

# Decomposing the educational inequalities in the risk factors of severe acute malnutrition among under-five children in low and middle-income countries

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## Research article

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# Abstract

**Background** Low- and Middle-income countries (LMIC) are still plagued with the burden of severe acute malnutrition (SAM). While studies have identified factors that influence SAM, efforts have not been made to decompose the educational inequalities across the individual, neighbourhood and national levels in LMIC. This study aims to decompose educational-related inequalities in the prevalence of SAM across LMIC.

**Methods** We pooled successive secondary data from the Demographic and Health Survey (DHS) conducted between 2010 and 2018 in 51 LMIC. We analysed data of 532,680 under-five children nested within 55,823 neighbourhoods. Severe acute malnutrition was the outcome variable while the literacy status of mothers (literate vs illiterate) was the main exposure variable. The explanatory variables cut across the individual-, household and neighbourhood-level factors of the mothers-children pair. Oaxaca-Blinder decomposition method was used to analyse the educational gap in the factors associated with SAM.

**Results** Mothers with no formal education ranged from 0.1% in Armenia and Kyrgyz to as much as 86.1% in Niger. The overall prevalence of SAM in the group of children whose mothers had no education was 5.8% compared with 4.2% among those whose mothers were educated. Thirteen countries had statistically significant pro-illiterate inequality (i.e. SAM concentrated among uneducated mothers) while none of the countries showed statistically significant pro-literate inequality. There were variations in the important factors responsible for the educational inequalities across the countries. On average, neighbourhood socioeconomic status disadvantage, location of residence were the most important factors in most countries. Other contributors to the explanation of educational inequalities are birth weight, maternal age and toilet type.

**Conclusions** We identified that SAM is prevalent in most LMIC with wide educational inequalities. The occurrence of SAM was explained by the individual, household and community-level factor. A potential strategy to reduce the burden of SAM to reduce educational inequalities among mothers in the low- and middle-income countries through the promotion of women education.

## Introduction

Malnutrition among under-five children (U5C) remains both a social and public health burden [1,2] especially in the Low- and Middle- Income Countries (LMIC). According to the WHO, malnutrition is responsible, directly or indirectly, for 35% of deaths among children under five [3], of which Severe Acute (SAM) is crucial. SAM is the most extreme and visible form of undernutrition among U5C. Under-five children with SAM usually “have very low weight for their height and severe muscle wasting” [4]. The likelihood that a child with SAM will eventually die is very high [4,5]. Besides “children with severe acute malnutrition are nine times more likely to die than well-nourished children” [4]. As of 2015, UNICEF reported that SAM affected more than 16 million children globally in 2016 [4]. Although this figure is staggering, it is likely to have been underestimated [5].

The reduction of SAM is very crucial to decreasing child mortality and enhancement of maternal health [3]. To reduce the burden of SAM, there is a need to implement multi-sectoral evidence-based interventions. However, the development of the appropriate strategies, programmes and policies on the reduction of SAM, is hinged on the availability of information that can aid the

works of the child health programmers. While the literature is replete on the factors predisposing children to SAM and other poor nutrition outcomes, decomposition of these factors on key variables significant to poor nutrition is scarce in the literature. The identified factors are largely individual and household factors such as food insecurity, inadequate care and feeding, unhealthy environment, poor access to education, child's age and sex, mothers' employment status and income [1,6–12].

Nonetheless, little attention has been paid to the role of inequalities and disparities in the distribution of SAM in the LMIC. This neglect is despite the fact that UNICEF reported that putting an end to SAM requires tackling a complex social and political challenge[4]. Education inequalities have been reported to have a high level of influence on all factors associated with SAM[13]. Inequalities in maternal education remain a key barrier to the occurrence of SAM among U5C[9,11,12,14–17]. However, what explains the underlying causes of educational inequalities in the development of SAM among U5C remain poorly operationalized, studied and understood. In order to understand what explains the education-related inequality in the development of SAM among U5C and adapt the relevant strategies for interventions, we examined the factors associated to educational-related inequalities in the development of SAM among U5C in LMIC. We are motivated to account for the causes and extent to which educational inequalities in the development of SAM among U5C vary across countries in the LMIC beyond compositional characteristics. A good understanding of the gaps in the development of SAM among U5C in the LMIC would inform interventions for improving child nutrition.

## **Methods**

### **Study design and data**

The nationally representative cross-sectional data obtained from successive Demographic and Health Surveys (DHS) conducted in LMIC was used for this study. We extracted data from 51 most recent successive DHS surveys conducted between 2010 and 2018 and available as of March 2019 and that included under-five children (U5C) anthropometry data. Typically, the DHS uses a multi-stage, stratified sampling design with households as the sampling unit [18,19]. Country-specific sampling methodologies are also available at [dhsprogram.com](http://dhsprogram.com) and also available in report forms [20–22]. Within each sampled household, all women and men meeting the eligibility criteria are interviewed. Sampling weights are calculated to account for unequal selection probabilities including non-response whose application makes survey findings represent the full target populations. All the DHS questionnaires are standardized and implemented across countries with similar interviewer training, supervision, and implementation protocols. In this study, we used the DHS children recode data. The data covered the health experiences of under-five children born to sampled women within five years preceding the survey date. The anthropometry measurements were taken using standard procedures.

### **Dependent variable**

The dependent variable in this study is severe acute malnutrition defined as “a very low weight for height score (WHZ) below -3 z-scores of the median WHO growth standards, by visible severe

wasting, or by the presence of nutritional oedema”[3]. It was a composite score of children’ weight and height. We generated z-scores using WHO-approved methodologies [23] and categorized children with z-scores  $<-3$  standard deviation as having SAM(Yes= 1) and as No=0 if otherwise.

### **Main determinant variable**

Maternal education was used as a proxy for literacy in this study. Literacy a key skill and an important measure of a population’s level of education. Literacy is the ability to both read and write a short, simple statement about one's own life[24]. We, therefore, categorized education as no formal education (illiterate) and educated (at least completed primary education - Literate).

### **Independent variables**

Individual-level factors: sex of the children (male versus female), children age in years (under 1 year and 12-59 months), maternal age (15 to 24, 25 to 34, 35 to 49), occupation (working or not working), access to media (at least one of radio, television, or newspaper), sources of drinking water (improved or unimproved), toilet type (improved or unimproved), weight at birth (average+, small, and very small), birth interval (firstborn,  $<36$  months, and  $>36$  months) and birth order (1, 2, 3, and 4+). We used the DHS wealth index as a proxy indicator for socioeconomic status (SES). The methods used in computing DHS wealth index have been described previously[25].

### **Neighbourhood-level factors**

In this study, the term “neighbourhood” was used to describe clustering within the same geographical living environment. Neighbourhoods were based on sharing a common primary sample unit (PSU) within the DHS data [18,19]. Operationally, we defined “neighbourhood” as clusters and “neighbours” as member of the same cluster. The PSUs were identified using the most recent census in each country where DHS was carried out. We considered neighbourhood socioeconomic disadvantage as a community-level variable in this study. Neighbourhood socioeconomic disadvantage was operationalized with a principal component comprised of the proportion of respondents with no education (illiterate), unemployed, rural resident, and living below the poverty level.

### **Statistical analyses**

In this study, we carried out analytical analyses comprising descriptive statistics and multivariate analysis. Univariable and bivariable analysis were used to describe the study population. Descriptive statistics was used to show the distribution of respondents by country and key variables. In the multivariate analysis, Blinder-Oaxaca decomposition techniques using binary logistic regressions was used to test for the association between the independent variables and the dependent variable. Estimates were expressed as percentages and confidence intervals. We computed the risk difference in the development of SAM between U5C whose mothers were literate and the others that are not literate.

A risk difference (RD) greater than 0 suggests that SAM are prevalent among children born to uneducated mothers (pro-illiterate inequality). Conversely, a negative RD indicates that SAM is prevalent among children born to educated mothers (pro-educated inequality). Finally, the logistic regression method using the pooled cross-sectional data from the 51 LMIC was used to carry out a Blinder-Oaxaca decomposition analysis. The Blinder-Oaxaca decomposition[26,27] was a counterfactual methodology with an assumption that children born to uneducated mothers had the same characteristics as their educated counterparts.

Our choice of the Blinder-Oaxaca method is hinged on the fact that it allows for the decomposition of the differences in an outcome variable between 2 groups into 2 components so that the gaps can be seen more clearly. The first component of the decomposition is the “explained” portion of that gap that captures differences in the distributions of the measurable characteristics (also known as the “compositional” or “endowments”) of these groups. This method enabled the quantification of how much of the gap between the “advantaged” and the “disadvantaged” groups is attributable to differences in specific measurable characteristics. The second component is the “unexplained” part (also referred to as the structural component) which captures the gap due to the differences in the regression coefficients and the unmeasured variables between the two groups been compared.

## Results

### Sample characteristics

We analysed data of 532,680 under-five children nested within 55,823 neighbourhoods from 51 LMIC who participated in the DHSs between 2010 and 2018. The regions of the world, countries, year of data collection, numbers of neighbourhoods, number of under-five children and the weighted prevalence of SAM and percentage of illiterate mothers are listed in Table 1. Mothers with no formal education ranged from 0.1 % in Armenia and Kyrgyz to 86.1 % in Niger with media of 20.1 % in Haiti.

### Prevalence of SAM

We found a wide variation in the SAM prevalence among children of educated and uneducated mothers across the 51 LMIC studied (Table 1 and Figure 1). The overall SAM prevalence was 4.7% with a median prevalence of 1.8% ranging from 0.1 % in Guatemala to 9.9 % in Timor-Leste as shown in Table 1. The prevalence of SAM among children of uneducated mothers ranged from 0.0 % in Lesotho, Zimbabwe, Kyrgyz, Armenia and Guatemala to 12.7 % in Timor-Leste, while it ranged from 0.1 % in Peru, Guatemala to 9.4% in Timor-Leste among children of the educated mothers.

Table 1: Description of Demographic and Health Surveys data by countries and SAM prevalence among under-five children in LMIC, 2010-2018

Country	Year of Survey	Number of Under-5 Children	Weighted SAM prevalence (%)	Weighted No Education (%)	*Weighted SAM (%) Uneducated	Weighted SAM (%) Educated
All		532,680	4.7	31.1	5.8	4.2
Eastern Africa		67,418	1.5	29.4	2.5	1.1
Burundi	2016	6,052	0.9	47.5	0.9	0.9
Comoro	2012	2,387	3.9	47.8	*4.9	*2.9
Ethiopia	2016	8,919	3.0	65.8	*3.5	*2.0
Kenya	2014	18,656	1.0	11.9	*2.3	*0.8
Malawi	2016	5,178	0.6	13.3	0.5	0.6
Mozambique	2011	9,313	2.1	37.6	*2.6	*1.9
Rwanda	2015	3,538	0.6	14.4	0.9	0.6
Tanzania	2016	8,962	1.3	21.5	1.5	1.2
Uganda	2016	4,413	1.4	11.2	2.0	1.3
Middle Africa		37,136	2.5	32.4	4.1	1.8
Angola	2016	6,407	1.0	28.9	1.4	0.9
Cameroon	2010	5,033	1.9	26.2	*4.3	*1.0
Chad	2015	9,826	4.3	65.3	*5.2	*2.3
Congo	2012	4,475	1.6	7.0	2.8	1.5
DRC	2014	8,059	2.7	19.3	2.7	2.7
Gabon	2012	3,336	1.2	6g.9	1.6	1.1
Northern Africa		13,682	3.8	17.9	4.3	3.7
Egypt	2014	13,682	3.8	17.9	4.3	3.7
Southern Africa		20,273	1.7	7.2	2.3	1.6
Lesotho	2016	1,312	0.7	0.9	0.0	0.7
Namibia	2013	1,558	2.2	6.8	*7.9	*1.7
South Africa	2016	1,082	0.5	2.1	3.1	0.5
Zambia	2014	11,407	2.1	11.2	2.0	2.1
Zimbabwe	2015	4,914	1.1	1.2	0.0	1.1
Western Africa		85,462	4.7	60.8	5.4	3.7
Benin	2018	12,033	1.1	65.7	1.2	0.9
Burkina Faso	2010	6,532	5.8	83.8	6.1	4.5
Cote d'Ivoire	2012	3,200	1.8	64.8	1.7	2.0
Gambia	2013	3,098	4.7	59.6	4.9	4.4
Ghana	2014	2,720	0.7	28.8	0.9	0.7
Guinea	2012	3,085	3.7	78.7	4.1	2.4

Liberia	2013	3,171	2.2	42.5	2.1	2.3
						4.5
Mali	2013	4,306	5.1	82.9	5.2	4.5
Niger	2012	4,771	6.2	86.1	6.2	6.2
Nigeria	2013	24,505	8.8	46.4	*11.9	*6.2
Senegal	2017	10,787	1.5	61.6	*1.9	*1.0
Sierra Leone	2013	4,069	3.8	69.8	3.6	4.3
Togo	2014	3,185	1.6	40.6	*2.2	*1.1
Central Asia		9,883	1.5	1.7	1.0	1.6
Kyrgyz	2012	4,016	1.1	0.1	0.0	1.1
Tajikistan	2017	5,867	1.8	2.7	1.0	1.8
South-Eastern Asia		4,324	2.4	13.2	2.9	2.4
Cambodia	2014	4,324	2.4	13.2	2.9	2.4
Southern Asia		240,849	7.1	29.4	7.8	6.8
Bangladesh	2014	6,965	3.1	16.3	3.0	3.1
India	2016	225,002	7.4	29.7	*8.1	*7.1
Maldives	2016	2,362	2.0	1.2	0.0	2.0
Nepal	2016	2,369	1.9	34.5	1.7	2.0
Pakistan	2018	4,151	2.3	48.6	*2.6	*2.1
Western Asia		1561	1.5	0.1	0.0	1.5
Armenia	2016	1561	1.5	0.1	0.0	1.5
Central America		21,717	0.2	12.6	0.1	0.2
Guatemala	2012	11,744	0.1	18.6	0.0	0.1
Honduras	2016	9,973	0.3	4.9	0.4	0.3
South America		9,213	0.1	3.1	0.3	0.1
						0.1
Peru	2012	9,213	0.1	3.1	0.3	0.1
					2.	
South Europe		2,462	0.5	1.1	2.7	0.5
Albania	2018	2,462	0.5	1.1	2.7	0.5
Caribbean		18,700	3.9	17.7	6.7	3.3
Dominica	2013	3,187	0.6	2.2	1.2	0.6
Haiti	2016	5,598	0.9	20.1	1.2	0.8
Myanmar	2016	4,197	1.4	16.6	1.4	1.4
Timor-Leste	2016	5,718	9.9	24.4	*13.4	*8.8

Table 2 presents the descriptive statistics for the pooled sample of children across the 51 LMIC. About 51 % of the children were male while only 20% were infants. About 53% of the mothers were between 25 to 34 years old and about 41% had no formal education. Nearly one-third of the mothers were not working at the time of the survey. The overall prevalence of SAM in the group of children whose mothers had no education was 5.8 % compared with 4.2 % among those whose mothers were educated. Mantel Haenszel test of homogeneity of odds ratio was used to test statistical significance using urban-rural as an effect modifier. All characteristics considered were independently significant with the occurrence of SAM. Infants, male children and mothers at extreme age intervals; 15 to 24 and 34 to 49 had overall higher SAM prevalence. For wealth index, births of women from lowest wealth quintile had the highest rate of SAM within the “uneducated” group compared with those from richest wealth quintile (6.8 % vs 3.4%) but the margins were closer within the “educated” group.

Table 2: Summary of pooled sample characteristics of the studied children in 51 LMIC

Characteristics	Weighted n	Weighted %	Weighted (%) Uneducated (%)	SAM (%) Uneducated	SAM (%) Educated
<b>Individual Level</b>					
<b>Age</b>					
<12 Months	103,379	20.0	29.0	9.0	6.7
12 - 59 Months	413,718	80.0	31.7	5.1	3.5
<b>Sex</b>					
Female	252,541	48.8	31.5	5.4	3.8
Male	264,556	51.2	30.8	6.3	4.5
<b>Maternal Age</b>					
15-24	160,133	31.0	22.4	6.7	4.8
25-34	273,802	52.9	31.8	5.8	4.1
35-49	83,162	16.1	45.7	5.1	2.7
<b>Wealth Index</b>					
Poorest	122,991	23.8	54.5	6.8	4.3
Poorer	112,755	21.8	37.0	5.7	4.4
Middle	104,194	20.1	26.4	5.3	4.2
Richer	96,896	18.7	18.3	4.4	4.2
Richest	80,261	15.5	8.8	3.4	3.8
<b>Employment</b>					
Yes	366,033	70.8	31.7	5.9	4.6
No	151,064	29.2	31.1	5.5	3.2
<b>Access To Media</b>					
No	188,357	36.5	55.8	6.1	4.3
Yes	328,311	63.5	17.0	5.3	4.1
<b>Drinking-Water Sources</b>					
Unimproved	95,544	19.2	43.9	5.4	3.1
Improved	402,688	80.8	28.7	5.9	4.3
<b>Toilet Type</b>					
Unimproved	248,331	49.9	45.3	6.0	4.4
Improved	249,753	50.1	18.1	5.2	3.9
<b>Marital Status</b>					
Never Married	12,199	2.4	10.0	3.5	1.7
Currently Married	484,949	93.8	32.0	5.9	4.3
Formerly Married	19,946	3.9	23.5	4.1	1.8
<b>Weight At Birth</b>					
Average+	423,017	85.4	30.4	5.7	4.2

Small	52,939	10.7	33.5	6.0	4.4
Very Small	19,624	4.0	43.7	7.7	5.4
<b>Birth Interval</b>					
1st	157,067	30.4	17.0	6.3	4.5
<36	193,030	37.4	39.9	5.8	4.4
36+	165,780	32.1	34.5	5.6	3.5
<b>Birth Order</b>					
1	157,065	30.4	17.0	6.3	4.5
2	134,436	26.0	23.3	5.9	4.6
3	83,134	16.1	34.7	6.0	3.9
4	142,462	27.6	52.0	5.5	3.1
<b>Community SES Quintiles</b>					
1 (Highest)	117,186	20.2	9.6	4.5	4.2
2	101,302	20.0	17.8	4.8	4.2
3	103,795	20.1	28.9	5.0	3.9
4	100,611	20.0	42.6	6.0	4.2
5 (Lowest)	94,203	19.7	62.4	6.7	4.2
Total (or median)	532,680	100.0	31.1	5.8	4.2

### Magnitude and variations in educational inequality in SAM

Figures 1 and 2 show the risk difference (a measure of inequality) between children of uneducated and educated women across the 51 countries studied. Among the 51 countries included in this analysis, 14 countries showed statistically significant pro-illiterate inequality (i.e. SAM more prevalent among children from uneducated mothers). None of the countries showed statistically significant pro-literacy (i.e. SAM prevalent among children from educated mothers) while 37 countries showed no statistically significant inequality. As illustrated by Fig. 1, in Eastern Africa, the educational difference was largest for Ethiopia (20.55 per 1000 children) and lowest for Malawi (-0.50). In Western Africa, the largest educational difference was in Nigeria (48.22) and lowest for Cote d'Ivoire (-6.41). In The Caribbean, the difference was largest for Timor Leste (32.60) and lowest for Myanmar (-0.96). Burundi and Senegal with 2.5 % weight each had the largest contribution to the pooled result. In the pooled analysis, Nigeria still had the highest pro-illiterate inequality (48.22) and followed by Namibia (44.75) as shown in Figure 2. Overall, there was significant pro-illiterate in the total pooled sample of children in this study. The risk difference was 7.18 (95% CI: 3-12) per 1000 children among children of uneducated mothers compared with those of educated mothers as shown in the random effects in Figure 1.

Two of the nine countries in Eastern Africa showed statistically significant pro-illiterate inequality, 2 of the countries in Middle Africa, none in Northern Africa, only Namibia in Southern

Africa. In Western Africa, 2 of the 13 countries showed statistically significant pro-illiterate inequality. Similarly, in Southern Asia, 2 of the five countries showed statistically significant pro-illiterate inequality compared with only one country among the four countries studied in the Caribbean.

Relationship between prevalence of SAM and magnitude of the educational inequality  
Figure 3 shows the relationship between the prevalence of SAM and the magnitude of inequality for all the 51 countries in this study. The 51 countries were categorized into 4 distinct categories: (1) High severe acute malnutrition and high pro-illiterate inequality such as Timor-Leste and Nigeria; (2) High severe acute malnutrition and high pro-literate inequality was not found in any country; (3) Low severe acute malnutrition and high pro-illiterate inequality such as Namibia and Kenya; and (4) Low severe acute malnutrition and high pro-literate inequality was not found in any country.

### **Decomposition of educational inequality in the prevalence of SAM**

Figure 4 and 5 show the detailed decomposition of the part of the inequality that was caused by compositional effects of the determinants of SAM among under-five children. There were variations in the important factors responsible for the educational inequalities across the countries. On average, neighbourhood socioeconomic status disadvantage, location of residence were the most important factors in most countries. In Senegal, the largest contributions to the educational inequality in the prevalence of SAM was by neighbourhood socioeconomic disadvantage, followed by the location of residence, wealth index and access to media. Wealth index and media access narrowed the inequality in the development of SAM between children from educated and uneducated mothers. In Togo, location of residence had the largest contribution to the educational inequality followed by neighbourhood socioeconomic status disadvantage and followed by media access. Marital status, child age and sex, birth weight and mother's employment status didn't show any significant contribution to educational inequality in the development of SAM in any of the 13 countries.

Figure 1: Risk difference between children from uneducated and educated mothers in the prevalence of SAM by countries

Figure 2: Risk difference between children born to uneducated and educated mothers in the prevalence of SAM by countries.

Figure 3: Scatter plot of rate of SAM and risk difference between children born to uneducated and educated mothers in LMIC

Figure 4: Contributions of differences in the distribution 'compositional effect' of the determinants of SAM to the total gap between children from uneducated and educated mothers by countries.

Figure 5: Contributions of differences in the distribution 'compositional effect' of the determinants of under-five mortality to the total gap between children from rural and urban areas in under-five mortality rates by countries

## Discussion

The main goal of this study is to use the DHS data to analyse and decompose educational inequalities in the development of SAM across 51 low and middle-income countries. This study was carried out with the purpose of improving our knowledge of the compositional and structural factors associated with educational inequalities in the development of SAM in the countries. The study is premised on the fact that SAM has continued to be a major public health challenge. We found wide variations in the prevalence of SAM among children of illiterate and literate mothers. Our results show significant education-related differences in that could be explained by structural and compositional factors nested both at the neighbourhoods and the country levels. We also found a wide inter-country differences viz-a-viz literacy level in the prevalence of SAM. The inter-country variations could be ascribed to the prevalent differences in individual country socioeconomic characteristics, policies, strategies and intervention on child nutrition. Our findings are corroborated by some previous research which found similar differentials in the prevalence of SAM.

In particular, the analysis in this study shows the unequal distribution in the prevalence of SAM between the children of the educated and uneducated mothers, suggesting the presence of educational inequalities. In 13 of the 51 countries, SAM was significantly prevalent among children born to uneducated mothers (pro-illiterate inequality) but pro-literate inequality, although higher in 16 countries, was insignificant in any of the countries. The risk difference used as the measure of inequality in our study showed that among countries with statistically significant pro-illiterate inequalities ranged from 8 to 48 per 1000 of children born to uneducated mothers will develop SAM compared with educated mothers.

Overall, there was significant pro-illiterate among the total pooled sample of children in this study with 7 of every 1000 children of uneducated mothers developing SAM compared with children born to educated mothers. Educational attainment of caregivers is an important factor in the determination of whether a child develops SAM or not. Our finding is in consonance with previous studies which reported that children whose mothers were not educated were associated to poor range of nutritional outcomes such as stunting, wasting and malnutrition [7,12,16,28-31]. This finding has several implications, first, there is a need for LMIC to develop child nutrition public health policies, interventions and programmes that particularly focus the uneducated mothers on the need to provide their children with adequate nutrition.

Also, there is a need to increase the where-wither of mothers and households in general so that they can have a higher capacity to afford good nutrition for their children. In addition, governments may wish to subsidize children foods as a means of relieving household the huge burden of getting food for their wards. Nonetheless, such public health intervention should be all-encompassing. It should include health education and promotion, adequate communication, seminars, political will and the involvement of the community and religious leaders on the need for children to have good nutrition. This is consistent with a UNICEF report that prevention and long term solutions to the burden of SAM will involve “dismantling unequal power structures, improving equitable access to health services and nutritious foods, promoting breastfeeding and

optimal infant and young child feeding practices, improving water and sanitation, and planning for cyclic food shortages and emergencies” [4].

It is very evident from our analysis that compositional effects of the additional explanatory variables explored were mainly responsible for the majority of the inequality in SAM between the uneducated and educated mothers in Chad, Timor-Leste and Mozambique. While in Togo, and Kenya, structural effects of the determinants were responsible for most of the inequality in SAM.

The decomposition of the analysis has shown that compositional factors such as neighbourhood SES, location of residence, wealth index and access to media were the most important contributor to education-related inequalities across the countries. Obviously, to attain a meaningful reduction in educational inequalities in SAM, there is need to look outside the box and properly understand the connection among the structure, composition and the context in which the children live. A wholesome approach should be used to address the challenges of educational-inequalities in child health. This finding underscores the advantage of enhancing both the compositional and structural characteristics if the education-related inequalities in SAM are to be reduced. These characteristics are the neighbourhood SES, media access, rural-urban location of residence and household wealth index amongst others. Earlier reports on child malnutrition have clearly indicated the nuance of individual, community and country-level factors associated with child nutrition [2,4,8,10].

We find interesting results in our attempt to map the relationships between the prevalence of SAM and educational inequality. Some countries such as Namibia and Kenya had a low SAM prevalence and high pro-illiterate inequality while countries such as Timor-Leste and Nigeria had a high SAM prevalence and high pro-illiterate inequality. These variations can be explained by access to media, household wealth status, country-level policies and programmes for child nutrition, famine, war, internal displacement, political and economic instability etc. It is quite understandable that we did not find significant pro-literate inequality in any of the countries studied. An educated mother is expected to know good nutritional practices for her wards.

Our findings on the effect of neighbourhood SES on the likelihood of children of educated mother to have SAM are consistent with the literature on compositional and structure effects. These studies showed that residents in high socioeconomic areas have a higher likelihood of more positive outcomes than persons who reside in socioeconomically disadvantaged areas [32,33]. It is therefore important that the countries with high SAM and high pro-illiterate inequalities in SAM rework their child nutrition policies by taking a cue from the countries with a low SAM and low pro-educated inequalities. For instance, researchers and health programmers in such countries may wish to explore the differentials in child health and nutrition in Nigeria and Kenya. Why is SAM higher in Nigeria than in Kenya despite that the two countries have pro-illiteracy inequalities?

#### Study Limitations and Strengths

We have used household wealth status as a proxy for household income as the DHS survey questionnaire does not contain data on household income. So our findings may not be generalizable in settings where direct measurement of income is available. While multilevel

analysis is an efficient method to understand disparities and to monitor health care indicators, Blinder-Oaxaca decomposition analysis does not clearly allow causal interpretation of the results but gives robust evidence of inequalities after controlling for the exposure variable. There may be a need for a further study to examine the association of structural and compositional factors associated with educational-inequalities in the prevalence of SAM. Nonetheless, our study has major strengths, as shown in Figure 5, we were able to quantify the magnitude of the explained and unexplained factors associated with our outcome measure. The study covered 51 LMIC using the DHS data is reputed for accuracy and comparability across countries.

## **Conclusions**

We identified that SAM is prevalent in most LMIC with wide educational variations. The occurrence of SAM was explained by the individual, household and community-level factor. The overall significance of our exposure variable in explain the difference in SAM prevalence is a pointer that education of the whole population, especially the girl child is very important to child health. The advantages of education in human endeavour cannot be overemphasized. The low and middle-income countries must beef up their tactics in child nutrition with the goal of eradication of severe acute malnutrition and thereby reduce child morbidity, opportunistic infections and mortality. To address the educational inequalities in SAM, an urgent child nutrition intervention is a must in LMIC especially in those identified as having pro-illiterate inequalities.

## **Declarations**

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### **Competing interests**

The authors declare that they have no competing interests.

### **Availability of data and materials**

The data supporting this article is available at <http://dhsprogram.com>.

### **Authors Contributions**

OU conceived the study, AFF and OU designed the study and analysed the data; AFF retrieved and merged the data and drew the Figures; AFF, OU, and NBK carried out the literature search,

data interpretation, and writing of the manuscript. All authors read and consented to the final version of the manuscript.

### **Consent for publication**

All authors agreed to the publication

### **Ethics approval and consent to participate**

This study was based on an analysis of existing survey data with all identifier information removed. The survey was approved by the Ethics Committee of the ICF Macro at Fairfax, Virginia in the USA and by the National Ethics Committees in their respective countries. All study participants gave informed consent before participation and all information was collected confidentially. The full details can found at <http://dhsprogram.com>.

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## Figures

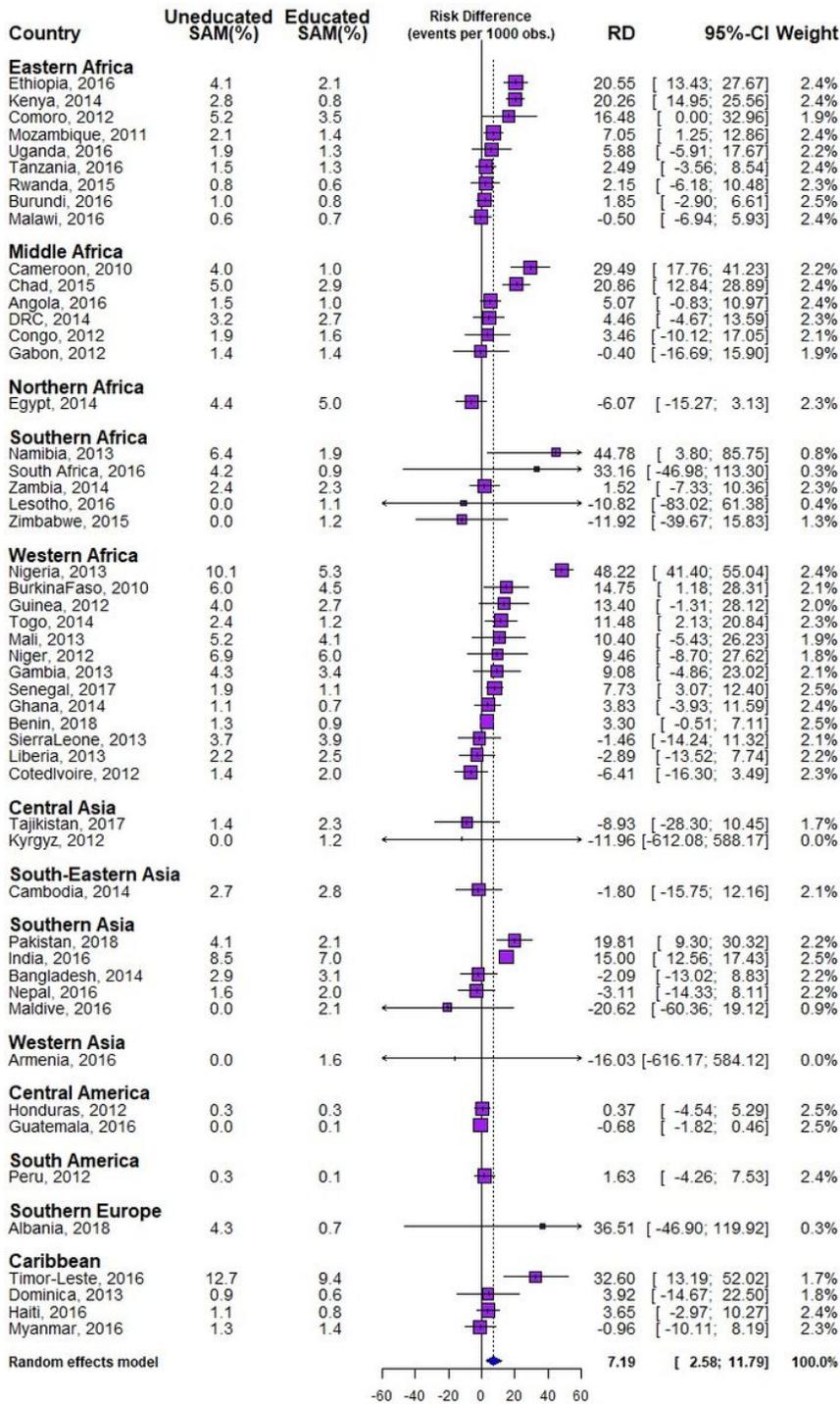
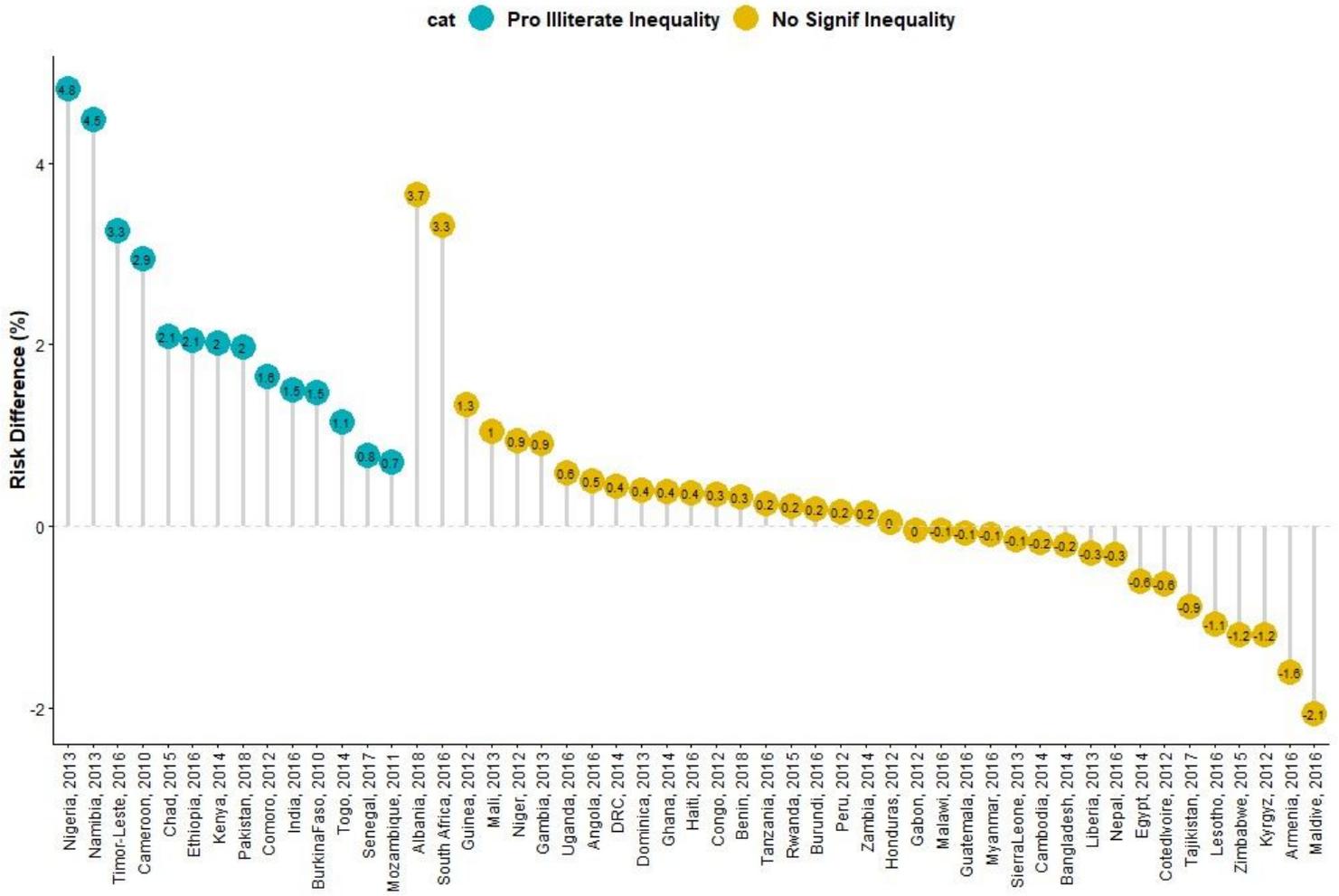


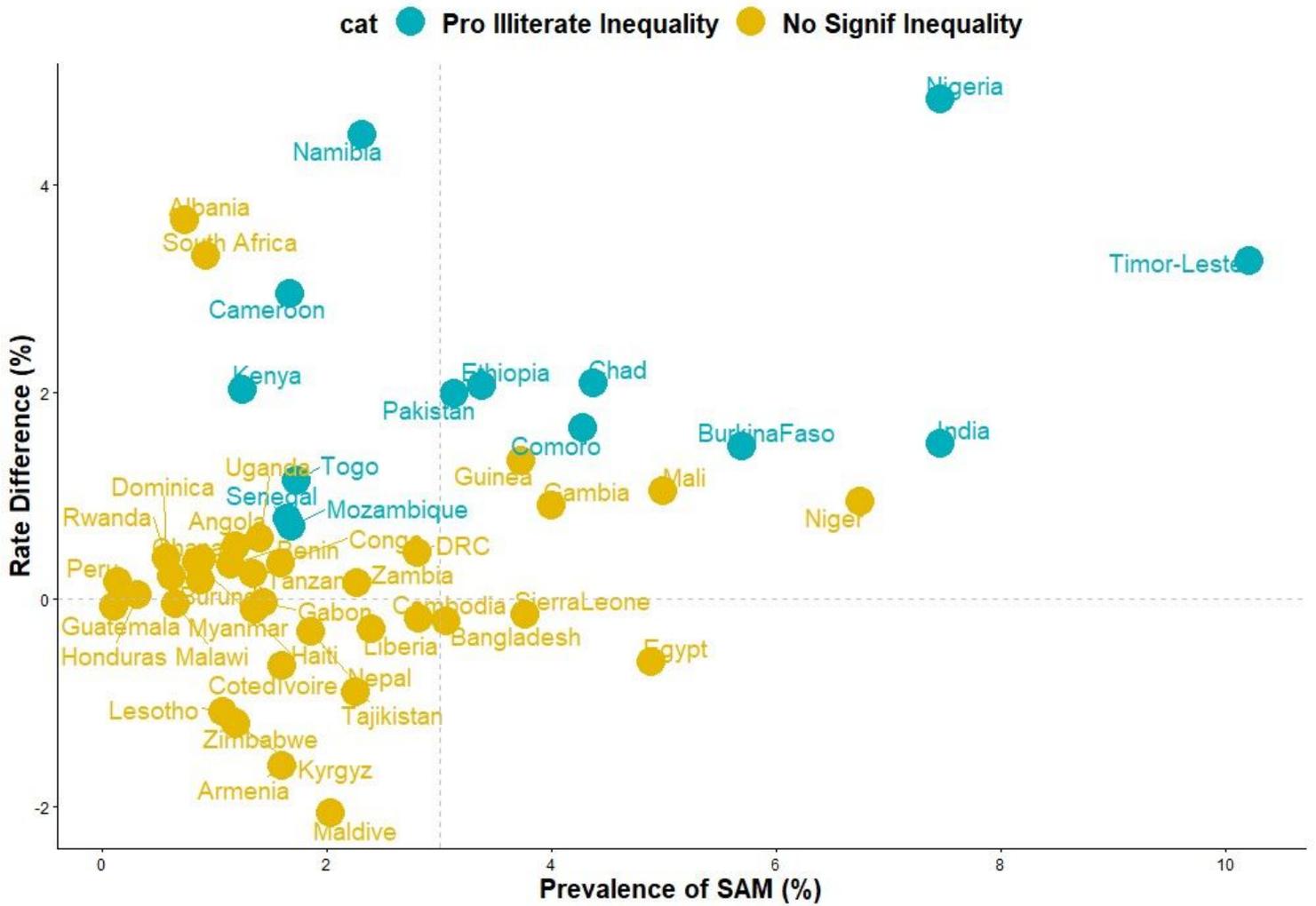
Figure 1

Risk difference between children from uneducated and educated mothers in the prevalence of SAM by countries



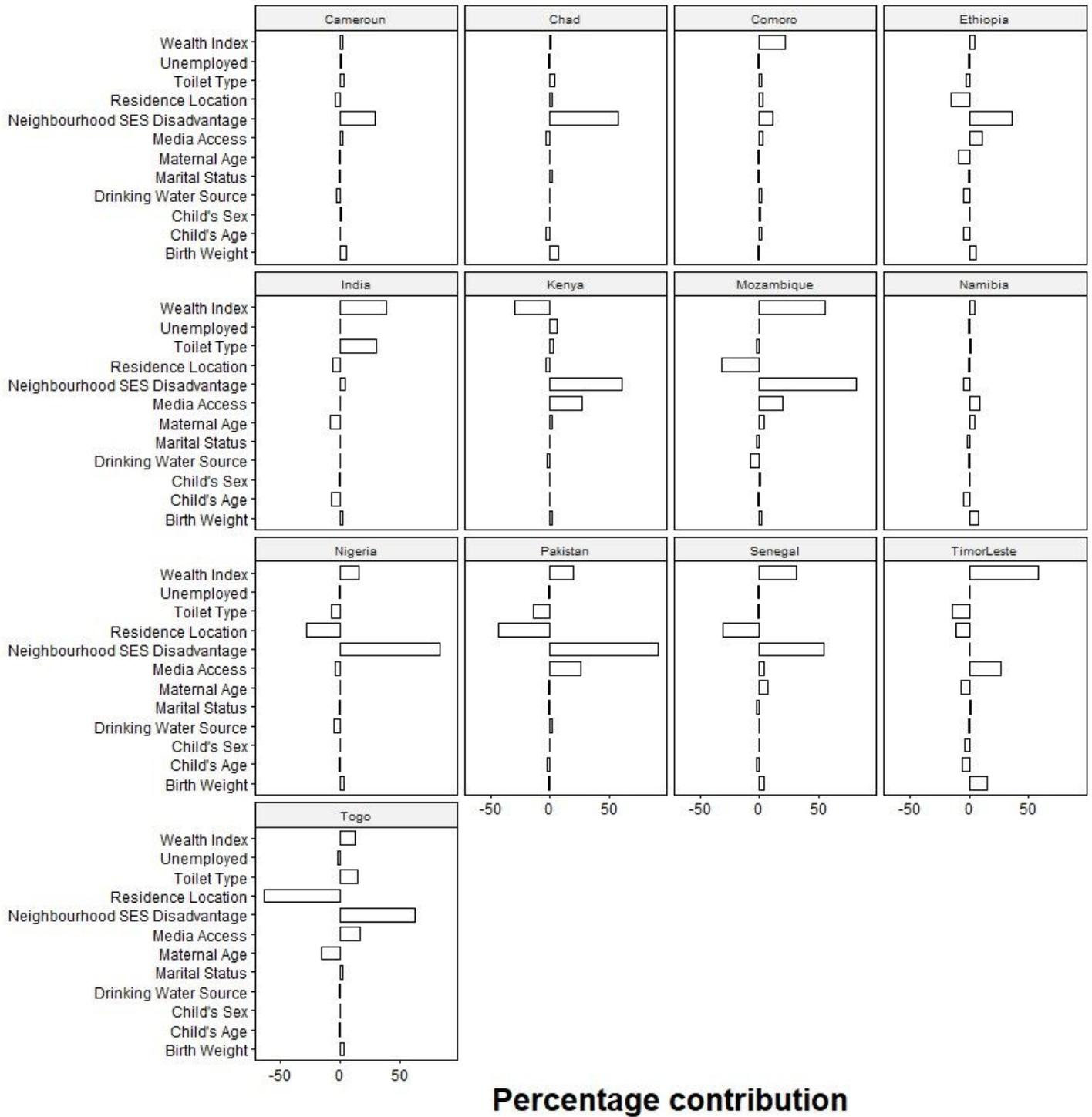
**Figure 2**

Risk difference between children born to uneducated and educated mothers in the prevalence of SAM by countries.



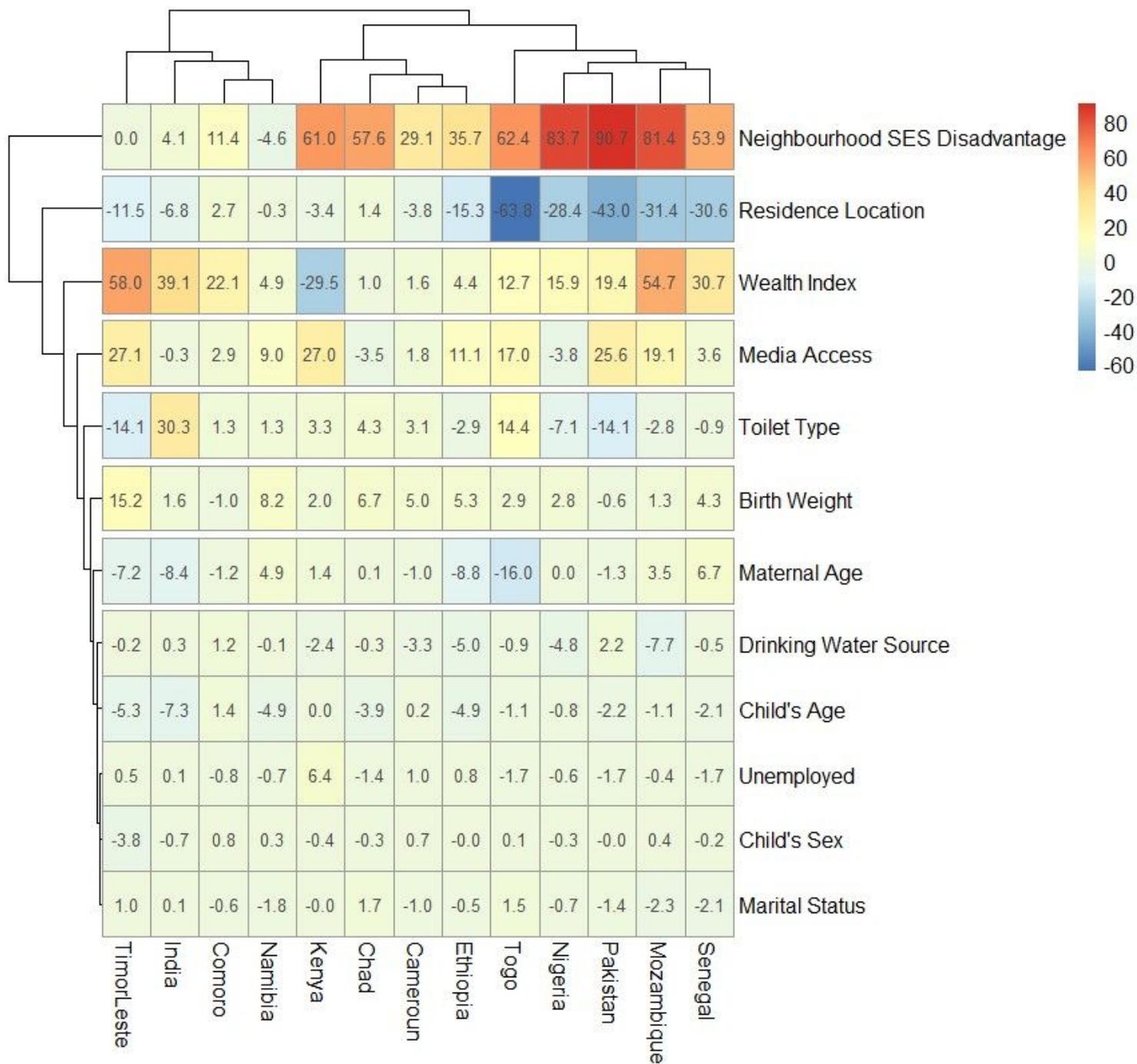
**Figure 3**

Scatter plot of rate of SAM and risk difference between children born to uneducated and educated mothers in LMIC



**Figure 4**

Contributions of differences in the distribution 'compositional effect' of the determinants of SAM to the total gap between children from uneducated and educated mothers by countries.



**Figure 5**

Contributions of differences in the distribution 'compositional effect' of the determinants of under-five mortality to the total gap between children from rural and urban areas in under-five mortality rates by countries