Income and education disparities in childhood malnutrition: a multi-country decomposition analysis

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Abstract

Introduction Childhood malnutrition is a complex issue with a range of contributing factors. The consequences of malnutrition are severe, particularly for children. This study aims to identify the factors contributing to inequality gaps in childhood malnutrition. Our study provides insights into modifiable elements to inform interventions targeted at distinct contexts and populations to improve child nutrition.

Methods This study utilized data from the Demographic and Health Surveys (DHS) of 27 countries. First, the risk differences (RDs) between the prevalence of childhood malnutrition among the determinant variables, household income, and maternal education categories were calculated. The Blinder–Oaxaca decomposition was subsequently used to determine the extent to which the difference in childhood malnutrition prevalence between low-income and high-income groups and maternal education levels results from the contributory effects of the explanatory variables: child and maternal individual-level compositional factors.

Results We examined data from 138,782 children in 27 countries from 2015 to 2020. The prevalence of childhood malnutrition (10.5%) varied across countries, ranging from 6.5% in Burundi to 29.5% in Timor Leste. On average, the prevalence of childhood malnutrition was 11.0% in low-income households and 10.7% among mothers without education. Some nations had pro-low-income (i.e., malnutrition concentrated among children from poor households) or pro-no-maternal education (i.e., malnutrition concentrated among children from mothers with no formal education) inequality in childhood malnutrition, but most did not. We found a complex interplay of compositional effects, such as the child's age, maternal education, maternal health behavior, and place of residence, that influence the inequality in childhood malnutrition rates across 10 pro-low-income countries. In addition, we also found that a complex mix of compositional effects, such as the household wealth index, maternal health behavior, and maternal age, contribute to childhood malnutrition inequality between educated and uneducated mothers across the 7 pro-no maternal education countries.

Conclusion The prevalence of childhood malnutrition varies among low-income, high-income, and no maternal education-maternal education groups. This study highlights the need for a country-specific approach to addressing childhood malnutrition, with policies and interventions tailored to each country's specific context.

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Background

Childhood malnutrition is a complex issue with a range of contributing factors. Multiple studies have identified poverty as the most pervasive cause of malnutrition [1–3]. Other factors identified include food insecurity, parental education, government policies, and socioeconomic inequalities [1–3]. Feei et al. (2022) identified poverty not only as a cause of malnutrition but also as a consequence of malnutrition [4]. They described the interconnectedness of these factors as a vicious cycle. Additionally, climate change has been noted as a critical factor in childhood malnutrition, primarily affecting food availability, access, and utilization, as well as water, sanitation, and exposure to health risks and diseases [5].

The consequences of malnutrition are severe, particularly for children. Malnutrition predisposes children to various illnesses, ranging from kwashiorkor to diet-related noncommunicable diseases, and reduces productivity during adulthood [6]. Additionally, childhood malnutrition can severely affect a child's cognitive and physical growth, leading to decreased quality of life in adults [6–8]. Therefore, malnutrition during childhood can have long-term effects on health outcomes later in life.

The double burden of childhood malnutrition is an evolving global health challenge that refers to the coexistence of undernutrition and overweight or obesity within individuals, households, and populations [9, 10]. On an individual level, this may entail the simultaneous occurrence of various forms of malnutrition at different life stages [9, 10]. Similarly, double-burdened households simultaneously experience multiple forms of malnutrition among their members [9, 10]. This reflects the prevalence of multiple forms of malnutrition in specific geographic areas at the population level [9, 10]. It is a complex and multifaceted issue that affects both developing and developed countries, with exceptionally high rates among children in low- and middle-income countries.

Several studies have noted the associations between socioeconomic determinants and childhood malnutrition [11–16]. Two studies highlighted the importance of socioeconomic factors in understanding childhood malnutrition disparities [12, 16]. In addition, social globalization has been associated with increased odds of double-burden of malnutrition [14]. A lower wealth index, maternal education, and living in rural areas have been noted to be significantly associated with childhood malnutrition [11, 13, 15, 17].

Although significant progress has been made in terms of global health and well-being, childhood malnutrition inequality remains a knotty issue, especially given the evolving double burden. To address this, it is crucial to gain a comprehensive understanding of the determinants and associated factors. Decomposition analysis allows us to examine all aspects of inequality by breaking it down into contributing factors [18]. Using this method, we can identify the specific factors responsible for the differences between the two groups and determine their role in moderating childhood malnutrition inequality [18]. This information is essential for designing effective and targeted interventions. Additionally, studies on the decomposition analysis of childhood malnutrition are limited, and there is a lack of research on interventions targeted at the double burden of malnutrition [19]. Therefore, our study aims to identify the extent of income and maternal education inequalities in childhood malnutrition across 27 countries.

Methods

Study design and data sources

This study utilized data from the Demographic and Health Surveys (DHS) conducted by ICF International. The DHS surveys are household surveys that collect nationally representative data on various healthcare areas, such as maternal and child health, child survival, HIV/AIDS and other sexually transmitted infections (STIs), and reproductive health [20]. These surveys are conducted every five years in more than 90 low- and middle-income countries (LMICs) [20]. The surveys follow a stratified multistage cluster sample design to collect data from women and men aged between 15 and 49 years and their young children under the age of five, living in randomly selected households within clusters that serve as the primary sampling unit [20]. For this analysis, the Children's Recode of the most recent DHS surveys was used. Only country datasets with a full complement of our explanatory variables were included in this analysis. We excluded children with missing or flagged weight-for-height Z scores from our analysis.

Outcome variable

We employed the WHO child growth standard weight-for-height to determine the outcome variable, with the weight and height z-scores obtained from weight and length measurements [21]. The z-scores had been precalculated and were available in the DHS dataset for children under the age of five. Moderately and severely wasted children are classified as those with z-scores below -2 and -3 standard deviations, respectively, whereas those with z-scores above $+2$ standard deviations are considered overweight [21]. Children with z-scores between the

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two aforementioned standard deviations are classified as not wasted or as having excess weight [21]. Consequently, we created the outcome variable as a factor variable with two categories: not wasted or overweight and wasted or overweight. We selected weight for height as the anthropometric indicator because of its comparative robustness [22].

Determinant variables

Two determinant variables were used in this study, which was informed by findings from our previous study: poverty level (categorized as low-income or high-income) and maternal education (categorized as no maternal education or maternal education) [23]. In addition, the maternal education variable was recoded into two categories: not educated (no education at all) and educated (a minimum of primary school education). In addition, the DHS dataset included a household wealth quintile variable, a proxy measure derived from asset ownership, which was originally divided into five categories of 20% each [24]. However, this study's wealth determinant variable was reclassified into two categories: low income (lower 40%) and high income (upper 60%).

Explanatory variables

We controlled for child and maternal individual-level factors. Child-level factors such as age, sex, diarrhea and fever occurrence in the two weeks before the survey, breastfeeding status at the time of the survey, place of residence, and childbirth type were considered. Maternal individual-level variables such as age, employment status, marital status, and maternal health behavior were also considered. Maternal health behavior was obtained through principal component analysis of three individual-level factors: the mother's knowledge of Oral Rehydration Salts (ORS), the place of delivery, and immunization records. The maternal education and wealth index also separately doubled as explanatory variables for the income and maternal education decomposition analyses.

Statistical analyses

We conducted a descriptive analysis of the variables, with respondents' distributions expressed as absolute numbers (percentages) and means (SDs) for categorical and continuous variables, respectively. The analysis was adjusted for sample weight. Additionally, Pearson chi-square tests were performed to assess the relationships between the determinants and explanatory variables.

The risk differences (RDs) between the prevalence of childhood malnutrition among the determinant variables' categories were calculated separately. For example, suppose that the risk difference is greater than 0. This indicated a higher prevalence of childhood malnutrition among children in poor households (pro-low income inequality) and those born to mothers with no education (pro-no maternal education inequality), and vice versa. The prevalence of childhood malnutrition and the distribution of RDs for each determinant variable were visualized via charts.

We employed the logit Fairlie decomposition technique, a nonlinear variant of the Oaxaca-Blinder decomposition technique. The Fairlie technique decomposes the difference in proportions on the basis of either a probit or logit model. This method was then used to examine outcome differences after adjusting for explanatory variables through logistic regression, with datasets from countries with significant pro-low income and pro-no maternal education inequalities.

Blinder−Oaxaca decomposition is a counterfactual method that determines the extent to which the difference in the prevalence of childhood malnutrition between the categories of the determinant variables results from the contributory effects of the characteristics [18, 25, 26]. The method divides the childhood malnutrition variable between two groups into two parts: the "explained" or compositional portion and the "unexplained" or structural portion [18, 25, 26]. The "explained" or compositional portion refers to differences attributable to the explanatory variables, whereas the "unexplained" or structural portion captures differences arising from variations in the relationship between explanatory variables and any unmeasured variables [18, 25, 26]. All tests were two-tailed, and $p < 0.05$ was considered significant.

Descriptive and decomposition analyses were performed using STATA 17, and all charts and figures were drawn with R, a language and environment for statistical computing [27–29].

Results

Survey and sample characteristics

The study analyzed data from 138,782 children residing in 13,788 communities across 27 countries from DHS surveys conducted between 2015 and 2020. The number of children per country ranged from 1,082 in South Africa to 12,033 in Benin, with a median of 466 clusters (Table 1). Most countries included in the study were in Africa, accounting for 18 of 27 countries (Table 1). The remaining six countries were from Asia, while one country each was from the Americas, Europe, and Oceania regions (Table 1). The percentage of children who were wasted or overweight was 10.5%, which varied across countries, with Burundi having the lowest rate at 6.5% and Timor Leste having the highest rate at 29.5% (Table 1).

On average, 43.6% of the households fell into the low-income category, while 33.5% of the mothers had no

Table 1 Description of demographic and health survey data by country and childhood malnutrition prevalence from 2015–2020

Continent	Country	Survey Year	Number of Children	Number of Clusters	Malnutrition (%)	Low Income Households (%)	No Maternal Education (%)
Europe	Albania	2018	2,462	631	412 (18.3)	44.5	1.1
Africa	Angola	2016	6,407	625	514 (8.6)	45.4	28.9
Asia	Armenia	2016	1,561	304	265 (17.7)	40.4	0.0
Africa	Benin	2018	12,033	555	846 (7.0)	41.6	65.7
Africa	Burundi	2017	6,052	554	404 (6.5)	42.5	47.5
Africa	Cameroon	2019	4,477	428	725 (15.5)	46.0	27.0
Africa	Gambia	2020	3,811	279	264 (7.5)	42.4	44.7
Africa	Guinea	2018	3,430	399	502 (15.1)	47.1	76.6
Americas	Haiti	2017	5,598	449	393 (7.4)	46.6	20.1
Africa	Liberia	2020	2,457	324	179 (8.2)	48.1	36.3
Africa	Malawi	2016	5,178	850	379 (7.3)	47.5	13.4
Asia	Maldives	2017	2,362	260	268 (13.3)	44.7	1.2
Africa	Mali	2018	8,588	345	977 (10.9)	42.0	73.1
Asia	Nepal	2016	2,369	375	260 (11.0)	42.2	34.5
Africa	Nigeria	2018	11,405	1,378	1,028 (9.0)	38.0	38.8
Asia	Pakistan	2018	4,151	554	331 (9.5)	42.0	48.6
Oceania	Papua New Guinea	2018	3,290	674	602 (18.2)	40.4	24.9
Africa	Rwanda	2020	3,809	500	271 (6.9)	43.4	12.0
Africa	Senegal	2019	5,531	214	531 (10.4)	46.8	64.1
Africa	Sierra Leone	2019	4,144	564	425 (10.5)	48.1	54.2
Africa	South Africa	2016	1,082	466	171 (16.2)	47.5	2.1
Asia	Tajikistan	2017	5,867	366	546 (8.8)	39.2	2.7
Africa	Tanzania	2016	8,962	607	748 (8.5)	46.4	21.5
Asia	Timor-Leste	2016	5,718	455	1,706 (29.5)	39.9	24.4
Africa	Uganda	2016	4,413	688	337 (7.8)	43.2	11.2
Africa	Zambia	2019	8,711	545	821 (9.6)	47.7	10.2
Africa	Zimbabwe	2015	4,914	399	486 (9.4)	44.4	1.2
			138,782	**13,788**	**14,390 (10.5)**	**43.6**	**33.5**

formal education (Table 1). Guinea had the highest percentage of mothers with no education at 76.6%, whereas Armenia (0%) and Albania (1.1%) had the lowest percentages. Sierra Leone and Liberia had the highest percentage of low-income households at 48.1%, whereas Nigeria had the lowest at 38% (Table 1).

The mean age of the children included in the study was 28 months, and the study population was evenly split between males and females, with males accounting for 50.6% of the total population (Table 2). Approximately one-third of the mothers of the children had no education (33.5%) and lived in urban areas (33.0%), whereas just over half (56.4%) were in the middle to richest wealth quintiles (Table 2). Most of the mothers of the children in the study were married, between 25 and 34 years old, and employed (Table 2). We found statistically significant income differences in all the explanatory variables except for the child's age, sex, childbirth type, and maternal employment (Table 2). Similarly, we also found statistically significant maternal education differences in all the explanatory variables except the child's sex and

diarrhea experience in the two weeks preceding the survey (Table 2).

Household wealth

Magnitude and variations in inequality

Figures 1 and 2 display the inequality in childhood malnutrition between children residing in low-income and high-income households across the 27 countries examined in this study. In low-income households, the prevalence of childhood malnutrition was highest in Timor-Leste (33.4%), whereas Rwanda had the lowest rate, recorded at 6.3%. For high-income households, Burundi had the lowest prevalence of childhood malnutrition at 5.4%, whereas Timor-Leste had the highest at 26.9%. The majority of the countries (14) did not exhibit significant inequality. However, in 10 countries (Armenia, Burundi, Cameroon, Mali, Nigeria, Pakistan, Papua New Guinea, South Africa, Timor Leste, Uganda), children living in low-income households had a significantly greater prevalence of malnutrition (pro-low-income inequality), with risk differences ranging from 1.8% (95%

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Table 2 Descriptive statistics of pooled sample characteristics of the demographic and health survey data

Variables	Overall	Household Income			Maternal Education		
	N = 138,782	High Income	Low Income	P value[1]	Maternal Education	No Maternal Education	P value[1]
Age in months Mean (SD)	28.4 (17.3)	28.4	28.4	0.87	28.0	29.2	< 0.001
Sex				0.49			0.85
Male	69,116 (50.6)	50.7	50.4		50.5	50.6	
Female	67,589 (49.4)	49.3	49.6		49.5	49.4	
Childbirth Type				0.08			0.004
Single Birth	132,734 (97.1)	97.0	97.2		97.2	96.8	
Multiple Births	3,972 (2.9)	3.0	2.8		2.8	3.2	
Diarrhea in the last 2 weeks preceding the survey				< 0.001			0.10
No Diarrhea	116,081 (85.2)	85.8	84.3		85.0	85.5	
Had Diarrhea	20,213 (14.8)	14.2	15.7		15.0	14.5	
Child Fever in the last 2 weeks preceding the survey				< 0.001			< 0.001
No Fever	107,760 (79.0)	80.3	77.4		79.4	78.2	
Had Fever	28,623 (21.0)	19.7	22.6		20.6	21.8	
Currently Breastfeeding				< 0.001			< 0.001
No	84,532 (63.0)	64.5	60.9		63.3	62.3	
Yes	49,715 (37.0)	35.5	39.1		36.7	37.7	
Maternal Age (Y)				< 0.001			< 0.001
15–24 years	36,601 (26.8)	25.6	28.4		30.11	20.2	
25–34 years	68,629 (50.2)	52.3	47.5		50.9	48.9	
35–49 years	31,476 (23.0)	22.1	24.2		19.0	31.0	
Maternal Education*				< 0.001			
No Education	45,750 (33.5)	23.4	46.6		N/A	N/A	N/A
Primary	42,928 (31.4)	28.4	35.3				
Secondary	39,992 (29.3)	38.8	16.9				
Higher	8,029 (5.8)	9.4	1.3				
Maternal Marital Status				< 0.001			< 0.001
Never Married	6,530 (4.8)	5.4	4.0		6.4	1.6	
Married/In Union	123,035 (90.0)	89.9	90.1		87.7	94.6	
Divorced/Widowed/Separated	7,141 (5.2)	4.7	5.9		6.0	3.8	
Maternal Employment				0.08			< 0.001
Not Employed	56,486 (41.3)	41.7	40.8		44.1	35.8	
Employed	80,194 (58.7)	58.3	59.2		55.9	64.3	
Residence				< 0.001			< 0.001
Urban	45,119 (33.0)	51.6	9.0		39.1	20.8	
Rural	91,587 (67.0)	48.5	91.0		60.9	79.2	
Wealth Index*							< 0.001
Poorest	30,506 (22.3)	N/A	N/A	N/A	16.4	34.0	
Poorer	29,057 (21.3)				18.6	26.6	
Middle	27,761 (20.3)				20.5	19.9	
Richer	26,495 (19.4)				22.3	13.5	
Richest	22,885 (16.7)				22.2	5.9	
Maternal Health Behavior				< 0.001			< 0.001
First Quantile (Least)	47,853 (35.9)	27.0	47.5		32.9	41.8	
Second Quantile	44,560 (33.5)	34.6	31.9		34.0	32.4	
Third Quantile	24,083 (18.1)	22.6	12.3		18.6	17.1	
Fourth Quantile	6,321 (4.8)	5.9	3.2		5.5	3.2	
Fifth Quantile (Highest)	10,402 (7.8)	9.9	5.1		9.0	5.4	

[1] Pearson's X^2

* Variable separately doubles as determinant and explanatory variables for the decomposition analyses

Country, year	Low Income %	High Income %	Risk Difference (events per 100 obs.)	RD	95%-CI
Papua New Guinea, 2018	22.4	15.3		7.1	[4.3; 9.8]
Armenia, 2016	21.9	14.8		7.0	[3.0; 11.1]
Timor-Leste, 2016	33.4	26.9		6.5	[4.0; 8.9]
South Africa, 2016	18.8	13.9		4.9	[0.4; 9.4]
Nigeria, 2018	11.4	7.5		3.9	[2.8; 5.0]
Pakistan, 2018	11.4	8.2		3.2	[1.2; 5.2]
Burundi, 2017	8.0	5.4		2.6	[1.3; 3.9]
Cameroon, 2019	16.8	14.4		2.3	[0.3; 4.4]
Mali, 2018	12.0	10.1		1.9	[0.6; 3.2]
Uganda, 2016	8.8	7.0		1.8	[0.2; 3.4]
Senegal, 2019	11.0	9.9		1.1	[-0.6; 2.7]
Maldives, 2017	13.5	13.0		0.5	[-2.5; 3.5]
Zimbabwe, 2015	9.6	9.3		0.3	[-1.3; 1.9]
Benin, 2018	7.0	7.0		-0.0	[-1.0; 0.9]
Haiti, 2017	7.2	7.5		-0.2	[-1.7; 1.2]
Angola, 2016	8.4	8.8		-0.4	[-1.9; 1.0]
Zambia, 2019	9.3	9.8		-0.5	[-1.8; 0.7]
Malawi, 2016	7.0	7.6		-0.5	[-2.0; 0.9]
Guinea, 2018	14.8	15.4		-0.6	[-3.0; 1.9]
Albania, 2018	18.0	18.5		-0.6	[-3.8; 2.6]
Tanzania, 2016	8.1	8.9		-0.9	[-2.1; 0.3]
Gambia, 2020	7.0	7.9		-0.9	[-2.7; 0.8]
Rwanda, 2020	6.3	7.4		-1.1	[-2.7; 0.5]
Nepal, 2016	10.3	11.5		-1.2	[-3.7; 1.4]
Sierra Leone, 2019	9.4	11.5		-2.2	[-4.1; -0.3]
Tajikistan, 2017	7.3	9.8		-2.4	[-3.8; -1.0]
Liberia, 2020	6.8	9.6		-2.8	[-5.1; -0.5]

Heterogeneity: $I^2 = 85\%$, $\tau^2 = 0.0005$, $p < 0.01$

Fig. 1 Forest plot of the risk difference in the prevalence of childhood malnutrition between children in low-income and high-income households, by country

CI 0.1–3.4) in Uganda to 7.1% (95% CI 4.3–9.8) in Papua New Guinea. In contrast, only three countries (Liberia, Tajikistan, and Sierra Leone) presented significant pro-high-income inequality, with risk differences of -2.8% (95% CI -5.1–0.5), -2.4% (95% CI -3.8–1.0), and −2.2% (95% CI 4.1–0.3), respectively.

Decomposition of inequality

Figure 3 illustrates the proportion of differences in childhood malnutrition prevalence between low-income and high-income households in the 10 pro-low-income inequality countries, which can be attributed to explanatory variables (explained or compositional effects). The largest explained difference is observed in Cameroon, where 165.6% of the gap in childhood malnutrition between households is attributed to these factors. In contrast, the explained differences are much smaller in other countries, including Nigeria (47.8%), Armenia (39.4%), Mali (38.0%), Uganda (30.8%), and Timor-Leste (23.9%). The explanatory variables accounted for an even smaller portion of the differences in Pakistan (10.6%), Papua New Guinea (4.8%), and South Africa (1.3%). Burundi (-0.2%)

presents a negatively explained difference, indicating a very slight narrowing of the relative gap by the explanatory variables, structural effects not accounted for by the explanatory variables, and other unmeasured determinants responsible for the differences in childhood malnutrition prevalence between low-income and high-income households.

The key explanatory variables driving the explained differences in childhood malnutrition prevalence between low-income households and high-income households differed across countries. Figure 4 highlights the contribution and magnitude of the decomposition of inequality caused by the compositional effects of explanatory variables, with a negative percentage indicating a narrowing of the relative gap and a positive percentage indicating a widening gap between low-income and high-income households. Armenia and Cameroon experienced the most significant widening of the relative gap in rural residence among the explanatory variables. No maternal education contributed the most to the widening gap in Nigeria, Timor Leste, Mali, and Pakistan. Moreover, the child's age contributed the most to the widening gap in
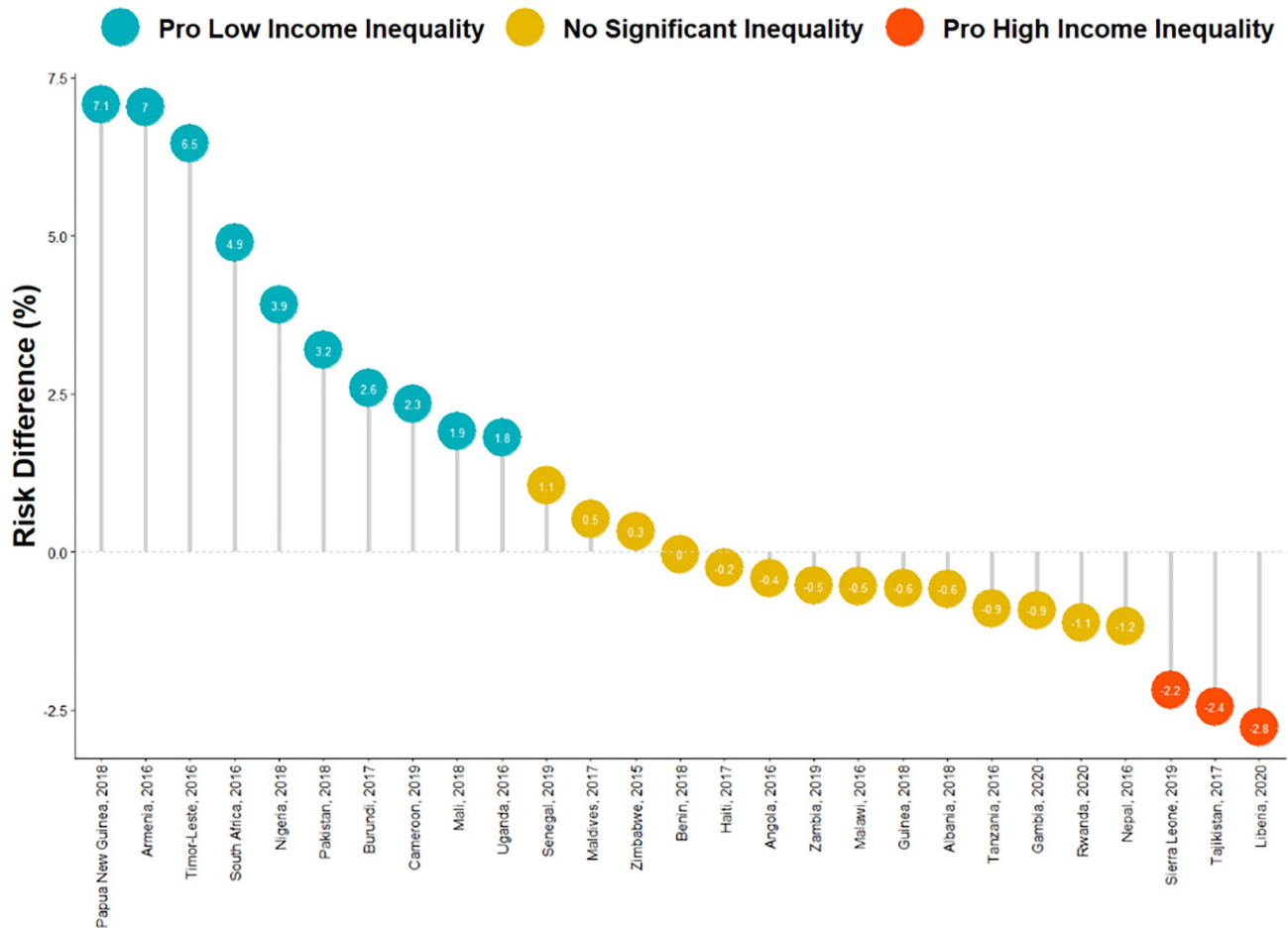
Fig. 2 Risk difference in the prevalence of childhood malnutrition between children in low-income and high-income households, by country

Uganda, South Africa, and Burundi and poor maternal health behavior in Papua New Guinea.

In contrast, maternal unemployment most narrowed the gap in Cameroon, Armenia, and South Africa. Rural residence had the highest negative percentage contribution among the explanatory variables in Pakistan, Mali, and Burundi. Poor maternal health behavior in Nigeria and Timor Leste, no maternal education in Papua New Guinea, and maternal age in Uganda were the factors that most narrowed the gap.

Among these explanatory variables, no maternal education and rural residence contributed the most and were clustered together. The child's age and poor maternal health behavior also had significant contributions. The child's sex, maternal age, and fever during the two weeks preceding the survey and birth type, breastfeeding status, and diarrhea during the two weeks preceding the survey formed two separate clusters, which were then clustered together at a higher level and joined by the maternal unemployment and marital status cluster.

Maternal education

Magnitude and variations in inequality

Figures 5 and 6 depict the childhood malnutrition inequality measure between children of uneducated mothers and those with educated mothers across 27 countries. Among children with educated mothers, Timor-Leste had the highest prevalence (28.0%) of childhood malnutrition, whereas Burundi had the lowest, at 6.6%. For children with uneducated mothers, Maldives (4.0%) and Timor-Leste (34.1%) presented the lowest and highest prevalence rates of childhood malnutrition, respectively. Notably, all the women respondents in Armenia were educated.

Among these countries, 14 displayed no significant inequality. However, 7 countries, Cameroon, Mali, Nepal, Nigeria, Pakistan, Papua New Guinea, and Timor Leste, exhibited pro-no-maternal education inequality, with a significantly higher prevalence of childhood malnutrition among mothers with no education. The risk differences ranged from 1.5% (95% CI 0.1–3.0) in Mali to 6.1% (95% CI 3.3–8.9) in Timor Leste. On the other hand, 5 countries (Gambia, Liberia, Maldives, South Africa,
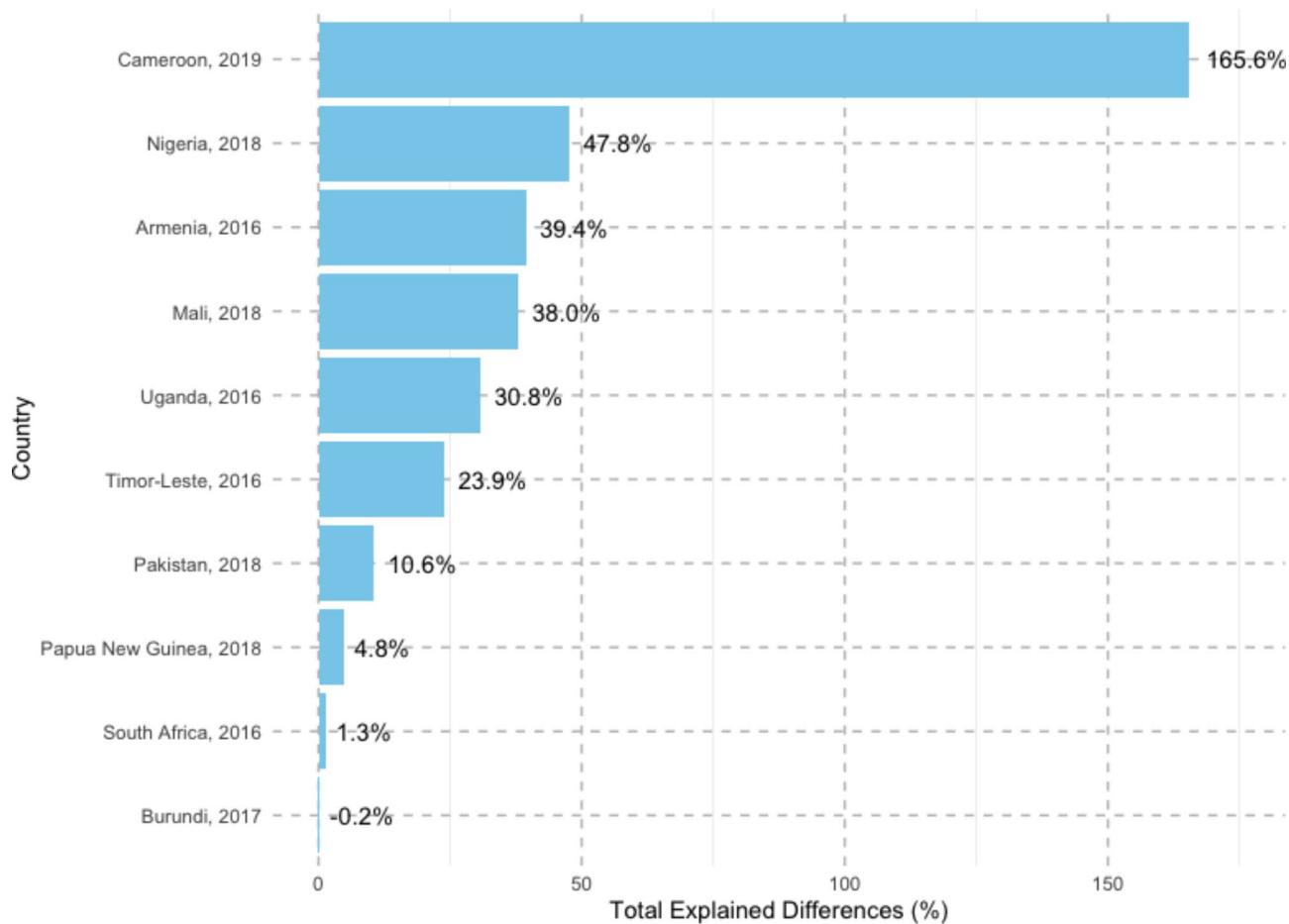
Fig. 3 Total compositional differences in childhood malnutrition between children in low-income and high-income households, by country[1]
[1]Logit Fairlie Decomposition Analysis estimates of the total explained difference as a portion of the overall difference

and Tajikistan) had significant pro-maternal education inequality, with risk differences varying from −11.9% (95% CI -20.9– -2.9) in South Africa to -2.3% (95% CI -4.6–0.004) in Liberia. All mothers of children in Armenia were educated, and hence, no results were returned.

Decomposition of inequality

Figure 7 shows the percentage of differences in the prevalence of childhood malnutrition in educated and uneducated mothers in the 7 pro-no maternal education countries attributable to explanatory variables (explained or compositional effects). Papua New Guinea (126.8%) exhibited the largest explained difference, followed by Timor-Leste (41.6%), Cameroon (26.2%), Nigeria (13.3%), and Pakistan (3.9%). These countries are listed in descending order of explained differences in childhood malnutrition between these two groups of mothers. In contrast, Nepal (-3.9%) and Mali (-5.3%) show negative total explained differences, indicating a narrowing of the relative gap and that the difference is due to structural effects and unmeasured variables (Fig. 7).

Figure 8 provides a detailed breakdown of the contribution and magnitude of the key explanatory variables driving the explained differences in childhood malnutrition inequality, with a negative percentage contribution indicating a reduction in the relative gap and a positive percentage contribution indicating an increase in the relative gap among educated and uneducated mothers. Among the explanatory variables, poor households had the most significant relative gap widening in Timor Leste, Mali, and Nigeria. In Nepal, Papua New Guinea, and Pakistan, poor maternal health behavior accounted for the greatest contribution to widening the gap; rural residence made the highest percentage contribution in Cameroon. Conversely, poor maternal health behavior had the most significant gap-narrowing effect in Nigeria and Mali. Rural residence in Nepal and Pakistan, the child's age in Papua New Guinea and Timor Leste, and marital status in Cameroon were the factors that narrowed the gap the most. Among the explanatory variables, poor households, poor maternal health behavior, and maternal age contributed the most and were the most consistent contributors in at least 5 countries.
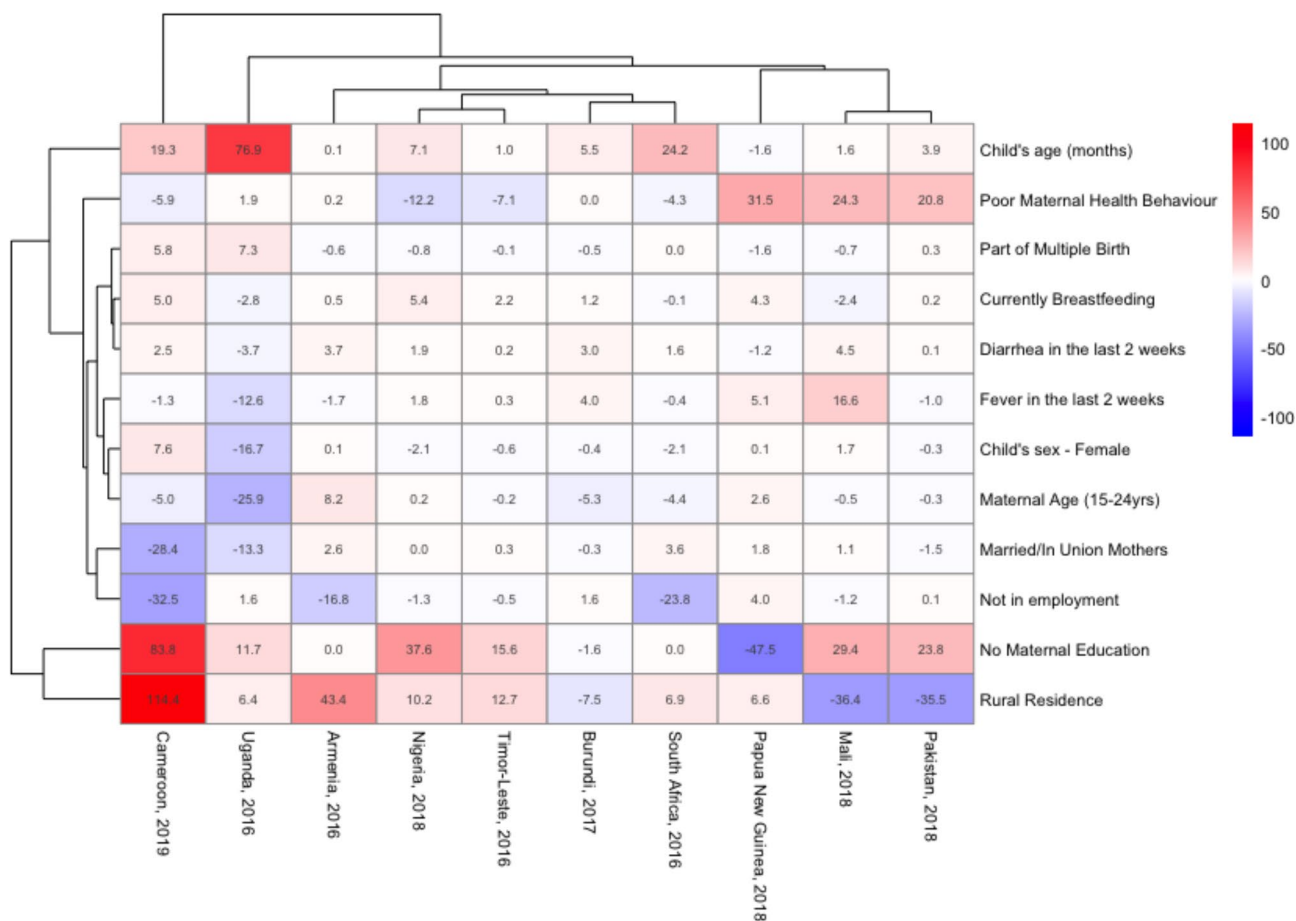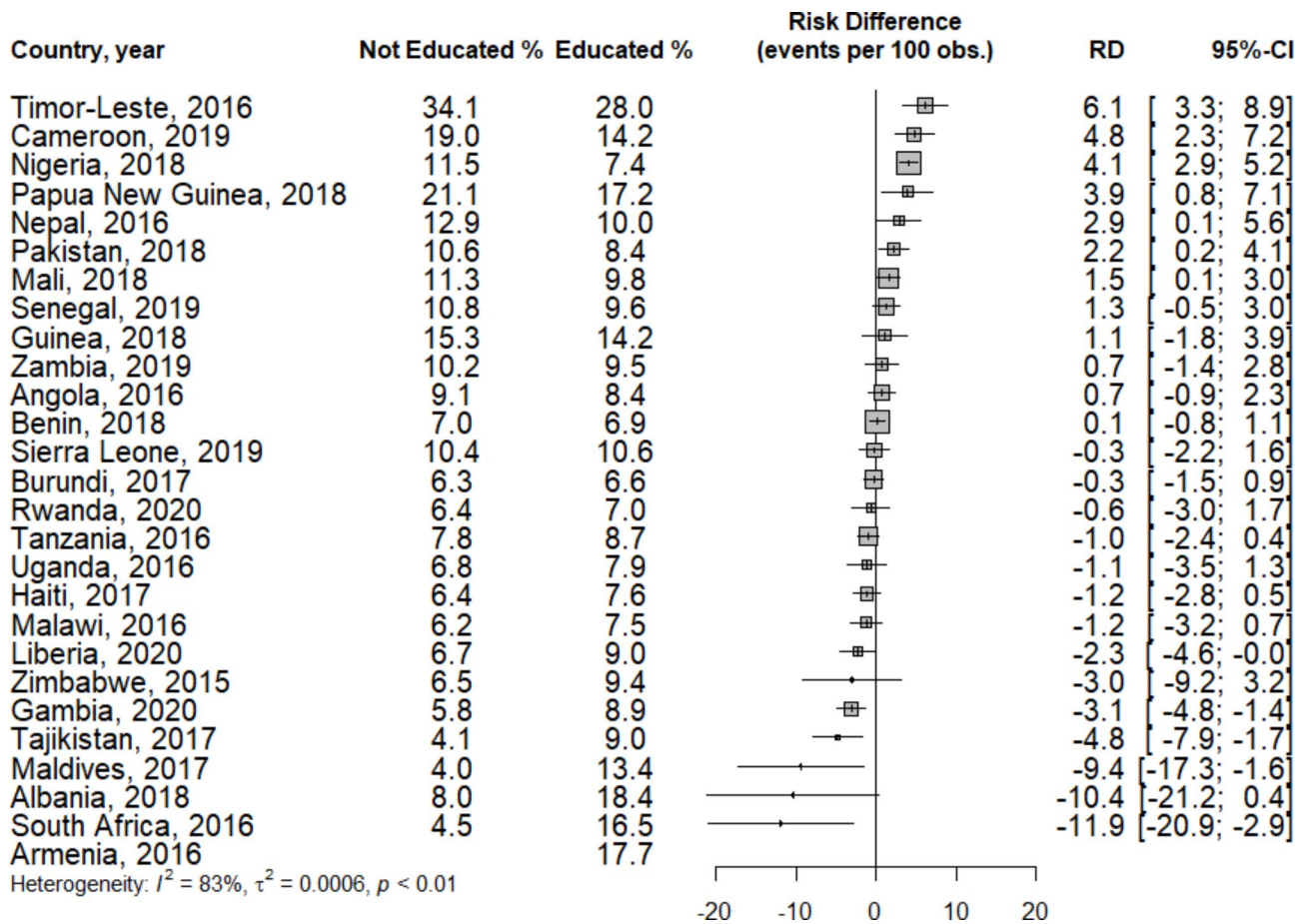
Fig. 4 Compositional effects of the determinants of childhood malnutrition in low-income and high-income households, by country[1]
[1] Logit Fairlie Decomposition Analysis estimates of the compositional explained difference attributable to the explanatory variables

Discussion

The prevalence of childhood malnutrition (10.5%) varied across countries, ranging from 6.5% in Burundi to 29.5% in Timor Leste. The prevalence of childhood malnutrition in low-income households was 11.0%, and it was 10.7% among mothers without education. Our review of childhood malnutrition inequality revealed that 10 countries had a significantly greater prevalence of malnutrition among children living in low-income households (pro-low-income inequality). In comparison, only three countries showed significant pro-high-income inequality. However, in our exploration of childhood malnutrition inequality between educated and uneducated mothers, 7 had pro-no-maternal education inequality, and five had pro-maternal education inequality.

Among the 10 pro-low-income countries, Cameroon (165.6%) had the largest explained difference (compositional effects) in childhood malnutrition between households, whereas the least explained differences were observed in countries such as Pakistan (10.6%), Papua New Guinea (4.8%), and South Africa (1.3%). Burundi (-0.2%) showed a slight negative explained difference

(-0.2%), indicating a narrowing of the gap by the explanatory variables. The explanatory variables contributing to the most significant widening of the gap varied among countries. This included the child's age, maternal education, maternal health behavior, and place of residence. Conversely, factors such as maternal employment, maternal age, maternal marital status, and child sex significantly contributed to narrowing the gap in several countries. The analysis results revealed the influence of maternal education on childhood malnutrition inequality in the 7 pro-no maternal education inequality countries, with Papua New Guinea showing the largest explained difference (126.8%), followed by Timor-Leste, Cameroon, Nigeria, and Pakistan. In contrast, Nepal and Mali presented negative explained differences, suggesting a narrowing of the malnutrition gap between educated and uneducated mothers by the explanatory variables. Factors such as the household wealth index, maternal health behavior, and maternal age contributed the most to the gap across the pro-no maternal education inequality countries. Notably, childbirth type, child age, place

Country, year	Not Educated %	Educated %	Risk Difference (events per 100 obs.)	RD	95%-CI
Timor-Leste, 2016	34.1	28.0		6.1	[3.3; 8.9]
Cameroon, 2019	19.0	14.2		4.8	[2.3; 7.2]
Nigeria, 2018	11.5	7.4		4.1	[2.9; 5.2]
Papua New Guinea, 2018	21.1	17.2		3.9	[0.8; 7.1]
Nepal, 2016	12.9	10.0		2.9	[0.1; 5.6]
Pakistan, 2018	10.6	8.4		2.2	[0.2; 4.1]
Mali, 2018	11.3	9.8		1.5	[0.1; 3.0]
Senegal, 2019	10.8	9.6		1.3	[-0.5; 3.0]
Guinea, 2018	15.3	14.2		1.1	[-1.8; 3.9]
Zambia, 2019	10.2	9.5		0.7	[-1.4; 2.8]
Angola, 2016	9.1	8.4		0.7	[-0.9; 2.3]
Benin, 2018	7.0	6.9		0.1	[-0.8; 1.1]
Sierra Leone, 2019	10.4	10.6		-0.3	[-2.2; 1.6]
Burundi, 2017	6.3	6.6		-0.3	[-1.5; 0.9]
Rwanda, 2020	6.4	7.0		-0.6	[-3.0; 1.7]
Tanzania, 2016	7.8	8.7		-1.0	[-2.4; 0.4]
Uganda, 2016	6.8	7.9		-1.1	[-3.5; 1.3]
Haiti, 2017	6.4	7.6		-1.2	[-2.8; 0.5]
Malawi, 2016	6.2	7.5		-1.2	[-3.2; 0.7]
Liberia, 2020	6.7	9.0		-2.3	[-4.6; -0.0]
Zimbabwe, 2015	6.5	9.4		-3.0	[-9.2; 3.2]
Gambia, 2020	5.8	8.9		-3.1	[-4.8; -1.4]
Tajikistan, 2017	4.1	9.0		-4.8	[-7.9; -1.7]
Maldives, 2017	4.0	13.4		-9.4	[-17.3; -1.6]
Albania, 2018	8.0	18.4		-10.4	[-21.2; 0.4]
South Africa, 2016	4.5	16.5		-11.9	[-20.9; -2.9]
Armenia, 2016		17.7			

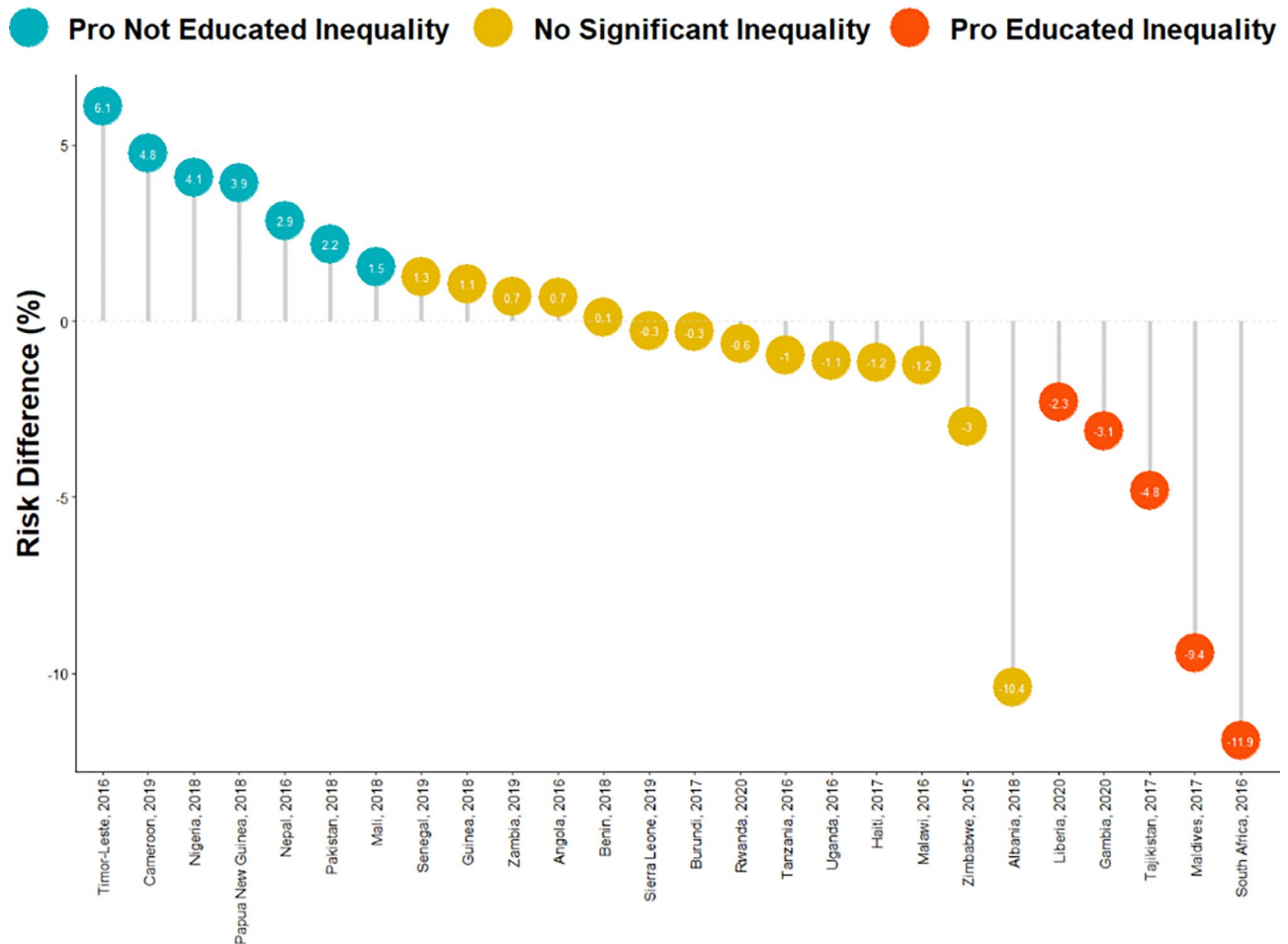Heterogeneity: $I^2 = 83\%$, $\tau^2 = 0.0006$, $p < 0.01$

Fig. 5 Forest plot of the risk difference in the prevalence of childhood malnutrition between children of uneducated mothers and those of educated mothers, by country

of residence, and breastfeeding status played significant roles in narrowing the relative gap in several countries.

Prior decomposition studies assessing childhood malnutrition income inequality have also revealed that maternal education, maternal health behavior, place of residence, and child's age widened the relative gap, similar to our findings of the most significant explanatory variables across 10 pro-low-income countries [30–34]. Low levels of education among mothers in low-income households have been linked with limited knowledge of nutrition, inadequate dietary practices, diminished decision-making power, and poor health-seeking behavior [33, 35]. In rural areas, children's nutritional outcomes are affected by their corresponding lower parental income levels, unsanitary living conditions, and larger family sizes [36, 37]. Maternal health behavior also plays a pivotal role in shaping children's nutritional outcomes, with those with better access to facilities, health information, and healthcare services and greater financial resources being more likely to provide their children with better nutritional options [36, 38]. Moreover, the dire economic situation of low-income households has been

postulated to be associated with poor health behaviors, unhealthy eating habits, limited access to healthcare services, and substandard living conditions, all of which negatively impact child health [33, 39, 40]. Additionally, child age has also been previously highlighted as a significant predictor of malnutrition, particularly among younger children who are more vulnerable to nutritional deficiencies [41, 42].

Similar to our findings from exploring childhood malnutrition inequality between educated and uneducated mothers, household wealth, maternal age, and poor maternal health behaviors have previously been identified as significant contributors to education inequality [43–45]. As discussed earlier, there is an interconnectedness between the household wealth index and maternal education. Improving a household's economic conditions directly enhances nutritional availability and indirectly influences other determinants, such as health behaviors [46]. With respect to maternal age, younger mothers often provide poorer quantity and quality of care and nursing for their children because of psychological and physiological immaturity, readiness for pregnancy

Fig. 6 Risk difference in the prevalence of childhood malnutrition between children of uneducated mothers and those of educated mothers, by country

and childbirth, and typically disadvantageous socioeconomic and power dynamics [47, 48]. Conversely, other studies have noted that older maternal age can be associated with childhood malnutrition due to factors such as reduced metabolic activity, a sedentary lifestyle, and overall maternal health status [49, 50].

In addition to the diverse range of the most significant compositional contributors to inequality between income and education groups, the number and magnitude of the compositional contributors varied within countries and between countries. Furthermore, within groups, contributors to the widening of the relative inequality gap in one country could be the reverse in another country and vice versa. Moreover, some of these compositional contributors had similar percentage contributions across countries and between groups.

This contrasting and varied impact of socioeconomic determinants, such as income, education, residence, and employment, may depend on the country's profile. For example, children from lower socioeconomic backgrounds in high-income countries and those from higher socioeconomic backgrounds in low- to middle-income

countries are most at risk of being overweight [51, 52]. In high-income countries, poor dietary and lifestyle practices among children from lower socioeconomic backgrounds have been identified as key contributors to this increased risk [53]. Similarly, in low- to middle-income countries, being overweight is often seen as a status symbol among children from higher socioeconomic backgrounds [53]. Conversely, children from higher socioeconomic backgrounds in high-income countries tend to adopt healthier diets and lifestyles, resulting in better nutrition, unlike their counterparts in low- to middle-income countries [53]. On the other hand, children from lower socioeconomic backgrounds in low- to middle-income countries are more likely to face challenges such as food availability and accessibility, limited access to healthcare, and poor educational environments, leading to childhood undernutrition [53].

A systematic review and meta-analysis by Alao et al. (2021) revealed a consistently greater risk of child undernutrition in lower socioeconomic households, regardless of the country's economic profile [40]. Furthermore, similar patterns of inequality were noted in countries
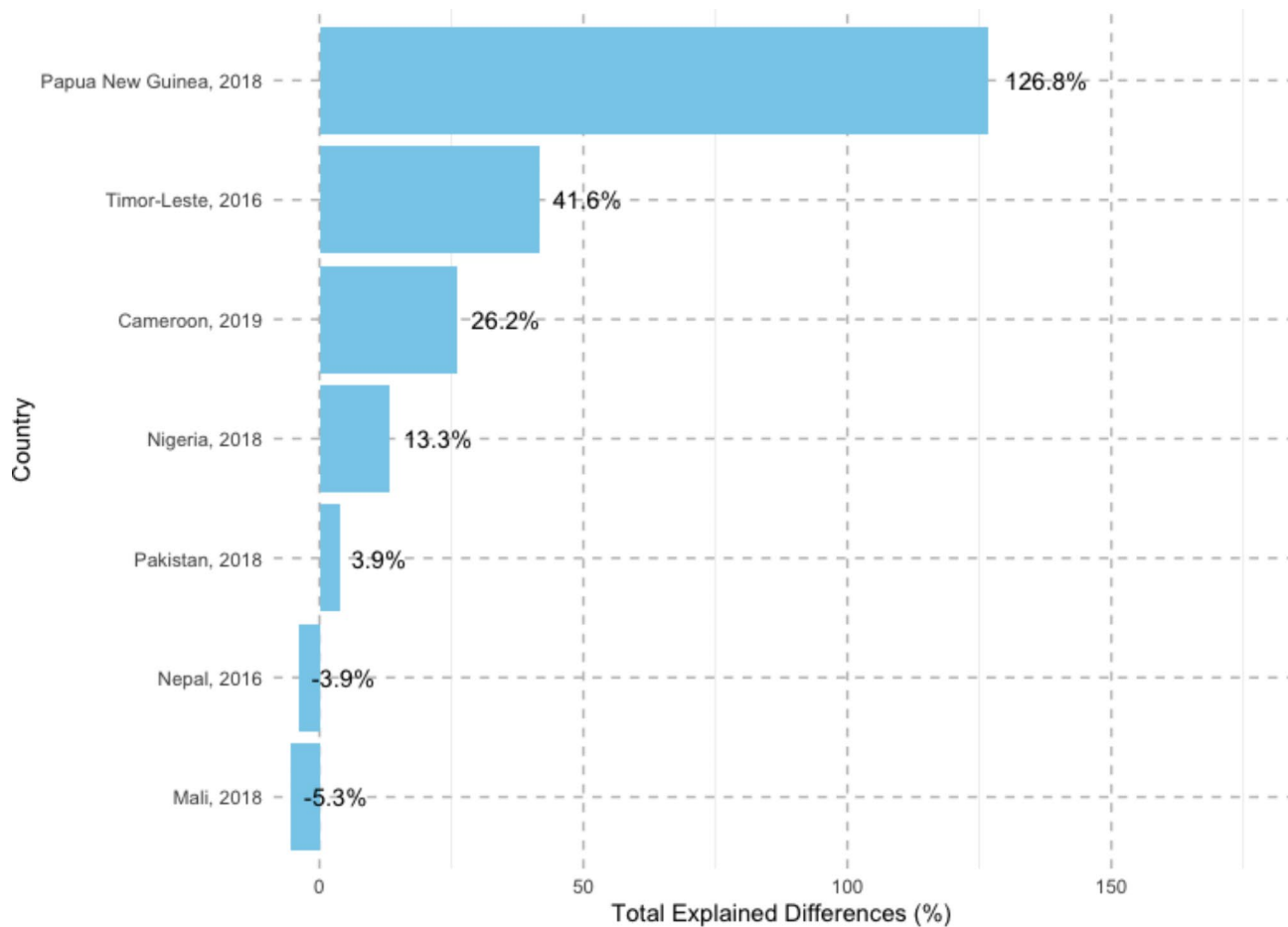
Fig. 7 Total compositional differences in childhood malnutrition between children born to uneducated and educated mothers, by country[1]
[1] Logit Fairlie Decomposition Analysis estimates of the total explained difference as a portion of the overall difference

with comparable socioeconomic profiles [40]. They also observed regional clustering of child undernutrition in contiguous countries, likely due to shared geopolitical, environmental, and food security challenges [40].
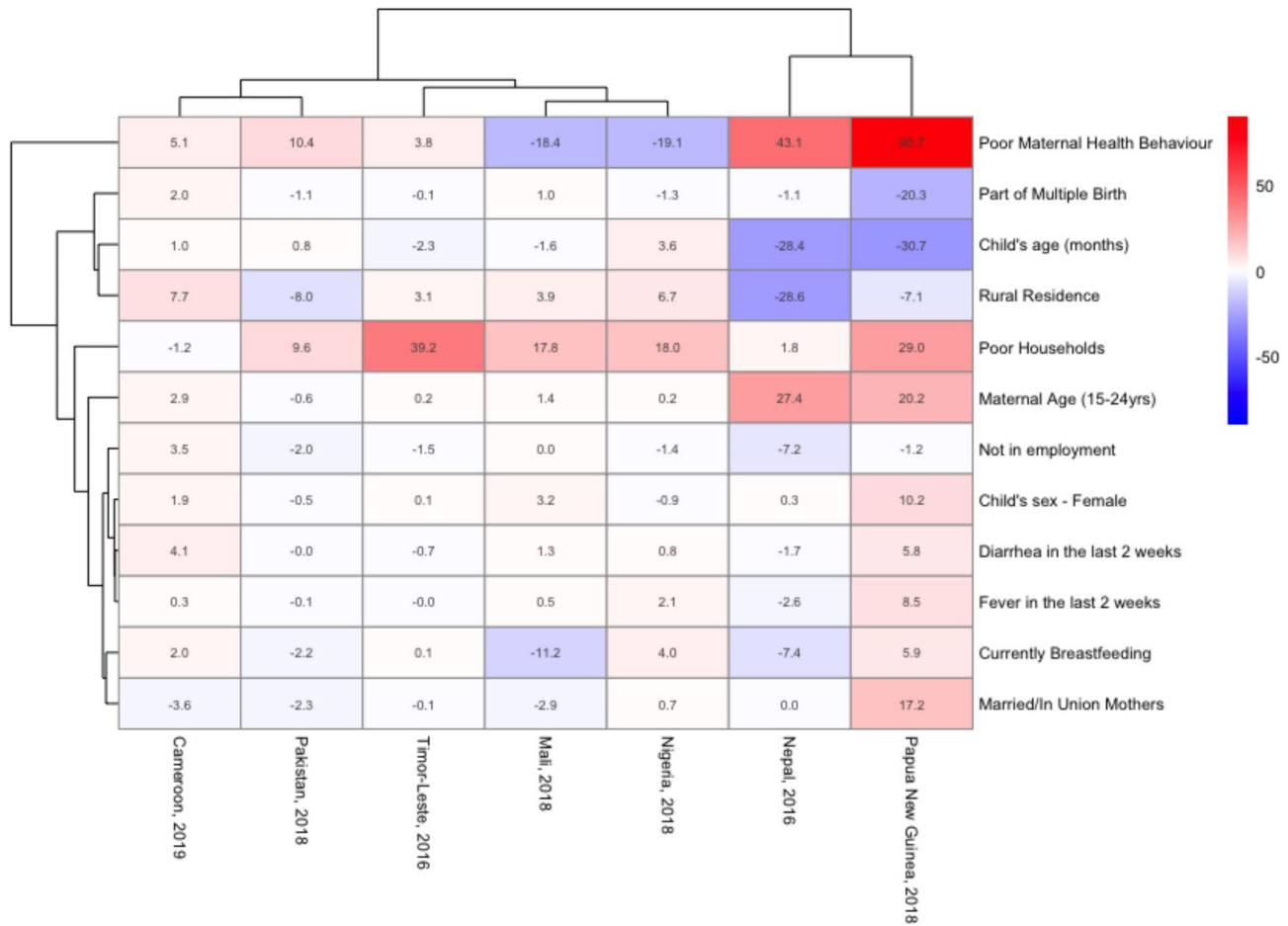
The intersectionality between income, education, and the explanatory variables at the individual, community, and structural levels demonstrates how multiple disadvantages compound to exacerbate malnutrition and drive health disparities [54]. An unaccounted biological factor, race, has long been considered a key driver of health inequalities [55]. For example, marginalized racial groups with lower socioeconomic status face a heightened risk of childhood malnutrition [56]. Additionally, traditional gender roles in childcare and household responsibilities increase children's vulnerability to malnutrition [57, 58]. Gender inequality, particularly in female-headed households, also contributes to elevated risk [57, 58]. Environmental factors, such as climate change, further exacerbate these issues by reducing crop yields, diminishing nutrient quality, and lowering dietary diversity, all of which negatively impact food security and childhood nutrition [59].

Our results underscore the intricate blend of factors shaping malnutrition inequality, further highlighting their importance in regional, subregional, and global responses to malnutrition.

Policy and practice implications
This study highlights the need for a country-specific approach to addressing childhood malnutrition. The prevalence of childhood malnutrition and the factors contributing to childhood malnutrition inequality vary significantly across countries, with the household wealth index, maternal health behavior, place of residence, maternal education, and child and maternal ages being key contributors. Therefore, policies and response programs must be tailored to each country's context, addressing the underlying factors contributing to childhood malnutrition.

Additionally, our study revealed significant low-income/high-income and no-maternal education/maternal education disparities in childhood malnutrition prevalence. These findings suggest the need for targeted interventions that address the specific needs of these

	Cameroon, 2019	Pakistan, 2018	Timor-Leste, 2016	Mali, 2018	Nigeria, 2018	Nepal, 2016	Papua New Guinea, 2018	
	5.1	10.4	3.8	-18.4	-19.1	43.1	90.7	Poor Maternal Health Behaviour
	2.0	-1.1	-0.1	1.0	-1.3	-1.1	-20.3	Part of Multiple Birth
	1.0	0.8	-2.3	-1.6	3.6	-28.4	-30.7	Child's age (months)
	7.7	-8.0	3.1	3.9	6.7	-28.6	-7.1	Rural Residence
	-1.2	9.6	39.2	17.8	18.0	1.8	29.0	Poor Households
	2.9	-0.6	0.2	1.4	0.2	27.4	20.2	Maternal Age (15-24yrs)
	3.5	-2.0	-1.5	0.0	-1.4	-7.2	-1.2	Not in employment
	1.9	-0.5	0.1	3.2	-0.9	0.3	10.2	Child's sex - Female
	4.1	-0.0	-0.7	1.3	0.8	-1.7	5.8	Diarrhea in the last 2 weeks
	0.3	-0.1	-0.0	0.5	2.1	-2.6	8.5	Fever in the last 2 weeks
	2.0	-2.2	0.1	-11.2	4.0	-7.4	5.9	Currently Breastfeeding
	-3.6	-2.3	-0.1	-2.9	0.7	0.0	17.2	Married/In Union Mothers

Fig. 8 Compositional effects of the determinants of childhood malnutrition in children born to uneducated and educated mothers, by country[1]
[1] Logit Fairlie Decomposition Analysis estimates of the compositional explained difference attributable to the explanatory variables

groups. For example, interventions to improve maternal education, increase access to healthcare services, and improve maternal health behavior in low-income households can help reduce the prevalence of childhood malnutrition in this group.

Fundamentally, policymakers should prioritize nutrition-specific interventions, such as micronutrient supplementation and infant and young child feeding practices [60]. Concurrently, investments in nutrition-sensitive interventions, including agriculture and social welfare systems, are equally important [61]. Broader socioeconomic policies that aim to reduce poverty, improve education, and enhance living conditions in poor communities must also be integrated [62, 63].

Finally, our analysis provides valuable insights into the factors contributing to childhood malnutrition in different countries and highlights the need for further research. Governments and international organizations should prioritize the collection of high-quality data on childhood malnutrition prevalence and invest in research to better understand the underlying factors and inform transformative interventions.

Study limitations

The limitations of our study are primarily due to the use of secondary data. The explanatory variables we could select were dependent on availability, and there is a possibility of recall bias in the data. Household income information was unavailable in the DHS survey, so we relied on household wealth index quintiles from asset ownership as a substitute. The Blinder-Oaxaca decomposition method used in this study does not establish causality but provides strong evidence of disparities between the two groups. A key strength of our study was the use of nationally representative and generalizable DHS datasets from 27 countries across five continents, which are typically high quality with high response rates, a sound methodology, and well-documented data sources. In addition, these surveys utilize standardized modules and protocols, enabling cross-country comparisons.

Conclusions

We examined childhood malnutrition prevalence across 27 countries from studies conducted between 2015 and 2020 and provided evidence on inequality in low- and

high-income households and maternal education levels. The results showed that the prevalence of childhood malnutrition varied across countries. While most countries did not exhibit significant inequality, some showed pro-low-income or pro-no-maternal education inequality. The most common causes of inequality were the household wealth index, maternal health behavior, place of residence, maternal education, and child and maternal age. At the same time, other explanatory variables contributed to inequality in different countries. This study highlights the importance of addressing the socioeconomic determinants of childhood malnutrition to reduce inequality and improve child health.

Supplementary Information

The online version contains supplementary material available at https://doi.org/10.1186/s12889-024-20378-z.

Supplementary Material 1

Supplementary Material 2

Supplementary Material 3

Supplementary Material 4

Supplementary Material 5

Author contributions
All the authors participated in discussions about the data source and planning of the analyses and critically revised successive versions of the paper. MAI and OAU conceived the study, MAI and S.A. performed the analyses, and MAI prepared the first draft of the paper. All the authors have reviewed and approved the final version of the paper.

Data availability
All the data and datasets generated and/or analyzed during the current study are available on the DHS program website https://dhsprogram.com/data.

Declarations

Ethics approval and consent to participate
This study is based on a secondary dataset from the DHS; therefore, ethical approval was not needed.

Consent for publication
Not applicable.

Competing interests
The authors declare no competing interests.

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