Socioeconomic disparities in child malnutrition: An analysis of evidence from Kenya Demographic and Health Survey, 2014 - 2022

Amos Okutse[1,2*], Second Author[2], Third Author[2], Fourth Author[2]

[1*]Department of Biostatistics, Brown University School of Public Health, Providence, USA, 2903, RI, 121 South Main St.
[2]Other Organisation.
[3]Other Organisation.

*Corresponding author(s). E-mail(s): amos_okutse@brown.edu;

Abstract

Purpose: The abstract serves both as a general introduction to the topic and as a brief, non-technical summary of the main results and their implications. The abstract must not include subheadings (unless expressly permitted in the journal's Instructions to Authors), equations or citations. As a guide the abstract should not exceed 200 words. Most journals do not set a hard limit however authors are advised to check the author instructions for the journal they are submitting to.
Methods: The abstract serves both as a general introduction to the topic and as a brief, non-technical summary of the main results and their implications. The abstract must not include subheadings (unless expressly permitted in the journal's Instructions to Authors), equations or citations. As a guide the abstract should not exceed 200 words. Most journals do not set a hard limit however authors are advised to check the author instructions for the journal they are submitting to.
Results: The abstract serves both as a general introduction to the topic and as a brief, non-technical summary of the main results and their implications. The abstract must not include subheadings (unless expressly permitted in the journal's Instructions to Authors), equations or citations. As a guide the abstract should not exceed 200 words. Most journals do not set a hard limit however authors are advised to check the author instructions for the journal they are submitting to.
Conclusion: The abstract serves both as a general introduction to the topic and as a brief, non-technical summary of the main results and their implications.

The abstract must not include subheadings (unless expressly permitted in the journal's Instructions to Authors), equations or citations. As a guide the abstract should not exceed 200 words. Most journals do not set a hard limit however authors are advised to check the author instructions for the journal they are submitting to.}

Keywords: Child malnutrition, Decomposition, Socioeconomic disparities, Kenya, Stunting, Underweight, Wasting, Demographic Health Survey

1 Introduction

Child Malnutrition remains a dominant public health challenge globally. In 2022, for instance, about 148.1 million (22.3%) children below 5 years were stunted, whereas 45 million (6.8%) and 37 million (5.6%) were wasted and overweight, respectively [2]. While there has been some progress in the actualization of the global nutrition targets, this progress is slow, and the levels of malnutrition continue to persist. Africa and Asia account for almost half the world's child malnutrition burden [2].

In the East African region, stunting prevalence (32.6%) was higher than the global average (22.3%), whereas wasting and overweight were 5.2% and 4.0%, respectively [7]. With the possibility of suffering from more than one form of malnutrition, children remain largely susceptible to the perilous effects posed by this condition. According to nutrition statistics, 3.62% of all children under the age of five years (15.95 million) have been reported as being both stunted and wasted, whereas 1.87% of all children (8.23 million) have been reported to experience both stunting and overweight globally [8].

In the first half of 2022, Kenya reported about 942,000 cases of acute malnutrition among children between 6 and 59 months [3]. According to the 2022 Kenya Demographic and Health Survey (KDHS) [14], 18% of children under 5 are stunted (chronically undernourished), 5% are wasted (acutely malnourished), whereas 3% and 10% are overweight and underweight, respectively. While Kenya has substantially reduced the burden of child malnutrition, undernutrition is estimated to cost the country over US$38.3 billion in Gross Domestic Product (GDP) following losses in workforce labor and productivity for 2010–2030 [26].

Malnutrition denotes "a state of nutrition in which a deficiency, or an excess, of energy, protein, and micronutrient causes measurable adverse effects on tissue/ body form (body shape, size, and composition), function, and clinical outcome" [25]. Malnutrition has been attributed to several diverse interlinked factors with detrimental short and long-term effects [20, 21]. Not only does it affect the physical and cognitive development of a child, but it also drastically increases their risk of infections and contributes negatively to their mortality and morbidity [11, 12, 16, 22, 24, 27, 31].

Stunting, underweight, and wasting remain the recommended three indicators of malnutrition [11]. Stunting refers to low height for age and reflects the growth in linear terms achieved at the age at which the anthropometric measurements were taken. Underweight is low weight for age, resulting from a short-term lack of food.

In contrast, wasting is severe undernutrition resulting from inadequate food intake and infections [11]. In children under 5 years, stunting is the most significant measure of overall health and well-being capable of highlighting salient social disparities [18]. Moreover, because stunting measures linear growth in children, it is considered an accurate measure of malnutrition in the long term due to its insensitivity to variations in food consumption [10, 32].

1.1 Socioeconomic disparities in child malnutrition

Kenya is classified as a middle-income country based on its Gross National Income (GNI) per capita. Under this classification frame, countries are classified into three categories based on their income as either low, middle, or high-income countries [11]. A country's attainment of the middle-income classification status is often seen as an indication of progress resulting from such activities as heightened investments across all government sectors and improved productivity. Shifts in a country's classification from low to middle, then to high income, indicate economic advancement. As expected of growth, such advancements are expected to impact the well-being of a country's population positively. For instance, economic advancements are expected to create employment opportunities, translating into increased disposable income, improved health, and education [4, 23]. Improved living standards following economic advancement are expected to translate into exceptional and improved nutritional consequences for children and adults.

The economic status associated with a country has been shown in previous studies to result in improved health status of a population [5, 15]. However, economic advancement does not necessarily translate to equitable distribution of positive prospects across the population. Often, these tend to be skewed, with some groups benefiting more than others.

Kenya has made commendable progress in reducing the burden of malnutrition as part of the Standard Development Goals (SDGs), which have considerably reduced the stunting rate. Even so, the overall prevalence of the condition remains larger than those observed for other forms of malnutrition [9, 11]. Given the danger malnutrition poses to child growth, survival, and well-being, its consequences are of substantial interest to the government, public health professionals, and policymakers.

This study contributes significantly to the available knowledge on socioeconomic disproportions in the Kenyan child malnutrition burden, examining trends in stunting, underweight, and wasting across socioeconomic groups, geographical locations, and selected household, child, maternal, and paternal characteristics. We also examine the determinants of child malnutrition and employ standard procedures of inequality to quantify the trends [36] and decompose vicissitudes in the concentration indices to determine factors that drive socioeconomic disparities in child malnutrition in Kenya. The study utilizes current data from the Kenya Demographic Health Survey (DHS) (2014 to 2022) to comprehensively analyze the scope of the problem, specifically focusing on children below five years.

2 Methods

2.1 Study data

We utilized data from the 2014 and 2022 Kenya Demographic and Health Surveys (KDHS) (standard DHS). These surveys adopted a two-stage stratified cluster sampling approach: clusters in the first stage and households in the second. In 2014, a response rate of 99% was achieved from 39,679 households, and in 2022, a 98% response rate from 38,731 occupied households [KNBSICF2015; KNBS and ICF [14]]. Analyses considered all live children (0-59 months) of interviewed mothers, excluding those with missing anthropometric data. The data was weighted for non-response and used with DHS authorization.

2.2 Variables

2.2.1 Outcome

Malnutrition was characterized by stunting (low height-for-age z-scores, HAZ), underweight (low weight-for-age z-scores, WAZ), and wasting (low weight-for-height z-scores, WHZ) [11, 13]. Stunting indicates a child's linear growth at a given age. Underweight results from short-term food deprivation, while wasting stems from both inadequate food intake and infections [11].

In children under five, a HAZ, WAZ, or WHZ between -2 and -3 standard deviations (SD) below the median suggests moderate stunting, underweight, or wasting, respectively. Z-scores less than -3 SD below the World Health Organization's (WHO) child growth standards median indicate severe conditions [19].

We categorized children with HAZ, WAZ, and WHZ scores below -2 SD of the WHO growth standards median as stunted, underweight, or wasted, respectively. Notably, stunting in children under five highlights chronic undernutrition, whereas wasting and underweight can imply both acute and chronic malnutrition [13].

2.2.2 Covariates

In this study, we considered a comprehensive set of determinants linked to child malnutrition. Child-specific variables included age (in months), gender, place and region of residence, delivery location, and birth order. At the household level, we accounted for characteristics such as religion and socioeconomic status. Maternal indicators included age, education level, and birth interval, while we also considered paternal education. These determinants are grounded in existing literature and were available in our data set [6, 11, 13].

2.3 Statistical analysis

2.3.1 Analysis of disparities in child malnutrition

The extent and trends of socioeconomic disparities in stunting, underweight, and wasting were quantified using concentration indices (CIs) estimated based on the corresponding z-scores [17, 28, 29]. Concentration indices quantify the socioeconomic

disparities in a health variable and allow assessment of the extent and levels of disparities. CIs were computed as double the area between the concentration curve and the line of equality – the 45° line.

According to O'Donnell et al. [17]:

$$CI = \frac{2}{\mu}\text{cov}(h, r) \tag{1}$$

In Equation 1, μ is the average of malnutrition (stunting, underweight, and wasting) in children under five children, h denotes observation-specific child malnutrition, and r is the rank of the socioeconomic status of a household. The CI of a given health variable usually takes values between -1 and +1, with 0 suggesting perfect equity of the health variable between the poorest and the richest socioeconomic groups. Negative values suggest a higher concentration of malnutrition among the poorest group, and positive values suggest a higher concentration of inequity among the richest socioeconomic group [1, 11, 13, 28]. As in Kien et al. [13], the continuous forms of the variables for stunting, underweight, and wasting were employed to enhance precision.

2.3.2 Analysis of determinants of child malnutrition

Determinants of child malnutrition were investigated using binary logistic regression. Separate models were fitted for stunting, underweight, and wasting. Odds ratios were computed for each adjustment covariate to examine associations between the child malnutrition indicators and each explanatory variable in 2.2.2. Results from the fitted logistic regression models were used in the construction and decomposition of the Wagstaff normalized CIs described in 2.3.3.

2.3.3 Decomposition of socioeconomic inequities in child malnutrition

Contributions of the determinants of malnutrition in children under five to the observed socioeconomic disparities were examined through a decomposition analysis. These decompositions were restricted to stunting and underweight, indicators that exhibited substantial differences between 2014 and 2022. This analysis framework utilized categorical forms of the response variables.

We considered a linear regression model where the response variable (y) is modeled as a linear combination of the k determinants (X_k) as:

$$y = \alpha + \sum_k \beta_k X_k + \epsilon \tag{2}$$

where β_k denotes the coefficient of X_k (the set of explanatory variables) and ϵ is the error term.

In terms of the CI for the response y, 2 reduces to:

$$CI = \sum_k \left(\frac{\beta_k \bar{X}_k}{\mu}\right) CI_k + \frac{GCI_\epsilon}{\mu} \tag{3}$$

where μ denotes the average of y, $\bar{X}_k$ denotes the mean of the k^{th} variable, β_k denotes the coefficient of each determinant, CI_k denotes the CI of each of the regressors in the model, and GCI_ϵ denotes the generalized concentration index for the error term, ϵ.

Equation 3 has two components: the explained $\left((\beta_k \bar{X}_k)/\mu)CI_k\right)$ and the unexplained component (GCI_ϵ/μ). $(\beta_k \bar{X}_k)/\mu$ is the elasticity –the effect of each $CI_k $ on the overall CI of the outcome variable, y [28, 30].

We employed the Wagstaff normalization technique for CI values and used total differential decomposition to decipher the determinants' contribution to CI variations. This decomposition follows from Wagstaff et al. [30]. It permits approximation of the effects of child malnutrition disparities on variations in regression coefficients, variations in means of malnutrition determinants, and variations in the extent of inequity in child malnutrition determinants. These decompositions were applied to height-for-age and weight-for-age z-scores.

The formula for the decomposition applied was:

$$\begin{aligned} dC = &-\frac{c}{\mu} d\alpha + \sum_k \frac{\bar{X}_k}{\mu} (CI_k - CI)\, d\beta_k \\ &+ \sum_k \frac{\beta_k}{\mu} (CI_k - CI)\, d\bar{X}_k + \sum_k \frac{\beta_k \bar{X}_k}{\mu} dCI_k + d\frac{GCI}{\mu}\epsilon \end{aligned} \tag{4}$$

where dC denotes the overall change in the CI, $d\alpha$ constant value, $d\beta_k$ the coefficients of the determinants, $d\bar{X}_k$ mean values of the determinants, dCI_k determinant-specific CI and $d((GCI)/\mu)_\epsilon$, the error term [30].

3 Results

3.1 Weighted prevalence of child malnutrition

Figure 1 highlights the weighted prevalence of under five child malnutrition by selected child, household, maternal, and paternal characteristics grouped by the survey year.

Table 1: Weighted prevalence of stunting, underweight, and wasting among children under five years by selected child, household, maternal, and paternal characteristics (2014 – 2022)

	2014									2022								
	Stunted (HAZ<-2SD)			**Underweight** (WAZ<-2SD)			**Wasted** (WHZ<-2SD)			**Stunted)** (HAZ<-2SD)			**Underweight** (WAZ<-2SD)			**Wasted** (WHZ<-2SD)		
	n	*n*(%)	*P*	*n*	*n*(%)	*P*	*n*	*n*(%)	*P*	*n*	*n*(%)	*P*	*n*	*n*(%)	*P*	*n*	*n*(%)	*P*
Weighted n	17291	4466 (25.8)		17291	1841 (10.6)		17291	701 (4.1)		15336	2665 (17.5)		15368	1543 (10.0)		15329	752 (4.9)	
Child age, mean (SE)		30.8 (0.2)	0.00		31.8 (0.5)	0.00		26.1 (1.0)	0.00		27.7 (0.4)	0.08		30.8 (0.5)	0.00			
Birth interval, mean (SE)		39.5 (0.5)	0.00		38.2 (0.7)	0.00		39.8 (1.2)	0.00		43.8 (0.8)	0.00		41.8 (1.0)	0.00			
Birth order , mean (SE)		3.6 (0.1)	0.00		3.8 (0.1)	0.00		3.6 (0.1)	0.01		3.3 (0.1)	0.00		3.5 (0.1)	0.00			
Child sex			**0.00**			**0.00**			**0.09**			**0.00**						**0.01**
Male	8763	2586 (57.9)		8763	1028 (55.9)		8763	382 (54.6)		7755	1523 (57.2)		7767	857 (55.6)		7758	420 (55.9)	
Female	8528	1880 (42.1)		8528	812 (44.1)		8528	318 45.4)		7581	1142 (42.8)		7601	685 (44.4)		7571	331 (44.1)	
Delivery place			**0.00**			**0.00**			**0.00**			**0.00**			**0.00**			**0.00**
Home	6513	2157 (48.5)		6512	1033 (56.4)		6512	390 (55.9)		1110	302 (16.9)		1116	205 (23.4)		1116	104 (25.7)	
Public	7919	1749 (39.3)		7919	629 (34.3)		7919	235 (33.6)		6095	1147 (64.2)		6114	513 (58.6)		6094	217 (53.1)	
Private	2637	495 (11.1)		2637	153 (8.4)		2637	68 (9.7)		2217	321 (18.0)		2217	150 (17.2)		2202	80 (53.1)	
Other	176	50 (1.1)		176	16 (0.9)		176	5 (0.7)		50	14 (0.8)		50	7 (0.8)		49	5 (1.4)	
Residence			**0.00**			**0.00**			**0.03**			**0.00**			**0.00**			**0.01**
Urban	5927	1168 (26.1)		5926	397 (21.6)		5926	200 (28.6)		5411	662 (24.8)		5424	361 (23.4)		5410	215 (28.7)	
Rural	11364	3298 (73.9)		11364	1443 (78.4)		11364	500 (71.4)		9924	2003 (75.2)		9944	1182 (76.6)		9918	536 (71.3)	
Religion			**0.00**			**0.00**			**0.00**			**0.01**			**0.03**			**0.00**
Catholic	3097	728 (16.3)		3097	296 (16.1)		3097	126 (18.1)		2670	445 (16.7)		2676	276 (17.9)		2667	128 (17.1)	
Protestant	12228	3200 (71.8)		12228	1257 (68.4)		12228	444 (63.5)		10527	1864 (70.0)		10541	1012 (65.6)		10513	432 (57.5)	
Muslim	1440	346 (7.8)		1440	195 (10.6)		1440	106 (15.2)		1485	232 (8.7)		1489	190 (12.3)		1494	159 (21.2)	
Atheist	457	181 (4.1)		457	79 (4.3)		457	18 (2.6)		213	59 (2.2)		217	24 (1.6)		213	12 (1.7)	
Other	42	5.4 (0.1)		42	8.5 (0.5)		42	4 (0.7)		439	63 (2.4)		442	40 (2.6)		440	19 (2.5)	
Economic status			**0.00**			**0.00**			**0.00**			**0.00**			**0.00**			**0.00**
Poorest	4178	1489 (33.4)		4178	792 (43.0)		4178	303 (43.2)		3583	986 (37.0)		3596	679 (44.0)		3583	340 (45.2)	
Poorer	3631	1099 (24.6)		3631	435 (23.7)		3631	116 (16.6)		2840	598 (22.4)		2846	286 (18.5)		2849	88 (11.8)	
Middle	3182	808 (18.1)		3182	286 (15.6)		3182	117 (16.8)		2703	439 (16.5)		2707	249 (16.1)		2701	116 (15.5)	
Richer	2969	620 (13.9)		2969	204 (11.1)		2969	76 (11.0)		3052	354 (13.3)		3062	190 (12.4)		3040	124 (16.5)	
Richest	3330	446 (10.0)		3330	122 (6.7)		3330	86 (12.4)		3155	286 (10.7)		3154	137 (8.9)		3154	82 (10.9)	

Table 1: (continued)

	n	n(%)	P	n	n(%)	P	n	n(%)	P	n	n(%)	P	n	n(%)	P	n	n(%)	P
Mothers education			**0.00**			**0.00**			**0.00**			**0.00**			**0.00**			**0.00**
None	2057	628 (14.1)		2057	421 (22.9)		2057	210 (30.0)		1606	354 (13.3)		1614	355 (23.0)		1611	248 (33.1)	
Primary	9735	2890 (64.7)		9735	1111.7 (60.4)		9735	329 (47.0)		5820	1283 (48.2)		5834	688 (44.6)		5829	257 (34.2)	
Higher	5497	946 (21.2)		5497	307 (16.7)		5497	161.7 (23.1)		7909	1027 (38.6)		7919	500 (32.4)		7888	246 (32.7)	
Mothers age			**0.20**			**0.01**			**0.35**			**0.00**			**0.54**			**0.11**
under 24	5000	1349 (30.2)		5000	474 (25.8)		5000	182 (26.1)		4084	817 (30.7)		4094	390 (25.3)		4083	173 (23.1)	
25 - 34	8855	2228 (49.9)		8855	946 (51.4)		8855	375 (53.6)		7852	1313 (49.3)		7874	800 (51.8)		7855	394 (52.4)	
35+	3435	888 (19.9)		3435	420 (22.8)		3435	142 (20.3)		3400	534 (20.1)		3400	353 (22.9)		3390	184 (24.5)	
Mother employed			**0.54**			**0.32**			**0.00**			**0.20**			**0.00**			**0.00**
No	3041	770 (35.9)		3041	342 (38.6)		3041	149 (49.0)		7596	1362 (51.1)		7625	853 (55.3)		7602	434 (57.8)	
Yes	5263	1378 (64.1)		5263	545 (61.4)		5263	155 (51.0)		7739	1302 (48.9)		7742	689 (44.7)		7726	317 (42.2)	
Fathers education			**0.00**			**0.00**			**0.00**			**0.00**			**0.00**			**0.00**
None	727	213 (10.7)		727	155 (18.5)		727	81 (27.6)		1257	304 (14.5)		1263	292 (23.8)		1260	188 (30.4)	
Primary	3964	1183 (59.3)		3964	453 (53.9)		3964	120 (40.8)		4637	961 (45.8)		4651	517 (42.0)		4647	217 (35.1)	
Higher	3019	599 (30.0)		3019	232 (27.6)		3019	93 (31.6)		6629	833 (39.7)		6638	419 (34.1)		6615	213 (34.5)	
Region			**0.00**			**0.00**			**0.00**			**0.00**			**0.00**			**0.00**
Coast	1774	532 (11.9)		1774	226 (12.3)		1774	75 (10.8)		1441	204 (13.2)		1441	204 (13.2)		1430	91 (12.2)	
N.Eastern	557	134 (3.0)		557	100 (5.5)		557	72 (10.3)		562	104 (6.8)		562	104 (6.8)		562	99 (13.2)	
Eastern	2147	640 (14.3)		2147	259 (14.1)		2147	97 (13.9)		1857	206 (13.4)		1857	206 (13.4)		1850	108 (14.4)	
Central	1605	289 (6.5)		1605	78 (4.3)		1605	33 (4.7)		1737	94 (6.1)		1737	94 (6.1)		1730	46 (6.2)	
R. Valley	5047	1502 (33.7)		5047	772 (41.9)		5047	289 (41.3)		4768	623 (40.4)		4768	623 (40.4)		4763	287 (38.2)	
Western	2031	506 (11.3)		2031	164 (8.9)		2031	41 (6.0)		1514	117 (7.6)		1514	117 (7.6)		1508	31 (4.1)	
Nyanza	2448	556 (12.5)		2448	183 (10.0)		2448	47 (6.8)		1877	106 (6.9)		1877	106 (6.9)		1874	44 (5.9)	
Nairobi	1678	302 (6.8)		1678	56 (3.0)		1678	43 (6.1)		1610	86 (5.6)		1610	86 (5.6)		1609	43 (5.8)	

Note: HAZ: height-for-age z-score; WAZ: weight-for-age z-score; WHZ: weight-for-height z-score; SD: standard deviation;

* P based on a Pearson chi-square test for categorical variable and T-test for continuous variables.

3.2 Trends in child malnutrition and socioeconomic inequality

Figure 2 summarizes the prevalence of child malnutrition by the household socioeconomic status between 2014 and 2022.

Table 2 Malnutrition prevalence by household socioeconomic status, % (SE)

	Poorest	Poorer	Middle	Richer	Richest	All
Stunting (height for age < -2 SD)						
2014	34.2 (0.6)	30.2 (0.7)	24.9 (0.8)	20.6 (0.7)	12.9 (0.7)	27.1 (0.3)
2022	25.6 (0.6)	20.5 (0.7)	15.4 (0.7)	11.7 (0.6)	07.7 (0.6)	18.0 (0.3)
Diff-1	08.6 (0.8)*	09.8 (1.0)*	09.4 (1.0)*	08.9 (1.0)*	05.2 (0.9)*	09.1 (0.4)*
Underweight (weight for age < -2 SD)						
2014	21.2 (0.5)	12.7 (0.5)	09.3 (0.5)	07.4 (0.5)	04.1 (0.4)	13.2 (0.2)
2022	21.8 (0.5)	10.6 (0.5)	09.6 (0.5)	06.2 (0.4)	04.5 (0.4)	12.6 (0.3)
Diff-2	-00.6 (0.7)	02.0 (0.8)*	-00.3 (0.7)	01.2 (0.7)	-00.3 (0.6)	00.6 (0.3)
Wasting (weight for height < -2 SD)						
2014	09.4 (0.4)	03.6 (0.3)	03.8 (0.3)	03.2 (0.3)	02.9 (0.3)	05.5 (0.2)
2022	12.9 (0.4)	04.2 (0.4)	05.3 (0.4)	04.3 (0.4)	02.9 (0.3)	07.2 (0.2)
Diff-3	-03.5 (0.6)*	-00.6 (0.4)	-01.6 (5.3)*	-01.1 (0.5)	00.0 (0.5)	-01.7 (0.3)*

Note:

Diff-1, Diff-2, Diff-3: difference in under five stunting, underweight, and wasting, respectively.

SE: standard error; SD: standard deviation

* significance based on two-sample comparisons of differences in proportions

Table 3 presents the concentration indices of under five child malnutrition.

Table 3 Under five child malnutrition concentration indices (CI), 2014 – 2022

	Stunted (HAZ < -2 SD)		Underweight (WAZ < -2 SD)		Wasted (WHZ < -2 SD)	
	CI (SE)	$P*$	CI (SE)	$P*$	CI (SE)	$P*$
Year 2014	-0.15 (0.01)	0.00	-0.27 (0.02)	0.00	12.37 (22.61)	0.58
Year 2022	-0.79 (0.01)	0.00	-0.88 (0.01)	0.00	-1.96 (0.05)	0.00
Diff	-0.64 (0.01)	0.00	-0.61 (0.02)	0.00	-14.33 (22.62)	0.53

Note:

Diff: difference in child malnutrition concentration indices between 2014 and 2022;

SE: standard error; SD: standard deviation; HAZ: height-for-age Z-score; WAZ: weight-for-age Z-score; WHZ: weight-for-height Z-score

* P-value based on a two-tailed independence test comparing the differences in the CIs with a test value of 0

3.3 Determinants of child malnutrition

Table 4 presents a summary of the determinants of under five child stunting, underweight, and wasting based on the multivariable logistic regression model. Results are based on the analysis of the aggregate 2014 and 2022 KDHS datasets.

3.4 Decomposition of the concentration indices for stunting and underweight

In Table 5 we present each determinant of child malnutrition and its percentage contribution to the observed inequality in child stunting and underweight for the period 2014 and 2022. Negative values suggest contributions to decreases in socioeconomic inequality whereas positive values indicate contributions to increase in inequality.

4 Discussion

5 Conclusion

Supplementary information.

Acknowledgments.

Declarations

Some journals require declarations to be submitted in a standardised format. Please check the Instructions for Authors of the journal to which you are submitting to see if you need to complete this section. If yes, your manuscript must contain the following sections under the heading 'Declarations':

- Funding
- Conflict of interest/Competing interests (check journal-specific guidelines for which heading to use)
- Ethics approval
- Consent to participate
- Consent for publication
- Availability of data and materials
- Code availability
- Authors' contributions

If any of the sections are not relevant to your manuscript, please include the heading and write 'Not applicable' for that section.

References

[1] Akombi BJ, Agho KE, Renzaho AM, et al (2019) Trends in socioeconomic inequalities in child undernutrition: Evidence from nigeria demographic and health survey (2003 – 2013). PLoS ONE 14. https://doi.org/10.1371/journal.pone.0211883

[2] BANK U (2023) Levels and trends in child malnutrition: Unicef / who / world bank group joint child malnutrition estimates key findings of the 2023 edition. URL https://www.who.int/publications/i/item/9789240073791

[3] Bhavnani R, Schlager N, Donnay K, et al (2023) Household behavior and vulnerability to acute malnutrition in kenya. Humanities and Social Sciences Communications 10. https://doi.org/10.1057/s41599-023-01547-8

[4] Bloom DE, Canning D, Sevilla J (2004) The effect of health on economic growth: A production function approach. World Development 32. https://doi.org/10.1016/j.worlddev.2003.07.002

[5] Ettner SL (1996) New evidence on the relationship between income and health. Journal of Health Economics 15. https://doi.org/10.1016/0167-6296(95)00032-1

[6] Farah AM, Endris BS, Gebreyesus SH (2019) Maternal undernutrition as proxy indicators of their offspring's undernutrition: Evidence from 2011 ethiopia demographic and health survey. BMC Nutrition 5. https://doi.org/10.1186/s40795-019-0281-z

[7] Group IE (2022) Global nutrition report — country nutrition profiles - global nutrition report. https://globalnutritionreport.org/resources/nutrition-profiles/africa/eastern-africa/, [Internet]. [cited 2023 Sep 5]

[8] Group IE (2022) Global nutrition report | country nutrition profiles - global nutrition report. URL https://globalnutritionreport.org/resources/nutrition-profiles/asia/south-eastern-asia/indonesia/

[9] Haddad L, Achadi E, Bendech MA, et al (2015) The global nutrition report 2014: Actions and accountability to accelerate the world's progress on nutrition. Journal of Nutrition 145. https://doi.org/10.3945/jn.114.206078

[10] Hoddinott J, Alderman H, Behrman JR, et al (2013) The economic rationale for investing in stunting reduction. Maternal and Child Nutrition 9. https://doi.org/10.1111/mcn.12080

[11] Jonah CMP, Sambu WC, May JD (2018) A comparative analysis of socioeconomic inequities in stunting: a case of three middle-income African countries. Archives of Public Health 76(1):77. https://doi.org/10.1186/s13690-018-0320-2

[12] Kar BR, Rao SL, Chandramouli BA (2008) Cognitive development in children with chronic protein energy malnutrition. Behavioral and Brain Functions 4(1):31. https://doi.org/10.1186/1744-9081-4-31

[13] Kien VD, Lee HY, Nam YS, et al (2016) Trends in socioeconomic inequalities in child malnutrition in Vietnam: findings from the Multiple Indicator Cluster Surveys, 2000–2011. Global Health Action 9(1):29263. https://doi.org/10.3402/gha.v9.29263

[14] KNBS, ICF (2023) Kenya demographic and health survey 2022. key indicators report. Tech. rep., KNBS and ICF, Nairobi, Kenya, and Rockville, Maryland,

USA

[15] Marmot M (2002) The influence of income on health: Views of an epidemiologist. Health Affairs 21. https://doi.org/10.1377/hlthaff.21.2.31

[16] Mendez MA, Adair LS (1999) Severity and timing of stunting in the first two years of life affect performance on cognitive tests in late childhood. The Journal of Nutrition 129(8):1555–1562. https://doi.org/10.1093/jn/129.8.1555

[17] O'Donnell O, van Doorslaer E, Wagstaff A, et al (2008) Analyzing health equity using household survey data : a guide to techniques and their implementation. Washington, DC: World Bank, https://doi.org/10.1596/978-0-8213-6933-3

[18] de Onis M, Branca F (2016) Childhood stunting: A global perspective. Maternal and Child Nutrition 12. https://doi.org/10.1111/mcn.12231

[19] Organization WH (2010) Nutrition landscape information system (nlis) country profile indicators: interpretation guide. http://www.who.int/nutrition/nlis_interpretationguide_isbn9789241599955/en/, accessed: 2023-09-07

[20] Pelletier DL, Frongillo EA (2003) Changes in child survival are strongly associated with changes in malnutrition in developing countries. Journal of Nutrition 133. https://doi.org/10.1093/jn/133.1.107

[21] Pelletier DL, Frongillo EA, Schroeder DG, et al (1995) The effects of malnutrition on child mortality in developing countries. Bulletin of the World Health Organization 73(4):443

[22] Rabbani A, Khan A, Yusuf S, et al (2016) Trends and determinants of inequities in childhood stunting in Bangladesh from 1996/7 to 2014. International Journal for Equity in Health 15(1):186. https://doi.org/10.1186/s12939-016-0477-7

[23] Ranis G, Stewart F, Ramirez A (2000) Economic growth and human development. World Development 28. https://doi.org/10.1016/S0305-750X(99)00131-X

[24] Rice AL, Sacco L, Hyder A, et al (2000) Malnutrition as an underlying cause of childhood deaths associated with infectious diseases in developing countries. Bulletin of the World Health Organization 78(10):1207–1221

[25] Stratton RJ, Green CJ, Elia M (eds) (2003) Disease-related malnutrition: an evidence-based approach to treatment. CABI, Wallingford, https://doi.org/10.1079/9780851996486.0000

[26] USAID (2018) Kenya: Nutrition profile. in: Kenya nutrition profile. Tech. rep., URL https://www.usaid.gov/sites/default/files/documents/1864/Kenya-Nutrition-Profile-Mar2018-508.pdf, cited 12 Feb 2021

[27] Victora CG, Adair L, Fall C, et al (2008) Maternal and child undernutrition: consequences for adult health and human capital. The Lancet 371(9609):340–357. https://doi.org/10.1016/S0140-6736(07)61692-4

[28] Wagstaff A, van Doorslaer E (2000) Chapter 34 Equity in health care finance and delivery. https://doi.org/10.1016/S1574-0064(00)80047-5

[29] Wagstaff A, Paci P, van Doorslaer E (1991) On the measurement of inequalities in health. Social Science and Medicine 33. https://doi.org/10.1016/0277-9536(91)90212-U

[30] Wagstaff A, Doorslaer EV, Watanabe N (2003) On decomposing the causes of health sector inequalities with an application to malnutrition inequalities in vietnam. Journal of Econometrics 112. https://doi.org/10.1016/S0304-4076(02)00161-6

[31] Walker SP, Chang SM, Wright A, et al (2015) Early childhood stunting is associated with lower developmental levels in the subsequent generation of children ,. The Journal of Nutrition 145(4):823–828. https://doi.org/10.3945/jn.114.200261

[32] Zere E, McIntyre D (2003) Inequities in under-five child malnutrition in south africa. International Journal for Equity in Health 2. https://doi.org/10.1186/1475-9276-2-7

Table 4 Determinants of under five child malnutrition, KDHS 2014 – 2022

	Stunted (HAZ<-2SD)		**Underweight** (WAZ<-2SD)		**Wasted** (WHZ<-2SD)	
	AOR 95% CI	*p*	**AOR 95% CI**	*p*	**AOR 95% CI**	*p*
Year 2014	1.04 (0.90 - 1.19)	0.60	0.74 (0.63 - 0.88)	0.00	0.71 (0.56 - 0.91)	0.01
Child age (months)	1.01 (1.01 - 1.02)	0.00	1.01 (1.00 - 1.01)	0.00	0.99 (0.98 - 0.99)	0.00
Birth interval	0.99 (0.99 - 1.00)	0.00	0.99 (0.99 - 1.00)	0.00	0.93 (0.87 - 1.00)	0.04
Birth order number	1.05 (1.01 - 1.10)	0.01	0.96 (0.91 - 1.00)	0.07	0.99 (0.98 - 0.99)	0.00
Childs sex						
Male	1.45 (1.30 - 1.62)	0.00	1.35 (1.17 - 1.55)	0.00	1.22 (1.00 - 1.48)	0.05
Female	ref		ref		ref	
Delivery place						
Home	ref		ref		ref	
Public	0.81 (0.70 - 0.94)	0.01	0.67 (0.56 - 0.81)	0.00	0.71 (0.54 - 0.94)	0.02
Private	0.85 (0.69 - 1.06)	0.15	0.67 (0.50 - 0.89)	0.01	0.75 (0.50 - 1.14)	0.18
Other	1.18 (0.72 - 1.93)	0.50	1.19 (0.63 - 2.25)	0.59	1.96 (0.79 - 4.87)	0.15
Residence						
Urban	0.88 (0.74 - 1.03)	0.11	0.79 (0.64 - 0.99)	0.04	1.01 (0.76 - 1.34)	0.96
Rural	ref		ref		ref	
Religion						
Catholic	0.42 (0.31 - 0.58)	0.00	0.54 (0.38 - 0.78)	0.00	0.39 (0.26 - 0.59)	0.00
Protestant	0.47 (0.35 - 0.63)	0.00	0.53 (0.38 - 0.73)	0.00	0.48 (0.33 - 0.71)	0.00
Muslim	0.35 (0.24 - 0.51)	0.00	0.34 (0.22 - 0.53)	0.00	0.41 (0.24 - 0.69)	0.00
Other	0.47 (0.26 - 0.83)	0.01	0.59 (0.31 - 1.13)	0.11	0.54 (0.24 - 1.20)	0.13
Atheist	ref		ref		ref	
Economic status						
Poorest	1.67 (1.24 - 2.26)	0.00	1.08 (0.74 - 1.56)	0.69	0.90 (0.58 - 1.42)	0.66
Poorer	1.46 (1.08 - 1.98)	0.01	0.80 (0.56 - 1.16)	0.24	0.51 (0.31 - 0.82)	0.01
Middle	1.32 (0.98 - 1.79)	0.07	0.85 (0.59 - 1.23)	0.39	1.05 (0.65 - 1.69)	0.85
Richer	1.23 (0.91 - 1.66)	0.07	0.76 (0.53 - 1.11)	0.16	0.85 (0.55 - 1.31)	0.46
Richest	ref		ref		ref	
Mothers education						
None	ref		ref		ref	
Primary	1.12 (0.92 - 1.37)	0.27	0.82 (0.65 - 1.03)	0.08	0.61 (0.45 - 0.83)	0.00
Higher	0.81 (0.64 - 1.04)	0.10	0.46 (0.34 - 0.63)	0.00	0.42 (0.27 - 0.65)	0.00
Mother's age (years)						
Under 24	ref		ref		ref	
25 - 34	0.78 (0.66 - 0.93)	0.00	1.34 (1.08 - 1.66)	0.01	1.25 (0.94 - 1.66)	0.13
35+	0.65 (0.50 - 0.84)	0.00	1.49 (1.08 - 2.05)	0.00	1.60 (1.04 - 2.46)	0.03
Mother employed						
No	ref		ref		ref	
Yes	1.06 (0.93 - 1.21)	0.37	1.02 (0.87 - 1.21)	0.80	0.91 (0.72 - 1.15)	0.44
Fathers education						
None	ref		ref		ref	
Primary	0.91 (0.75 - 1.11)	0.36	0.67 (0.53 - 0.85)	0.00	0.64 (0.46 - 0.89)	0.01
Higher	0.75 (0.59 - 0.94)	0.01	0.65 (0.49 - 0.86)	0.00	0.64 (0.43 - 0.96)	0.03
Region						
Coast	0.62 (0.41 - 0.93)	0.02	0.85 (0.54 - 1.33)	0.48	0.70 (0.39 - 1.26)	0.23
N.eastern	0.34 (0.22 - 0.55)	0.00	0.82 (0.52 - 1.29)	0.38	1.29 (0.71 - 2.36)	0.40
Eastern	0.62 (0.42 - 0.91)	0.01	0.87 (0.58 - 1.29)	0.49	0.98 (0.56 - 1.70)	0.93
Central	0.48 (0.31 - 0.74)	0.00	0.58 (0.36 - 0.96)	0.03	0.48 (0.23 - 1.00)	0.05
R. Valley	0.51 (0.35 - 0.74)	0.00	0.79 (0.54 - 1.15)	0.21	0.84 (0.50 - 1.40)	0.50
Western	0.39 (0.26 - 0.59)	0.00	0.48 (0.30 - 0.76)	0.00	0.42 (0.21 - 0.82)	0.01
Nyanza	0.36 (0.24 - 0.54)	0.00	0.52 (0.34 - 0.79)	0.00	0.45 (0.25 - 0.83)	0.01
Nairobi	ref		ref		ref	

Table 5 Decomposition of the concentration indices and contributions of determinants of under five child stunting and underweight, 2014 and 2022

	Stunting				**Underweight**			
	2014		**2022**		**2014**		**2022**	
	CI	% Contribution	CI	% Contribution	CI	% Contribution	CI	% Contribution
Childs sex	-0.002	-0.003	-0.003	-0.005	-0.003	-0.005	-0.003	-0.004
Residence	-0.540	-0.332	-0.617	-0.634	-0.617	-0.636	-0.617	-0.636
Religion	-0.050	-0.007	-0.019	-0.001	-0.020	-0.018	-0.020	-0.018
Mothers education	0.390	0.226	0.449	-0.165	0.449	0.589	0.449	0.589
Mothers age (years)	-0.012	-0.012	0.040	0.011	0.040	-0.011	0.040	-0.011
Mothers work	0.078	-0.021	0.180	-0.021	0.180	0.005	0.180	0.005
Fathers education	0.404	-0.006	0.494	0.275	0.494	0.390	0.494	0.390
Delivery place	0.332	0.046	0.181	-0.051	0.181	0.003	0.181	0.003
Region	0.131	0.034	0.122	0.088	0.122	0.084	0.122	-0.026
Birth interval (months)	0.110	0.078	0.098	0.069	-0.216	0.068	0.098	0.068
Birth order number	-0.154	0.163	-0.144	0.057	-0.144	-0.029	-0.144	-0.029
Childs age (months)	0.003	-0.003	-0.002	0.006	-0.002	0.003	-0.002	0.003
Wealth index	0.677	0.896	0.693	1.744	0.693	0.969	0.693	0.969