



# Trends in socio-economic, sex and geographic disparities in childhood underweight in Mauritania: evidence from Multiple Indicator Cluster Surveys (2007–2015)

Gebretsadik Shibre<sup>a</sup>, Betregiorgis Zegeye<sup>b</sup>, Bright Opoku Ahinkorah<sup>c</sup>, Abdul-Aziz Seidu <sup>d,e</sup>,  
Edward Kwabena Ameyaw<sup>c</sup>, Mpho Keetile<sup>f</sup> and Sanni Yaya <sup>g,\*</sup>

<sup>a</sup>Department of Reproductive, Family and Population Health, School of Public Health, Addis Ababa University, Addis Ababa, Ethiopia; <sup>b</sup>HaSET Maternal and Child Health Research Program, Addis Ababa, Ethiopia; <sup>c</sup>School of Public Health, Faculty of Health, University of Technology Sydney, Sydney, NSW, Australia; <sup>d</sup>Department of Population and Health, University of Cape Coast, Cape Coast, Ghana; <sup>e</sup>College of Public Health, Medical and Veterinary Sciences, James Cook University, Townsville, QLD, Australia; <sup>f</sup>Department of Population Studies and Demography, University of Botswana, Gaborone, Botswana; <sup>g</sup>University of Parakou, Faculty of Medicine, Parakou, Benin

\*Corresponding author: Tel: +229 96 65 85 11; E-mail: [sanni.yaya@gmail.com](mailto:sanni.yaya@gmail.com)

Received 9 February 2021; revised 12 April 2021; editorial decision 8 June 2021; accepted 11 June 2021

**Background:** Underweight is one of the largest contributors to child morbidity and mortality and is considered to be the largest contributor to the global burden of diseases in low- and middle-income countries. In Mauritania, where one-fifth of children are underweight, there is a dearth of evidence on socio-economic, sex and geographic disparities in childhood underweight. As a result, this study aimed at investigating the socio-economic, sex and geographic disparities in childhood underweight in Mauritania.

**Methods:** Using the World Health Organization's (WHO) Health Equity Assessment Toolkit (HEAT) software, data from the Mauritania Multiple Indicator Cluster Surveys (MICSs) conducted between 2007 and 2015 were analysed. Childhood underweight was disaggregated by five equity stratifiers: education, wealth, residence, region and sex. In addition, absolute and relative inequality measures, namely difference (D), population attributable risk (PAR), ratio (R) and population attributable fraction (PAF) were calculated to understand inequalities from wider perspectives. Corresponding 95% confidence intervals (CIs) were computed to measure statistical significance.

**Results:** Substantial absolute and relative socio-economic, sex and geographic disparities in underweight were observed from 2007 to 2015. Children from the poorest households (PAR = -12.66 [95% CI -14.15 to -11.16]), those whose mothers were uneducated (PAF = -9.11 [95% CI -13.41 to -4.81]), those whose mothers were rural residents (R = 1.52 [95% CI 1.37 to 1.68]), residents of HodhCharghy (PAF = -66.51 [95% CI -79.25 to -53.76]) and males (D = 4.30 [95% CI 2.09 to 6.52]) experienced a higher burden of underweight. Education-related disparities decreased from 2007 to 2015. The urban-rural gap in underweight similarly decreased over time with the different measures showing slightly different reductions. Wealth-driven disparities decreased marginally from 2011 to 2015. The sex-based and regional disparities increased, at least on average, over the 8-y intersurvey period.

**Conclusions:** The burden of underweight was significantly higher among children from disadvantaged subpopulations, those with uneducated and poorest/poor mothers, those living in rural areas and those living in HodhCharghy. Special nutrition intervention and efforts focused on these deprived subpopulations are required to reduce childhood morbidity and mortality associated with underweight and help achieve the Sustainable Development Goals.

**Keywords:** geographic, global health, malnutrition, public health, socio-economic, trend, underweight.

## Introduction

Proper nourishment of children in their early stages of life is necessary for their physical and mental development and helps protect them from childhood diseases.<sup>1</sup> When their bodies lack adequate nutrients (proteins, carbohydrates) and micronutrients (minerals and vitamins), which are essential for their body functioning, immune system development and growth, they become malnourished.<sup>2</sup> Beyond the immediate complication, malnutrition has devastating effects on children's intellectual abilities, increases their susceptibility to metabolic diseases and compromises their performance capacity and productivity in general.<sup>2-4</sup>

Globally, approximately half of under-five mortality is related to undernutrition, which consists of wasting (low weight for height), stunting (low height for age) and underweight (low weight for age).<sup>5</sup> An underweight child may be stunted, wasted or both.<sup>5</sup> In low- and middle-income countries (LMICs), underweight has become a major public health problem, as it poses a significant threat to the performance and the survival of children.<sup>6</sup> Much attention has been given to underweight because it is the leading cause of global disease burden among children<sup>7</sup> and is associated with a high risk of contagious diseases such as diarrhoea and pneumonia.<sup>8</sup> According to the World Health Organization (WHO), underweight is the single greatest risk factor in the burden of diseases in LMICs<sup>9</sup> and contributes to more than half (52.5%) of all deaths among young children.<sup>8</sup> It also accounts for 15% of the total disability-adjusted life years lost in countries with high child mortality.<sup>7</sup>

It has been estimated that approximately 101 million children are underweight globally.<sup>10</sup> In LMICs, one of every four (27%) children <5 y of age are underweight.<sup>11</sup> In sub-Saharan Africa, 28% of children <5 y of age are underweight.<sup>11</sup> In Mauritania, where one-fourth of the population live in poverty, malnutrition remains endemic throughout the country.<sup>12</sup> The country continues to experience high rates of acute malnutrition and infant mortality, as well as increased food insecurity and limited access to social services.<sup>13</sup> The estimated prevalence of acute malnutrition and severe acute malnutrition among children <5 y of age in the country ranges from 9.8% and 1.6%, respectively, in non-emergency situations to 11.6% and 2.3%, respectively, during crisis seasons. One in eight Mauritanian children <5 y of age suffer from acute malnutrition, with high prevalence rates in regions like Gorgol.<sup>13</sup> Moreover, more than one in five children suffer from chronic malnutrition. Consequently the nation faces challenges from frequently occurring life-threatening cyclical deprivations of food.<sup>14</sup> In 2015, the national prevalence of stunting in children <5 y of age was 27.9%, which was greater than the average in LMICs (25%). The prevalence of wasting was 14.8%, a figure greater than the average of 8.9% in LMICs,<sup>15</sup> and nearly 20% of children <5 y of age in Mauritania were underweight.<sup>16</sup>

Evidence shows that socio-economic factors such as maternal education level and household economic status, as well as geographic factors like place of residence and subnational region, are the main determinants for childhood undernutrition.<sup>17-19</sup> Disparities across groups based on their socio-economic status worsen the problems of childhood undernutrition.<sup>19-21</sup> Decreasing health inequalities and leaving no child behind is part of the 2030 Agenda for Sustainable Development,<sup>22,23</sup> and determining the magnitudes and acting on inequalities and their drivers will play

a crucial role in accomplishing the six Global Targets of 2025 of improving maternal, infant and children nutritional status.<sup>24</sup> The Lancet published a series on maternal and child undernutrition in 2013 that re-evaluated the burden of the problem nationally and globally; the first series was published in 2008.<sup>25</sup> These have been reiterated by recent publications on the progress made in maternal and child undernutrition.<sup>26,27</sup> Targeting inequality as a development agenda will increase evidence-based information to aid in the planning, design and implementation of public health nutrition policies.<sup>24</sup>

The main focus of studies has been on general determinants<sup>28</sup> and socio-economic factors;<sup>29,30</sup> other studies on disparities in undernutrition used old data (2000-2001)<sup>27</sup> and did not assess trends in disparities.<sup>28,30</sup> As a result, the current study aimed at examining the extent and trends in socio-economic, sex and geographic disparities in underweight among children <5 y of age using nationally representative Mauritania MICs from 2007 to 2015.

## Methods

### Study setting

Mauritania is a parched country in northwest Africa, bordered on one side by the Atlantic Ocean.<sup>12</sup> Given that it has made noteworthy progress in decreasing poverty and chronic malnutrition, its fast increasing population still faces major challenges, including land degradation, food insecurity, malnutrition and gender inequality.<sup>12</sup> Nearly 74% of the poor people in Mauritania live in rural settings, where they engage in agricultural activity.<sup>12</sup> Of this population, about 60% are low-level farmers and 20% of the farmers do not have their own land and are seasonal workers; the majority are women who are deprived opportunity and have an unequal burden of unpaid labor.<sup>12</sup>

### Data sources

The United Nations Children's Fund started collecting data through the Multiple Indicator Cluster Survey (MICS) as early as the mid-1990s. The MICS focused on providing data for policy-makers and different stakeholders in order to track progress towards the Millennium Development Goals (MDGs), particularly related to education, health and mortality.<sup>31</sup> With about 60 surveys in each round, there have been six MICS rounds conducted in LMICs. The survey includes topics such as maternal and child health, human immunodeficiency virus/acquired immunodeficiency syndrome, immunization and education. The MICS was initially conducted every 5 y but is now conducted every 3 y.<sup>31</sup> The MICS4 was conducted in 2011 and the MICS5 was in 2015. A total of 12 754 and 14 342 women 15-49 y of age were successfully interviewed from 10 116 and 11 765 households in 2011 and 2015, respectively. Additionally, 9278 (in 2011) and 10 663 (in 2015) questionnaires for children <5 y of age were completed.<sup>32,33</sup>

### Selection and measures of variables

We examined inequality in underweight among children <5 y of age. The variable was dichotomous and categorized as

'underweight' or 'not underweight'. This was derived from the calculation of weight for age. Children whose weight for age was  $< -2$  standard deviations from the reference population median were classified as underweight.<sup>5,34,35</sup>

Inequality in underweight was examined using five equity stratifiers: economic status, education status, place of residence, subnational region and sex of the child. Economic status was approximated by the wealth index, which was computed based on household assets and characteristics of the household. In the MICS, the wealth index is computed using principal component analysis.<sup>36</sup> It is classified as poorest, poorer, middle, richer and richest. The education status of the mother was categorized as no education, primary and secondary/higher education. Residence was classified as urban vs rural, with 18 subnational regions, and neonate sex as male and female.

### Statistical analyses

Using the 2019 updated WHO Health Equity Assessment Toolkit (HEAT) version 3.1,<sup>37</sup> analyses of inequality in childhood underweight were conducted. First, underweight was disaggregated by the five equity stratifiers: economic status, education status, place of residence, subnational region and sex of the child. Inequality was then calculated using four measures of inequality: difference (D), population attributable risk (PAR), population attributable fraction (PAF) and ratio (R). D and R are simple measures, while PAR and PAF are complex measures. While R and PAF are relative measures, D and PAR are absolute summary measures. The choice of summary measures was based on evidence suggesting the scientific significance of adopting both absolute and relative summary measures in a single health inequality study.<sup>37-39</sup> The main reason being that relative and absolute inequality measures could potentially lead to different, even contrasting, conclusions<sup>37-39</sup> and failing to identify these different scenarios can lead to biased decision making.

Complex measures account for the size of categories of a subpopulation, unlike simple measures. When a population shift is likely to occur, especially when trend analysis is an aim in the study, complex measures are likely to reflect the true change over time.<sup>37-39</sup> Simple measures are easy for interpretation and understanding. Therefore an inequality study should combine simple and complex, as well as relative and absolute measures, to provide a more comprehensive analysis.

The procedures followed for calculating summary measures are discussed in the HEAT software technical notes<sup>37</sup> and in the WHO handbook on health inequality monitoring.<sup>38</sup> Therefore, only a short account is provided here. For economic status and education, D was calculated as childhood underweight in the poorest group minus childhood underweight in the richest group and childhood underweight in the 'uneducated' group minus childhood underweight in the 'secondary/higher education' group, respectively. Likewise, for the place of residence, D is the difference between rural and urban populations, for sex, it is male minus female and for subnational region, it is the region with the highest estimate minus the region with the lowest estimate.

The PAR was computed as the difference between the childhood underweight estimate for the reference group,  $y_{ref}$ , and the national average of childhood underweight prevalence. For ordered dimensions,  $y_{ref}$  refers to the most-advantaged group. In

our case, the richest group and secondary/higher groups for economic dimensions and education, respectively. For binary dimensions like sex,  $y_{ref}$  refers to the group with the lowest estimate, which is female in our case. For non-ordered dimensions like subnational region,  $y_{ref}$  refers to the group or region with the lowest estimate, which is Dakhlet Nouadibou in our case. The PAF was computed by dividing the PAR by the national average  $\mu$  and multiplying the fraction by 100 ( $PAF = [PAR/\mu] * 100$ ). While zero indicates an absence of inequality, a greater absolute value of PAR and PAF indicates a higher level of inequality.

The change in childhood underweight prevalence over time was examined by referring to the 95% confidence intervals (CIs) of the different survey years. When the CIs do not overlap, it implies that there is a statistically significant difference between the two CIs. If the CIs overlap, then no inequality exists.

### Ethical consideration

The analyses were completed using the publicly available data from demographic health surveys. Institutions that commissioned, funded or managed the surveys were in charge of the ethical procedures. ICF International as well as an institutional review board (IRB) in Mauritania approved all MICSs in order to ensure that the protocols were in compliance with the U.S. Department of Health and Human Services regulations for the protection of human subjects.

### Results

In this study, a total sample of 27 052 individuals participated in the 2007, 2011 and 2015 MICSs in Mauritania. A total of 58.7% were rural residents and 50.4% were male children. Regarding education status, 29.3% of the respondents had no formal education, while 27.8% attended primary school and 21.2% and 23.6% were from the poorer and poorest groups, respectively.

Table 1 shows the prevalence of childhood underweight across socio-economic, urban-rural, sex and region groups in Mauritania from 2007 to 2015. The prevalence of childhood underweight significantly varied across wealth quintiles, with high concentrations observed among the poorest, poorer and middle wealth status groups. For instance, compared with the richest group, underweight prevalence among the poorest groups was higher by 23.4 percentage points (95% CI 20.09 to 26.72), 26.7 percentage points (95% CI 23.32 to 30.09) and 20.1 percentage points (95% CI 16.88 to 23.40) in 2007, 2011 and 2015, respectively.

The burden of childhood underweight was higher among the uneducated group compared with the secondary/higher education group. For instance, the prevalence of underweight in 2000, 2007 and 2015 was higher among uneducated groups by 19.3 percentage points (95% CI 15.96 to 22.63), 15.4 percentage points (95% CI 11.92 to 18.78) and 5.5 percentage points (95% CI 2.47 to 8.50) than among more educated groups, respectively. While the prevalence of underweight increased across primary school and secondary/higher groups from 2011 to 2015, it remained among the uneducated groups over the 8-y study period.

The results show a disproportionately higher prevalence of childhood underweight among rural residents compared with urban residents. For instance, in 2015 the prevalence of

**Table 1.** Trends in the prevalence of childhood underweight across socio-economic, urban-rural, sex and region populations

Dimension of inequality	Group	2007		2011		2015	
		Estimate (95% CI)	Population, n	Estimate (95% CI)	Population, n	Estimate (95% CI)	Population, n
Economic status	Quintile 1 (poorest)	34.46 (32.00 to 37.01)	2066	36.44 (33.67 to 39.31)	1951	32.67 (30.31 to 35.12)	2377
	Quintile 2	34.46 (31.88 to 37.13)	1667	30.65 (28.09 to 33.33)	1825	30.65 (28.23 to 33.18)	2245
	Quintile 3	26.66 (24.21 to 29.25)	1534	24.45 (22.02 to 27.05)	1657	26.36 (24.10 to 28.75)	1998
	Quintile 4	15.85 (13.73 to 18.23)	1542	16.04 (13.92 to 18.43)	1651	19.62 (17.25 to 22.23)	1927
	Quintile 5 (richest)	11.05 (9.04 to 13.44)	1456	9.73 (8.01 to 11.78)	1438	12.52 (10.48 to 14.90)	1713
Education	None	30.84 (28.59 to 33.18)	2556	29.91 (27.37 to 32.59)	2343	30.26 (27.97 to 32.65)	3023
	Primary school	23.27 (21.05 to 25.63)	2410	21.87 (19.99 to 23.88)	2726	26.94 (24.73 to 29.27)	2391
	Secondary school or higher	11.54 (9.32 to 14.19)	1002	14.56 (12.46 to 16.94)	1302	24.77 (22.91 to 26.73)	3346
Place of residence	Rural	31.27 (29.45 to 33.15)	4898	29.69 (28.02 to 31.42)	5149	29.58 (28.02 to 31.20)	5845
	Urban	16.91 (15.09 to 18.90)	3369	16.35 (14.59 to 18.29)	3374	19.36 (17.74 to 21.09)	4417
Sex	Female	31.27 (29.45 to 33.15)	4898	14.56 (12.46 to 16.94)	4149	29.58 (28.02 to 31.20)	5144
	Male	24.40 (22.56 to 26.34)	4062	22.96 (21.46 to 24.53)	4210	23.04 (21.58 to 24.56)	5118
Region	HodhCharghy	26.40 (24.66 to 28.21)	4204	25.83 (24. to 27.44)	4312	27.34 (25.72 to 29.02)	5118
	HodhGharby	33.01 (29.30 to 36.94)	1003	33.51 (28.54 to 38.88)	911	35.45 (32.13 to 38.91)	1309
	Assaba	27.34 (23.27 to 31.83)	786	31.07 (26.91 to 35.57)	817	25.75 (22.47 to 29.33)	1094
	Gorgol	32.36 (28.08 to 36.96)	926	31.74 (27.54 to 36.26)	1036	27.44 (24.17 to 30.97)	1218
	Brakna	35.81 (31.06 to 40.86)	821	31.68 (26.43 to 37.44)	628	27.78 (25.62 to 30.05)	1254
	Trarza	26.83 (24.02 to 29.84)	769	24.94 (21.57 to 28.63)	820	30.10 (26.24 to 34.27)	974
	Adrar	19.44 (16.06 to 23.32)	818	16.61 (13.63 to 20.09)	787	23.53 (19.70 to 27.86)	708
	Dakhlet Nouadibou	27.62 (20.64 to 35.90)	143	24.70 (19.98 to 30.12)	182	24.90 (20.32 to 30.12)	39
	Tagant	12.50 (9.62 to 16.08)	279	6.85 (4.77 to 9.74)	257	8.43 (6.43 to 10.99)	297
	Guidimaka	34.39 (26.49 to 43.25)	164	30.83 (26.05 to 36.05)	201	33.38 (29.42 to 37.59)	47
	Tiris Zemmour	36.88 (33.25 to 40.67)	505	33.97 (29.77 to 38.45)	743	30.74 (26.10 to 35.80)	855
	Nouakchott (Inchiri)	18.63 (15.47 to 22.27)	116	18.16 (13.66 to 23.72)	147	16.05 (12.25 to 20.75)	41
	Nouakchott	19.02 (11.50 to 29.80)	16	12.74 (10.93 to 14.80)	1987	20.17 (11.34 to 33.29)	11
	Nouakchott	13.22 (11.13 to 15.64)	1916	15.47 (13.11 to 18.17)	8523	25.18886	10,262
	National coverage		25.4211	8266	24.41651	8523	25.18886



**Table 2.** Trends in socio-economic, urban-rural, sex and region populations in childhood underweight in Mauritania

Dimension	Measure	2007, estimate (95% CI)	2011, estimate (95% CI)	2015, estimate (95% CI)
Economic status	D	23.41 (20.09 to 26.72)	26.71 (23.32 to 30.09)	20.14 (16.88 to 23.40)
	PAF	-56.50 (-62.56 to -50.43)	-60.11 (-66.16 to -54.06)	-50.26 (-56.19 to -44.32)
	PAR	-14.36 (-15.90 to -12.82)	-14.67 (-16.15 to -13.20)	-12.66 (-14.15 to -11.16)
	R	3.11 (2.46 to 3.77)	3.74 (2.96 to 4.51)	2.60 (2.11 to 3.10)
Education	D	19.29 (15.96 to 22.63)	15.35 (11.92 to 18.78)	5.48 (2.47 to 8.50)
	PAF	-52.97 (-60.69 to -45.25)	-37.60 (-45.23 to -29.97)	-9.11 (-13.41 to -4.81)
	PAR	-13.00 (-14.89 to -11.10)	-8.77 (-10.55 to -6.99)	-2.48 (-3.65 to -1.31)
	R	2.67 (2.07 to 3.26)	2.05 (1.69 to 2.41)	1.22 (1.08 to 1.35)
Residence	D	14.36 (11.71 to 17.01)	13.33 (10.83 to 15.84)	10.22 (7.91 to 12.53)
	PAF	-33.47 (-37.64 to -29.30)	-32.99 (-37.30 to -28.69)	-23.12 (-26.83 to -19.40)
	PAR	-8.50 (-9.57 to -7.44)	-8.05 (-9.10 to -7.00)	-5.82 (-6.76 to -4.88)
	R	1.84 (1.61 to 2.08)	1.81 (1.58 to 2.04)	1.52 (1.37 to 1.68)
Sex	D	1.99 (-0.58 to 4.58)	2.87 (0.67 to 5.06)	4.30 (2.09 to 6.52)
	PAF	-3.99 (-7.75 to -0.24)	-5.95 (-9.72 to -2.17)	-8.52 (-11.85 to -5.20)
	PAR	-1.01 (-1.97 to -0.06)	-1.45 (-2.37 to -0.53)	-2.14 (-2.98 to -1.31)
	R	1.08 (0.97 to 1.19)	1.12 (1.02 to 1.22)	1.18 (1.08 to 1.29)
Region	D	24.38 (19.48 to 29.28)	27.12 (22.14 to 32.10)	27.01 (22.94 to 31.08)
	PAF	-50.80 (-66.16 to -35.45)	-71.93 (-84.92 to -58.94)	-66.51 (-79.25 to -53.76)
	PAR	-12.91 (-16.81 to -9.01)	-17.56 (-20.73 to -14.39)	-16.75 (-19.96 to -13.54)
	R	2.94 (2.13 to 3.76)	4.95 (3.08 to 6.83)	4.20 (3.00 to 5.39)

childhood underweight was higher among rural residents by 10.2 percentage points (95% CI 7.91 to 12.53) compared with their urban counterparts. Regarding the pattern of underweight prevalence across urban-rural groups, the prevalence among rural residents was stable, while it increased by about 3 percentage points among urban residents from 2011 to 2015.

The results also revealed a higher prevalence of underweight among male vs female children across the 8-y study period. For example, in 2015 the prevalence of underweight among male children was higher by 4.3 percentage points (95% CI 2.09 to 6.52) compared with female children. This prevalence continued with a constant pattern in both subgroups from 2007 to 2015.

Significant variation in the prevalence of childhood underweight across regions was observed in 2007 to 2015. For instance, in 2015, underweight among children living in HodhCharghy was higher by 27 percentage points (95% CI 22.94 to 31.08) compared with children living in Dakhlet Nouadibou. The prevalence of underweight in the regions had different rates of change over time, with Dakhlet Nouadibou experiencing a significant decline over the study period. For more details, see Table 1.

### Magnitude and trends of inequalities

Table 2 shows that socio-economic, urban-rural, sex and region inequalities in childhood underweight from 2007 to 2015, with children of low socio-economic status, rural residents and from regions such as Guidimaka (for 2007 and 2011) and HodhCharghy (for 2015) being most affected.

Substantial absolute and relative wealth-driven disparities in childhood underweight were observed from 2007 to 2015 both by simple (D, R) and complex (PAF, PAR) measures that favour

children from the richest socio-economic strata. The pattern of disparities was constant from 2007 to 2011 for all four measures, however, economic-related disparities decreased from 2011 to 2015.

The R measure indicated that underweight among children in the poorest families was 2.6 times (95% CI 2.11 to 3.10) higher compared with children from the richest households in 2015. The finding also suggests that it was possible to reduce the 2007, 2011 and 2015 prevalence of childhood underweight by 56.5%, 60.1% and 50.3%, respectively, if the country had avoided the relative wealth-related inequalities. Similarly, if the absolute economic inequalities had been avoided, the 2007, 2011 and 2015 prevalence of underweight could have been reduced approximately 14.4, 14.7 and 12.7 percentage points, respectively.

Absolute and relative education-related disparities in the prevalence of underweight were observed from 2007 to 2015 when using both simple (D, R) and complex (PAR, PAF) measures. These inequalities favoured children from advantaged populations (secondary schools and richest households). The education-related disparities decreased for all the measures over the 8-y study period. For example, in 2015 the prevalence of underweight among children of uneducated mothers was higher by 5.5 percentage points (95% CI 2.47 to 8.50) compared with children from mothers who attended secondary schools and above. The results also showed that the prevalence of underweight among children of uneducated mothers was 1.2 times (95% CI 1.08 to 1.35) higher compared with children whose mothers' had completed secondary school and above. If the country had avoided both relative and absolute education-related disparities, it could have been possible to reduce the 2015 underweight

prevalence approximately 9.1% and 2.5 percentage points, respectively.

Significant pro-urban disparities in childhood underweight were identified by using both absolute (D, PAR) and relative (R, PAF) measures over the 8-y study period. For instance, in 2015 the prevalence of underweight among children living in rural settings was higher by 10.2 percentage points compared with children living in urban settings. Interestingly, the urban-rural disparities in underweight significantly decreased from 2011 to 2015. Absolute and relative sex-based disparities in underweight were observed from 2007 to 2015, with a higher burden among male children. For example, in 2015 the prevalence of underweight among male children was higher by 4.3 percentage points (95% CI 2.09 to 6.52) compared with their counterparts. In 2007, no male-female disparity was observed by the simple measures but was observed by the complex measures.

Regional disparities in underweight were identified using simple and relative measures. In 2015, for instance, underweight prevalence was higher by approximately 23–31 percentage points among children <5 y of age living in HodhCharghy compared with children living in Dakhlet Nouadibou. This finding also shows that the 2015 national childhood underweight prevalence could be decreased, on average, by 66.5% and 16.8 percentage points if the relative and absolute regional disparities were removed, respectively.

## Discussion

Underweight is a major public health problem, is a major risk factor for childhood morbidity and mortality and has negative effects on performance throughout the lifetime. It contributes to more than half (52.5%) of all deaths among young children.<sup>8</sup> Evidence shows that socio-economic and geographic inequalities exacerbate the problems of childhood underweight.<sup>19–21</sup> In this study, we measured the magnitude and dynamics of socio-economic, urban-rural, sex-based and regional disparities in childhood underweight in Mauritania from 2007 to 2015 using simple as well as absolute and relative summary measures.

Consistent with previous studies,<sup>35,40–44</sup> we found substantial pro-rich inequalities in childhood underweight over the 8-y study period. Children from wealthy families are not as vulnerable to food insecurity, have a better chance of getting treatment (fewer affordability issues)<sup>45</sup> and their parents are more likely to have a high level of education and greater awareness of childcare practices.<sup>35,46</sup> In contrast, children of underprivileged families frequently endure a greater burden of morbidity due to undernutrition.<sup>46</sup> Poverty can lead to childhood undernutrition through inadequate food intake, unsanitary living environments and a lack of essential healthcare due to affordability issues.<sup>47</sup> One study showed that state-level economic growth has no effect on child undernutrition,<sup>48</sup> as it failed to show growth of a country's economy is protective against undernutrition in children. Thus the presence of economic growth may not translate into preventing malnutrition, especially when the poor do not benefit from the economic growth. Similarly, another multicounty study revealed a very small to null effect of increasing per-head gross domestic product on decreasing child undernutrition. Instead, direct investments that aim specifically at improving the nutri-

tional status of children need to be emphasized to better fight undernutrition in children.<sup>49</sup>

A disproportionately higher burden of underweight was observed among children of non-educated mothers as compared with children whose mothers attended secondary schools and above. Our finding is comparable with previous available studies.<sup>35,50,51</sup> This is because mothers with a higher education level are believed to have better awareness and behavioural practice in promoting child health.<sup>35</sup> A study in sub-Saharan Africa showed increasing awareness and better care of children among educated women, particularly those who attended secondary school and above.<sup>52</sup> Additionally, educated women are more responsible, provide better care for their children in the course of an illness<sup>53</sup> and have autonomy and decision-making power in the household.<sup>54</sup> Frequent visits to health facilities, better health-seeking behaviour and health service uptake are documented among educated women, providing early treatment for their child when illness occurs.<sup>55–57</sup> For instance, educated women have better antenatal care uptake, which can lead to improvement in childhood nutrition status.<sup>58</sup>

We noticed pro-urban disparities in childhood underweight over the 8-y study period. In the 2015 survey for example, the prevalence of childhood underweight among rural residents was higher by 10.2 percentage points (95% CI 7.91 to 12.53) compared with urban children. If the country removed the relative urban-rural disparities, it could have been possible to reduce the 2015 childhood underweight by 19.4–26.8 percentage points. Children from rural areas are at a disadvantage when compared with those from urban areas.<sup>59</sup>

Consistent with a previous study,<sup>60</sup> male children were more underweight than female children. As documented in Zambia, female children often have a greater appetite than boys in terms of feeding.<sup>61</sup> Furthermore, girls have a tendency to spend more time than boys with caregivers and this closeness may enable more frequent feedings for girls.<sup>61</sup> Interestingly, the available justifications on the sex differential of undernutrition in male children is speculative rather than evidence driven.<sup>62</sup>

We also found variations in the burden of underweight across regions of the country.<sup>63</sup> This could be because of differences in physical remoteness and infrastructure, including the transportation system, which in turn creates difference in socio-economic status,<sup>64,65</sup> getting medical services and the availability of food and other resources across households in different regions.<sup>66,67</sup> In 2019, Mauritania's southern agro-pastoral regions encountered a third consecutive year of drought-like conditions, putting additional hardship on already impoverished communities.<sup>68</sup> Our findings are in agreement with other studies that exposed regional variations of malnutrition in children. The difference in nutritional behaviour of people across regions may explain the variation in the burden of underweight in different regions in Mauritania.<sup>69</sup>

## Strengths and limitations of the study

This study has some strengths. First, this study not only assessed the magnitude of disparities in childhood underweight but also trends over time for different dimensions of inequality, including socio-economic, education, urban-rural, sex and region, using both simple and complex as well as absolute and relative

summary measures. This could help policymakers to view the magnitude of the problem from a different perspective. Second, using the WHO recommended disparities assessment methodology<sup>36</sup> increased the reliability and strength of the findings. However, the study should be understood in light of the following limitations. First, the study focused on the descriptive nature of the problems and further decomposition studies for investigating explanatory factors for these disparities are needed. Second, the study might not represent disparities below the region level and further small-scale studies might be required. Also, due to the cross-sectional nature of the design, we cannot claim causality for our results.

## Conclusions

The burden of underweight was significantly higher among children from disadvantaged population with un-educated and poorest/poorer mothers and those living in rural areas and regions such as HodhCharghy and Guidimaka. Special nutrition interventions for these deprived populations are required to reduce childhood morbidity and mortality and help achieve the Sustainable Development Goals.

**Authors' contributions:** SY, GS and BZ contributed to the study design, conceptualization, literature review and data analysis and drafted the manuscript. BOA, EKA, AS and MK provided technical support and critically reviewed the manuscript for intellectual content. SY had final responsibility to submit for publication. All authors read and amended drafts of the manuscript and approved the final version.

**Acknowledgements:** The authors thank the WHO for producing and releasing the HEAT software for free.

**Funding:** None.

**Competing interests:** None declared.

**Ethics approval:** Not required.

**Data availability:** The datasets generated and/or analysed during the current study are available in the WHO's HEAT version 3.1 ([https://www.who.int/gho/health\\_equality/assessment\\_toolkit/en/](https://www.who.int/gho/health_equality/assessment_toolkit/en/)).

## References

- Black RE, Allen LH, Bhutta ZA, et al. Maternal and child undernutrition: global and regional exposures and health consequences. *Lancet*. 2008;371(9608):243–60.
- United Nations Children's Fund. Facts for life. Available from: [https://www.unicef.org/publications/files/Facts\\_for\\_Life\\_EN\\_010810.pdf](https://www.unicef.org/publications/files/Facts_for_Life_EN_010810.pdf) [accessed 2 May 2020].
- Victora CG, Adair L, Fall C, et al. Maternal and child undernutrition: consequences for adult health and human capital. *Lancet*. 2008;371(9609):340–57.
- World Health Organization. Global nutrition policy review: what does it take to scale up nutrition action? Available from: [http://apps.who.int/iris/bitstream/10665/84408/1/9789241505529\\_eng.pdf](http://apps.who.int/iris/bitstream/10665/84408/1/9789241505529_eng.pdf) [accessed 2 May 2020].
- World Health Organization. Malnutrition. Fact sheet about malnutrition. Available from: <https://www.who.int/news-room/fact-sheets/detail/malnutrition>] [accessed 22 May 2020].
- Walker SP, Grantham-McGregor SM, Powell CA, et al. Effects of growth restriction in early childhood on growth, IQ, and cognition at age 11 to 12 years and the benefits of nutritional supplementation and psychosocial stimulation. *J Pediatr*. 2000;137(1):36–41.
- Ezzati M, Lopez AD, Rodgers A, et al. Selected major risk factors and global and regional burden of disease. *Lancet*. 2002;360(9343):1347–60.
- Caulfield LE, de Onis M, Blössner M, et al. Undernutrition as an underlying cause of child deaths associated with diarrhea, pneumonia, malaria, and measles. *Am J Clin Nutr*. 2004;80(1):193–8.
- Wekesah FM, Mbada CE, Muula AS, et al. Effective non-drug interventions for improving outcomes and quality of maternal health care in sub-Saharan Africa: a systematic review. *Syst Rev*. 2016;5:137.
- Mheta D, Mashamba-Thompson TP. Barriers and facilitators of access to maternal services for women with disabilities: scoping review protocol. *Syst Rev*. 2017;6:99.
- UNICEF. Progress for children. Available from: [https://www.unicef.org/progressforchildren/2006n4/index\\_howmany.html](https://www.unicef.org/progressforchildren/2006n4/index_howmany.html) [accessed 23 July 2020].
- Page MJ, Shamseer L, Tricco AC. Registration of systematic reviews in PROSPERO: 30,000 records and counting. *Syst Rev*. 2018;7:32.
- European Civil Protection and Humanitarian Aid Operations. Eradicating malnutrition in Mauritania: a challenging but achievable target. Available from: [https://ec.europa.eu/echo/blog/eradicating-malnutrition-mauritania-challenging-achievable-target\\_en](https://ec.europa.eu/echo/blog/eradicating-malnutrition-mauritania-challenging-achievable-target_en) [accessed 2 May 2020].
- Akaba GO, Ekele BA. Maternal and fetal outcomes of emergency obstetric referrals to a Nigerian teaching hospital. *Trop Doct*. 2018;48(2):132–5.
- Global Nutrition Report. Country nutrition profiles. Available from: <https://globalnutritionreport.org/resources/nutrition-profiles/africa/western-africa/mauritania/>] [accessed 5 May 2020].
- Ciapponi A, Lewin S, Herrera CA, et al. Delivery arrangements for health systems in low-income countries: an overview of systematic reviews. *Cochrane Database Syst Rev*. 2017;9:CD011083.
- De Plecker E, Zachariah R, Kumar AM, et al. Emergency obstetric care in a rural district of Burundi: what are the surgical needs? *PLoS One*. 2017;12(2):e0170882.
- Iwuh IA, Fawcus S, Schoeman L. Maternal near-miss audit in the Metro West maternity service, Cape Town, South Africa: a retrospective observational study. *S Afr Med J*. 2018;108(3):171–5.
- Pembe AB, Carlstedt A, Urassa DP, et al. Effectiveness of maternal referral system in a rural setting: a case study from Rufiji district, Tanzania. *BMC Health Serv Res*. 2010;10:326.
- Soma-Pillay P, Pattinson RC. Barriers to obstetric care among maternal near misses. *S Afr Med J*. 2016;106(11):1110–3.
- Awoonor-Williams JK, Bailey PE, Yeji F, et al. Conducting an audit to improve the facilitation of emergency maternal and newborn referral in northern Ghana. *Global Public Health*. 2015;10(9):1118–33.
- Bhopal SS, Halpin SJ, Gerein N. Emergency obstetric referral in rural Sierra Leone: what can motorbike ambulances contribute? A mixed-methods study. *Matern Child Health J*. 2013;17(6):1038–43.
- Pirkle CM, Fournier P, Tourigny C, et al. Emergency obstetrical complications in a rural African setting (Kayes, Mali): the link between

- travel time and in-hospital maternal mortality. *Matern Child Health J.* 2011;15(7):1081–7.
- 24 Essendi H, Mills S, Fotso JC. Barriers to formal emergency obstetric care services utilization. *J Urban Health.* 2011;88(Suppl 2):S356–69.
  - 25 World Health Organization. Maternal and child nutrition. *Lancet.* 2013. Available from: <https://www.thelancet.com/series/maternal-and-child-nutrition> [accessed 5 April 2021].
  - 26 Victora CG, Christian P, Vdaletti LP, et al. Revisiting maternal and child undernutrition in low-income and middle-income countries: variable progress towards an unfinished agenda. *Lancet.* 2021;397(10282):1388–99.
  - 27 Heidkamp RA, Piwoz E, Gillespie S, et al. Mobilising evidence, data, and resources to achieve global maternal and child undernutrition targets and the Sustainable Development Goals: an agenda for action. *Lancet.* 2021;397(10282):1400–18.
  - 28 Fournier P. Improved access to comprehensive emergency obstetric care and its effect on institutional maternal mortality in rural Mali. *Bull World Health Org.* 2009;87:30–8.
  - 29 Nuamah GB, Agyei-Baffour P, Akohene KM, et al. Incentives to yield to obstetric referrals in deprived areas of Amansie West district in the Ashanti Region, Ghana. *Int J Equity Health.* 2016;15:117.
  - 30 Cofie LE, Barrington C, Singh K, et al. Structural and functional network characteristics and facility delivery among women in rural Ghana. *BMC Pregnancy Childbirth.* 2017;17:425.
  - 31 Queensland Clinical Guidelines. Supplement: non-urgent referral for antenatal care. Available from: [https://www.health.qld.gov.au/\\_data/assets/pdf\\_file/0026/360197/s-non-urgent.pdf](https://www.health.qld.gov.au/_data/assets/pdf_file/0026/360197/s-non-urgent.pdf) [accessed 16 June 2021].
  - 32 Traore M, Arsenault C, Schoemaker-Marcotte C, et al. Obstetric competence among primary healthcare workers in Mali. *Int J Gynaecol Obstet.* 2014;126(1):50–5.
  - 33 Global Health Data Exchange. Mauritania Multiple Indicator Cluster Survey 2015. Available from: <http://ghdx.healthdata.org/record/mauritania-multiple-indicator-cluster-survey-2015> [accessed 3 May 2020].
  - 34 Singh S, Doyle P, Campbell OM, et al. Referrals between public sector health institutions for women with obstetric high risk, complications, or emergencies in India - a systematic review. *PLoS One.* 2016;11(8):e0159793.
  - 35 Australian College of Midwives. National midwifery guidelines for consultation and referral. Canberra City, ACT, Australia: Australian College of Midwives; 2014.
  - 36 Wheeler JL. Towards an understanding of midwifery practice in relation to managing the risk of severe perineal trauma for women of Asian ethnicity in the Australian setting: an ethnography. Sydney, NSW, Australia: University of Technology Sydney; 2014.
  - 37 Handorf S. Connecting movement and emotion for childbirth preparation: an exploratory study. Sydney, NSW, Australia: University of Technology Sydney; 2017.
  - 38 Sumankuuro J, Crockett J, Wang S. Sociocultural barriers to maternity services delivery: a qualitative meta-synthesis of the literature. *Public Health.* 2018;157:77–85.
  - 39 Hosseinpoor AR, Bergen N, Schlottheuber A, et al. Data resource profile: WHO Health Equity Monitor (HEM). *Int J Epidemiol.* 2016;45(5):1404–5e.
  - 40 Kyei-Onanjiri M, Carolan-Olah M, Awoonor-Williams JK, et al. Review of emergency obstetric care interventions in health facilities in the Upper East Region of Ghana: a questionnaire survey. *BMC Health Serv Res.* 2018;18:184.
  - 41 Forshaw J, Raybould S, Lewis E, et al. Exploring the third delay: an audit evaluating obstetric triage at Mulago National Referral Hospital. *BMC Pregnancy Childbirth.* 2016;16:300.
  - 42 Kyei-Nimakoh M, Carolan-Olah M, McCann TV. Access barriers to obstetric care at health facilities in sub-Saharan Africa—a systematic review. *Syst Rev.* 2017;6:110.
  - 43 World Health Organization. WHO recommendations on maternal health: guidelines approved by the WHO Guidelines Review Committee. Geneva: World Health Organization; 2017.
  - 44 World Health Organization. Pregnancy, childbirth, postpartum and newborn care: a guide for essential practice. Geneva: World Health Organization; 2015.
  - 45 World Health Organization. Standards for improving quality of maternal and newborn care in health facilities. Geneva: World Health Organization; 2016.
  - 46 Long Q, Allanson ER, Pontre J, et al. Onsite midwife-led birth units (OMBUs) for care around the time of childbirth: a systematic review. *BMJ Glob Health.* 2016;1(2):e000096.
  - 47 Afari H, Hirschhorn LR, Michaelis A, et al. Quality improvement in emergency obstetric referrals: qualitative study of provider perspectives in Assin North District, Ghana. *BMJ Open.* 2014;4(5):e005052.
  - 48 Subramanyam MA, Kawachi I, Berkman LF, et al. Is economic growth associated with reduction in child undernutrition in India? *PLoS Med.* 2011;8(3):e1000424.
  - 49 Vollmer S, Harttgen K, Subramanyam MA, et al. Association between economic growth and early childhood undernutrition: evidence from 121 Demographic and Health Surveys from 36 low-income and middle-income countries. *Lancet Global Health.* 2014;2(4):e225–3.
  - 50 Alasfoor D, Traissac P, Gartner A, et al. Determinants of persistent underweight among children, aged 6–35 months, after huge economic development and improvements in health services in Oman. *J Health Popul Nutr.* 2007;25(3): 359–69.
  - 51 Lassi ZS, Salam AR, Das JK, et al. Essential interventions for maternal, newborn and child health: background and methodology. *Reprod Health.* 2014;11(Suppl 1):S1.
  - 52 Oyekale AS. Factors explaining acute malnutrition among under-five children in sub-Sahara Africa (SSA). *Life Sci J.* 2012;9(4):2101–7.
  - 53 Subramanyam MA, Kawachi I, Berkman LF, et al. Is economic growth associated with reduction in child undernutrition in India? *PLoS Med.* 2011;8(3):e1000424.
  - 54 Bhutta ZA, Ahmed T, Black RE, et al. What works? Interventions for maternal and child under-nutrition and survival. *Lancet.* 2008;371(9610):417–40.
  - 55 Keats A. Women’s schooling, fertility, and child health outcomes: evidence from Uganda’s free primary education program. Mimeo, Wesleyan University; 2014.
  - 56 Tekce B, Shorter FC. Determinants of child mortality: a study of squatter settlements in Jordan. *Popul Dev Rev.* 1984;10(Suppl 1):257–80.
  - 57 Benyoussef A, Wessen AF. Utilization of health services in developing countries—Tunisia. *Soc Sci Med (1967).* 1974;8(5):287–304.
  - 58 Caldwell JC, Reddy PH, Caldwell P. The social component of mortality decline: an investigation in South India employing alternative methodologies. *Popul Stud.* 1983;37(2):185–205.
  - 59 Siddiqi MN, Haque MN, Goni MA. Malnutrition of under-five children: evidence from Bangladesh. *Asian J Med Sci.* 2011;2(2):113–9.
  - 60 Ambapour S, Hylod AM. “Pauvreté et Santé Nutritionnelle de l’Enfant au Congo”. Document de travail, BAMSIS no. 15/2008.



2008. [https://scholar.google.com/scholar?hl=en&as\\_sdt=0%2C5&q=Ambapour+5%2C+Hylod+AM.+%E2%80%9CPauvre%C3%A9+et+Sant%C3%A9+Nutritionnelle+de+l%E2%80%99Enfant+695+au+Congo%E2%80%9D.+Document+de+travail%2C+BAMSI+no.+15%2F2008.+2008.&btnG=](https://scholar.google.com/scholar?hl=en&as_sdt=0%2C5&q=Ambapour+5%2C+Hylod+AM.+%E2%80%9CPauvre%C3%A9+et+Sant%C3%A9+Nutritionnelle+de+l%E2%80%99Enfant+695+au+Congo%E2%80%9D.+Document+de+travail%2C+BAMSI+no.+15%2F2008.+2008.&btnG=).
- 61 Jennifer Y. Trends and inequalities in young child nutrition in Rwanda: further analysis of the 2014–15 Demographic and Health Survey. DHS Further Analysis Reports no. 109. Rockville, MD: ICF International; 2018.
- 62 Thurstans S, Opondo C, Seal A, et al. Boys are more likely to be undernourished than girls: a systematic review and meta-analysis of sex differences in undernutrition. *BMJ Global Health*. 2020;5:e004030.
- 63 Hasan MM, Uddin J, Pulok MH, et al. Socioeconomic inequalities in child malnutrition in Bangladesh: do they differ by region? *Int J Environ Res Public Health*. 2020;17(3):1079.
- 64 Fotso JC, Kuate-Defo B. Socioeconomic inequalities in early childhood malnutrition and morbidity: modification of the household-level effects by the community SES. *Health Place*. 2005;11(3):205–25.
- 65 Shamseer L, Moher D, Clarke M, et al. Preferred reporting items for systematic review and meta-analysis protocols (PRISMA-P) 2015: elaboration and explanation. *BMJ*. 2015;350:g7647.
- 66 Ali Z, Yunus M, Sen B. Regional inequality in Bangladesh in the 2000s: re-visiting the east-west divide debate. Dhaka, Bangladesh: Bangladesh Institute of Development Studies; 2015.
- 67 Fang P, Dong S, Xiao J, et al. Regional inequality in health and its determinants: evidence from China. *Health Policy*. 2010;94(1):14–25.
- 68 Stokes T, Shaw EJ, Camosso-Stefinovic J, et al. Barriers and enablers to guideline implementation strategies to improve obstetric care practice in low- and middle-income countries: a systematic review of qualitative evidence. *Implement Sci*. 2016;11(1):144.
- 69 Kandala NB, Madungu TP, Emina JB, et al. Malnutrition among children under the age of five in the Democratic Republic of Congo (DRC): does geographic location matter? *BMC Public Health*. 2011;11:261