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

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Abstract

Background: Child malnutrition remains a critical public health issue, with socioeconomic factors playing a significant role. Despite overall progress in reducing under-five child malnutrition in Kenya, disparities persist. This paper explores trends, determinants, contributions of these factors to health inequality, and their clinical utility as diagnostic tests for chronic under-five child malnutrition.

Methods: We used data from the Kenya Demographic and Health Survey (2014 – 2022) and analyzed malnutrition using three indicators: stunting, underweight, and wasting. Malnutrition determinants were analyzed using multivariable logistic regression. Trends in socioeconomic inequality were analyzed using concentration indices. Wagstaff decomposition was used to explore the contributions of determinants of child malnutrition. Diagnostic utility was investigated using sensitivity, specificity, predictive values, and area under the ROC curve.

Results: Socioeconomic inequality in under-five child malnutrition increased between 2014 and 2022 despite an overall decrease in prevalence. Children from the poorest (AOR = 1.67; 95% Confidence Interval [CI]: 1.24 – 2.26) and poorer (AOR = 1.46; 95%CI: 1.08 – 1.98) socioeconomic quintiles are disproportionately affected by stunting. A child's age (in months) (AOR = 1.01; 95%CI: 1.01 – 1.02), birth order number (AOR = 1.05; 95%CI: 1.01 – 1.10), and gender (male) (AOR = 1.45; 95%CI: 1.30 – 1.62) were also significantly associated with increased odds of stunting. Socioeconomic inequality was the largest contributing factor to health inequality. Sensitivity, specificity, and AUC values were 67.4% (95% CI:

66.4% – 68.4%), 50.6% (95%CI: 50.0% - 51.1%), and 0.59 (95%CI: 0.58 – 0.60), respectively when using socioeconomic status as a screening tool for stunting.
Conclusion: Socioeconomic disparities remain a barrier despite strides in reducing child malnutrition in Kenya. Targeted interventions addressing these disparities are essential for sustainable improvements in child health. Our findings underscore the importance of integrating socioeconomic factors into public health strategies to combat child malnutrition effectively.

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

1 Introduction

Child Malnutrition remains a dominant public health challenge globally. In 2022 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 [4]. 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 [4].

In East Africa, stunting prevalence (32.6%) was higher than the global average (22.3%), whereas wasting and overweight were 5.2% and 4.0%, respectively [11]. 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 [12].

In the first half of 2022, Kenya reported about 942,000 cases of acute malnutrition among children between 6 and 59 months [5]. According to the 2022 Kenya Demographic and Health Survey (KDHS) [22], 18% of children under five 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 [47].

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" [46]. This has been attributed to several diverse interlinked factors with detrimental short and long-term effects [35, 36]. 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 [17, 19, 29, 39, 42, 48, 52].

Stunting, underweight, and wasting remain the recommended indicators of malnutrition [17]. 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 [17]. In children under 5 years, stunting is the most significant measure of overall health and well-being capable of highlighting salient social disparities [32]. 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 [16, 54].

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 [17]. 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 [6, 41]. Improved living standards following economic advancement are expected to translate into improved nutritional consequences for children and adults [8, 25]. 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 [1, 17]. 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. First, we examine trends in stunting, underweight, and wasting across socioeconomic groups, geography, and selected household, child, maternal, and paternal characteristics. Second, we explore determinants of child malnutrition and employ standard procedures of inequality analysis to quantify their contributions to health inequality in Kenya. Finally, we examine the independent clinical utility of household socioeconomic status and significant child characteristics in acute malnutrition screening. The current study uses 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. We provide evidence to inform the design of competent public health strategies and targeted interventions for curbing under-five child malnutrition and provide a profound understanding of socioeconomic inequality and child well-being.

2 Methods

2.1 Study data

We utilized data from the 2014 and 2022 Kenya Demographic and Health Surveys (KDHS) (standard DHS). These surveys adopt a two-stage stratified cluster sampling approach with clusters sampled in the first stage and households at the second stage. 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 [21, 22]. 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) [17, 20]. 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 [17].

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 [33].

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 [20].

2.2.2 Covariates

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 religion and socioeconomic status. Maternal indicators were age, education level, and birth interval whereas paternal education was considered as a paternal characteristic. Our choice of these covariates is grounded in existing literature and availability in our data set [9, 17, 20].

2.3 Statistical analysis

2.3.1 Weighted prevalence of child malnutrition

The weighted prevalence of stunting, underweight, and wasting was estimated in relation to maternal, child, and household characteristics. Overall differences across categories were examined using a design-based Pearson chi-squared test whereas the significance of differences in group means was analyzed using two-sample t-tests for continuous variables. The significance of the differences in trends in child malnutrition by socioeconomic status between 2014 and 2022 was similarly analyzed using two-sample proportion tests.

2.3.2 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 [31, 49, 50]. Concentration indices quantify 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. [31]:

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

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 whereas positive values suggest a higher concentration of inequity among the richest socioeconomic group [3, 17, 20, 49].

2.3.3 Analysis of determinants of child malnutrition and utility in screening for child stunting

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 malnutrition indicators and explanatory variables in 2.2.2. Results from the fitted logistic regression models were used in evaluating the clinical utility of each significant determinant of under-five child stunting. Our analyses here focus on this indicator since it suggests chronic malnutrition [17].

We estimated the diagnostic performance of a household's socioeconomic status and child characteristics, which we found to significantly impact under-five child stunting, including age, gender, and birth order. These factors were each used to independently predict a child's nutritional status (stunting) and compute sensitivity, specificity, predictive values, and area under the receiver operating characteristic curve (AUC). We leveraged the `diagti` command in STATA [44]. Stunting had a 22.7% (95%CI: 22.3% - 23.1%) prevalence in this dataset, suggesting a classification problem with an imbalanced data set. Evaluating the clinical utility of these risk factors would result in highly optimistic results characterized by a high hit ratio but poor explanatory capabilities.

Most classifiers rely on threshold scores to generate predictions, which greatly impacts the trade-off between positive and negative errors [38]. We used threshold-moving, a technique for training a cost-sensitive classifier. We adjusted the decision threshold to accurately predict the minority class and address class imbalance by setting the optimal threshold based on a random search maximizing the AUC [15]. The choice of the AUC as a performance metric was informed by its insensitivity to changes in class distribution. An AUC of 0.5 suggests limited discriminatory ability of a test that is no better than random guessing. Values between 0.7 to 0.8 are acceptable, 0.8 to 0.9 are excellent whereas those above 0.9 are considered exceptional [10, 24].

2.3.4 Decomposition of socioeconomic inequities in child malnutrition

Contributions of determinants of malnutrition in children under five to the observed socioeconomic disparities were examined through a decomposition analysis. This decomposition was restricted to stunting and underweight, indicators that exhibited substantial differences between 2014 and 2022.

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 and ϵ is the error term.

In terms of the CI for the response y, (2) becomes:

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

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 $\big((\beta_k \bar{X}_k)/\mu) CI_k\big)$ and the unexplained component (GCI_ϵ/μ). $(\beta_k \bar{X}_k)/\mu$ is the elasticity denoting the effect of each $CI_k $ on the overall CI of the outcome variable, y. We employed the Wagstaff normalization technique for CI values given our use of binary outcomes (the CI bounds would otherwise not be between -1 and +1) [49, 51].

3 Results

3.1 Weighted prevalence of child malnutrition

Table 1 highlights the weighted prevalence of under-five child malnutrition by selected child, household, maternal, and paternal characteristics grouped by the survey year (2014 - 2022). The sample size for the 2014 KDHS was n = 18702 (53%) and for the 2022 KDHS was n = 16883 (47%). In 2014, 26% (n = 4466) of children were found to be stunted, 11% (n = 1841) were underweight, and 4% (n = 701) were wasted. In contrast, the percentage of stunted children decreased to 18% (n = 2665) in 2022, while underweight and wasting decreased to 10% (n = 1543) and 5% (n = 752), respectively. The analyzed sample consisted of 51% male and 49% female children.

In 2014, the prevalence of stunting, underweight, and wasting was significantly higher among older male children delivered at home in rural areas, in households with the poorest socioeconomic status, and identifying as Protestant ($p < 0.05$). Most stunted children in this year were born to mothers between 25 and 34 years of age, with at most a primary school education ($p < 0.05$). We did not find evidence of a significant association between maternal age, employment status and child stunting ($p > 0.05$). In 2022, stunting prevalence remained similar, except that it was higher among children delivered in public hospitals.

The prevalence of child underweight or wasting was also higher among older male children who were delivered in protestant rural households with the poorest socio-economic status ($p < 0.05$). These children were mostly born to parents with at most primary education in the Rift Valley region ($p < 0.05$). Similar patterns in the prevalence of underweight and wasting were observed in 2022, except that most of these cases were deliveries in hospitals within the public sector.

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		30.8 (0.7)	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		43.1 (1.5)	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 (0.1)	0.00		3.5 (0.1)	0.00		3.5 (0.09)	
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**
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

Table 2 summarizes the prevalence of child malnutrition by the household socioeconomic status between 2014 and 2022. Stunting and underweight decreased substantially during this period. The absolute reduction was 9.1 and 1.7% for stunting and wasting, respectively. Underweight prevalence showed the smallest decline between 2014 and 2022 (0.6%). A more detailed examination revealed a substantial decline in underweight only in the poorest socioeconomic status quintile compared to stunting, where significant reductions occurred across all the socioeconomic status groups.

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. The CIs of stunting and underweight were significantly different from 0 between 2014 and 2022 ($p < 0.05$), whereas wasting did not show a significant difference during this period ($p > 0.05$). All differences in CIs were negative, suggesting that children from the poorest socioeconomic groups are more likely to be stunted, underweight, or wasted relative to those from the richest households. Additionally, absolute values of the CIs of stunting and underweight in 2022 were higher than in 2014, suggesting that inequalities in under-five child underweight and stunting increased during this period. On the other hand, the CI for wasting in 2022 was lower relative to 2014, suggesting that the inequality in child wasting declined during this period. The difference in the CI for wasting between 2014 and 2022 was, however, not significant ($p > 0.05$).

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 multiple logistic regression. Results are based on analysis of the aggregate 2014 and 2022 KDHS datasets. We found that a child's age

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.

(in months) (AOR = 1.01; 95%CI: 1.01 – 1.02), birth order number (AOR = 1.05; 95%CI: 1.01 – 1.10), gender (male vs female) (AOR = 1.45; 95%CI: 1.30 – 1.62), and household's socioeconomic status were significantly associated with increased odds of stunting. The odds of stunting were substantially higher for children from households in the poorest (AOR = 1.67; 95%CI: 1.24 – 2.26) and poorer (AOR = 1.46; 95%CI: 1.08 – 1.98) socioeconomic quintiles relative to children from households in the wealthiest socioeconomic status group.

Additionally, we found that the risk of underweight and wasting varied depending on the child's sex and mother's age. Male children were more likely to be underweight (AOR = 1.35; 95%CI: 1.17 – 1.55) and wasted (AOR = 1.22; 95%CI: 1.00 – 1.48) than female children. Similarly, children born to mothers aged above 35 years were more likely to be underweight (AOR = 1.49; 95%CI: 1.08 – 2.05) and wasted (AOR = 1.60; 95%CI: 1.04 – 2.46). On the other hand, older children were more likely to be underweight than younger children (AOR = 1.01; 95%CI: 1.00 – 1.01).

Table 5 summarizes the results based on screening for child stunting using a household's socioeconomic status, child's age, gender, and birth order, respectively. The sensitivity of a household's socioeconomic status as a diagnostic tool for under-five child malnutrition was 67.4% (95% CI: 66.4% – 68.4%), whereas the specificity was 50.6% (95%CI: 50.0% - 51.1%). The ability of a household's socioeconomic status to discriminate between stunted and non-stunted children was above random guessing (AUC = 0.59; 95%CI: 0.58 – 0.60). On the other hand, the sensitivity, specificity, and AUC values based on screening using the child's age were 49.6% (95%CI: 48.5% - 50.7%), 52.6% (95%CI: 52.0% - 53.2%), and 0.51 (95%CI: 0.50 – 0.52), respectively. On the other hand, sensitivity and specificity values based on screening for under-five child stunting using the child's gender and age were 57.0% (95%CI: 55.9% – 58.0%), 51.2% (95%CI: 50.6% - 51.8%) and 44.9% (95%CI: 43.8% - 46.0%), 63.8% (95%CI: 63.2% - 64.3%). The discriminatory ability based on using the child's age was limited (AUC = 0.51; 95%CI: 0.50 – 0.52), whereas that based on using gender (AUC = 0.54; 95%CI: 0.53 – 0.55) and birth order (AUC = 0.54; 95%CI: 0.54 – 0.55) was slightly above average.

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	
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 Results based on screening for child stunting using a household's socioeconomic status (SES), child's age, gender, and birth order number

Variable	Metric	95% Confidence Interval (CI)
Household SES		
	Sensitivity	67.4 (66.4 - 68.4)
	Specificity	50.6 (50.0 - 51.1)
	AUC	0.59 (0.58 - 0.60)
	NPV	84.1 (83.5 - 84.6)
	PPV	28.6 (28.0 - 29.2)
Child's age		
	Sensitivity	49.6 (48.5 - 50.7)
	Specificity	52.6 (52.0 - 53.2)
	AUC	0.51 (0.50 - 0.52)
	NPV	78.0 (77.4 - 78.6)
	PPV	23.5 (22.9 - 24.2)
Child's gender		
	Sensitivity	57.0 (55.9 - 58.0)
	Specificity	51.2 (50.6 - 51.8)
	AUC	0.54 (0.53 - 0.55)
	NPV	80.2 (79.6 - 80.8)
	PPV	25.5 (24.9 - 26.2)
Birth order number		
	Sensitivity	44.9 (43.8 - 46.0)
	Specificity	63.8 (63.2 - 64.3)
	AUC	0.54 (0.54 - 0.55)
	NPV	79.8 (79.2 - 80.3)
	PPV	26.7 (26.0 - 27.5)

Note:

SES: Socioeconomic status

AUC: Are under the curve

NPV: Negative predictive value

PPV: Positive predictive value.

3.4 Decomposition of the concentration indices for stunting and underweight

In Table 6 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. We decomposed the CIs of stunting and underweight which differed significantly between 2014 and 2022. The percentage contribution of variables in the Wagstaff decomposition represents the contribution of the variable to the overall health inequality. Negative values of this quantity suggest the variable contributes to reductions in overall inequality in child malnutrition.

A household's socioeconomic status (0.89), maternal education (0.22), and birth order number (0.16) contributed the most toward the observed disparities in child stunting in 2014. The contribution of a household's socioeconomic status increased to 1.7 in 2022, whereas that of a child's birth order number decreased to 0.06. The contribution of maternal education to inequality in child stunting disappeared in 2022.

In both 2014 and 2022, socioeconomic status (0.96), maternal education (0.58), and paternal education (0.39) were the largest contributors to disparities in child underweight. Socioeconomic status is a substantial factor contributing toward inequality in under-five children stunted and underweight.

4 Discussion

Nutrition remains a well-known health measure for children under five years old. In the current study, we investigated the trends of socioeconomic inequalities in child malnutrition, determinants, the utility of these determinants in child malnutrition screening, and the overall contributions of these determinants to disparities in child malnutrition in Kenya. Our findings indicate decreases in the prevalence of all three forms of child malnutrition across the periods examined. Stunting, the most common of child malnutrition indicators, recorded the highest decline (8%) between 2014 and 2022. Analyses by sex of the child revealed a consistently higher prevalence of all three indicators among male children compared to females. We found the highest burden of child malnutrition to be in rural areas despite reports of increases in poverty levels in urban areas [45].

The prevalence of child malnutrition was higher in children from impoverished households and reduced substantially as the socioeconomic status improved from the poorest to the wealthiest. The improvements in nutrition status from the poor to the rich can be explained to be the result of improvements in purchasing power and access to food and quality healthcare [2]. Concentration indices (in absolute values) for stunting and underweight increased significantly between 2014 and 2022 for stunting and underweight, suggesting that socioeconomic disparities in these malnutrition indicators worsened between these years. These analyses revealed a disproportionate effect of socioeconomic inequality on child malnutrition, where children from poor economic groups are disadvantaged relative to those from the wealthiest economic groups. Even though the overall under-five child malnutrition declined between 2014 and 2022, the inequalities persisted. This result aligns with previous studies where a disconnect has been reported between economic endowment and the distribution of these rewards between economic groups [17, 18, 28].

Our analyses of determinants of under-five child malnutrition revealed the child's age, birth order number, gender, and household's socioeconomic status as significant factors associated with an increased risk of child stunting. These findings conform with those found in previous studies in low and middle-income countries [2, 3, 17, 18, 20, 39]. Birth order has been implicated as a significant predictor of child stunting, with higher-order children (>fifth order) being more likely to be stunted due to less attention and care from their parents [40]. Additionally, with births spaced in quick succession, high-order children are likely to receive limited lacteal feeding, a factor that predisposes them to malnutrition [13]. The effect of age can be explained similarly. We explain the higher risk of stunted growth among male children to be partly the result of their faster growth rate, which increases their susceptibility to stunted growth when malnourished, higher biological fragility [23] and preferential treatment of the female child [9, 53].

Table 6 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

The socioeconomic status of a household is a substantial factor in determining the nutritional status of children and the inequality in under-five child malnutrition. A similar result on the contribution of socioeconomic status of a household to disparities in under-five child malnutrition has been reported elsewhere in low and middle-income countries [20]. The contribution of this factor appeared to increase in 2022 relative to 2014. The nutritional status of the Kenyan population has improved as part of the standard development goals. However, the rapid population growth recorded over the years has yet to be at par with the rate of growth of the economy. The result has been that a more significant subset of the population has remained in poverty [31].

Consequently, the disparities in the population's economic status have worked to reduce access to essential services for people with low incomes. While the rich have access to high-quality education, healthcare, and food, the poor struggle to meet their basic needs [26, 27, 34]. With limited finances, a household's ability to afford a stable supply of food is significantly reduced, the effects of which include adverse effects on child growth and cognitive development [7, 14, 30, 37, 43].

Stunting remains a significant indicator of child stunting. In assessing the nutritional status of children, anthropometric data −weight-for-height, height-for-age, and weight-for-age − are often collected. These data are often prone to random error due to the complexities involved in their collection in younger children [9]. We explored the clinical utility of a household's socioeconomic status, child's gender, age, and birth order as diagnostic factors for child stunting. We found that the ability of a household's socioeconomic status to distinguish stunted from non-stunted children was higher than that of age, gender, and birth order, with a 67% sensitivity. We allude this performance to the significance of socioeconomic status in determining child health outcomes.

Findings presented in this investigation bear a lot of merits. First, we used nationally representative population-based survey data to examine the socioeconomic disparities in child malnutrition and provide crucial insight into the design of strategies to curb this inequality. These data present the advantage of relatively large sample sizes and commendable response rates ($> 90\%$).

Second, we found that socioeconomic disparities in under-five child malnutrition have substantially increased since 2014, even though the overall prevalence of child malnutrition waned. This has been partly due to commendable improvements in health status and changes in income and lifestyle, among other factors [20]. While the country has experienced economic growth, our findings suggest a disconnect between this growth and the distribution of wealth in the general population, with poor households disproportionately affected. Consequently, inequality in under-five child malnutrition has worsened even though the overall health indicators have improved.

Third, we decomposed the concentration indices of each determinant of under-five child malnutrition to decipher the nature of their contribution to the observed socioeconomic disparities in stunting and underweight. Our results thus break ground and foster knowledge on causes and variations in under-five child malnutrition prevalence by income groups. Fourth, we further explored the utility of significant malnutrition-related factors as screening tests for chronic malnutrition and found some potential for socioeconomic status.

The results from this investigation provide pivotal insights for public health policy and practice. For instance, we found a household's socioeconomic status to be the largest contributor to health inequality, with children from poor households being the most vulnerable. These findings will enable public health policymakers to strategically target socioeconomic differences to develop effective and thorough childhood nutrition interventions through policies that improve outcomes for children from poor households while bridging the gap between rural and urban development through equitable distribution of resources.

Furthermore, the public health sector can adopt strategies including the provision of easily accessible medical care, improved sanitation, and provision of clean drinking water. The government should consider strategies to reduce migration of people from rural areas to urban areas through job creation schemes in rural areas, providing child support to households in poverty, diversifying source of livelihoods for people in rural areas through provisions of viable alternatives such as commerce, provision of unemployment benefits as well as taking insurance for the agricultural sector to enhance food security and enhance equity.

The following limitations should be considered while interpreting the findings of this study. First, due to reliance on cross-sectional study data, our findings cannot be construed as suggesting a causal relationship between socioeconomic indices and child malnutrition. Second, residence was classified as either urban or rural. Classifying this variable into these two localities might pose a problem following the heterogeneity associated with large cities and the unavailability of data to quantify these dissimilarities. Third, our analysis adjusted for potentially confounding variables which did not have substantial missingness and might not include all possible confounders. However, our employment of standard statistical practices and the included covariates allow for a robust analysis of the scope of the problem.

5 Conclusion

Understanding the nature of under-five child malnutrition and its variations by socioeconomic quintiles is crucial in the design of strategies that target individuals who are most affected by malnutrition and in keeping the existing disparities under check. Socioeconomic inequality in under-five child malnutrition increased between 2014 and 2022 despite an overall decrease in prevalence, with children from poor households disproportionately affected. These inequalities are fueled by differences in endowments, a significant proportion of which is held by the household's socioeconomic status. Our exploration of the utility of a child's age, gender, birth order number, and household's socioeconomic status as a diagnostic tool for under-five child stunting showed some potential for a household's socioeconomic status. Despite the economic growth Kenya has experienced in the recent past, there is a disconnect between this growth and income distribution between social classes. Efforts to tackle inequalities in under-five child malnutrition should target reducing the perceived differences in endowments between the rich and poor. The Kenyan government should enhance poor households' access to food, education, and essential resources.

Declarations

- Ethics approval and consent to participate

  Not applicable

- Consent for publication

  Not applicable

- Availability of data and materials

  All data pertaining to the study are available from the Demographic and Health Survey at https://dhsprogram.com/data/ upon reasonable request.

- Competing interests

  The authors have no competing interests to declare.

- Funding

  Not applicable

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