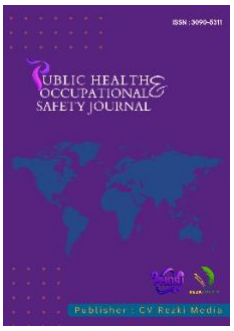

Maternal education and child stunting in Kenya: The role of socio-economic confounding using DHS 2022 data

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ABSTRACT

Background: Child stunting remains a major public health challenge in Kenya, reflecting long-term nutritional deprivation and socioeconomic inequalities. Although maternal education is widely considered protective, its independent effect is often unclear due to confounding by structural factors.

Objectives: To examine the association between maternal education and child stunting among children under five in Kenya and to assess the extent of confounding and effect modification by key sociodemographic factors.

Methods: A cross-sectional analytical study was conducted using data from the 2022 Kenya Demographic and Health Survey (KDHS). The sample included 19,530 children aged 0–59 months. Stunting was defined using height-for-age z-scores (<-2 SD). Descriptive, bivariate, stratified, and multivariable logistic regression analyses were performed, accounting for the complex survey design.

Results: Stunting prevalence was 18.2%. Stunting decreased with increasing maternal education, from 21.4–21.7% among children of mothers with no or primary education to 8.7% among those with higher education ($\chi^2 = 238$, $p < 0.001$). However, the association was weak (Cramer's V = 0.117) and attenuated after adjustment for socioeconomic factors. Household wealth was the strongest predictor, with children in the richest households having significantly lower odds of stunting than those in the poorest households (AOR = 0.268; 95% CI: 0.222–0.323; $p < 0.001$). Stunting risk increased with age, particularly among children aged 6–23 months, while females had lower odds than males (OR = 0.717; 95% CI: 0.662–0.776). Stratified analyses showed stronger protective effects of maternal education among older children. In contrast, variation across wealth groups should be interpreted cautiously, given inconsistent and non-significant findings in some strata. No meaningful effect modification by child sex was identified.

Conclusions: Child stunting in Kenya is primarily driven by structural socioeconomic factors. While maternal education is associated with reduced stunting, its effect is highly context dependent. Addressing poverty and inequality is essential for effective and equitable reductions in child stunting.

Keywords: malnutrition, maternal education, public health, stunting, underweight, wasting.

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INTRODUCTION

Child malnutrition remains one of the most persistent public health and development challenges globally, particularly in low- and middle-income countries. Despite progress in recent decades, undernutrition continues to contribute significantly to child morbidity and mortality, impaired cognitive development, and reduced economic productivity across the life course (Akombi et al., 2019; Amalia et al., 2025; Pramesti et al., 2025). Stunting, defined as a height-for-age z-score (HAZ) below -2 standard deviations (SD) from the World Health Organization (WHO) Child Growth Standards (CGS), is a key indicator of chronic undernutrition (WHO, 2025). Unlike acute forms of malnutrition, stunting represents long-term growth failure arising from persistent inadequate nutrition, recurrent illness, and unfavorable environmental conditions. It is widely used as an indicator of chronic deprivation and underlying social and economic inequalities (Raiten & Bremer, 2020).

Stunted children are more likely to experience delayed cognitive development, reduced school performance, and lower economic productivity in adulthood. At the population level, high rates of stunting reduce human capital and hinder national development. Emerging evidence further suggests that early-life undernutrition is associated with increased risk of non-communicable diseases later in life (Dewey & Begum, 2011). According to recent global estimates, approximately 22% of children under five years are stunted (United Nations Children's Fund et al., 2023).

In Kenya, undernutrition remains a critical concern. With a population of over 7.2 million children under five years (Kenya National Bureau of Statistics, 2019), the under-five mortality rate is approximately 41 deaths per 1,000 live births, and malnutrition contributes to nearly half of all under-five deaths (UNICEF, 2026). Over 18% of children under five are chronically stunted, with rates reaching 46% in regions such as Kitui and West Pokot (IPC, 2024).

Drought, poverty, and poor feeding practices drive high rates of malnutrition, especially in arid areas, while urban areas face rising malnutrition due to processed diets. Only 26% of urban children aged 6–23 months receive a minimum acceptable diet, while processed foods and sugary drinks increasingly dominate diets (IPC, 2024). High morbidity rates, including diarrhea and respiratory infections, combined with poor water, sanitation, and hygiene practices, further worsen nutritional status (Rogawski McQuade et al., 2020).

Among the determinants of child nutrition, maternal education has consistently been identified as a key factor. Educated mothers are more likely to adopt appropriate infant and young child feeding practices, access healthcare services, and utilize preventive interventions (Cunningham et al., 2017). Education is also associated with increased autonomy and decision-making power within households, which can positively influence child health outcomes (Abuya et al., 2012). However, the relationship between maternal education and child nutritional status is complex. Maternal education is closely linked to broader socioeconomic conditions, including household wealth and access to resources, making it difficult to disentangle its independent effect (Abuya et al., 2012).

In addition to maternal education, child nutritional outcomes are influenced by household wealth, maternal age, household size, marital status, and child-level factors such as age and sex. Household size may lead to resource dilution, while child age reflects increased vulnerability following the transition to complementary feeding (Vaivada et al., 2020). Regional variation captures differences in climate, food

availability, and access to services, particularly in arid and semi-arid areas (IPC, 2024). Place of residence reflects disparities in infrastructure and access to services (UNICEF, 2026). Religion was included as a socio-cultural variable shaping feeding practices, health-seeking behavior, and household decision-making (Moreno et al., 2023). From an epidemiologic perspective, these factors are potential confounders that can distort the observed relationship between maternal education and stunting.

Although maternal education is widely recognized as a key determinant of child stunting in Kenya and sub-Saharan Africa, existing studies largely focus on identifying associations using standard regression models. Few have rigorously quantified the extent to which socioeconomic factors confound this relationship, nor have they systematically examined effect modification across key demographic and household characteristics. Furthermore, much of the available evidence relies on multi-country analyses that mask country-specific patterns or on localized studies with limited generalizability.

Several studies have identified maternal education as an important determinant of child stunting in Kenya and other sub-Saharan African countries. Mbuma et al. (2021), using KDHS 2014 data, demonstrated a strong educational gradient in child stunting and highlighted the role of parental investment; however, the study did not systematically quantify the extent of socioeconomic confounding or compare crude and adjusted effects. Similarly, Ettyang & Sawe (2016) examined the determinants of stunting among children under 2 years old in Kenya using a DHS framework. However, their analysis primarily focused on conventional regression-based associations without assessing effect modification or the underlying confounding structure. Comparative DHS research by Ettyang et al. (2019) further emphasized the greater influence of household wealth than maternal factors on stunting in Kenya and Cambodia. However, the pathways linking maternal education to stunting were not explicitly explored.

Additional evidence from Kenya has identified multiple socioeconomic and caregiving determinants of stunting among young children. For instance, Njoroge et al. (2026) reported several important predictors among children aged 0–3 years, although the study's localized nature limited broader generalizability. Likewise, a national policy-oriented report by KIPPRA (2024) confirmed the importance of maternal education and household wealth in reducing stunting. However, it did not investigate whether these relationships were confounded or modified by demographic and socioeconomic characteristics. At the broader regional level, Ahmed et al. (2023) provided strong population-level evidence on modifiable risk factors associated with childhood stunting. However, the pooled multi-country approach may obscure Kenya-specific heterogeneity and interaction effects. Tamir et al. (2024) also identified education, wealth, and environmental conditions as major determinants of stunting across low- and middle-income African countries. However, the analysis focused primarily on adjusted associations rather than explicitly quantifying confounding or effect modification. Similarly, multi-country DHS analyses by Zenbaba & Yaya (2026) emphasized intergenerational influences and maternal nutritional factors, while Rezaeizadeh et al. (2024) confirmed, through a global meta-analysis, the importance of maternal education for child growth outcomes. Nevertheless, these studies did not adequately address heterogeneity across wealth groups, child age categories, or other context-specific interactions.

Taken together, the existing literature consistently demonstrates an association between maternal education and child stunting; however, important gaps remain.

Few studies have explicitly quantified the extent to which socioeconomic factors confound this relationship, and evidence regarding effect modification across child age, sex, and household wealth remains limited and inconsistent. Moreover, many existing studies rely on pooled multi-country analyses or localized datasets, limiting the ability to capture nationally representative and context-specific patterns within Kenya. These gaps highlight the need for a comprehensive analysis using recent nationally representative DHS data to disentangle the independent role of maternal education while simultaneously examining socioeconomic confounding and potential effect modification.

Overall, despite the extensive use of Demographic and Health Survey (DHS) data in examining childhood stunting in Kenya, no previous nationally representative study has systematically evaluated both confounding and effect modification in the relationship between maternal education and child stunting. Most existing studies have focused primarily on identifying statistical associations using conventional regression approaches, with limited attention to the extent to which socioeconomic factors may distort or modify these relationships across population subgroups. To address this gap, the present study applies a structured epidemiologic approach to examine the association between maternal education and child stunting among children under five years in Kenya using the DHS 2022 data. Specifically, the study investigates the prevalence of child stunting, assesses the association between maternal education and stunting, evaluates whether this association persists after adjustment for socioeconomic and demographic confounders, and examines potential effect modification across key subgroups, including child age, sex, and household wealth status.

This study is guided by the hypothesis that maternal education is significantly associated with child stunting and that this relationship is influenced by socioeconomic and demographic characteristics, particularly household wealth. By explicitly disentangling crude and adjusted relationships while simultaneously assessing subgroup heterogeneity, this study provides a more comprehensive understanding of the maternal education–stunting relationship within the Kenyan context. The findings are expected to contribute to the epidemiologic literature by clarifying the relative importance of maternal education compared with broader socioeconomic determinants and by identifying population groups in which educational effects may be stronger or weaker. From a policy perspective, the study provides evidence to support more targeted, context-sensitive nutrition and child health interventions, particularly those that integrate maternal education strategies with poverty-reduction and household socioeconomic improvement programs.

METHODS

Study Design and Participants

This study employed a cross-sectional analytical design using secondary data from the 2022 Kenya Demographic and Health Survey (DHS). The analysis utilized the Children's Recode (KR) dataset, which contains detailed information on children under five years of age, including anthropometric measurements, maternal characteristics, and household-level variables.

The study population consisted of children aged 0–59 months. Eligibility criteria included the availability of valid anthropometric measurements and complete information on maternal education and key covariates. The final analytical sample

comprised 19,530 children. No formal sample size calculation was performed, as the analysis used the full nationally representative sample of eligible children under 5 years old.

Several strategies were employed to minimize bias. The use of DHS data reduced selection bias through probabilistic two-stage sampling procedures and high response rates. In addition, flagged or implausible anthropometric values (HAZ > 5.96) were excluded to minimize measurement error. Multivariable analyses were conducted to control for confounding, while stratified analyses were used to assess interaction and residual confounding.

Ethical approval statement

The study used publicly available DHS secondary data, which were accessed through formal registration and approval procedures.

Conceptual Framework and Variables

The study was guided by an epidemiologic framework distinguishing exposure, outcome, and confounding variables. Maternal education was conceptualized as a distal social determinant, while child stunting was treated as a biological outcome influenced by multiple structural and intermediate factors. Household wealth, maternal age, household size, marital status, place of residence, child age and sex, religion, and region were included as potential confounders due to their theoretical and empirical association with both maternal education and child nutritional outcomes (WHO, 2016).

The primary outcome variable was child stunting, defined using height-for-age z-scores (HAZ) according to WHO criteria, where children with HAZ values below -2 standard deviations were classified as stunted, while those with HAZ values greater than or equal to -2 standard deviations were classified as not stunted (WHO, 2025). The outcome variable was dichotomized (stunted = 1; not stunted = 0) to facilitate binary logistic regression analysis. The main exposure variable was maternal education, categorized by DHS educational attainment levels: no education, primary education, secondary education, and higher education.

Covariates were selected based on epidemiologic theory and prior literature. Household wealth was measured using the DHS wealth index and categorized into quintiles (poorest, poorer, middle, richer, and richest). Maternal age was categorized into five-year groups (15–19, 20–24, 25–29, 30–34, 35–39, 40–44, and 45–49 years). Household size was grouped into categories of 0–5, 6–10, 11–15, 16–20, and 21–25 members. Marital status included never in union, married, living with a partner, widowed, divorced, and separated.

Child-level characteristics included age (0–5, 6–23, and 24–59 months) and sex (male or female). Place of residence was classified as urban or rural, and Kenya's 47 counties were used to categorize the region. Religion was categorized as Catholic, Protestant, Evangelical churches, African instituted churches, Orthodox, Islam, Hindu, Traditionalists, and no religion/atheists.

Quantitative variables such as wealth, maternal age, household size, and child age were categorized to facilitate meaningful epidemiologic interpretation and account for potential non-linear relationships.

Research Instruments

All variables were derived from the 2022 DHS Children's Recode (KR) dataset. Anthropometric indicators, maternal characteristics, and household-level variables

were obtained from the standardized DHS survey instruments and measurement procedures.

Data Analysis

Data analysis followed a stepwise epidemiologic approach using SPSS version 29. Sampling weights were applied to account for unequal selection probabilities; however, the analysis did not fully account for the complex survey design due to software limitations. Therefore, standard errors and confidence intervals should be interpreted cautiously.

Descriptive statistics were used to summarise the study population using percentages, means, and standard deviations (SD). Bivariate analyses were conducted using cross-tabulations and Pearson's chi-square tests to examine crude associations between maternal education, covariates, and child stunting. Statistical significance was assessed using p-values, while Cramer's V was used to evaluate the strength of associations.

Stratified analyses were performed to assess confounding and effect modification by comparing p-values and odds ratios across population subgroups. Binary logistic regression analysis was subsequently conducted to estimate Adjusted Odds Ratios (AORs) while simultaneously controlling for multiple confounding variables. The extent of confounding was evaluated by comparing Crude Odds Ratios (CORs) and AORs, where changes of less than 10% were considered no meaningful confounding, 10–20% indicated moderate confounding, values greater than or equal to 20% reflected meaningful confounding, and values greater than or equal to 30% indicated strong confounding. Effect modification was assessed by comparing stratum-specific odds ratios across subgroup analyses.

Model diagnostics included the Hosmer–Lemeshow goodness-of-fit test, Nagelkerke pseudo-R^2, and Variance Inflation Factors (VIFs) to assess model fit and multicollinearity. Approximately 11.3% of HAZ values identified as flagged were excluded from regression analyses using a complete-case approach across all covariates. These flagged values were considered likely to reflect measurement or recording error, extreme outliers, or missed measurements, and were removed to improve data quality and minimize measurement bias. Additional logistic regression analyses were conducted to assess whether missing or flagged data were associated with key sociodemographic variables, including child age, sex, maternal education, and household wealth.

RESULTS

Model Diagnostics and Goodness-of-Fit

To evaluate the performance and validity of the multivariable logistic regression model, several diagnostic measures were employed, including the Nagelkerke pseudo-R^2 and the Hosmer–Lemeshow goodness-of-fit test. The Cox and Snell R^2 was 0.064, while the Nagelkerke R^2 reached 0.105, indicating that approximately 10.5% of the variation in child stunting was explained by the independent variables included in the model. Although the explanatory power was modest, this finding is consistent with epidemiologic evidence suggesting that child undernutrition is influenced by complex biological, environmental, behavioral, and socioeconomic processes that are not fully captured in cross-sectional survey data.

The Hosmer–Lemeshow goodness-of-fit test was not statistically significant (χ^2 =

9.490, p = 0.303, df = 8), indicating no significant discrepancy between observed and predicted values and suggesting an acceptable model fit. Classification analysis yielded an overall prediction accuracy of 81.8%, comparable to that of the null model. The correct identification of non-stunted children largely drove the high classification accuracy. In contrast, the prediction of stunted cases remained relatively limited, reflecting the imbalance in outcome distribution within the study population.

Several variables demonstrated statistically significant associations with child stunting and were retained for further multivariable analysis, including household wealth, child age, child sex, and maternal education ($p < 0.001$). In contrast, region, religion, place of residence, ethnicity, maternal age, and household size were not statistically significant and were therefore excluded from the final analytical model.

Multicollinearity among independent variables was assessed using Variance Inflation Factors (VIFs) derived from a linear regression model. VIF values between 1 and 2 were interpreted as indicating no multicollinearity, values between 3 and 5 as mild but acceptable multicollinearity, and values greater than 10 as problematic multicollinearity. All included variables demonstrated VIF values below 2, including child sex (VIF = 1.000), maternal education (VIF = 1.552), child age group (VIF = 1.004), and household wealth index (VIF = 1.546), with tolerance values below 1, indicating the absence of problematic multicollinearity in the final model.

Demographic Characteristics

A total of 19,530 children aged 0–59 months were included (50.9% male). The prevalence of stunting was 18.2%. Age distribution was skewed toward older children (59.3% aged 24–59 months; mean age 29.1 months, SD = 17.3). Most households were small to medium in size (mean = 5.87 members, SD = 2.59), and the majority of mothers were aged 25–29 years (mean = 29.2 years, SD = 5.5). Maternal education levels were 22.9% none, 35.3% primary, 28.4% secondary, and 13.5% higher. Most mothers were married or cohabiting (82.3%). A larger proportion of households were located in rural areas (65.8%) and in lower wealth quintiles, with 32.9% classified as poorest (Table 1).

Binary Logistic Regression analysis

Adjusted odds ratios from the multivariable logistic regression model are presented in Table 3. Logistic regression analysis indicated that missing/flagged anthropometric data were significantly associated with child age group, household wealth, and maternal education ($p < 0.001$), but not with child sex ($p = 0.098$). Compared to the reference groups, older children had nearly twice the odds of missing data (OR = 1.958; 95% CI: 1.650–2.325). Children from wealthier households were more likely to have missing data than those from the poorest households, with odds increasing across wealth categories (OR (poorer) = 1.061; 95% CI: 0.908–1.240; OR (richest) = 2.399; 95% CI: 2.037–2.825). Similarly, children of mothers with primary education had significantly higher odds of missing anthropometric data than those with higher education (OR (primary) = 1.540; 95% CI: 1.275–1.860; OR (higher) = 1.416; 95% CI: 1.214–1.650). These findings indicate that missingness was not completely random and is more consistent with a Missing-At-Random (MAR) mechanism.

Maternal Education and Child Stunting

Bivariate associations between maternal education, household wealth, child age, child sex, and child stunting are presented in Table 2. Stunting prevalence was similar

among children of mothers with no education (21.4%) and primary education (21.7%) but declined with secondary education (15.8%) and higher education (8.7%). The association between maternal education and child stunting was statistically significant ($\chi^2 = 238$, $p < 0.001$), though weak in magnitude (Cramer's V = 0.117). Children of mothers with primary education had higher odds of being stunted (OR = 1.220; 95% CI: 1.008–1.477), while children of mothers with secondary education had substantially higher odds of being stunted (OR = 1.610; 95% CI: 1.352–1.917), and those with higher education also had elevated odds of being stunted (OR = 1.417; 95% CI: 1.192–1.684). The apparent lack of a protective effect of maternal education in the adjusted model reflects strong confounding rather than a true absence of effect.

Table 1. Summary of the Demographic and Socio-economic Characteristics of the Households

Background Characteristic	Number / Percentage/SD	Background Characteristic	Number / Percentage/SD
Total children under five	19,530	**Maternal marital status**	
Sex of child		Married/cohabiting	82.30%
Male	50.90%	Single/divorced/separated/widowed	17.70%
Female	49.10%	Female-headed households	3%
Child's age groups (months)		**Religion**	
0–5	10.40%	Christian	67%
6–23	30.30%	Muslim	21.30%
24–59	59.30%	African Independent Churches	7.20%
Mean age (months)	29.05 (SD 17.34)	Traditionalist	0.60%
Nutritional status (stunting)		Atheist/None	3.50%
Not stunted	81.80%	**Place of residence**	
Stunted	18.20%	Urban	34.20%
Missing/flagged values	11.30%	Rural	65.80%
Household size		**Ethnicity**	
Small (1–5)	52.30%	Kalenjin	16.20%
Medium (6–10)	42.30%	Somali	12.40%
Large (11–25)	5.40%	Luhya	11.20%
Mean HH size	5.87 (SD 2.59)	Kikuyu	10.80%
Maternal age years		**Wealth quintile**	
15-19	4.85%	Poorest	32.90%
20-24	22.47%	Poorer	17.10%
25-29	28.40%	Middle	17.30%
30-34	21.41%	Richer	18.80%
35-39	15.61%	Richest	14.00%
40-44	5.84%		
45-49	1.41%		
Mean maternal age	29.17 (SD 6.5)		
Maternal education			
No education	22.90%		
Primary	35.30%		
Secondary	28.40%		
Higher	13.50%		

Maternal education shows varying levels of confounding, with moderate confounding for primary education (-19.6%), but strong confounding for secondary education (-133.67%) and higher education (-306%). The reversal of association

indicates that crude estimates may have been misleading due to confounding. This indicates that correlated socio-economic factors partly explain the apparent protective effect of higher education. The extent of confounding across key covariates is summarized in Table 4.

Child Stunting by Child Sex

Overall stunting prevalence was higher among males (20.5%) than among females (15.8%). Associations were statistically significant for both sexes ($\chi^2 = 66$, $p < 0.001$), with weak effect sizes (Cramer's V = 0.115 for males and 0.123 for females). Females have lower odds of stunting compared to the reference group (OR = 0.717; 95% CI: 0.662–0.776). Sex shows minimal confounding at 0.83%. With effect modification, the AORs for males and females are similar across education levels (no interaction was observed; both p-values <0.001), but it is evident that stunting decreases with higher education.

Table 2. Summary of Bivariate Analysis

Variable	Category	Stunted (%)	Not Stunted (%)
Maternal education	No education	21.37%	78.63%
	Primary	21.66%	78.34%
	Secondary	15.77%	84.23%
	Higher	8.66%	91.34%
Wealth quintile	Poorest	25.80%	74.20%
	Poorer	20.71%	79.29%
	Middle	15.49%	84.51%
	Richer	11.82%	88.18%
	Richest	7.72%	92.28%
Child age group (months)	0–5	10.84%	89.16%
	6–23	19.84%	80.16%
	24–59	18.65%	81.35%
Child Sex	Male	20.54%	79.46%
	Female	15.75%	84.25%

Table 3. Summary of Multivariate Analysis Adjusted Odds Ratio

Covariates	B	S.E.	Wald	df	Sig.	Exp(B)	95% C.I.for EXP(B)	
							Lower	Upper
Highest educational level			**48.508**	**3**	**0.000**			
Primary	0.199	0.097	4.185	1	0.041	1.220	1.008	1.477
Secondary	0.476	0.089	28.608	1	0.000	1.610	1.352	1.917
Higher	0.348	0.088	15.552	1	0.000	1.417	1.192	1.684
Wealth index combined			**302.857**	**4**	**0.000**			
Poorer	-0.345	0.058	34.824	1	0.000	0.708	0.631	0.794
Middle	-0.677	0.064	113.139	1	0.000	0.508	0.449	0.576
Richer	-0.941	0.070	183.118	1	0.000	0.390	0.340	0.447
Richest	-1.317	0.096	188.720	1	0.000	0.268	0.222	0.323
child age group (months)			**74.481**	**2**	**0.000**			
6–23	0.711	0.083	73.805	1	0.000	2.036	1.731	2.394
24–59	0.622	0.080	60.729	1	0.000	1.862	1.593	2.178
Sex of child (Female)	-0.333	0.041	67.604	1	0.000	0.717	0.662	0.776

Child Stunting by Child Age

Stunting prevalence increased markedly with age, nearly doubling between 0–5 months (10.8%) and 6–23 months (19.8%). Associations were statistically significant

(χ^2 = 79, p < 0.001) but with a weak effect size (Cramer's V (middle age) = 0.10, Cramer's V (older age) = 0.14). Children aged 6–23 months and 24–59 months, compared to the reference age group, had significantly higher odds of being stunted (OR = 2.036; 95% CI: 1.731–2.394 and OR = 1.862; 95% CI: 1.593–2.178), indicating increased risk of stunting with advancing age. The highest risk was observed among children aged 6–23 months, indicating increased vulnerability during the complementary feeding period.

Child age demonstrates minimal confounding at 0.05% and 1.27%, although significant age effect modification was evident (p-value < 0.001 for 6-23 and 24-59 months). Stratified analyses demonstrating effect modification across wealth, child age, and child sex categories are presented in Table 5. The protective effect of maternal education emerges at 6-23 months and increases progressively with child age, peaking at 24-59 months (primary =OR 0.983; 95% CI: 0.87-1.111, secondary= OR 0.62; 95% CI: 0.537-0.715, and higher=OR 0.257 95% CI: 0.203-0.324.

Table 4. Summary of Confounding Effect on Covariates

	Crude Odds Ratio	Adjusted Odds Ratio	Percentage Change	Interpretation
Wealth Quantile				
poorer	0.751	0.708	5.73%	
Middle class	0.527	0.508	3.61%	minimal
richer	0.386	0.39	-1.04%	
Richest	0.24	0.268	-11.67%	moderate
Child Age Group (months)				
6-23 months	2.037	2.036	0.05%	minimal
24-59	1.886	1.862	1.27%	
Child Sex				
Female	0.723	0.717	0.83%	minimal
Maternal Education				
Primary	1.017	1.22	-19.96%	moderate
Secondary	0.689	1.61	-133.67%	Strong
Higher	0.349	1.417	-306.02%	Strong

Table 5. Summary of Effect Modification by Strata on Covariates

Covariates (p.values) / Maternal Education: ORs (95%CL)	Primary	Secondary	Higher
Wealth Quantile			
poorest (p=0.009)	1.204 (1.062-1.365)	0.909 (0.741-1.115)	1.017 (0.495-2.09)
poorer (p=0.031)	1.6 (1.154-2.218)	1.369 (0.973-1.926)	1.408 (0.842-2.355)
middle (p<0.001)	2.954 (1.87-4.666)	2.514 (1.585-3.988)	1.832 (1.065-3.152)
richer (p=0.07)	1.707 (1.051-2.772)	1.549(0.963-2.494)	1.042 (0.620-1.751)
Richest (p=0.002)	1.033 (0.383-2.787)	1.001 (0.386-2.593)	0.535 (0.205-1.394)
Child Age Group (months)			
0-5 (p=0.261)	1.407 (0.921-2.149)	1.126 (0.733-1.730)	0.957 (0.555-1.651)
6-23 (p<0.001)	1.039 (0.873-1.236)	0.778 (0.648-0.935)	0.442 (0.340-0.574)
24-59 (p<0.001)	0.983 (0.87-1.111)	0.62 (0.537-0.715)	0.257 (0.203-0.324)
Child Sex			
Male (p<0.001)	0.999 (0.876-1.14)	0.717 (0.621-0.829)	0.378 (0.306-0.466)
Female (p<0.001)	1.033 (0.895-1.192)	0.644 (0.547-0.759)	0.301 (0.232-0.391)

Child Stunting by Household Wealth

Stunting declined steadily with increasing wealth: 25.8% in the poorest, 20.7% in the poorer, 15.5% in the middle, 11.8% in the richer, and 7.7% in the richest households. The association between wealth and stunting was statistically significant ($\chi^2 = 509$, $p < 0.001$), but weak overall (Cramer's V = 0.117).

Wealth was the strongest predictor in the model. Compared to children from the poorest households, those from wealthier households had progressively lower odds of being stunted (OR (poorer) = 0.708; 95% CI: 0.631–0.794; OR (middle) = 0.508; 95% CI: 0.449–0.576; OR (richer) = 0.390; 95% CI: 0.340–0.447; and OR (richest) = 0.268; 95% CI: 0.222–0.323), demonstrating a clear dose–response relationship between increasing wealth and reduced stunting risk.

Household wealth shows minimal confounding, but with higher wealth quantiles showing moderate confounding (-11.6%). The reversal of association indicates that crude estimates may have been misleading due to confounding. However, significance effect modification differences was observed within the quantiles (poorest (p=0.009), poorer (p=0.031), middle (p<0.001), richer (p=0.07) and Richest (p=0.002)), and the richest quantiles having children with the lowest odds of being stunted compared to the other quantiles (primary = OR 1.033; 95% CI: 0.383-2.787, Secondary= OR 1.001; 95% CI: 0.386-2.593, Higher=OR 0.535; 95% CI: 0.205-1.394). The null hypothesis of no confounding was rejected.

DISCUSSION

This study shows that although maternal education appeared to be associated with child stunting in crude analysis, the relationship was substantially influenced by confounding and effect modification. Differences between crude and adjusted estimates indicate that household wealth, child age, and sex altered the observed association. As defined by Gordis (2014), confounding occurs when the association between an exposure and an outcome is distorted by a third variable related to both.

Descriptive findings showed a clear gradient, with stunting declining from 21.7% among children of mothers with primary education to 8.7% among those with higher education, and from 25.8% in the poorest households to 7.7% in the richest. In adjusted analysis, children in the richest households had significantly lower odds of stunting (OR = 0.268; 95% CI: 0.222–0.323), while children aged 6–23 months had higher odds than infants (OR = 2.036; 95% CI: 1.731–2.394). Household wealth emerged as the strongest determinant of stunting, reflecting its central role in shaping food security, living conditions, and access to healthcare (United Nations Children's Fund et al., 2023; Rogawski McQuade et al., 2020; Shahid et al., 2024). Maternal education also contributes by improving knowledge and caregiving practices (Rahman et al., 2015), though its effect depends on the economic context (Kajjura et al., 2019). Child age and sex further indicate biological and behavioral vulnerabilities (Thompson, 2021).

Confounding analysis indicated a moderate influence of wealth and a minimal influence of age and sex. While maternal education showed substantial reversal confounding, particularly at higher levels (primary -19.96%, secondary -133.67%, higher -306.02%). This suggests that the observed association between maternal education and stunting is not independent but is largely explained by underlying socioeconomic conditions. Similar patterns have been reported in DHS-based

studies, where the effect of education is attenuated after adjusting for wealth (Mbuma et al., 2021; Ettyang et al., 2019).

Stratified analysis further demonstrated effect modification, with the association between maternal education and stunting varying across subgroups. The effect was strongest by child age, with the protective effect increasing among older children and being minimal across sex. In addition, wealth also showed a complex relationship, where the protective effect of maternal education was heavily dependent on the household's economic status (primary = OR 1.033; 95% CI: 0.383-2.787, Secondary= OR 1.001; 95% CI: 0.386-2.593, Higher=OR 0.535; 95% CI: 0.205-1.394). These context-dependent effects are consistent with previous findings that the benefits of maternal education may be constrained by resource limitations (Njoroge et al., 2026; Rezaeizadeh et al., 2024). These results align with evidence from Kenya and sub-Saharan Africa demonstrating strong socioeconomic gradients in stunting. Household wealth remains a key determinant, with children from wealthier households experiencing substantially lower risk of stunting (Ettyang & Sawe, 2016; Ahmed et al., 2023; Tamir et al., 2024).

Overall, this study highlights that maternal education operates within broader socioeconomic structures rather than as an independent determinant. By explicitly quantifying confounding and effect modification, it extends previous DHS-based research, which has largely focused on adjusted associations without examining underlying interactions (KIPPRA, 2024; Tamir et al., 2024). These findings reinforce the importance of considering both structural factors and interaction effects when interpreting determinants of child stunting.

Overall, these findings confirm that child stunting is driven by multiple interacting factors (WHO, 2016). The relatively low explanatory power of the model (Nagelkerke $R^2 = 10.7\%$) suggests that important determinants, such as diet, maternal nutrition, biological markers, and environmental exposures, were not captured.

The study also highlights a key gap in practice: reliance on descriptive analyses without accounting for confounding and effect modification can lead to misleading conclusions and ineffective interventions. Future research should examine how maternal education translates into improved nutrition in resource-constrained settings and explore pathways linking socioeconomic inequality to child growth.

Limitations of the study

This study has several limitations. First, the cross-sectional design precludes establishing temporal relationships, limiting causal inference and introducing the possibility of reverse causation. Second, reliance on secondary DHS data limits the analysis to available variables; important determinants such as dietary intake, maternal nutritional status, environmental exposures, and caregiving practices are not captured, potentially leading to residual confounding. Third, systematic differences between children with complete and missing data suggest potential selection bias and reduced precision. However, the pattern of missingness suggests that this bias is unlikely to overestimate stunting substantially. Fourth, dichotomization of stunting may have reduced sensitivity to gradations in growth faltering. Finally, unmeasured contextual heterogeneity across regions may limit generalisability to specific local settings due to limitations in the statistical software used.

CONCLUSIONS

This study found that maternal education was associated with child stunting in Kenya; however, the relationship was substantially influenced by underlying socioeconomic conditions, particularly household wealth. Household wealth emerged as the strongest determinant of stunting, while child age and sex also contributed to differences in risk. The findings further demonstrate the importance of assessing confounding and effect modification in epidemiologic analyses, as crude associations may not accurately reflect underlying relationships. Overall, the study suggests that reducing child stunting requires integrated approaches that address not only maternal education but also broader structural socioeconomic inequalities and early childhood vulnerabilities.

Recommendation

Programmatic Recommendations

Interventions should prioritize economic-strengthening and poverty-reduction strategies, focusing on households in the lowest wealth quintiles. Nutrition interventions should be implemented through coordinated, multi-sectoral actions linking agriculture, health, WASH, social protection, and early childhood development.

Policy Recommendations

Policies must confront structural inequalities that sustain poverty, recognizing household wealth as a foundational determinant of child health. Investments in maternal education should be paired with targeted economic empowerment initiatives to maximize impact on child growth and wellbeing.

Research and Methodological Recommendations

Future research should adopt longitudinal designs and incorporate broader genetic, biological, household, and environmental variables. Researchers should move beyond descriptive analyses by applying robust multivariable, stratified, and theory-driven epidemiologic methods.

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DATA AVAILABILITY

The datasets analysed during the current study are available from the Demographic and Health Surveys (DHS) Program repository. Access to the 2022 Kenya DHS Children's Recode (KR) dataset is granted upon registration and approval by the DHS Program at The DHS Program.

AI DISCLOSURE STATEMENT

This paper was edited using AI-assisted tools (Microsoft M365 Copilot) solely to improve language clarity, grammar, and flow. AI generated no academic content. The command used was "Rephrase the sentence for clarity". All analyses, interpretations, discussions, conclusions, and recommendations were authored by me and informed by the literature.

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The authors hereby declares that this research is free from conflicts of interest with any party.

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