005 (0.0003 to 0.0010)***	−0.76	0.010 (0.00011 to 0.021)*	−15.01
	Affar	0.0006 (0.0001 to 0.001)*	−0.79	0.0002 (−0.0013 to 0.002)	−0.34
	Amhara	−0.002 (−0.0033 to 0.00014)*	2.50	0.012 (−0.022 to 0.045)	−17.17
	Oromiya	−0.0021 (−0.0052 to 0.001)	3.02	0.023 (−0.044 to 0.090)	−33.24
	Somali	−0.0004 (−0.005, 0.004)	0.62	0.001 (−0.0034 to 0.005)	−1.26
	Benishangul-Gumuz	0.00001 (−0.00001 to 0.00003)	−0.02	0.0006 (−0.0012 to 0.0025)	−0.90
	SNNP	−0.0007 (−0.0016 to 0.00033)	0.94	0.013 (−0.021 to 0.047)	−18.83
	Gambela	−0.0001 (−0.0002 to 0.00004)	0.10	0.0002 (−0.0004 to 0.001)	−0.24
	Harari	0.0001 (0.00002 to 0.00014)**	−0.12	0.0004 (0.0001 to 0.001)*	−0.61
	Addis Ababa	1	1	1	1
	Dire Dawa	0.0001 (−0.0001 to 0.00023)	−0.10	0.0001 (−0.0004 to 0.001)	−0.12
Place of delivery	Home	1	1	1	1
	Health institution	0.007 (−0.0062 to 0.020)	−10.14	0.004 (−0.005 to 0.012)	−5.35
	Others	−0.002 (−0.003 to 0.0004)*	2.35	−0.002 (−0.003 to 0.0004)*	2.29
Dietary diversity	No	1	1	1	0.00
	Yes	0.0004 (−0.0013 to 0.0022)	−0.61	−0.026 (−0.050 to 0.003)*	36.92

*pvalue<0.05; **pvalue<0.01; ***pvalue<0.001
EDHS, Ethiopia Demographic and Health Survey.

rate of stunting. In contrast, increase in the proportion of mothers with a primary education between the comparison periods had reduced decline in stunting by 13.97% (table 5).

Stunting was more common in children from the poorest, poorer, middle and richer families than in children from the richest families. Between the surveys, changes in family composition among poorer, medium and richer households increased change in the prevalence rate of stunting by 0.13%, 3.11% and 2.28%, respectively, but changes in family composition among the poorest families decreased change in stunting prevalence rate by 1.12%. The shift in age structure among children included in the 2011 and 2019 EDHS accelerated the pace of change in stunting prevalence rate by 4.23%. More female children were included in the 2019 EDHS, which resulted in a 0.32% increase in the stunting prevalence rate change. Between the surveys, change in the proportion of children in Tigray, Affar and Harari declined change in stunting prevalence rate by 0.76%, 0.79% and 0.12%, respectively. However, between the surveys, changes in the composition of children in the

Amhara region and changes in the composition of the place of delivery increased the change in the prevalence rate of stunting by 2.5% and 2.35%, respectively. Finally, decrease in coverage of an unimproved water source from 40.06% to 37.54% accounts for 8.57% decline in change in the prevalence rate of stunting as compared with increase in coverage of improved water source from 36.61% to 37.23% (table 5).

Difference due to effects of coefficient (coefficients); 2011–2019 EDHS

The multivariate decomposition logistic regression analysis of 2011–2019 found that behavioural changes towards duration of breast feeding, dietary diversity, age in months, place of delivery and region had a significant effect on change in the prevalence rate of stunting between surveys when keeping compositional characteristics constant. During the study period, changing the behaviour of breastfed children resulted in a 57.2% rise in change in the prevalence rate of stunting. Stunting had been dropped by 134.53% as a result of age-related behavioural changes in children aged less than 5 years. Behavioural modifications in children from the Tigray and Harari regions have a detrimental effect on change in stunting by 15.01% and 0.61%, respectively. It was able to boost the change in stunting prevalence rate by 36.92% between the survey years by changing children's behaviour towards dietary diversification. Finally, behavioural adjustments towards other places of delivery resulted in a 2.29% increase in stunting prevalence rate change (table 5).

DISCUSSION

The aim of this study was to estimate changes in the prevalence rate of stunning, factors associated with stunting and changes in the prevalence rate among Ethiopian children aged less than 5 years from 2005 to 2019. In the previous 15 years, Ethiopia has increased the number of national policies and large-scale health, nutrition and food security programmes,[36] resulting in a steady drop in stunting from 47% in 2005 to 37% in 2019, which is comparable to other countries.[37] Stunting, on the other hand, continues to be a serious problem in Ethiopia due to a variety of circumstances. The risk of stunting was higher in children aged less than 5 years whose mothers had no education than in those whose mothers had a higher education level, according to a multilevel logistic regression analysis of the 2016 EDHS. A multivariate decomposition analysis of the EDHS from 2005 to 2011 and 2005 to 2016 revealed that lowering the number of mothers without education contributed to a reduction in stunting. There is a considerable link between maternal education and children's nutrition, according to earlier studies. Children born to educated mothers are less likely to be stunted than children born to uneducated mothers.[38 39] Women's higher education is a critical component in improving a family's socioeconomic level,[40] and excellent socioeconomic

status influences predictors of stunting such as reproductive factors, feeding patterns and healthcare utilisation.[41] Our findings, and those of earlier studies, have major policy implications because they imply that by boosting mother's formal education, Ethiopia could ameliorate the impact of stunting on children and lessen the country's high stunting-related ill health among children.

When compared with children aged less than 5 years from mothers with higher education, the coverage of parent's primary education rose from previous to recent surveys; yet, it had a negative significant compositional impact on the decline in stunting. This finding is consistent with a large-scale study conducted across three African countries, which found that women's primary education had no significant impact on child stunting.[42] These findings suggest that educating women at the primary school level may not be adequate to reduce stunting to the levels desired, and that policies to keep mothers in school beyond primary school should be prioritised in order to reduce the number of stunted children in the country.

Behavioural changes towards mother's education did not indicate a significant relation to stunting reduction in any of the analyses. Although a variety of initiatives, such as the Sustainable Development Goals, are emerging in Ethiopia to support and encourage women's empowerment, reaching this goal has not been straightforward and has been hampered by persisting regional inequities. In most regions, community attitudes on women's engagement in development, women's access to and management of productive resources, and gender-based equalities in training and education are unsatisfactory.[43] The current finding implies that focusing on women's perceptions and attitudes, as well as boosting women's education, may have a good impact on bringing about the desired behavioural change in the community regarding child nutrition.

In a multilevel logistic regression analysis, maternal height was found to be inversely related to the prevalence of childhood stunting. Between 2005 and 2011, as well as 2005 and 2011, and 2011 and 2016, community compositional changes in responder height had a favourable impact on change in stunting. Aside from genetics, environmental factors including maternal nutrition, feeding patterns, and nutritional quality and quantity can all influence growth of children before the age of 2 years.[16] In addition, a variety of socioeconomic issues, ranging from general conditions to poor feeding practices, which may result in low maternal stature, may have an impact on early childhood growth and development.[44] In addition to heredity and shared environmental factors, the biological significance of the mother milieu during pregnancy and lactation could have explained the link between maternal height and early life stunting.[16] It is plausible to claim that stunting is a cyclical process in which women who were stunted as children have stunted offspring, producing an intergenerational cycle of poverty and diminished human capital that is difficult to break.[45] As a result, policies and tactics that consider mothers and

are implemented over a short, medium or long period of time may have the desired effect on childhood stunting. Furthermore, genetic studies are highly recommended to determine the long-term interaction of material stunting and child growth retardation. Breastfed children were more likely to be stunted than children who had been breast fed previously but not during the study period. In a multivariate decomposition logistic regression analysis, the decline in the proportion of children who were breast feeding between the surveys had a positive contribution to change in prevalence rate of stunting between the 2005–2011 and 2005–2016 EDHS, compared with children who were breast fed before but not during the data collection period. This could never be explained by the breast milk itself, but rather by a combination of factors that directly and indirectly influence a child's feeding habits at this age. According to the descriptive statistics, the majority of children who are still breast fed are under the age of 6–24 months, one of the most significant periods for linear development failure. Due to strong demand for nutrients combined with low quality and quantity of complementary foods, especially in underdeveloped countries, this is the time when the hazard of stunting reaches its pick.[7 46 47] Poor nutrition is caused not just by a lack of food, but also by improper feeding methods, such as poor timing, quality and quantity of foods given to infants and young children. If optimal breast feeding is not combined with complementary feeding practices, which are necessary to meet the nutritional demands of children in their first 2 years of life, it is not enough to prevent stunting.[48] In Ethiopia, however, only 14% of children aged 6–23 months have a diet that satisfies minimum dietary diversity guidelines, and only 7% have a diet that is minimally acceptable, according to the DHS report.[49] In a pocket study, 12.0% of children aged 6–24 months met the dietary diversity criteria by eating from four or more of the seven food categories.[50] Additionally, there is a wide spectrum of harmful child feeding practices in Ethiopia. The median age for exclusive breast feeding in northern Gamo Gofa was 3.7 months, whereas it was 10 months to over 12 months in North and South Gondar, North and South Wello, and Tigray. Likewise, in northern Gamo Gofa, the median age for complementary food introduction was 3.7 months, whereas in North Gondar and Tigray, it was 12.1 months.[48] In conclusion, lack of age-appropriate breast feeding, delays in the introduction of complementary feeding, caregiver knowledge gaps, which are strongly correlated with delays in complementary feeding, and failure to provide minimum dietary diversity, regardless of wealth status, education or remoteness, all contribute to the high burden of stunting in the breastfeeding category of children.[51 52] This finding means that the child's first 2 years after birth would be identified as the most significant window of opportunity for measures to combat stunting.

Behavioural changes such as good feeding habits among children who were breast feeding during the survey time had a positive contribution for change in stunting among children compared with children who were breast feeding previously but not currently, according to the multivariate decomposition logistic regression analysis of 2005–2011, 2005–2016 and 2011–2019. The National Nutrition Strategy of the Federal Democratic Republic of Ethiopia, which has been implemented over the last few decades, focuses on mainstreaming and strengthening nutrition activities through community-based nutrition programmes that help to reduce food insecurity and unbalanced nutrient consumption. Community-based health and agriculture extension programmes, health service delivery, education and gender programmes all received more attention. The community-based nutrition programme also includes growth monitoring and promotion for all children under the age of 2 years, as well as caregiver counselling.[53 54] Thus, the encouraging drop in stunting observed due to behavioural changes among children who were breast fed during data collection could be attributed to the implementation of a community-based nutrition programme. This indicates that further enhancing the programme will provide very promising results in terms of eradicating stunting among Ethiopian children.

Between 2005 and 2011, the number of children in the poorest wealth index category increased, and stunting among children decreased, according to the analysis of the EDHS data set. At the same time, between 2011 and 2019, the proportion of children from lower, middle and upper-middle-class families decreased, resulting in a faster fall in child stunting. Previous findings that attempted to investigate the effects of economic growth on undernutrition in Ethiopia have similarly confirmed the direct effect of economic growth on stunting.[55] According to a study, a 10% rise in GDP per capita reduces the frequency of child stunting by 2.7%. In this regard, the average cost of stunting in poor nations has been estimated to be around 13.5% of GDP per capita.[56] According to published literature, the link between the prevalence of stunting and economic growth is stronger among children from low-income nations,[57 58] implying that the household's financial level is the foundation for all nutritional interventions implemented in disadvantaged areas. These findings may serve as a reminder to Ethiopian policymakers to place a greater emphasis on policies that promote economic growth as well as nutrition-related programmes.

Similarly, a multivariate decomposition logistic regression assessment of 2011–2016 revealed that behavioural changes such as poor feeding habits among children from middle-income families were associated with an increase in stunting. Ethiopia's Growth and Transformation Plan is a 5-year development plan that runs from 2010/2011 to 2014/2015.[59] In both the health and agriculture sectors, community-based service delivery systems have been made available throughout this time period to assure decentralised and democratised public services. Health extension workers, in particular, play a critical role in strengthening and accelerating social and behavioural changes in children's eating habits, both in

rural and urban regions.[53] As a result, the decrease in stunting owing to behavioural changes among children from middle-income homes could be the outcome of programmes established during this time period, which could be a useful lesson in achieving the country's aim.

The risk of stunting grew as the child's age climbed month by month. Changes in age structure (lower mean age) among children in the EDHS from 2005 to 2011, 2005 to 2016, and 2011 to 2019 showed an increase in stunting. To achieve optimal growth in children, the amount and frequency with which they are fed should be increased: two to three meals per day for infants aged 6–8 months, three to four meals per day for infants aged 9–23 months, plus one to two additional snacks as needed.**60** However, findings from national representative data showed that the frequency of infant and child feeding practices dropped as the child's age increased by one unit.[61] In most locations, young child feeding practice is also inadequate, and providing children the minimum appropriate diet variety does not grow with age.[62] On the other hand, despite the fact that optimal birth spacing is regarded as an important element in children's health, Ethiopia's birth interval is short.[63] After the arrival of the second child, the amount and quality of care given to the first child may gradually decrease. All of these things could be contributing factors to the child's inability to achieve optimal growth as they get older.

The decomposition analysis of the EDHS for the years 2005–2011, 2005–2019 and 2011–2019 revealed that age-related behavioural changes such as improvement in good feeding habit among children from young to old age played a favourable role in stunting reduction. Since 2004, Ethiopia's Federal Ministry of Health's Family Health Department has adopted a national policy to improve baby and child feeding practices, with the goal of gradually increasing food consistency and diversity as newborns grow older, while responding to their needs and skills.[64] Ethiopia made significant progress in extending community-based primary healthcare delivered by health extension workers as a result of these programmes. Because of their influence on eating decisions and access to mass media, Alive & Thrive launched a radio and television campaign aimed largely at men to reinforce and expand the impact of community interventions and to reach individuals outside of programme areas. Each television and radio broadcast emphasised the importance of male involvement in infant feeding.[65] The decrease in stunting may be due to changes in parental behaviour towards newborn and young child feeding practices, which may have been affected by radio and television programmes used as communication tools under Ethiopia's Growth and Nutrition programme.[66] This means that, while the economic and political hurdles to improving Ethiopia's nutritional status are enormous and appear insurmountable, strengthening the existing nutritional interventions can make more of a difference in reducing early life growth failure.

From 2005 to 2016, and from 2011 to 2019, the proportion of female children included in the study increased. Stunting among children aged less than 5 years has decreased significantly as a result of this compositional change. Male children aged less than 5 years in sub-Saharan Africa are more likely than girls to be stunted.[67] Gender differences in mortality and morbidity could explain this. Even though there is no clear understanding of early childhood health inequalities, epidemiological research consistently shows that boys have higher mortality and morbidity than girls.[68] Other potential determinants, such as social role valorisation of daughters and nutritional discrimination, have not been widely investigated in Ethiopia, implying the need for more exploratory research in the area.

In all combinations of survey data, a decrease in the proportion of children from the Amhara region increased the change in stunting. Amhara has the country's third highest rate of monetary poverty, as well as the greatest disparity between rural and urban communities.[69 70] Many households can only generate enough food to meet their nutritional needs for about 6 months of the year.[71] Amhara region's children are similarly worse off than the national average in terms of basic necessities and services.[72] There are significant gaps in healthcare professionals' knowledge and abilities, facility readiness, administration and leadership, and the availability of crucial supplies in various parts of the region. Maternal and newborn health services are still underused, and maternal and newborn care is of poor quality.[72 73] This could all be contributing to the high rate of early life growth failure in the Amhara region, implying the need for a variety of interventions to guarantee children have access to both meals and health services that would effectively meet their multifaceted needs for growth and development.

Between 2011 and 2019, the proportion of children in the Tigray region who were stunted dropped. Despite considerable improvements in access to healthcare services in the region, producing an acceptable amount of food is extremely challenging due to a scarcity of suitable farmland. Of the population, 89% earns less than £2 a day, while the bulk of the population produces less than half of their annual minimum food requirements.[74] However, between 2005 and 2019, behavioural changes among children in the Tigray region contributed significantly to a large decrease in the frequency of childhood stunting. This could be attributed to the successful execution of a health extension programme and the expansion of healthcare facilities.[75] In the Tigray area, total universal health service coverage is nearly comparable to Addis Ababa, and is complemented by a high level of facility delivery and children vaccination.[76 77] All of these could aid communities in developing appropriate child feeding practices in the region.

Similarly, between 2011 and 2019, the proportion of children in the Harari and Affar regions who were stunted increased. Harari has had a significant decrease in monetary poverty in recent decades, beginning in

2004/2005. The region's overall monetary poverty rate has dropped to 7%, the lowest in the country. Similarly to monetary poverty, the number of people living in food poverty has considerably dropped.[78] According to reports, children in the Harari region are less likely than the national average to be deprived of a greater number of fundamental requirements and rights.[79] Despite the fact that many people in the Afar region face chronic food poverty, over 90% of the Afar community relies on a pastoralist subsistence strategy.[78] As a result, there is a relatively high culture of feeding children animal products with great nutritional content to counteract stunting.[80] As a result, when additional children from the two locations are sampled between the surveys, a relatively low degree of stunting is anticipated. In contrast, between 2005 and 2016, a fall in the proportion of children from less risky areas such as Dire Dawa city had a deleterious effect on stunting reduction.

From 2011 to 2016, behavioural modifications among children in the Oromia and SNNP regions were responsible for a significant drop in stunting change. Between 2011 and 2019, this was also true in the Harari region. This could be linked to the political resistance that existed in the southern part of Ethiopia, particularly in the Oromia region. Oromia has underperformed on maternity and child healthcare over this time period. During the study period, good practices such as facility delivery, ANC and postnatal care that might change mothers' behaviour towards childfeeding practice were the lowest in all regions.[81] In the pastoralist areas of Oromia, the execution of the Health Extension Programme has also been hampered.[82] Similarly, despite its economic success, SNNPR has Ethiopia's highest multidimensional child deprivation rate.[83] Despite the fact that Ethiopia has experienced significant poverty reduction in these areas, coordination for the development of good child feeding habits is lacking due to a lack of awareness, frequent turnover of focal persons and management, a lack of accountability and responsibility, and a lack of nutrition structures in each specific area.[83 84]

Anaemia and a lack of improved water sources, both of which are well-known causes of chronic malnutrition, are also negative drivers of stunting change in our study.[85] On the other hand, behavioural changes towards nutritional diversity, ANC follow-up, place of delivery, and eating solid, semisolid or soft foods have all been linked to a reduction in childhood stunting. Ethiopia could reduce the burden of early life growth failure by increasing access to improved water sources, maternal and child care, and well-structured patient education programmes to increase self-awareness and a positive attitude towards maternal care and child feeding practice, according to this finding.

CONCLUSION

Despite the fact that several projects to eliminate stunting have been implemented in Ethiopia, a significant number of children remain stunted. Compositional features of children, including as wealth index, parental education, child's age in months, sex of child, duration of breast feeding, anaemia, unimproved water supply and region, all had a statistically significant impact on stunting change. Changes in coefficients such as dietary diversity, ANC follow-up, place of delivery, eating solid, semisolid or soft meals, and age all exhibited a significant association with change in stunting. The Ethiopian Ministry of Health should maintain its present efforts to improve dietary diversity, ANC follow-up, institutional delivery and the feeding of solid, semisolid or soft foods to children above the age of 6 months. The Ethiopian government and the ministry of health should place a specific emphasis on impoverished areas, such as the Amhara region, and vulnerable groups, such as boys, who require special attention. Finally, more steps should be taken by the Ministry of Education to strengthen female empowerment via education.

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