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## Triple burden of malnutrition among mother-child pairs in low and middle-income countries: In the era of sustainable development goals

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## 1 **Triple burden of malnutrition among mother-child pairs in low and** 2 **middle-income countries: In the era of sustainable development goals**

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## 29 Abstract

30 **Objective:** This study aimed to assess the prevalence and determinants of the triple burden of  
31 malnutrition among mother-child pairs in low-and middle-income countries.

32 **Design:** Cross-Sectional Study

33 **Setting:** Low-and middle-income countries

34 **Participants:** Women and children

35 **Primary outcome:** Triple burden of malnutrition

36 **Methods:** Data for this study were drawn from recent 22 low and middle-income countries  
37 Demographic and Health Surveys (DHSs). A total weighted sample of 116,795 mother-child pairs  
38 was included in the study. STATA version 14.2 was used to clean, code and analyze the data.  
39 Multilevel logistic regression was employed to identify factors associated with the problem.  
40 Adjusted odds ratio with 95% CI and a P value <0.05 was reported to indicate statistical  
41 association. Model fitness and comparison were done using ICC, MOR, PCV, and deviance.

42 **Result:** The pooled prevalence of the triple burden of malnutrition among mother-child pairs was  
43 11.39%. It showed statistically significant positive associations with mothers aged  $\geq 35$  years  
44 (AOR=2.25,95%CI 2.08-2.44), family size >10 (AOR=1.17,95%CI 1.08-1.26), delivery by CS  
45 (AOR=1.93,95%CI 1.83-2.03), the richest household (AOR=1.72,95%CI 1.56-1.88), grand  
46 multiparous (AOR=1.62, 95% CI 1.46-1.81), age of child 36-47 months (AOR=1.77, 95% CI 1.64-  
47 1.90), at a p-value of <0.05. Whereas breastfeeding (AOR=0.94,95%CI 0.89-0.99), married  
48 mothers (AOR=0.87,95%CI 0.78-0.96), female children (AOR=0.88,95%CI 0.84-0.92), improved  
49 toilet (AOR=0.23,95%CI 0.17-0.29), improved source of drinking water (AOR=0.28,95%CI 0.21-  
50 0.35), rural residents (AOR=0.66,95%CI 0.62-0.69) had a contrasting relationship with the triple  
51 burden of malnutrition

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3 52 **Conclusions:** About 1 out of 10 households suffer from the triple burden of malnutrition in low  
4  
5 53 and middle-income countries. This study revealed that several maternal, child, household, and  
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7 54 community-level factors have a significant impact on the triple burden of malnutrition among  
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9 55 mother-child pairs. Prevention of the problem requires collective efforts from the governments,  
10  
11 56 the scientific and medical communities, and the industry towards changing dietary and lifestyle  
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13 57 habits.  
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17 58 **Keywords:** Triple burden, mother-child pairs, malnutrition, low and middle-income countries.  
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### 21 59 **Strengths and limitations of this study**

- 22  
23 60 ➤ The findings were supported by large datasets covering 22 LMICs.  
24  
25 61 ➤ We employed multilevel analysis which is an appropriate methodology for such data  
26  
27 62 ➤ The data were collected using a common internationally acceptable methodological procedure.  
28  
29 63 ➤ DHS used a cross-sectional survey design, and the causal relationship between the triple  
30  
31 64 burden of malnutrition and the independent variables cannot be established.  
32  
33 65 ➤ We didn't include important covariates such as dietary intake, physical activity level, or  
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35 66 comorbidities as the DHS did not collect information on these variables  
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## 73 **Background**

74 The triple burden of malnutrition, defined as the coexistence of overnutrition, undernutrition, and  
75 micronutrient deficiencies is increasing in low and middle-income countries (LMICs) (1). The  
76 World Health Organization (WHO) characterized overnutrition (Obesity and overweight) as a  
77 pandemic of a major public health concern due to the increased frequency of the problem in many  
78 countries (2). It is ranked as the sixth leading cause of disability-adjusted life years (DALYs) and  
79 accounts for approximately 4 million people dying each year worldwide (3-5). Several previous  
80 studies have shown, following marked dietary change that obesity/overweight is increasing more  
81 rapidly in low and middle-income countries compared to higher-income countries (6, 7).

82 Similarly, undernutrition continues to be a major public health concern throughout the developing  
83 world (8, 9). Nearly half of all deaths in children under 5 are attributable to undernutrition and it  
84 encompasses wasting, stunting, underweight, and micronutrient deficiencies (anemia) (10, 11).  
85 Despite stunting having declined steadily, faster progress is needed to reach the 2030 target (12,  
86 13). Wasting and underweight persisting at alarming rates require a reversal in trajectory if the  
87 2030 target is to be achieved (14). Since 2000, a significant reduction in the prevalence of anemia  
88 in children under five has been observed in many low- and lower-middle-income countries (15).  
89 Children are more vulnerable to inadequate pre-natal, infant, and young child nutrition, particularly  
90 in resource-constrained settings (16, 17). Endorsing early childhood feeding best practices is  
91 crucial to improve the health of children (18).

92 Malnutrition has a tremendous negative impact on the normal functioning of every organ system  
93 (19). It can cause permanent, widespread damage to a child's growth, development, and well-being  
94 (20). Scientific evidence has shown that malnutrition in children is associated with poorer school  
95 performance, increased susceptibility to infections, and slow recovery from illness (21, 22).

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3 96 Maternal malnutrition increases the risk of poor pregnancy outcomes including obstructed labor,  
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5 97 premature or low-birth-weight babies, and postpartum hemorrhage (23, 24). To reduce the problem  
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7 98 the United Nations (UN) adopted the Sustainable Development Goals (SDGs), especially those  
8  
9 99 targeted to end poverty in all its forms everywhere (SDG 1), end hunger, achieve food security,  
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11 100 improve nutrition, promote sustainable agriculture (SDG 2), ensure healthy lives, and promote  
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13 101 well-being for all at all ages (SDG 3) (25, 26).  
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17 102 Previous literature recognizes the basic and underlying causes of malnutrition including the  
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19 103 environmental, economic, and sociopolitical contextual factors, with poverty having a central role  
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21 104 (11, 27-29). Given the persistent and high levels of triple burden of malnutrition among mother-  
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23 105 child pairs in low and middle-income countries, there is a strong need for action. To design and  
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25 106 deliver effective interventions adequate understanding of the socioeconomic, environmental, and  
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27 107 cultural factors is highly important. Besides if the SDG targets are to be met, coordinated action is  
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29 108 required toward not only sustaining current rates of decline but also accelerating progress.  
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31 109 Therefore, the objective of this study was to assess the prevalence of the triple burden of  
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33 110 malnutrition among mothers and children and the potential factors associated with it in low and  
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35 111 middle-income countries.  
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## 41 **Materials and methods**

### 42 **Study design, setting, and period**

43  
44 113 The present study is based on 22 low and middle-income countries that have had Demographic  
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46 114 and Health Surveys (DHS) since 2016. The DHS used a cross-sectional survey study design to  
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48 115 collect data and provide population and health indicators at the national level. The list of those  
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50 116 countries and the respective year of surveys is provided in Table 1.  
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118 Table 1. Study setting and year of surveys

Country	Year of survey	Region
Albania	2017/18	Southeastern Europe
Benin	2017/18	West Africa
Burundi	2016/17	East-central Africa
Cameroon	2018	West-central Africa
Ethiopia	2016	East Africa
Gambia	2019/20	West Africa
Guinea	2018	West Africa
Haiti	2016/17	Caribbean
India	2019/21	South Asia
Liberia	2019/20	West Africa
Madagascar	2021	East Africa
Mali	2018	West Africa
Mauritania	2019/21	Northwest Africa
Maldives	2016/17	South Asia
Nigeria	2018	West Africa
Nepal	2016	South Asia
Rwanda	2019/20	East Africa
Sierra Leone	2019	West Africa
Tajikistan	2017	Central Asia
Timor Leste	2016	South Asia
Uganda	2016	East Africa
South Africa	2016	South Africa

119

### 120 Data source and sampling procedure

121 The current analyses was based on pooled data from DHSs in 22 LMICs. These are nationally  
 122 representative surveys that collect data on reproductive, maternal, neonatal, child health, and  
 123 nutrition in LMIC. The surveys are similarly designed that used standardized questionnaires and  
 124 data collection procedures, allowing therefore comparability of results. The survey employed a  
 125 two-stage cluster sampling technique. In the first stage, the selection of proportional  
 126 clusters/enumeration areas was performed using each country's most recent population and  
 127 housing census as a sampling frame. In the second stage, a systematic selection of households from  
 128 the newly created cluster was performed. A detailed description of the DHS sampling design and

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2  
3 129 data collection procedures has been found in each country's DHS report. The study population for  
4  
5 130 this study was mother-child pairs.  
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## 8 131 **Definition of variables**

### 9 10 132 **Outcome variable:**

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13 133 The triple burden of malnutrition was the outcome variable of this study where the mother was  
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15 134 overweight/obese and children under 5 years of age were undernourished and anemic. At the same  
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17 135 household level, first, we created four different categories of malnutrition such as  
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19 136 overweight/obese mother and stunted child, overweight/obese mother and wasted child,  
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21 137 overweight/obese mother and underweight child, and overweight/obese mother and anemic child.  
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23 138 Then we further combined overweight/obese mothers, undernourished children, and anemic  
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25 139 children to generate the triple burden of malnutrition.  
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### 29 140 **Independent variables:**

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31 141 Based on previous works of literature and the likelihood of influencing the outcome of interest,  
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33 142 several explanatory variables including the age of mothers, mother's education, marital status,  
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35 143 current breastfeeding, delivery by cesarean section, family size, wealth index, media access, parity,  
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37 144 age of the child, sex of the child, type of toilet facility, source of drinking water, residence and  
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39 145 distance to health facility were considered.  
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## 43 146 **Statistical analyses**

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45 147 We append the dataset of each country to generate pooled data. The data extraction, coding, and  
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47 148 analysis were carried out using STATA software version 14.2. We weighted the sample to restore  
48  
49 149 the representativeness of the sample so that the total sample looks like the country's actual  
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51 150 population. Due to the hierarchical nature of the DHS, the multilevel analysis was fitted to identify  
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53 151 significantly associated factors. Four models were fitted; the null model (with no predictors), the  
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3 152 model I (adjusted for individual-level variables only), model II (adjusted for community-level  
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5 153 variables only), and model III (model adjustment for both individual and community-level  
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7 154 variables simultaneously). Adjusted OR (AOR) with 95% CI and  $p < 0.05$  were used to determine  
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9 155 significant predictors. Model fitness and comparison were done using Intraclass Correlation  
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11 156 Coefficient (ICC), Proportional Change in Variance (PCV), Median Odds Ratio (MOR), the  
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14 157 Likelihood Ratio test (LR), and deviance computed.

### 158 **Patient and public involvement statement**

159 As our study used secondary analysis of DHS data, participants and the public were not involved  
160 in the study design or planning of the study. The study participants were not consulted to interpret  
161 the results and write or editing of this document for readability or accuracy.

### 162 **Results**

163 A total of 116,795 mother-child pairs were included in the study. Over half (56.48%) of mothers  
164 were in the age category of 25-34 years. About 22.98% of mothers were illiterate and the majority  
165 (46.39%) had attended secondary education. Approximately 95.73% of mothers were married and  
166 62.89% were currently breastfeeding. About 20.33% and 21.21% of the households were in the  
167 low wealth quintile of poorest and poorer respectively. Over a quarter (27.62%) of the families  
168 had never been exposed to any type of media. The majority of the children (32.59%) were aged  
169  $\leq 12$  months. A large proportion (83.60%) of the households had improved sources of drinking  
170 water and almost two-thirds (67.02%) of the households had improved toilet facilities. Almost  
171 three fourth (71.03%) of participants lived in rural areas and for over a quarter (27.42%) of those  
172 participants, the distance to access health facilities was a big problem (**Table 2**).

173 Table 2. Socio-demographic characteristics of the study participants

Variables	Categories	Unweighted frequency (%)	Weighted frequency (%)
Age of mothers	15-24	34,983 (29.05)	35,918 (30.75)
	25-34	68,386 (56.78)	65,971 (56.48)
	≥35	17,073 (14.18)	14,906 (12.76)
Mothers education	No education	27,995 (23.24)	26,845 (22.98)
	Primary education	19,684 (16.34)	18,633 (15.95)
	Secondary	57,008 (47.33)	54,185 (46.39)
	Higher	15,755 (13.08)	17,131 (14.67)
Mothers marital status	Not in union	5,583 (4.64)	4,987 (4.27)
	Married	114,859 (95.36)	111,807 (95.73)
Currently breastfeeding	No	44,160 (36.66)	43,338 (37.11)
	Yes	76,282 (63.34)	73,457 (62.89)
Delivery by cesarean section	No	99,291 (82.49)	93,974 (80.51)
	Yes	21,077 (17.51)	22,748 (19.49)
Family size	≤5	56,365 (46.80)	53,677 (45.96)
	6-10	54,605 (45.34)	53,258 (45.60)
	>10	9,472 (7.86)	9,859 (8.44)
Wealth index	Poorest	28,097 (23.33)	23,749 (20.33)
	Poorer	27,352 (22.71)	24,774 (21.21)
	Middle	24,741 (20.54)	24,330 (20.83)
	Richer	22,180 (18.42)	23,880 (20.45)
	Richest	18,072 (15.00)	20,061 (17.18)
Media access	No	33,942 (28.18)	32,256 (27.62)
	Yes	86,500 (71.82)	84,539 (72.38)
Parity	Primiparous	36,241 (30.09)	35,333 (30.25)
	Multiparous	76,092 (63.18)	73,823 (63.21)
	Grand Multiparous	8,109 (6.73)	7,639 (6.54)
Age of child	≤12	38,959 (32.35)	38,059 (32.59)
	13-23	25,382 (21.07)	24,819 (21.25)
	24-35	22,208 (18.44)	21,478 (18.39)
	36-47	17,948 (14.90)	17,204 (14.73)
	48-59	15,945 (13.24)	15,234 (13.04)
Sex of child	Male	63,660 (52.86)	62,008 (53.09)
	Female	56,782 (47.14)	54,787 (46.91)
Type of toilet facility	Unimproved	37,519 (31.15)	38,518 (32.98)
	Improved	82,923 (68.85)	78,277 (67.02)
Source of drinking water	Unimproved	20,959 (17.40)	19,159 (16.40)
	Improved	99,483 (82.60)	97,636 (83.60)
Residence	Urban	28,722 (23.85)	33,838 (28.97)
	Rural	91,720 (76.15)	82,957 (71.03)
Distance to health facility	No problem	84,605 (70.25)	84,776 (72.58)
	Big problem	35,837 (29.75)	32,019 (27.42)

174

175 **Prevalence of triple burden of malnutrition**

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3 176 In 22 low and middle-income countries, the pooled prevalence of the triple burden of malnutrition  
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5 177 among mother-child pairs was found at 11.39 % (95% CI 9.56%, 13.23%). Ethiopia has the lowest  
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7 178 (3.54 %) prevalence of triple burden while Mauritania (31.66%) bears the highest (**Figure 1**).

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10  
11 179 Fig 1. The pooled prevalence of the triple burden of malnutrition  
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## 14 180 **Multilevel analyses**

### 15 16 17 181 **Random parameter estimation and model selection**

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19 182 Based on the result of random effect analysis, the ICC of the null model was 0.30, indicating that  
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21 183 30% of the total variability in triple burden prevalence was attributable to between-cluster  
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23 184 variability, while about 70% was due to individual differences. The null model MOR was 3.04,  
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25 185 which indicates that a mother/child from a cluster with a high triple burden prevalence has a 3.04  
26  
27 186 times higher probability of being malnourished than a mother/child from a cluster with a lower  
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29 187 prevalence. Model III was the best-fitted model since it has the highest log likelihood (-91665)  
30  
31 188 and the lowest deviance (183,330) value (**Table 3**).

### 32 33 34 35 36 189 **Factors associated with the triple burden of malnutrition (Fixed effects)**

37  
38 190 The existence of triple burden of malnutrition showed statistically significant positive associations  
39  
40 191 with mothers aged 25-34 years (AOR=1.54, 95% CI 1.45 - 1.63),  $\geq 35$  years (AOR=2.25, 95% CI  
41  
42 192 2.08 - 2.44), mothers attended secondary education (AOR=1.08, 95% CI 1.02-1.15), family size  
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44 193  $>10$  (AOR=1.17, 95% CI 1.08 - 1.26), delivery by CS (AOR=1.93, 95% CI 1.83 - 2.03), the richer  
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46 194 household (AOR=1.63, 95% CI 1.49 - 1.76), the richest household (AOR=1.72, 95% CI 1.56 -  
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48 195 1.88), multiparous (AOR=1.42, 95% CI 1.34 - 1.49), grand multiparous (AOR=1.62, 95% CI 1.46  
49  
50 196 - 1.81), age of child 36-47 months (AOR=1.77, 95% CI 1.64 - 1.90), age of child 48-59  
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52 197 (AOR=1.51, 95% CI 1.39 - 1.64), at a p-value of  $<0.05$ . Whereas breastfeeding (AOR=0.94, 95%  
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198 CI 0.89 - 0.99), married mothers (AOR=0.87, 95% CI 0.78 - 0.96), female children (AOR=0.88,  
 199 95% CI 0.84 - 0.92), improved toilet facility (AOR=0.23, 95% CI 0.17 - 0.29), improved source  
 200 of drinking water (AOR=0.28, 95% CI 0.21 - 0.35), rural residents (AOR=0.66, 95% CI 0.62 -  
 201 0.69) showed a contrasting relationship with the triple burden of malnutrition (**Table 3**).

202  
 203 Table 3. Multivariable multilevel logistic regression analysis of the triple burden of malnutrition.

Variables	Categories	Null model	Model I AOR 95% CI	Model II AOR 95% CI	Model III AOR 95% CI
Age of mothers	15-24	1.00			1.00
	25-34		1.54 (1.46 - 1.63)**	—	1.54 (1.45 - 1.63)**
	≥35		2.28 (2.11 - 2.47)**	—	2.25 (2.08 - 2.44)**
Mothers education	No education	1.00			1.00
	Primary education		1.04 (0.97 - 1.12)	—	1.04 (0.97 - 1.12)
	Secondary		1.08 (1.01 - 1.15)*	—	1.08 (1.02 - 1.15)*
	Higher		0.94 (0.86 - 1.02)	—	0.94 (0.86 - 1.02)
Mothers marital status	Not in union	1.00			1.00
	Married		0.83 (0.75 - 0.93)*	—	0.87 (0.78 - 0.96)**
Currently breast feeding	No	1.00			1.00
	Yes		0.92 (0.87 - 0.97)*	—	0.94 (0.89 - 0.99)*
Delivery by CS	No	1.00			1.00
	Yes		1.94 (1.84 - 2.04)**	—	1.93 (1.83 - 2.03)**
Family size	≤5	1.00			1.00
	6-10		1.00 (0.97 - 1.08)	—	1.01 (0.98 - 1.08)
	>10		1.14 (1.06 - 1.24)**	—	1.17 (1.08 - 1.26)**
Wealth index	Poorest	1.00			1.00
	Poorer		1.41 (1.31 - 1.52)**	—	1.38 (1.28 - 1.49)**
	Middle		1.60 (1.48 - 1.73)**	—	1.49 (1.38 - 1.62)**
	Richer		1.86 (1.72 - 2.02)**	—	1.63 (1.49 - 1.76)**
	Richest		2.15 (1.97 - 2.35)**	—	1.72 (1.56 - 1.88)**
Media access	No	1.00			1.00
	Yes		1.01 (0.98 - 1.08)	—	1.02 (0.99 - 1.11)
Parity	Primiparous	1.00			1.00
	Multiparous		1.42 (1.34 - 1.50)**	—	1.42 (1.34 - 1.49)**
	Grand Multiparous		1.61 (1.44 - 1.79)**	—	1.62 (1.46 - 1.81)**
Age of child	≤12	1.00			1.00
	13-23		1.41 (1.32 - 1.50)**	—	1.41 (1.32 - 1.50)**
	24-35		1.62 (1.52 - 1.73)**	—	1.63 (1.53 - 1.74)**
	36-47		1.75 (1.62 - 1.89)**	—	1.77 (1.64 - 1.90)**
	48-59		1.50 (1.38 - 1.62)**	—	1.51 (1.39 - 1.64)**

Sex of child	Male	1.00		1.00
	Female	0.88 (0.84 - 0.92)**	—	0.88 (0.84 - 0.92)**
Type of toilet facility	Unimproved	1.00		1.00
	Improved	0.24 (0.18 - 1.31)	—	0.23 (0.17 - 0.29)**
Source of drinking water	Unimproved	1.00		1.00
	Improved	0.21 (0.16 - 0.28)	—	0.28 (0.21 - 0.35)**
<b>Community-level variables</b>				
Residence	Urban		1.00	1.00
	Rural	—	0.49 (0.46 - 0.52)**	0.66 (0.62 - 0.69)**
Distance to health facility	No problem		1.00	1.00
	Big problem	—	0.87 (0.82 - 0.91)**	0.94 (0.89 - 0.98)**
<b>Random effect</b>				
	Variance	1.40	1.24	1.31
	ICC	0.30	0.27	0.28
	MOR	3.04	2.88	2.96
	PCV	Reff	11.42	6.43
<b>Model comparison</b>				
	Log likelihood ratio	-100585	-92108	-97815
	Deviance	201,170	184,216	195,630

\* = P-value < 0.05, \*\* = P-value < 0.01,

ICC = Inter cluster correlation coefficient, MOR =Median odds ratio, PCV = proportional change in variance.

AOR=adjusted odds ratio; CI= confidence interval,

204

## 205 Discussion

206 Low and middle-income countries are increasingly facing the triple burden of malnutrition where  
 207 women and children are among the hardest hit by the burden (30, 31). The present study examined  
 208 the co-occurrence of undernutrition, overweight/obesity, and anemia among mother-child pairs in  
 209 the same household using nationally representative data. The finding showed that the prevalence  
 210 of triple burden found at 11.39 % (95% CI 9.56%, 13.23%), Ethiopia has the lowest (3.54 %)   
 211 prevalence while Mauritania (31.66%) bears the highest. The variation among countries could be  
 212 attributed to differences in socio-economic status, food environment, physical activity, genetic  
 213 factors, health care system strength, national policy, and political commitments.

214 This study revealed that several maternal, child, household, and community-level factors have a  
 215 significant impact on the triple burden of malnutrition among mother-child pairs. It has found a

1  
2  
3 216 parallel correlation between the triple burden of malnutrition and maternal age. The odds of being  
4  
5 217 malnourished increase as the age of the mother increases where older mothers bear the highest risk  
6  
7 218 compared to younger ones. Various findings (32, 33) have revealed that older women have an  
8  
9 219 increased risk of malnutrition, this could be because of reduced physical activity, less energy  
10  
11 220 requirement, and hormonal changes. Similarly, mothers who attended secondary education were  
12  
13 221 more likely to be malnourished (33). A plausible explanation for this could be the shifts from  
14  
15 222 manual labor to more sedentary occupations and the related decline in physical activity.  
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20 223 Being married reduced the risk of the triple burden of malnutrition. Partners together could  
21  
22 224 generate more money, reduce food insecurity, and tend to take better care of themselves and their  
23  
24 225 children. It is been reported that children in single-parent households suffered from undernutrition  
25  
26 226 significantly more than children brought up by both parents (34, 35). Likewise, this study revealed  
27  
28 227 breastfeeding reduced the triple burden of malnutrition. Breastfeeding plays a vital role in the  
29  
30 228 prevention of different forms of childhood malnutrition (36). Delivery by cesarean section (C-  
31  
32 229 section) delays the timely initiation of breastfeeding and prelacteal feeding (37). Previous studies  
33  
34 230 have reported that C-section increases maternal obesity and negatively affects the breastfeeding of  
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36 231 children, which results suffer from malnutrition (38, 39). Moreover, malnutrition in children is  
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38 232 related to gut microbiota alteration and C-section contributes to microbial alterations in the small  
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40 233 intestine (40).  
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46 234 Our study revealed a parallel relationship between the household wealth quintiles and the triple  
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48 235 burden of malnutrition. As household income increases, the odds of malnutrition increase (41, 42).  
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50 236 High income could increase the purchasing power for food, influencing the type of foods  
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52 237 consumed and the intake of prepared or processed food (30). Economic growth and the food  
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54 238 industry's rapid penetration into the market have resulted in diets based on energy-dense and  
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239 nutrient-poor foods (43). In recent years, the dietary preference in LMICs has changed as the food  
240 environment is dominated by media advertising and relatively cheap and highly tasty energy-dense  
241 foods (44).

242 This study identified that the odds of triple burden of malnutrition were higher in a household with  
243 a family size >10. A plausible explanation is that in a household with a large family, providing  
244 optimum nutritious food to all the family members and children could be difficult (45, 46).  
245 Moreover giving proper care and time to children and the family could be unlikely and this could  
246 lead to malnutrition. Likewise, Parity was found a determinant of the triple burden of malnutrition.  
247 Higher parity increased the odds of malnutrition. The possible explanation could be that women  
248 gain weight during pregnancy, and weight loss does not occur in the post-partum period (47). This  
249 mother's obesity/overweight is also correlated with child malnutrition.

250 The present study revealed that child age and sex were significant factors in malnutrition. Older  
251 under-five children were more likely to be malnourished compared to younger ones (48). A  
252 previous study (49) revealed that there was an increased frequency of parasite infection in older  
253 children leads to a higher prevalence of malnutrition compared to the younger ones. In addition,  
254 gender was found a significant determinant of malnutrition where a female child was less likely to  
255 be malnourished (50). The cause of the gender gap in malnutrition is unknown however, some  
256 studies argued that male children are known to be more vulnerable than females to diseases  
257 including lower respiratory infections, diarrhoeal diseases, malaria, and preterm birth. Those  
258 problems have been reported as factors for undernutrition among young male children (51, 52).  
259 Others also claimed that boys are more vulnerable to environmental problems while playing, such  
260 as exposure to toxins and air pollution than girls (53).

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3 261 Being rural residents was associated with lower odds of the triple burden of malnutrition. This  
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5 262 urban-rural difference could be attributable to factors including access to different food types,  
6  
7 263 overcrowding and concurrent disease, physical activity, and sedentary lifestyles. Previous studies  
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10 264 depicted that urbanization affects the way of life, and access to processed and junk foods could  
11  
12 265 exacerbate malnutrition among women and children (42, 54).  
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15 266 Our study has some strengths and limitations. It used large nationally representative samples with  
16  
17 267 appropriate statistical modeling. The use of large nationally representative data and multilevel  
18  
19 268 analysis helps to provide more robust estimates of observed associations as well as enhance the  
20  
21 269 generalizability of the results. Despite the strengths, this study used cross-sectional data, which  
22  
23 270 did not indicate a temporal relationship between the factors and triple burden. No important  
24  
25 271 covariates, such as dietary intake, physical activity level, comorbidities, and nutrition status during  
26  
27 272 pregnancy, were incorporated into the study as the DHS did not provide a complete record of these  
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29 273 variables.  
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## 34 274 **Conclusions and recommendations**

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37 275 About 1 out of 10 households suffer from the triple burden of malnutrition in low and middle-  
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39 276 income countries. This study revealed that several maternal, child, household, and community-  
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41 277 level factors have a significant impact on the triple burden of malnutrition among mother-child  
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43 278 pairs. Prevention of the problem requires collective efforts from the governments, the scientific  
44  
45 279 and medical communities, and the industry towards changing dietary and lifestyle habits.  
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48

## 49 280 **Abbreviations**

50  
51 281 AOR, Adjusted Odds Ratio; DHSs, Demographic and Health Surveys; ICC, Intra cluster  
52  
53 282 correlation coefficient; LMICs, low and middle-income countries; MOR, median odds ratio; PCV,  
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283 a proportional change in variance; SDGs, Sustainable Development Goals; WHO, World Health  
284 Organization

## 285 **Declarations**

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

287 Permission to access the data was obtained from the measure DHS program  
288 (<http://www.dhsprogram.com>) via online request. The website and the data used were publicly  
289 available with no personal identifier. All methods were carried out in accordance with relevant  
290 guidelines and regulations.

### 291 **Consent for publication**

292 Not applicable.

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

294 Data are available online in a public, open-access repository ([www.measuredhs.com/data](http://www.measuredhs.com/data)).

### 295 **Competing interests**

296 The authors declare that they have no competing interests.

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298 No funder.

### 299 **Author Contributions**

300 Conceptualization: DC. Study design: DC, DGB, MWM, AAK, AZA, MHA, FMA. Execution:  
301 DC, DGB, MWM, AAK, AZA, MHA, FMA. Acquisition of the data: DC, DGB, MWM, AAK,  
302 AZA, MHA, FMA. Analysis and interpretation: DC, DGB, MWM, AAK, AZA, MHA, FMA.

1  
2  
3 303 Writing: DC, DGB, MWM, AAK, AZA, MHA, FMA. Review and editing: DC, DGB, MWM,  
4  
5 304 AAK, AZA, MHA, FMA.  
6  
7

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9  
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11  
12  
13 307

## 15 308 **References**

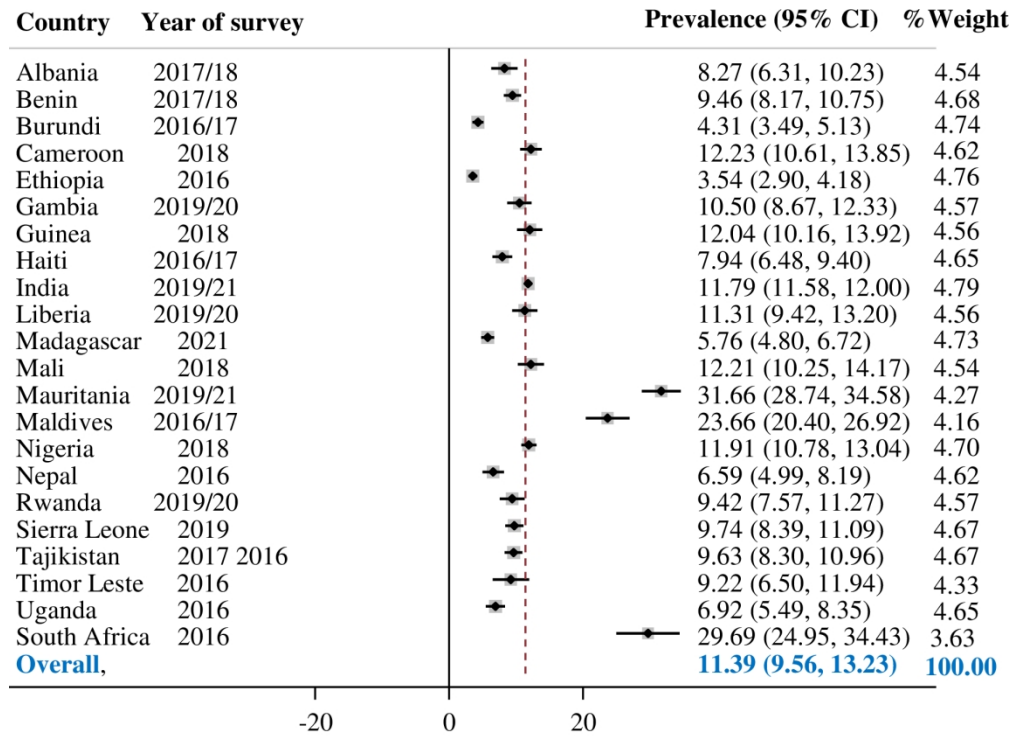
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NOTE: Weights are from random-effects model

161x123mm (300 x 300 DPI)



## STROBE Statement—checklist of items that should be included in reports of observational studies

	Item No	Recommendation	Page No
<b>Title and abstract</b>	1	(a) Indicate the study's design with a commonly used term in the title or the abstract	1
		(b) Provide in the abstract an informative and balanced summary of what was done and what was found	2, 3
<b>Introduction</b>			
Background/rationale	2	Explain the scientific background and rationale for the investigation being reported	4
Objectives	3	State specific objectives, including any prespecified hypotheses	5
<b>Methods</b>			
Study design	4	Present key elements of study design early in the paper	5
Setting	5	Describe the setting, locations, and relevant dates, including periods of recruitment, exposure, follow-up, and data collection	5
Participants	6	(a) <i>Cohort study</i> —Give the eligibility criteria, and the sources and methods of selection of participants. Describe methods of follow-up <i>Case-control study</i> —Give the eligibility criteria, and the sources and methods of case ascertainment and control selection. Give the rationale for the choice of cases and controls <i>Cross-sectional study</i> —Give the eligibility criteria, and the sources and methods of selection of participants	7
		(b) <i>Cohort study</i> —For matched studies, give matching criteria and number of exposed and unexposed <i>Case-control study</i> —For matched studies, give matching criteria and the number of controls per case	
Variables	7	Clearly define all outcomes, exposures, predictors, potential confounders, and effect modifiers. Give diagnostic criteria, if applicable	7
Data sources/ measurement	8*	For each variable of interest, give sources of data and details of methods of assessment (measurement). Describe comparability of assessment methods if there is more than one group	7
Bias	9	Describe any efforts to address potential sources of bias	
Study size	10	Explain how the study size was arrived at	6
Quantitative variables	11	Explain how quantitative variables were handled in the analyses. If applicable, describe which groupings were chosen and why	7
Statistical methods	12	(a) Describe all statistical methods, including those used to control for confounding	7,8
		(b) Describe any methods used to examine subgroups and interactions	
		(c) Explain how missing data were addressed	
		(d) <i>Cohort study</i> —If applicable, explain how loss to follow-up was addressed <i>Case-control study</i> —If applicable, explain how matching of cases and controls was addressed <i>Cross-sectional study</i> —If applicable, describe analytical methods taking account of sampling strategy	
		(e) Describe any sensitivity analyses	

Continued on next page

<b>Results</b>			
Participants	13*	(a) Report numbers of individuals at each stage of study—eg numbers potentially eligible, examined for eligibility, confirmed eligible, included in the study, completing follow-up, and analysed (b) Give reasons for non-participation at each stage (c) Consider use of a flow diagram	8
Descriptive data	14*	(a) Give characteristics of study participants (eg demographic, clinical, social) and information on exposures and potential confounders (b) Indicate number of participants with missing data for each variable of interest (c) <i>Cohort study</i> —Summarise follow-up time (eg, average and total amount)	8,9
Outcome data	15*	<i>Cohort study</i> —Report numbers of outcome events or summary measures over time <i>Case-control study</i> —Report numbers in each exposure category, or summary measures of exposure <i>Cross-sectional study</i> —Report numbers of outcome events or summary measures	9
Main results	16	(a) Give unadjusted estimates and, if applicable, confounder-adjusted estimates and their precision (eg, 95% confidence interval). Make clear which confounders were adjusted for and why they were included (b) Report category boundaries when continuous variables were categorized (c) If relevant, consider translating estimates of relative risk into absolute risk for a meaningful time period	10/12
Other analyses	17	Report other analyses done—eg analyses of subgroups and interactions, and sensitivity analyses	
<b>Discussion</b>			
Key results	18	Summarise key results with reference to study objectives	12/15
Limitations	19	Discuss limitations of the study, taking into account sources of potential bias or imprecision. Discuss both direction and magnitude of any potential bias	15
Interpretation	20	Give a cautious overall interpretation of results considering objectives, limitations, multiplicity of analyses, results from similar studies, and other relevant evidence	15
Generalisability	21	Discuss the generalisability (external validity) of the study results	15
<b>Other information</b>			
Funding	22	Give the source of funding and the role of the funders for the present study and, if applicable, for the original study on which the present article is based	

\*Give information separately for cases and controls in case-control studies and, if applicable, for exposed and unexposed groups in cohort and cross-sectional studies.

**Note:** An Explanation and Elaboration article discusses each checklist item and gives methodological background and published examples of transparent reporting. The STROBE checklist is best used in conjunction with this article (freely available on the Web sites of PLoS Medicine at <http://www.plosmedicine.org/>, Annals of Internal Medicine at <http://www.annals.org/>, and Epidemiology at <http://www.epidem.com/>). Information on the STROBE Initiative is available at [www.strobe-statement.org](http://www.strobe-statement.org).

# BMJ Open

## Triple burden of malnutrition among mother-child pairs in low and middle-income countries: A cross-sectional study

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# 1 Triple burden of malnutrition among mother-child pairs in low and 2 middle-income countries: A cross-sectional study

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30

**Abstract**

**Objective:** This study aimed to assess the prevalence and determinants of the triple burden of malnutrition among mother-child pairs in low-and middle-income countries.

**Design:** Cross-Sectional Study

**Setting:** Low-and middle-income countries

**Participants:** Women and children

**Primary outcome:** Triple burden of malnutrition (overweight/obese mother with undernourished and anemic under 5 years child)

**Methods:** Data for this study were drawn from recent 22 low and middle-income countries Demographic and Health Surveys (DHSs). A total weighted sample of 116,795 mother-child pairs was included in the study. STATA version 14.2 was used to clean, code and analyze the data. Multilevel logistic regression was employed to identify factors associated with the problem. Adjusted odds ratio with 95% CI and a P value <0.05 was reported to indicate statistical association. Model fitness and comparison were done using ICC, MOR, PCV, and deviance.

**Result:** The pooled prevalence of the triple burden of malnutrition among mother-child pairs was 11.39%. It showed statistically significant positive associations with mothers aged  $\geq 35$  years (AOR=2.25,95%CI 2.08-2.44), family size >10 (AOR=1.17,95%CI 1.08-1.26), delivery by CS (AOR=1.93,95%CI 1.83-2.03), the richest household (AOR=1.72,95%CI 1.56-1.88), grand multiparous (AOR=1.62, 95% CI 1.46-1.81), age of child 36-47 months (AOR=1.77, 95% CI 1.64-1.90), at a p-value of <0.05. Whereas breastfeeding (AOR=0.94,95%CI 0.89-0.99), married mothers (AOR=0.87,95%CI 0.78-0.96), female children (AOR=0.88,95%CI 0.84-0.92), improved toilet (AOR=0.23,95%CI 0.17-0.29), improved source of drinking water (AOR=0.28,95%CI 0.21-

53 0.35), rural residents (AOR=0.66,95%CI 0.62-0.69) had a contrasting relationship with the triple  
54 burden of malnutrition

55 **Conclusion:** About 1 out of 10 households suffer from the triple burden of malnutrition in low  
56 and middle-income countries. This study revealed that several maternal, child, household, and  
57 community-level factors have a significant impact on the triple burden of malnutrition among  
58 mother-child pairs.

59 **Keywords:** Triple burden, mother-child pairs, malnutrition, low and middle-income countries.

### 60 **Strengths and limitations of this study**

- 61 ➤ The findings were supported by large datasets covering 22 LMICs.
- 62 ➤ We employed multilevel analysis which is an appropriate methodology for such data
- 63 ➤ The data were collected using a common internationally acceptable methodological procedure.
- 64 ➤ DHS used a cross-sectional survey design, and the causal relationship between the triple  
65 burden of malnutrition and the independent variables cannot be established.
- 66 ➤ We didn't include important covariates such as dietary intake, physical activity level, or  
67 comorbidities as the DHS did not collect information on these variables

## 74 **Background**

75 The triple burden of malnutrition, defined as the coexistence of overnutrition, undernutrition, and  
76 micronutrient deficiencies is increasing in low and middle-income countries (LMICs) (1). The  
77 World Health Organization (WHO) characterized overnutrition (Obesity and overweight) as a  
78 pandemic of a major public health concern due to the increased frequency of the problem in many  
79 countries (2). It is ranked as the sixth leading cause of disability-adjusted life years (DALYs) and  
80 accounts for approximately 4 million people dying each year worldwide (3-5). Several previous  
81 studies have shown, following marked dietary change that obesity/overweight is increasing more  
82 rapidly in low and middle-income countries compared to higher-income countries (6, 7).

83 Similarly, undernutrition continues to be a major public health concern throughout the developing  
84 world (8, 9). Nearly half of all deaths in children under 5 are attributable to undernutrition and it  
85 encompasses wasting, stunting, underweight, and micronutrient deficiencies (anemia) (10, 11).  
86 Despite stunting having declined steadily, faster progress is needed to reach the 2030 target (12,  
87 13). Wasting and underweight persisting at alarming rates require a reversal in trajectory if the  
88 2030 target is to be achieved (14). Since 2000, a significant reduction in the prevalence of anemia  
89 in children under five has been observed in many low- and lower-middle-income countries (15).  
90 Children are more vulnerable to inadequate pre-natal, infant, and young child nutrition, particularly  
91 in resource-constrained settings (16, 17). Endorsing early childhood feeding best practices is  
92 crucial to improve the health of children (18).

93 Malnutrition has a tremendous negative impact on the normal functioning of every organ system  
94 (19). It can cause permanent, widespread damage to a child's growth, development, and well-being  
95 (20). Scientific evidence has shown that malnutrition in children is associated with poorer school  
96 performance, increased susceptibility to infections, and slow recovery from illness (21, 22).



1  
2  
3 97 Maternal malnutrition increases the risk of poor pregnancy outcomes including obstructed labor,  
4  
5 98 premature or low-birth-weight babies, and postpartum hemorrhage (23, 24). To reduce the problem  
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7  
8 99 the United Nations (UN) adopted the Sustainable Development Goals (SDGs), especially those  
9  
10 100 targeted to end poverty in all its forms everywhere (SDG 1), end hunger, achieve food security,  
11  
12 101 improve nutrition, promote sustainable agriculture (SDG 2), ensure healthy lives, and promote  
13  
14 102 well-being for all at all ages (SDG 3) (25, 26).

15  
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17 103 Previous literature recognizes the basic and underlying causes of malnutrition including the  
18  
19 104 environmental, economic, and sociopolitical contextual factors, with poverty having a central role  
20  
21  
22 105 (11, 27-29). The triple burden of malnutrition among mother-child pairs is a relatively new issue  
23  
24 106 and only a few country-based studies explore the problem which couldn't give a panoramic view  
25  
26 107 of the problem in LMICs (30-32). Given the persistent and high levels of the problem in these  
27  
28 108 countries, there is a strong need for action. To design and deliver effective interventions adequate  
29  
30 109 understanding of the socioeconomic, environmental, and cultural factors is highly important.  
31  
32  
33 110 Besides if the SDG targets are to be met, coordinated action is required toward not only sustaining  
34  
35 111 current rates of decline but also accelerating progress. Therefore, the objective of this study was  
36  
37 112 to assess the prevalence of the triple burden of malnutrition among mothers and children and the  
38  
39 113 potential factors associated with it in low and middle-income countries.

## 40 41 42 43 114 **Materials and methods**

### 44 45 46 115 **Study design, setting, and period**

47  
48 116 The present study is based on 22 low and middle-income countries that have had Demographic  
49  
50 117 and Health Surveys (DHS) from 2016-2020. The DHS used a cross-sectional survey study design  
51  
52 118 to collect data and provide population and health indicators at the national level. The list of those  
53  
54 119 countries and the respective year of surveys is provided in Table 1.

120 Table 1. Study setting and year of surveys

Country	Year of survey	Region
Albania	2017/18	Southeastern Europe
Benin	2017/18	West Africa
Burundi	2016/17	East-central Africa
Cameroon	2018	West-central Africa
Ethiopia	2016	East Africa
Gambia	2019/20	West Africa
Guinea	2018	West Africa
Haiti	2016/17	Caribbean
India	2019/21	South Asia
Liberia	2019/20	West Africa
Madagascar	2021	East Africa
Mali	2018	West Africa
Mauritania	2019/21	Northwest Africa
Maldives	2016/17	South Asia
Nigeria	2018	West Africa
Nepal	2016	South Asia
Rwanda	2019/20	East Africa
Sierra Leone	2019	West Africa
Tajikistan	2017	Central Asia
Timor Leste	2016	South Asia
Uganda	2016	East Africa
South Africa	2016	South Africa

121

122 **Data source and sampling procedure**

123 The current analyses was based on pooled data from DHSs in 22 LMICs. These are nationally

124 representative surveys that collect data on reproductive, maternal, neonatal, child health, and

125 nutrition in LMIC. The surveys are similarly designed that used standardized questionnaires and

126 data collection procedures, allowing therefore comparability of results. The survey employed a

127 two-stage cluster sampling technique. In the first stage, the selection of proportional

128 clusters/enumeration areas was performed using each country's most recent population and

129 housing census as a sampling frame. In the second stage, a systematic selection of households from

130 the newly created cluster was performed. A detailed description of the DHS sampling design and

131 data collection procedures has been found in each country's DHS report. The study population for

1  
2  
3 132 this study was mother-child pairs. Weighting was done using the complex sample design weighting  
4  
5 133 and the “svyset” Stata command was applied. Variables v005 (sampling weight), v021 (primary  
6  
7 134 sampling unit), and v023 (stratification used in sample design) were used, and as the result, a total  
8  
9 135 weighted sample of 116,795 mother-child pairs was included in the analysis.  
10  
11

## 12 136 **Definition of variables**

### 137 **Outcome variable:**

138 The triple burden of malnutrition was the outcome variable of this study where the mother was  
139 overweight/obese and children under 5 years of age were undernourished and anemic (31, 33). At  
140 the same household level, first, we created four different categories of malnutrition such as  
141 overweight/obese mother and stunted child, overweight/obese mother and wasted child,  
142 overweight/obese mother and underweight child, and overweight/obese mother and anemic child.  
143 Then we further combined overweight/obese mothers, undernourished children, and anemic  
144 children to generate the triple burden of malnutrition. Categorization was made based on height-  
145 for-age z-score (HAZ), standard deviations (SD), weight-for-height z-score (WHZ), weight-for-  
146 age z-score (WAZ), hemoglobin level, and body mass index (BMI).

147 Stunting dichotomized and coded into 0=Not stunted (HAZ  $\geq$  -2SD and above) & 1= Stunted  
148 (HAZ  $<$  -2SD);

149 Wasting dichotomized and coded into 0=Not wasted (WHZ  $\geq$  -2SD to  $\leq$  +2SD) and 1=Wasted  
150 (WHZ  $<$  -2SD);

151 Underweight dichotomized and coded into 0= Not underweight (WHZ  $\geq$  -2SD and above) & 1=  
152 Underweight (WAZ  $<$  -2SD);

153 Child anemia dichotomized and coded into 0= Not anemic (hemoglobin level  $>$  11 g/dl), & 1=  
154 Anemic (hemoglobin level  $<$  11 g/dl);

1  
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3 155 Mother's BMI dichotomized and coded into 0= Normal (18.5–24.9 kg/m<sup>2</sup>) &  
4  
5 156 1= Overweight/Obese ( $\geq 25$  kg/m<sup>2</sup>)  
6

7  
8 157 The triple burden of malnutrition was dichotomized and coded into 0= NO (not overweight/obese  
9  
10 158 mother and not undernourished child plus not anemic child, and 1= YES (overweight/obese mother  
11  
12 159 and undernourished child plus anemic child)  
13

14  
15 160 An undernourished child is a child who is stunted or wasted or underweight.  
16

### 17 161 **Independent variables:**

18  
19 162 Based on previous works of literature and the likelihood of influencing the outcome of interest,  
20  
21 163 several explanatory variables including the age of mothers, mother's education, marital status,  
22  
23 164 current breastfeeding, delivery by cesarean section, family size, wealth index, media access, parity,  
24  
25 165 age of the child, sex of the child, type of toilet facility, source of drinking water, residence and  
26  
27 166 distance to health facility were considered.  
28  
29

### 30 31 167 **Statistical analyses**

32  
33 168 We append the dataset of each country to generate pooled data. The data extraction, coding, and  
34  
35 169 analysis were carried out using STATA software version 14.2. We weighted the sample to restore  
36  
37 170 the representativeness of the sample so that the total sample looks like the country's actual  
38  
39 171 population. Due to the hierarchical nature of the DHS, the multilevel analysis was fitted to identify  
40  
41 172 significantly associated factors. Four models were fitted; the null model (with no predictors), the  
42  
43 173 model I (adjusted for individual-level variables only), model II (adjusted for community-level  
44  
45 174 variables only), and model III (model adjustment for both individual and community-level  
46  
47 175 variables simultaneously). Adjusted OR (AOR) with 95% CI and  $p < 0.05$  were used to determine  
48  
49 176 significant predictors. Model fitness and comparison were done using Intraclass Correlation  
50  
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177 Coefficient (ICC), Proportional Change in Variance (PCV), Median Odds Ratio (MOR), the  
 178 Likelihood Ratio test (LR), and deviance computed.

179

## 180 **Patient and public involvement statement**

181 As our study used secondary analysis of DHS data, participants and the public were not involved  
 182 in the study design or planning of the study. The study participants were not consulted to interpret  
 183 the results and write or editing of this document for readability or accuracy.

## 184 **Results**

### 185 **Demographics and socioeconomic characteristics**

186 A total of 116,795 mother-child pairs were included in the study. Over half (56.48%) of mothers  
 187 were in the age category of 25-34 years. About 22.98% of mothers were illiterate and the majority  
 188 (46.39%) had attended secondary education. Approximately 95.73% of mothers were married and  
 189 62.89% were currently breastfeeding. About 20.33% and 21.21% of the households were in the  
 190 low wealth quintile of poorest and poorer respectively. Over a quarter (27.62%) of the families  
 191 had never been exposed to any type of media. The majority of the children (32.59%) were aged  
 192  $\leq 12$  months. A large proportion (83.60%) of the households had improved sources of drinking  
 193 water and almost two-thirds (67.02%) of the households had improved toilet facilities. Almost  
 194 three fourth (71.03%) of participants lived in rural areas and for over a quarter (27.42%) of those  
 195 participants, the distance to access health facilities was a big problem (**Table 2**).

196 Table 2. Socio-demographic characteristics of the study participants

Variables	Categories	Unweighted frequency (%)	Weighted frequency (%)
Age of mothers	15-24	34,983 (29.05)	35,918 (30.75)
	25-34	68,386 (56.78)	65,971 (56.48)

	≥35	17,073 (14.18)	14,906 (12.76)
Mothers education	No education	27,995 (23.24)	26,845 (22.98)
	Primary education	19,684 (16.34)	18,633 (15.95)
	Secondary	57,008 (47.33)	54,185 (46.39)
	Higher	15,755 (13.08)	17,131 (14.67)
Mothers marital status	Not in union	5,583 (4.64)	4,987 (4.27)
	Married	114,859 (95.36)	111,807 (95.73)
Currently breastfeeding	No	44,160 (36.66)	43,338 (37.11)
	Yes	76,282 (63.34)	73,457 (62.89)
Delivery by cesarean section	No	99,291 (82.49)	93,974 (80.51)
	Yes	21,077 (17.51)	22,748 (19.49)
Family size	≤5	56,365 (46.80)	53,677 (45.96)
	6-10	54,605 (45.34)	53,258 (45.60)
	>10	9,472 (7.86)	9,859 (8.44)
Wealth index	Poorest	28,097 (23.33)	23,749 (20.33)
	Poorer	27,352 (22.71)	24,774 (21.21)
	Middle	24,741 (20.54)	24,330 (20.83)
	Richer	22,180 (18.42)	23,880 (20.45)
	Richest	18,072 (15.00)	20,061 (17.18)
Media access	No	33,942 (28.18)	32,256 (27.62)
	Yes	86,500 (71.82)	84,539 (72.38)
Parity	Primiparous	36,241 (30.09)	35,333 (30.25)
	Multiparous	76,092 (63.18)	73,823 (63.21)
	Grand Multiparous	8,109 (6.73)	7,639 (6.54)
Age of child	≤12	38,959 (32.35)	38,059 (32.59)
	13-23	25,382 (21.07)	24,819 (21.25)
	24-35	22,208 (18.44)	21,478 (18.39)
	36-47	17,948 (14.90)	17,204 (14.73)
	48-59	15,945 (13.24)	15,234 (13.04)
Sex of child	Male	63,660 (52.86)	62,008 (53.09)
	Female	56,782 (47.14)	54,787 (46.91)
Type of toilet facility	Unimproved	37,519 (31.15)	38,518 (32.98)
	Improved	82,923 (68.85)	78,277 (67.02)
Source of drinking water	Unimproved	20,959 (17.40)	19,159 (16.40)
	Improved	99,483 (82.60)	97,636 (83.60)
Residence	Urban	28,722 (23.85)	33,838 (28.97)
	Rural	91,720 (76.15)	82,957 (71.03)
Distance to health facility	No problem	84,605 (70.25)	84,776 (72.58)
	Big problem	35,837 (29.75)	32,019 (27.42)

197

198 **Prevalence of triple burden of malnutrition**

199 In 22 low and middle-income countries, the pooled prevalence of the triple burden of malnutrition  
200 among mother-child pairs was found at 11.39 % (95% CI 9.56%, 13.23%). Ethiopia has the lowest  
201 (3.54 %) prevalence of triple burden while Mauritania (31.66%) bears the highest (**Figure 1**).

202 Fig 1. The pooled prevalence of the triple burden of malnutrition

## 203 **Multilevel analyses**

### 204 **Random parameter estimation and model selection**

205 Based on the result of random effect analysis, the ICC of the null model was 0.30, indicating that  
206 30% of the total variability in triple burden prevalence was attributable to between-cluster  
207 variability, while about 70% was due to individual differences. The null model MOR was 3.04,  
208 which indicates that a mother/child from a cluster with a high triple burden prevalence has a 3.04  
209 times higher probability of being malnourished than a mother/child from a cluster with a lower  
210 prevalence. Model III was the best-fitted model since it has the highest log likelihood (-91665)  
211 and the lowest deviance (183,330) value (**Table 3**).

### 212 **Factors associated with the triple burden of malnutrition (Fixed effects)**

213 The triple burden of malnutrition was statistically significant with mothers aged 25-34 years  
214 (AOR=1.54, 95% CI 1.45 - 1.63),  $\geq 35$  years (AOR=2.25, 95% CI 2.08 - 2.44), mothers attended  
215 secondary education (AOR=1.08, 95% CI 1.02-1.15), family size >10 (AOR=1.17, 95% CI 1.08 -  
216 1.26), delivery by CS (AOR=1.93, 95% CI 1.83 - 2.03), the richer household (AOR=1.63, 95% CI  
217 1.49 - 1.76), the richest household (AOR=1.72, 95% CI 1.56 - 1.88), multiparous (AOR=1.42,  
218 95% CI 1.34 - 1.49), grand multiparous (AOR=1.62, 95% CI 1.46 - 1.81), age of child 36-47  
219 months (AOR=1.77, 95% CI 1.64 - 1.90), age of child 48-59 (AOR=1.51, 95% CI 1.39 - 1.64),  
220 breastfeeding (AOR=0.94, 95% CI 0.89 - 0.99), married mothers (AOR=0.87, 95% CI 0.78 - 0.96),

221 female children (AOR=0.88, 95% CI 0.84 - 0.92), improved toilet facility (AOR=0.23, 95% CI  
 222 0.17 - 0.29), improved source of drinking water (AOR=0.28, 95% CI 0.21 - 0.35), rural residents  
 223 (AOR=0.66, 95% CI 0.62 - 0.69) at a p-value of <0.05 (**Table 3**).

224  
 225 Table 3. Multivariable multilevel logistic regression analysis of the triple burden of malnutrition.

Variables	Categories	Null model	Model I		Model II		Model III	
			AOR	95% CI	AOR	95% CI	AOR	95% CI
Age of mothers	15-24	1.00					1.00	
	25-34	1.54 (1.46 - 1.63)**		—		1.54 (1.45 - 1.63)**		
	≥35	2.28 (2.11 - 2.47)**		—		2.25 (2.08 - 2.44)**		
Mothers education	No education	1.00				1.00		
	Primary education	1.04 (0.97 - 1.12)		—		1.04 (0.97 - 1.12)		
	Secondary	1.08 (1.01 - 1.15)*		—		1.08 (1.02 - 1.15)*		
	Higher	0.94 (0.86 - 1.02)		—		0.94 (0.86 - 1.02)		
Mothers marital status	Not in union	1.00				1.00		
	Married	0.83 (0.75 - 0.93)*		—		0.87 (0.78 - 0.96)**		
Currently breast feeding	No	1.00				1.00		
	Yes	0.92 (0.87 - 0.97)*		—		0.94 (0.89 - 0.99)*		
Delivery by CS	No	1.00				1.00		
	Yes	1.94 (1.84 - 2.04)**		—		1.93 (1.83 - 2.03)**		
Family size	≤5	1.00				1.00		
	6-10	1.00 (0.97 - 1.08)		—		1.01 (0.98 - 1.08)		
	>10	1.14 (1.06 - 1.24)**		—		1.17 (1.08 - 1.26)**		
Wealth index	Poorest	1.00				1.00		
	Poorer	1.41 (1.31 - 1.52)**		—		1.38 (1.28 - 1.49)**		
	Middle	1.60 (1.48 - 1.73)**		—		1.49 (1.38 - 1.62)**		
	Richer	1.86 (1.72 - 2.02)**		—		1.63 (1.49 - 1.76)**		
	Richest	2.15 (1.97 - 2.35)**		—		1.72 (1.56 - 1.88)**		
Media access	No	1.00				1.00		
	Yes	1.01 (0.98 - 1.08)		—		1.02 (0.99 - 1.11)		
Parity	Primiparous	1.00				1.00		
	Multiparous	1.42 (1.34 - 1.50)**		—		1.42 (1.34 - 1.49)**		
	Grand Multiparous	1.61 (1.44 - 1.79)**		—		1.62 (1.46 - 1.81)**		
Age of child	≤12	1.00				1.00		
	13-23	1.41 (1.32 - 1.50)**		—		1.41 (1.32 - 1.50)**		
	24-35	1.62 (1.52 - 1.73)**		—		1.63 (1.53 - 1.74)**		
	36-47	1.75 (1.62 - 1.89)**		—		1.77 (1.64 - 1.90)**		
	48-59	1.50 (1.38 - 1.62)**		—		1.51 (1.39 - 1.64)**		
Sex of child	Male	1.00				1.00		
	Female	0.88 (0.84 - 0.92)**		—		0.88 (0.84 - 0.92)**		



Type of toilet facility	Unimproved	1.00		1.00
	Improved	0.24 (0.18 - 1.31)	—	0.23 (0.17 - 0.29)**
Source of drinking water	Unimproved	1.00		1.00
	Improved	0.21 (0.16 - 0.28)	—	0.28 (0.21 - 0.35)**
<b>Community-level variables</b>				
Residence	Urban		1.00	1.00
	Rural	—	0.49 (0.46 - 0.52)**	0.66 (0.62 - 0.69)**
Distance to health facility	No problem		1.00	1.00
	Big problem	—	0.87 (0.82 - 0.91)**	0.94 (0.89 - 0.98)**
<b>Random effect</b>				
	Variance	1.40	1.24	1.31
	ICC	0.30	0.27	0.28
	MOR	3.04	2.88	2.96
	PCV	Reff	11.42	6.43
<b>Model comparison</b>				
	Log likelihood ratio	-100585	-92108	-97815
	Deviance	201,170	184,216	195,630

\* = P-value < 0.05, \*\* = P-value < 0.01,

ICC = Inter cluster correlation coefficient, MOR =Median odds ratio, PCV = proportional change in variance.

AOR=adjusted odds ratio; CI= confidence interval,

226

## 227 Discussion

228 LMICs are increasingly facing the triple burden of malnutrition where women and children are  
 229 among the hardest hit by the burden (34, 35). This study assessed the triple burden of malnutrition  
 230 (co-occurrence of undernutrition, overweight/obesity, and anemia among mother-child pairs) in  
 231 the same household using nationally representative data. The finding showed that the prevalence  
 232 of triple burden found at 11.39 % (95% CI 9.56%, 13.23%), Ethiopia has the lowest (3.54 %)   
 233 prevalence while Mauritania (31.66%) bears the highest. The variation among countries could be  
 234 attributed to differences in socio-economic status, food environment, physical activity, genetic  
 235 factors, health care system strength, national policy, and political commitments.

236 The study revealed that several maternal, child, household, and community-level factors have a  
 237 significant impact on the triple burden of malnutrition among mother-child pairs. It has found a  
 238 parallel correlation between the triple burden of malnutrition and maternal age. The odds of being

1  
2  
3 239 malnourished increase as the age of the mother increases. This is in agreement with previous  
4  
5 240 studies where older mothers bear the highest risk compared to younger ones (31, 36). The possible  
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7  
8 241 explanation could be because of reduced physical activity, less energy requirement, and hormonal  
9  
10 242 changes among older mothers. Similarly, mothers who have attended secondary education were  
11  
12 243 more likely to be malnourished (31). A plausible explanation for this could be the shifts from  
13  
14 244 manual labor to more sedentary occupations and the related decline in physical activity.

15  
16  
17 245 Being married reduced the risk of the triple burden of malnutrition. Partners together could  
18  
19 246 generate more money, reduce food insecurity, and tend to take better care of themselves and their  
20  
21 247 children. It is been reported that children in single-parent households suffered from undernutrition  
22  
23 248 significantly more than children brought up by both parents (37, 38). Likewise, this study revealed  
24  
25 249 breastfeeding reduced the triple burden of malnutrition. Breastfeeding plays a vital role in the  
26  
27 250 prevention of different forms of childhood malnutrition (39). Delivery by cesarean section (C-  
28  
29 251 section) delays the timely initiation of breastfeeding and pre-lacteal feeding (40). Previous studies  
30  
31 252 have reported that C-section increases maternal obesity and negatively affect the breastfeeding of  
32  
33 253 children, which results suffer from malnutrition (41, 42). Moreover, malnutrition in children is  
34  
35 254 related to gut microbiota alteration and C-section contributes to microbial alterations in the small  
36  
37 255 intestine (43).

38  
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40  
41  
42  
43 256 Our study revealed a parallel relationship between the household wealth quintiles and the triple  
44  
45 257 burden of malnutrition. As household income increases, the odds of malnutrition increase (30, 44).  
46  
47 258 High income could increase the purchasing power for food, influencing the type of foods  
48  
49 259 consumed and the intake of prepared or processed food (34). Economic growth and the food  
50  
51 260 industry's rapid penetration into the market have resulted in diets based on energy-dense and  
52  
53 261 nutrient-poor foods (45). In recent years, the dietary preference in LMICs has changed as the food  
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1  
2  
3 262 environment is dominated by media advertising and relatively cheap and highly tasty energy-dense  
4  
5 263 foods (46).

6  
7  
8 264 The odds of the triple burden of malnutrition were higher in a household with a family size >10.

9  
10 265 A plausible explanation is that in a household with a large family, providing optimum nutritious

11  
12 266 food to all the family members and children could be difficult (47, 48). Moreover giving proper

13  
14 267 care and time to children and the family could be unlikely and this could lead to malnutrition.

15  
16 268 Likewise, Parity was found a determinant of the triple burden of malnutrition. Higher parity

17  
18 269 increased the odds of malnutrition. The possible explanation could be that women gain weight

19  
20 270 during pregnancy, and weight loss does not occur in the post-partum period (49). This mother's

21  
22 271 obesity/overweight is also correlated with child malnutrition.

23  
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26  
27 272 The present study revealed that child age and sex were significant factors for malnutrition. Older

28  
29 273 under-five children were more likely to be malnourished compared to younger ones (50). A

30  
31 274 previous study (51) revealed that there was an increased frequency of parasite infection in older

32  
33 275 children leads to a higher prevalence of malnutrition compared to the younger ones. In addition,

34  
35 276 gender was found a significant determinant of malnutrition where a female child was less likely to

36  
37 277 be malnourished (52). The cause of the gender gap in malnutrition is unknown however, some

38  
39 278 studies argued that male children are known to be more vulnerable than females to diseases

40  
41 279 including lower respiratory infections, diarrhoeal diseases, malaria, and preterm birth. Those

42  
43 280 problems have been reported as factors for undernutrition among young male children (53, 54).

44  
45 281 Others also claimed that boys are more vulnerable to environmental problems while playing, such

46  
47 282 as exposure to toxins and air pollution than girls (55).

48  
49 283 Being rural residents was associated with lower odds of the triple burden of malnutrition. This

50  
51 284 urban-rural difference could be attributable to factors including access to different food types,

1  
2  
3 285 overcrowding and concurrent disease, physical activity, and sedentary lifestyles. Previous studies  
4  
5 286 depicted that urbanization affects the way of life, and access to processed and junk foods could  
6  
7  
8 287 exacerbate malnutrition among women and children (30, 56).  
9

10  
11 288 Our study has some strengths and limitations. It used large nationally representative samples with  
12  
13 289 appropriate statistical modeling. The use of large nationally representative data and multilevel  
14  
15 290 analysis helps to provide more robust estimates of observed associations as well as enhance the  
16  
17  
18 291 generalizability of the results. Despite the strengths, this study used cross-sectional data, which  
19  
20 292 did not indicate a temporal relationship between the factors and triple burden. No important  
21  
22 293 covariates, such as dietary intake, physical activity level, comorbidities, and nutrition status during  
23  
24 294 pregnancy, were incorporated into the study as the DHS did not provide a complete record of these  
25  
26  
27 295 variables.  
28  
29

## 30 296 **Conclusions and recommendations**

31  
32  
33 297 About 1 out of 10 households suffer from the triple burden of malnutrition in low and middle-  
34  
35 298 income countries. This study revealed that several maternal, child, household, and community-  
36  
37 299 level factors have a significant impact on the triple burden of malnutrition among mother-child  
38  
39  
40 300 pairs. The triple burden requires the governments, the scientific and medical communities, and the  
41  
42 301 industry's efforts in changing dietary and lifestyle habits to address all forms of malnutrition and  
43  
44 302 should focus on women's nutrition to break the intergenerational triple burden of malnutrition.  
45

## 46 303 **Abbreviations**

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48  
49 304 AOR, Adjusted Odds Ratio; DHSs, Demographic and Health Surveys; ICC, Intra cluster  
50  
51 305 correlation coefficient; LMICs, low and middle-income countries; MOR, median odds ratio; PCV,  
52  
53  
54 306 a proportional change in variance; SDGs, Sustainable Development Goals; WHO, World Health  
55  
56 307 Organization  
57

1  
2  
3 308 **Declarations**  
4

5  
6 309 **Ethics approval and consent to participate**  
7

8 310 Permission to access the data was obtained from the measure DHS program  
9  
10 311 (<http://www.dhsprogram.com>) via online request. The website and the data used were publicly  
11  
12 312 available with no personal identifier. All methods were carried out in accordance with relevant  
13  
14 313 guidelines and regulations.  
15

16  
17  
18 314 **Consent for publication**  
19

20  
21 315 Not applicable.  
22

23  
24 316 **Availability of data and materials**  
25

26 317 Data are available online in a public, open-access repository ([www.measuredhs.com/data](http://www.measuredhs.com/data)).  
27  
28

29  
30 318 **Competing interests**  
31

32 319 The authors declare that they have no competing interests.  
33  
34

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36

37  
38 321 No funder.  
39

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41

42  
43 323 Conceptualization: DC. Study design: DC, DGB, MWM, AAK, AZA, MHA, NWT and FMA.  
44  
45 324 Execution: DC, DGB, MWM, AAK, AZA, MHA, NWT and FMA. Acquisition of the data: DC,  
46  
47 325 DGB, MWM, AAK, AZA, MHA, NWT and FMA. Analysis and interpretation: DC, DGB, MWM,  
48  
49 326 AAK, AZA, MHA, NWT and FMA. Writing: DC, DGB, MWM, AAK, AZA, MHA, NWT and  
50  
51 327 FMA. Review and editing: DC, DGB, MWM, AAK, AZA, MHA, NWT and FMA.  
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53

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330

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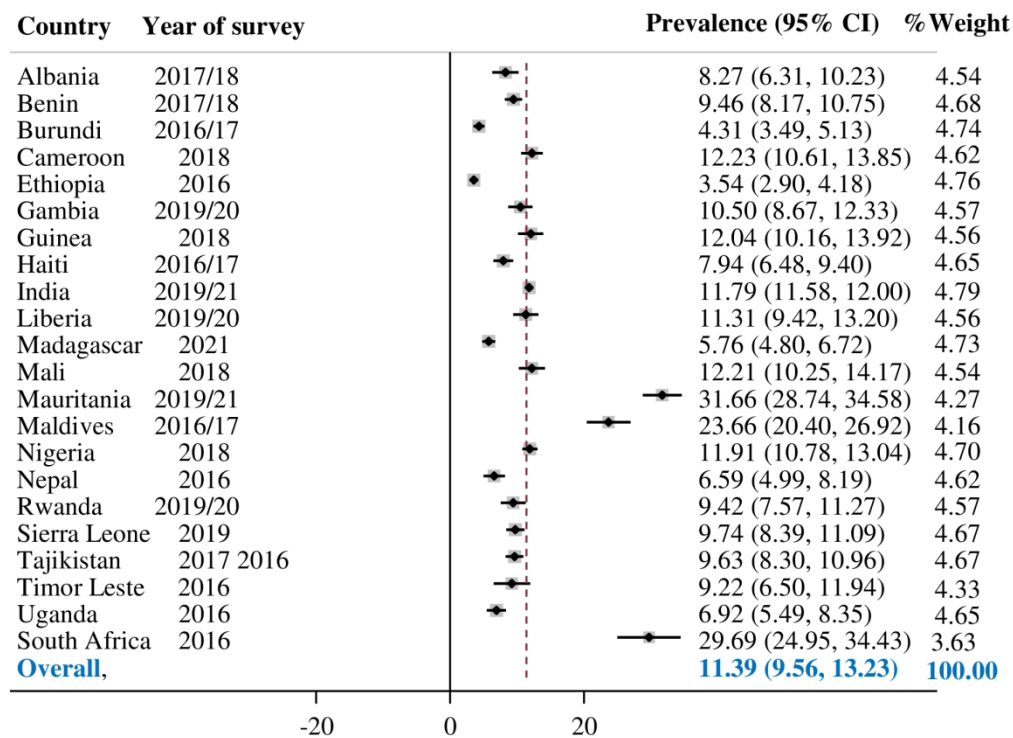
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NOTE: Weights are from random-effects model

161x123mm (300 x 300 DPI)

## STROBE Statement—checklist of items that should be included in reports of observational studies

	Item No	Recommendation	Page No
<b>Title and abstract</b>	1	(a) Indicate the study's design with a commonly used term in the title or the abstract	1
		(b) Provide in the abstract an informative and balanced summary of what was done and what was found	2, 3
<b>Introduction</b>			
Background/rationale	2	Explain the scientific background and rationale for the investigation being reported	4
Objectives	3	State specific objectives, including any prespecified hypotheses	5
<b>Methods</b>			
Study design	4	Present key elements of study design early in the paper	5
Setting	5	Describe the setting, locations, and relevant dates, including periods of recruitment, exposure, follow-up, and data collection	5
Participants	6	(a) <i>Cohort study</i> —Give the eligibility criteria, and the sources and methods of selection of participants. Describe methods of follow-up <i>Case-control study</i> —Give the eligibility criteria, and the sources and methods of case ascertainment and control selection. Give the rationale for the choice of cases and controls <i>Cross-sectional study</i> —Give the eligibility criteria, and the sources and methods of selection of participants	7
		(b) <i>Cohort study</i> —For matched studies, give matching criteria and number of exposed and unexposed <i>Case-control study</i> —For matched studies, give matching criteria and the number of controls per case	
Variables	7	Clearly define all outcomes, exposures, predictors, potential confounders, and effect modifiers. Give diagnostic criteria, if applicable	7
Data sources/ measurement	8*	For each variable of interest, give sources of data and details of methods of assessment (measurement). Describe comparability of assessment methods if there is more than one group	7
Bias	9	Describe any efforts to address potential sources of bias	
Study size	10	Explain how the study size was arrived at	6
Quantitative variables	11	Explain how quantitative variables were handled in the analyses. If applicable, describe which groupings were chosen and why	7
Statistical methods	12	(a) Describe all statistical methods, including those used to control for confounding	7,8
		(b) Describe any methods used to examine subgroups and interactions	
		(c) Explain how missing data were addressed	
		(d) <i>Cohort study</i> —If applicable, explain how loss to follow-up was addressed <i>Case-control study</i> —If applicable, explain how matching of cases and controls was addressed <i>Cross-sectional study</i> —If applicable, describe analytical methods taking account of sampling strategy	
		(e) Describe any sensitivity analyses	

Continued on next page

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<b>Results</b>			
Participants	13*	(a) Report numbers of individuals at each stage of study—eg numbers potentially eligible, examined for eligibility, confirmed eligible, included in the study, completing follow-up, and analysed (b) Give reasons for non-participation at each stage (c) Consider use of a flow diagram	8
Descriptive data	14*	(a) Give characteristics of study participants (eg demographic, clinical, social) and information on exposures and potential confounders (b) Indicate number of participants with missing data for each variable of interest (c) <i>Cohort study</i> —Summarise follow-up time (eg, average and total amount)	8,9
Outcome data	15*	<i>Cohort study</i> —Report numbers of outcome events or summary measures over time <i>Case-control study</i> —Report numbers in each exposure category, or summary measures of exposure <i>Cross-sectional study</i> —Report numbers of outcome events or summary measures	9
Main results	16	(a) Give unadjusted estimates and, if applicable, confounder-adjusted estimates and their precision (eg, 95% confidence interval). Make clear which confounders were adjusted for and why they were included (b) Report category boundaries when continuous variables were categorized (c) If relevant, consider translating estimates of relative risk into absolute risk for a meaningful time period	10/12
Other analyses	17	Report other analyses done—eg analyses of subgroups and interactions, and sensitivity analyses	
<b>Discussion</b>			
Key results	18	Summarise key results with reference to study objectives	12/15
Limitations	19	Discuss limitations of the study, taking into account sources of potential bias or imprecision. Discuss both direction and magnitude of any potential bias	15
Interpretation	20	Give a cautious overall interpretation of results considering objectives, limitations, multiplicity of analyses, results from similar studies, and other relevant evidence	15
Generalisability	21	Discuss the generalisability (external validity) of the study results	15
<b>Other information</b>			
Funding	22	Give the source of funding and the role of the funders for the present study and, if applicable, for the original study on which the present article is based	

\*Give information separately for cases and controls in case-control studies and, if applicable, for exposed and unexposed groups in cohort and cross-sectional studies.

**Note:** An Explanation and Elaboration article discusses each checklist item and gives methodological background and published examples of transparent reporting. The STROBE checklist is best used in conjunction with this article (freely available on the Web sites of PLoS Medicine at <http://www.plosmedicine.org/>, Annals of Internal Medicine at <http://www.annals.org/>, and Epidemiology at <http://www.epidem.com/>). Information on the STROBE Initiative is available at [www.strobe-statement.org](http://www.strobe-statement.org).

# BMJ Open

## Triple burden of malnutrition among mother-child pairs in low and middle-income countries: A cross-sectional study

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# 1 Triple burden of malnutrition among mother-child pairs in low and 2 middle-income countries: A cross-sectional study

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**Abstract**

**Objective:** This study aimed to assess the prevalence and determinants of the triple burden of malnutrition among mother-child pairs in low-and middle-income countries.

**Design:** Cross-sectional study

**Setting:** Low-and middle-income countries

**Participants:** Women and children

**Primary outcome:** Triple burden of malnutrition (overweight/obese mother with undernourished and anemic under 5 years child)

**Methods:** Data for this study were drawn from recent 22 low and middle-income countries Demographic and Health Surveys (DHSs). A total weighted sample of 116,795 mother-child pairs was included in the study. STATA version 14.2 was used to clean, code and analyze the data. Multilevel logistic regression was employed to identify factors associated with the problem. Adjusted odds ratio with 95% CI and a P value <0.05 was reported to indicate statistical association. Model fitness and comparison were done using ICC, MOR, PCV, and deviance.

**Result:** The pooled prevalence of the triple burden of malnutrition among mother-child pairs was 11.39%. It showed statistically significant positive associations with mothers aged  $\geq 35$  years (AOR=2.25,95%CI 2.08-2.44), family size >10 (AOR=1.17,95%CI 1.08-1.26), delivery by CS (AOR=1.93,95%CI 1.83-2.03), the richest household (AOR=1.72,95%CI 1.56-1.88), grand multiparous (AOR=1.62, 95% CI 1.46-1.81), age of child 36-47 months (AOR=1.77, 95% CI 1.64-1.90), at a p-value of <0.05. Whereas breastfeeding (AOR=0.94,95%CI 0.89-0.99), married mothers (AOR=0.87,95%CI 0.78-0.96), female children (AOR=0.88,95%CI 0.84-0.92), improved toilet (AOR=0.23,95%CI 0.17-0.29), improved source of drinking water (AOR=0.28,95%CI 0.21-



53 0.35), rural residents (AOR=0.66,95%CI 0.62-0.69) had a contrasting relationship with the triple  
54 burden of malnutrition

55 **Conclusion:** About 1 out of 10 households suffer from the triple burden of malnutrition in low  
56 and middle-income countries. This study revealed that several maternal, child, household, and  
57 community-level factors have a significant impact on the triple burden of malnutrition among  
58 mother-child pairs.

59 **Keywords:** Triple burden, mother-child pairs, malnutrition, low and middle-income countries.

### 60 **Strengths and limitations of this study**

- 61 ➤ The findings were supported by large datasets covering 22 LMICs.
- 62 ➤ We employed multilevel analysis which is an appropriate methodology for such data
- 63 ➤ The data were collected using a common internationally acceptable methodological procedure.
- 64 ➤ DHS used a cross-sectional survey design, and the causal relationship between the triple  
65 burden of malnutrition and the independent variables cannot be established.
- 66 ➤ We didn't include important covariates such as dietary intake, physical activity level, or  
67 comorbidities as the DHS did not collect information on these variables

## 74 **Background**

75 The triple burden of malnutrition, which is the coexistence of overnutrition, undernutrition, and  
76 micronutrient deficiencies is increasing in low and middle-income countries (LMICs) (1). The  
77 World Health Organization (WHO) characterized overnutrition (Obesity and overweight) as a  
78 pandemic of a major public health concern due to the increased frequency of the problem in many  
79 countries (2). It is ranked as the sixth leading cause of disability-adjusted life years (DALYs) and  
80 accounts for approximately 4 million people dying each year worldwide (3-5). Several previous  
81 studies have shown that following marked dietary change, obesity/overweight is increasing more  
82 rapidly in LMICs compared to higher-income countries (6, 7).

83 Similarly, undernutrition continues to be a major public health concern throughout the developing  
84 world (8, 9). Nearly half of all deaths in children under 5 are attributable to undernutrition and it  
85 encompasses wasting, stunting, underweight, and micronutrient deficiencies (anemia) (10, 11).  
86 Despite stunting having declined steadily, faster progress is needed to reach the 2030 target (12,  
87 13). Wasting and underweight persisting at alarming rates, require a reversal in trajectory if the  
88 2030 target is to be achieved (14). Since 2000, a significant reduction in the prevalence of anemia  
89 in children under five has been observed in many LMICs (15). Children are more vulnerable to  
90 inadequate pre-natal, infant, and young child nutrition, particularly in resource-constrained  
91 settings (16, 17). Endorsing early childhood feeding best practices is crucial to improve the health  
92 of children (18).

93 Malnutrition has a tremendous negative impact on the normal functioning of every organ system  
94 (19). It can cause permanent, widespread damage to a child's growth, development, and well-being  
95 (20). Scientific evidence has shown that malnutrition in children is associated with poorer school  
96 performance, increased susceptibility to infections, and slow recovery from illness (21, 22).

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3 97 Maternal malnutrition increases the risk of poor pregnancy outcomes including obstructed labor,  
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5 98 premature or low-birth-weight babies, and postpartum hemorrhage (23, 24). To reduce the problem  
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8 99 the United Nations (UN) adopted the Sustainable Development Goals (SDGs), targeted to end  
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10 100 poverty in all its forms everywhere (SDG 1), end hunger, achieve food security, improve nutrition,  
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12 101 promote sustainable agriculture (SDG 2), ensure healthy lives, and promote well-being for all at  
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14 102 all ages (SDG 3) (25, 26).

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17 103 Previous literature recognized the basic and underlying causes of malnutrition including the  
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19 104 environmental, economic, and sociopolitical contextual factors, with poverty having a central role  
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21 105 (11, 27-29). The triple burden of malnutrition among mother-child pairs is a relatively new issue  
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23 106 and only a few country-based studies explored the problem which couldn't give a panoramic view  
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25 107 of the problem in LMICs (30-32). Given the persistent and high levels of the problem in these  
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27 108 countries, there is a strong need for action. To design and deliver effective interventions adequate  
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29 109 understanding of the socioeconomic, environmental, and cultural factors is highly important.  
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31 110 Besides if the SDG targets are to be met, coordinated action is required toward not only sustaining  
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33 111 current rates of decline but also accelerating progress. Therefore, the objective of this study was  
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35 112 to assess the prevalence of the triple burden of malnutrition among mothers and children and the  
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37 113 potential factors associated with it in low and middle-income countries.  
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## 44 **Materials and methods**

### 45 **Study design, setting, and period**

46  
47 115 The present study is based on 22 low and middle-income countries that have had Demographic  
48  
49 116 and Health Surveys (DHS) from 2016-2020. The DHS used a cross-sectional survey study design  
50  
51 117 to collect data and provide population and health indicators at the national level. The list of those  
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53 118 countries and the respective year of surveys is provided in Table 1.  
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56 119

120 Table 1. Study setting and year of surveys

Country	Year of survey	Region
Albania	2017/18	Southeastern Europe
Benin	2017/18	West Africa
Burundi	2016/17	East-central Africa
Cameroon	2018	West-central Africa
Ethiopia	2016	East Africa
Gambia	2019/20	West Africa
Guinea	2018	West Africa
Haiti	2016/17	Caribbean
India	2019/21	South Asia
Liberia	2019/20	West Africa
Madagascar	2021	East Africa
Mali	2018	West Africa
Mauritania	2019/21	Northwest Africa
Maldives	2016/17	South Asia
Nigeria	2018	West Africa
Nepal	2016	South Asia
Rwanda	2019/20	East Africa
Sierra Leone	2019	West Africa
Tajikistan	2017	Central Asia
Timor Leste	2016	South Asia
Uganda	2016	East Africa
South Africa	2016	South Africa

121

122 **Data source and sampling procedure**

123 The current analysis was based on pooled data from DHSs in 22 LMICs. These are nationally

124 representative surveys that collect data on reproductive, maternal, neonatal, child health, and

125 nutrition in LMIC. The surveys are similarly designed that used standardized questionnaires and

126 data collection procedures, allowing therefore comparability of results. The survey employed a

127 two-stage cluster sampling technique. In the first stage, the selection of proportional

128 clusters/enumeration areas was performed using each country's most recent population and

129 housing census as a sampling frame. In the second stage, a systematic selection of households from

130 the newly created cluster was performed. A detailed description of the DHS sampling design and

131 data collection procedures has been found in each country's DHS report. The study population for

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3 132 this study was mother-child pairs. Weighting was done using the complex sample design weighting  
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5 133 and the “svyset” Stata command was applied. Variables v005 (sampling weight), v021 (primary  
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7 134 sampling unit), and v023 (stratification used in sample design) were used, and as the result, a total  
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9 135 weighted sample of 116,795 mother-child pairs was included in the analysis.  
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11

## 12 136 **Definition of variables**

### 13 14 15 137 **Outcome variable:**

16  
17 138 The triple burden of malnutrition was the outcome variable of this study where the mother was  
18  
19 139 overweight/obese and children under 5 years of age were undernourished and anemic (31, 33). At  
20  
21 140 the same household level, first, we created four different categories of malnutrition such as  
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23 141 overweight/obese mother and stunted child, overweight/obese mother and wasted child,  
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25 142 overweight/obese mother and underweight child, and overweight/obese mother and anemic child.  
26  
27 143 Then we further combined overweight/obese mothers, undernourished children, and anemic  
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29 144 children to generate the triple burden of malnutrition. Categorization was made based on height-  
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31 145 for-age z-score (HAZ), standard deviations (SD), weight-for-height z-score (WHZ), weight-for-  
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33 146 age z-score (WAZ), hemoglobin level, and body mass index (BMI).  
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35

36 147 Stunting dichotomized and coded into 0=Not stunted (HAZ  $\geq$  -2SD and above) & 1= Stunted  
37  
38 148 (HAZ  $<$  -2SD);  
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40

41 149 Wasting dichotomized and coded into 0=Not wasted (WHZ  $\geq$  -2SD to +2SD) and 1=Wasted  
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43 150 (WHZ  $<$  -2SD);  
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46 151 Underweight dichotomized and coded into 0= Not underweight (WHZ  $\geq$  -2SD and above) & 1=  
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48 152 Underweight (WAZ  $<$  -2SD);  
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51 153 Child anemia dichotomized and coded into 0= Not anemic (hemoglobin level  $>$  11 g/dl), & 1=  
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53 154 Anemic (hemoglobin level  $<$  11 g/dl);  
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3 155 Mother's BMI dichotomized and coded into 0= Normal (18.5–24.9 kg/m<sup>2</sup>) &  
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5 156 1= Overweight/Obese ( $\geq 25$  kg/m<sup>2</sup>)  
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7  
8 157 The triple burden of malnutrition was dichotomized and coded into 0= NO (not overweight/obese  
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10 158 mother and not undernourished child plus not anemic child, and 1= YES (overweight/obese mother  
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12 159 and undernourished child plus anemic child)  
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14  
15 160 An undernourished child is a child who is stunted or wasted or underweight.  
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### 17 161 **Independent variables:**

18  
19 162 Based on previous works of literature and the likelihood of influencing the outcome of interest,  
20  
21 163 several explanatory variables including the age of mothers, mother's education, marital status,  
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23 164 current breastfeeding, delivery by cesarean section, family size, wealth index, media access, parity,  
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25 165 age of the child, sex of the child, type of toilet facility, source of drinking water, residence and  
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27 166 distance to health facility were considered.  
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### 30 31 167 **Statistical analyses**

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33 168 We append the dataset of each country to generate pooled data. The data extraction, coding, and  
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35 169 analysis were carried out using STATA software version 14.2. We weighted the sample to restore  
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37 170 the representativeness of the sample so that the total sample looks like the country's actual  
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39 171 population. Due to the hierarchical nature of the DHS, the multilevel analysis was fitted to identify  
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41 172 significantly associated factors. Four models were fitted; the null model (with no predictors),  
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43 173 model I (adjusted for individual-level variables only), model II (adjusted for community-level  
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45 174 variables only), and model III (model adjustment for both individual and community-level  
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47 175 variables simultaneously). Adjusted OR (AOR) with 95% CI and  $p < 0.05$  were used to determine  
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49 176 significant predictors. Model fitness and comparison were done using Intraclass Correlation  
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3 177 Coefficient (ICC), Proportional Change in Variance (PCV), Median Odds Ratio (MOR), the  
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5 178 Likelihood Ratio test (LR), and deviance computed.  
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7

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## 10 180 **Patient and public involvement statement**

11  
12 181 As our study used secondary analysis of DHS data, participants and the public were not involved  
13  
14 182 in the study design or planning of the study. The study participants were not consulted to interpret  
15  
16 183 the results and write or editing of this document for readability or accuracy.  
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## 20 184 **Results**

### 21 185 **Demographics and socioeconomic characteristics**

22  
23 186 A total of 116,795 mother-child pairs were included in the study. Over half (56.48%) of mothers  
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25 187 were in the age category of 25-34 years. About 22.98% of mothers were illiterate and the majority  
26  
27 188 (46.39%) had attended secondary education. Approximately 95.73% of mothers were married and  
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29 189 62.89% were currently breastfeeding. About 20.33% and 21.21% of the households were in the  
30  
31 190 low wealth quintile of poorest and poorer respectively. Over a quarter (27.62%) of the families  
32  
33 191 had never been exposed to any type of media. The majority of the children (32.59%) were aged  
34  
35 192  $\leq 12$  months. A large proportion (83.60%) of the households had improved sources of drinking  
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37 193 water and almost two-thirds (67.02%) of the households had improved toilet facilities. Almost  
38  
39 194 three fourth (71.03%) of participants lived in rural areas and for over a quarter (27.42%) of those  
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41 195 participants, the distance to access health facilities was a big problem (**Table 2**).  
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49 196 Table 2. Socio-demographic characteristics of the study participants

Variables	Categories	Unweighted frequency (%)	Weighted frequency (%)
Age of mothers	15-24	34,983 (29.05)	35,918 (30.75)
	25-34	68,386 (56.78)	65,971 (56.48)

	≥35	17,073 (14.18)	14,906 (12.76)
Mothers education	No education	27,995 (23.24)	26,845 (22.98)
	Primary education	19,684 (16.34)	18,633 (15.95)
	Secondary	57,008 (47.33)	54,185 (46.39)
	Higher	15,755 (13.08)	17,131 (14.67)
Mothers marital status	Not in union	5,583 (4.64)	4,987 (4.27)
	Married	114,859 (95.36)	111,807 (95.73)
Currently breastfeeding	No	44,160 (36.66)	43,338 (37.11)
	Yes	76,282 (63.34)	73,457 (62.89)
Delivery by cesarean section	No	99,291 (82.49)	93,974 (80.51)
	Yes	21,077 (17.51)	22,748 (19.49)
Family size	≤5	56,365 (46.80)	53,677 (45.96)
	6-10	54,605 (45.34)	53,258 (45.60)
	>10	9,472 (7.86)	9,859 (8.44)
Wealth index	Poorest	28,097 (23.33)	23,749 (20.33)
	Poorer	27,352 (22.71)	24,774 (21.21)
	Middle	24,741 (20.54)	24,330 (20.83)
	Richer	22,180 (18.42)	23,880 (20.45)
	Richest	18,072 (15.00)	20,061 (17.18)
Media access	No	33,942 (28.18)	32,256 (27.62)
	Yes	86,500 (71.82)	84,539 (72.38)
Parity	Primiparous	36,241 (30.09)	35,333 (30.25)
	Multiparous	76,092 (63.18)	73,823 (63.21)
	Grand Multiparous	8,109 (6.73)	7,639 (6.54)
Age of child	≤12	38,959 (32.35)	38,059 (32.59)
	13-23	25,382 (21.07)	24,819 (21.25)
	24-35	22,208 (18.44)	21,478 (18.39)
	36-47	17,948 (14.90)	17,204 (14.73)
	48-59	15,945 (13.24)	15,234 (13.04)
Sex of child	Male	63,660 (52.86)	62,008 (53.09)
	Female	56,782 (47.14)	54,787 (46.91)
Type of toilet facility	Unimproved	37,519 (31.15)	38,518 (32.98)
	Improved	82,923 (68.85)	78,277 (67.02)
Source of drinking water	Unimproved	20,959 (17.40)	19,159 (16.40)
	Improved	99,483 (82.60)	97,636 (83.60)
Residence	Urban	28,722 (23.85)	33,838 (28.97)
	Rural	91,720 (76.15)	82,957 (71.03)
Distance to a health facility	No problem	84,605 (70.25)	84,776 (72.58)
	Big problem	35,837 (29.75)	32,019 (27.42)

197

198 **Prevalence of triple burden of malnutrition**



199 In 22 low and middle-income countries, the pooled prevalence of the triple burden of malnutrition  
200 among mother-child pairs was found at 11.39 % (95% CI 9.56%, 13.23%). Ethiopia has the lowest  
201 (3.54 %) prevalence of triple burden while Mauritania (31.66%) bears the highest (**Figure 1**).

202 Fig 1. The pooled prevalence of the triple burden of malnutrition

## 203 **Multilevel analyses**

### 204 **Random parameter estimation and model selection**

205 Based on the result of random effect analysis, the ICC of the null model was 0.30, indicating that  
206 30% of the total variability in triple burden prevalence was attributable to between-cluster  
207 variability, while about 70% was due to individual differences. The null model MOR was 3.04,  
208 which indicates that a mother/child from a cluster with a high triple burden prevalence has a 3.04  
209 times higher probability of being malnourished than a mother/child from a cluster with a lower  
210 prevalence. Model III was the best-fitted model since it has the highest log likelihood (-91665)  
211 and the lowest deviance (183,330) value (**Table 3**).

### 212 **Factors associated with the triple burden of malnutrition (Fixed effects)**

213 The triple burden of malnutrition was statistically significant with mothers aged 25-34 years  
214 (AOR=1.54, 95% CI 1.45 - 1.63),  $\geq 35$  years (AOR=2.25, 95% CI 2.08 - 2.44), mothers attended  
215 secondary education (AOR=1.08, 95% CI 1.02-1.15), family size >10 (AOR=1.17, 95% CI 1.08 -  
216 1.26), delivery by CS (AOR=1.93, 95% CI 1.83 - 2.03), the richer household (AOR=1.63, 95% CI  
217 1.49 - 1.76), the richest household (AOR=1.72, 95% CI 1.56 - 1.88), multiparous (AOR=1.42,  
218 95% CI 1.34 - 1.49), grand multiparous (AOR=1.62, 95% CI 1.46 - 1.81), age of child 36-47  
219 months (AOR=1.77, 95% CI 1.64 - 1.90), age of child 48-59 (AOR=1.51, 95% CI 1.39 - 1.64),  
220 breastfeeding (AOR=0.94, 95% CI 0.89 - 0.99), married mothers (AOR=0.87, 95% CI 0.78 - 0.96),

221 female children (AOR=0.88, 95% CI 0.84 - 0.92), improved toilet facility (AOR=0.23, 95% CI  
 222 0.17 - 0.29), improved source of drinking water (AOR=0.28, 95% CI 0.21 - 0.35), rural residents  
 223 (AOR=0.66, 95% CI 0.62 - 0.69) at a p-value of <0.05 (**Table 3**).

224

225 Table 3. Multivariable multilevel logistic regression analysis of the triple burden of malnutrition.

Variables	Categories	Null model	Model I		Model II		Model III	
			AOR	95% CI	AOR	95% CI	AOR	95% CI
Age of mothers	15-24	1.00					1.00	
	25-34	1.54 (1.46 - 1.63)**		—		1.54 (1.45 - 1.63)**		
	≥35	2.28 (2.11 - 2.47)**		—		2.25 (2.08 - 2.44)**		
Mothers education	No education	1.00				1.00		
	Primary education	1.04 (0.97 - 1.12)		—		1.04 (0.97 - 1.12)		
	Secondary	1.08 (1.01 - 1.15)*		—		1.08 (1.02 - 1.15)*		
	Higher	0.94 (0.86 - 1.02)		—		0.94 (0.86 - 1.02)		
Mothers marital status	Not in union	1.00				1.00		
	Married	0.83 (0.75 - 0.93)*		—		0.87 (0.78 - 0.96)**		
Currently breastfeeding	No	1.00				1.00		
	Yes	0.92 (0.87 - 0.97)*		—		0.94 (0.89 - 0.99)*		
Delivery by CS	No	1.00				1.00		
	Yes	1.94 (1.84 - 2.04)**		—		1.93 (1.83 - 2.03)**		
Family size	≤5	1.00				1.00		
	6-10	1.00 (0.97 - 1.08)		—		1.01 (0.98 - 1.08)		
	>10	1.14 (1.06 - 1.24)**		—		1.17 (1.08 - 1.26)**		
Wealth index	Poorest	1.00				1.00		
	Poorer	1.41 (1.31 - 1.52)**		—		1.38 (1.28 - 1.49)**		
	Middle	1.60 (1.48 - 1.73)**		—		1.49 (1.38 - 1.62)**		
	Richer	1.86 (1.72 - 2.02)**		—		1.63 (1.49 - 1.76)**		
	Richest	2.15 (1.97 - 2.35)**		—		1.72 (1.56 - 1.88)**		
Media access	No	1.00				1.00		
	Yes	1.01 (0.98 - 1.08)		—		1.02 (0.99 - 1.11)		
Parity	Primiparous	1.00				1.00		
	Multiparous	1.42 (1.34 - 1.50)**		—		1.42 (1.34 - 1.49)**		
	Grand Multiparous	1.61 (1.44 - 1.79)**		—		1.62 (1.46 - 1.81)**		
Age of child	≤12	1.00				1.00		
	13-23	1.41 (1.32 - 1.50)**		—		1.41 (1.32 - 1.50)**		
	24-35	1.62 (1.52 - 1.73)**		—		1.63 (1.53 - 1.74)**		
	36-47	1.75 (1.62 - 1.89)**		—		1.77 (1.64 - 1.90)**		
	48-59	1.50 (1.38 - 1.62)**		—		1.51 (1.39 - 1.64)**		
Sex of child	Male	1.00				1.00		
	Female	0.88 (0.84 - 0.92)**		—		0.88 (0.84 - 0.92)**		

Type of toilet facility	Unimproved	1.00		1.00
	Improved	0.24 (0.18 - 1.31)	—	0.23 (0.17 - 0.29)**
Source of drinking water	Unimproved	1.00		1.00
	Improved	0.21 (0.16 - 0.28)	—	0.28 (0.21 - 0.35)**
<b>Community-level variables</b>				
Residence	Urban		1.00	1.00
	Rural	—	0.49 (0.46 - 0.52)**	0.66 (0.62 - 0.69)**
Distance to a health facility	No problem		1.00	1.00
	Big problem	—	0.87 (0.82 - 0.91)**	0.94 (0.89 - 0.98)**
<b>Random effect</b>				
	Variance	1.40	1.24	1.31
	ICC	0.30	0.27	0.28
	MOR	3.04	2.88	2.96
	PCV	Reff	11.42	6.43
<b>Model comparison</b>				
	Log likelihood ratio	-100585	-92108	-97815
	Deviance	201,170	184,216	195,630

\* = P-value < 0.05, \*\* = P-value < 0.01,

ICC = Inter cluster correlation coefficient, MOR =Median odds ratio, PCV = proportional change in variance.

AOR=adjusted odds ratio; CI= confidence interval,

226

## 227 Discussion

228 LMICs are increasingly facing the triple burden of malnutrition where women and children are  
 229 among the hardest hit by the problem (34, 35). This study assessed the triple burden of malnutrition  
 230 (co-occurrence of undernutrition, overweight/obesity, and anemia among mother-child pairs) in  
 231 the same household, using nationally representative data in LMICs. The result showed that the  
 232 pooled prevalence of triple burden was 11.39 % (95% CI 9.56%, 13.23%); Ethiopia had the lowest  
 233 (3.54 %) prevalence while Mauritania (31.66%) had the highest. The variation among countries  
 234 could be attributed to differences in socio-economic status, food environment, physical activity,  
 235 genetic factors, health care system strength, national policy, and political commitments.

236 The study revealed that several maternal, child, household, and community-level factors have a  
 237 significant impact on the triple burden of malnutrition among mother-child pairs. It has found a  
 238 parallel correlation between the triple burden of malnutrition and maternal age. The odds of being

1  
2  
3 239 malnourished increase as the age of the mother increases. This is in agreement with previous  
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5 240 studies where older mothers bear the highest risk compared to younger ones (31, 36). The possible  
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7 241 explanation could be because of reduced physical activity, less energy requirement, and hormonal  
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9 242 changes among older mothers. Similarly, mothers who have attended secondary education were  
10  
11 243 more likely to be malnourished (31). A plausible explanation for this could be the shifts from  
12  
13 244 manual labor to more sedentary occupations and the related decline in physical activity.  
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16  
17 245 Being married reduced the risk of the triple burden of malnutrition. Partners together could  
18  
19 246 generate more money, reduce food insecurity, and tend to take better care of themselves and their  
20  
21 247 children. It is been reported that children in single-parent households suffered from undernutrition  
22  
23 248 significantly more than children brought up by both parents (37, 38). Likewise, this study revealed  
24  
25 249 breastfeeding reduced the triple burden of malnutrition. Breastfeeding plays a vital role in the  
26  
27 250 prevention of different forms of childhood malnutrition (39). However, delivery by cesarean  
28  
29 251 section (C-section) delays the timely initiation of breastfeeding and pre-lacteal feeding (40).  
30  
31 252 Previous studies have reported that C-section increases maternal obesity and negatively affect the  
32  
33 253 breastfeeding of children, which results in malnutrition (41, 42). Moreover, malnutrition in  
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35 254 children is related to gut microbiota alteration and C-section contributes to microbial alterations in  
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37 255 the small intestine (43).  
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43 256 Our study revealed a parallel relationship between the household wealth quintiles and the triple  
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45 257 burden of malnutrition. As household income increases, the odds of malnutrition increase (30, 44).  
46  
47 258 High income could increase the purchasing power for food, influencing the type of foods  
48  
49 259 consumed and the intake of prepared or processed food (34). Economic growth and the food  
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51 260 industry's rapid penetration into the market have resulted to depend on energy-dense and nutrient-  
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3 261 poor foods (45). In recent years, the dietary preference in LMICs has changed as the food  
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5 262 environment is dominated by media advertising, and relatively cheap, energy-dense foods (46).  
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8 263 The odds of the triple burden of malnutrition were higher in a household with a family size >10.  
9

10 264 A plausible explanation is that in a household with a large family, providing optimum nutritious  
11

12 265 food to all the family members and children could be difficult (47, 48). Moreover giving proper  
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14 266 care and time to children and the family could be unlikely and this could lead to malnutrition.  
15

16 267 Likewise, parity was found to be a determinant of the triple burden of malnutrition. Higher parity  
17

18 268 increased the odds of malnutrition. The possible explanation could be that women could gain  
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20 269 weight during pregnancy, and weight loss might not occur in the post-partum period which could  
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22 270 lead to child malnutrition. (49).  
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26 271 The present study revealed that child age and sex were significant factors for malnutrition. Older  
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28 272 under-five children were more likely to be malnourished compared to younger ones (50). A  
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30 273 previous study (51) revealed that there was an increased frequency of parasite infection in older  
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32 274 children leading to a higher prevalence of malnutrition compared to the younger ones. In addition,  
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34 275 gender was found a significant determinant of malnutrition where a female child was less likely to  
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36 276 be malnourished (52). The cause of the gender gap in malnutrition is unknown, however, some  
37

38 277 studies argued that male children are known to be more vulnerable than females to diseases  
39

40 278 including lower respiratory infections, diarrhoeal diseases, malaria, and preterm birth. Those  
41

42 279 diseases have been reported as factors for undernutrition among young male children (53, 54).  
43

44 280 Others also claimed that boys are more vulnerable to environmental problems while playing, such  
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46 281 as exposure to toxins and air pollution than girls (55).  
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50 282 Being rural residents was associated with lower odds of the triple burden of malnutrition. The  
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52 283 urban-rural difference could be attributable to factors including access to different food types,  
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3 284 overcrowding, concurrent disease, and sedentary lifestyles. Previous studies depicted that  
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5 285 urbanization affects the way of life, access to processed and junk foods could exacerbate  
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7  
8 286 malnutrition among women and children (30, 56).  
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10  
11 287 Our study has some strengths and limitations. It used large nationally representative samples with  
12  
13 288 appropriate statistical modeling. The use of large nationally representative data and multilevel  
14  
15 289 analysis helps to provide more robust estimates of observed associations as well as enhance the  
16  
17 290 generalizability of the results. Despite the strengths, this study used cross-sectional data, which  
18  
19 291 did not indicate a temporal relationship between the factors and triple burden. No important  
20  
21 292 covariates, such as dietary intake, physical activity level, comorbidities, and nutrition status during  
22  
23 293 pregnancy, were incorporated into the study as the DHS did not provide a complete record of these  
24  
25  
26 294 variables.  
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## 30 295 **Conclusions and recommendations**

31

32 296 About 1 out of 10 households suffer from the triple burden of malnutrition in low and middle-  
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34 297 income countries. This study revealed that several maternal, child, household, and community-  
35  
36 298 level factors have a significant impact on the triple burden of malnutrition among mother-child  
37  
38 299 pairs. The triple burden requires the governments, the scientific and medical communities, and the  
39  
40 300 industry's efforts in changing dietary and lifestyle habits to address all forms of malnutrition and  
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42 301 should focus on women's nutrition to break the intergenerational triple burden of malnutrition.  
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## 46 302 **Abbreviations**

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49 303 AOR, Adjusted Odds Ratio; DHSs, Demographic and Health Surveys; ICC, Intra cluster  
50  
51 304 correlation coefficient; LMICs, low and middle-income countries; MOR, median odds ratio; PCV,  
52  
53 305 a proportional change in variance; SDGs, Sustainable Development Goals; WHO, World Health  
54  
55  
56 306 Organization  
57

## 307 **Declarations**

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

309 Permission to access the data was obtained from the measure DHS program  
310 (<http://www.dhsprogram.com>) via online request. The website and the data used were publicly  
311 available with no personal identifier. All methods were carried out in accordance with relevant  
312 guidelines and regulations.

### 313 **Consent for publication**

314 Not applicable.

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

316 Data are available online in a public, open-access repository ([www.measuredhs.com/data](http://www.measuredhs.com/data)).

### 317 **Competing interests**

318 The authors declare that they have no competing interests.

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### 321 **Author Contributions**

322 Conceptualization: DC. Study design: DC, DGB, MWM, AAK, AZA, MHA, NWT, and FMA.

323 Execution: DC, DGB, MWM, AAK, AZA, MHA, NWT, and FMA. Acquisition of the data: DC,

324 DGB, MWM, AAK, AZA, MHA, NWT, and FMA. Analysis and interpretation: DC, DGB,

325 MWM, AAK, AZA, MHA, NWT, and FMA. Writing: DC, DGB, MWM, AAK, AZA, MHA,

326 NWT, and FMA. Review and editing: DC, DGB, MWM, AAK, AZA, MHA, NWT, and FMA.

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329

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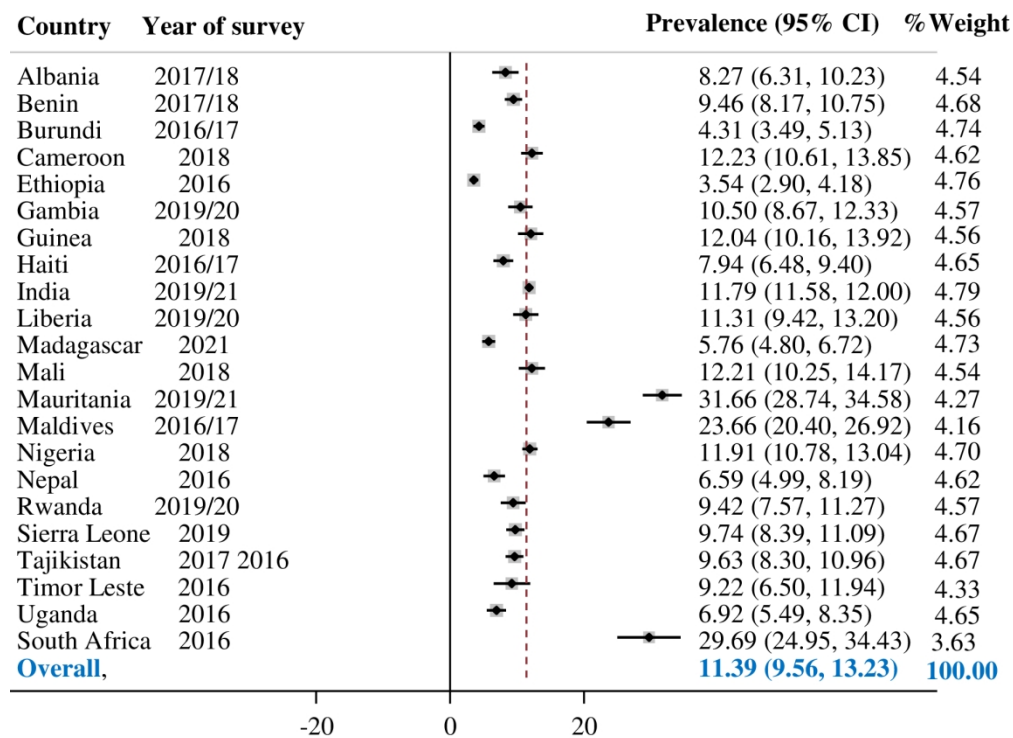


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NOTE: Weights are from random-effects model

161x123mm (300 x 300 DPI)

## STROBE Statement—checklist of items that should be included in reports of observational studies

	Item No	Recommendation	Page No
<b>Title and abstract</b>	1	(a) Indicate the study's design with a commonly used term in the title or the abstract	1
		(b) Provide in the abstract an informative and balanced summary of what was done and what was found	2, 3
<b>Introduction</b>			
Background/rationale	2	Explain the scientific background and rationale for the investigation being reported	4
Objectives	3	State specific objectives, including any prespecified hypotheses	5
<b>Methods</b>			
Study design	4	Present key elements of study design early in the paper	5
Setting	5	Describe the setting, locations, and relevant dates, including periods of recruitment, exposure, follow-up, and data collection	5
Participants	6	(a) <i>Cohort study</i> —Give the eligibility criteria, and the sources and methods of selection of participants. Describe methods of follow-up <i>Case-control study</i> —Give the eligibility criteria, and the sources and methods of case ascertainment and control selection. Give the rationale for the choice of cases and controls <i>Cross-sectional study</i> —Give the eligibility criteria, and the sources and methods of selection of participants	7
		(b) <i>Cohort study</i> —For matched studies, give matching criteria and number of exposed and unexposed <i>Case-control study</i> —For matched studies, give matching criteria and the number of controls per case	
Variables	7	Clearly define all outcomes, exposures, predictors, potential confounders, and effect modifiers. Give diagnostic criteria, if applicable	7
Data sources/ measurement	8*	For each variable of interest, give sources of data and details of methods of assessment (measurement). Describe comparability of assessment methods if there is more than one group	7
Bias	9	Describe any efforts to address potential sources of bias	
Study size	10	Explain how the study size was arrived at	6
Quantitative variables	11	Explain how quantitative variables were handled in the analyses. If applicable, describe which groupings were chosen and why	7
Statistical methods	12	(a) Describe all statistical methods, including those used to control for confounding	7,8
		(b) Describe any methods used to examine subgroups and interactions	
		(c) Explain how missing data were addressed	
		(d) <i>Cohort study</i> —If applicable, explain how loss to follow-up was addressed <i>Case-control study</i> —If applicable, explain how matching of cases and controls was addressed <i>Cross-sectional study</i> —If applicable, describe analytical methods taking account of sampling strategy	
		(e) Describe any sensitivity analyses	

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60**Results**

Participants	13*	(a) Report numbers of individuals at each stage of study—eg numbers potentially eligible, examined for eligibility, confirmed eligible, included in the study, completing follow-up, and analysed (b) Give reasons for non-participation at each stage (c) Consider use of a flow diagram	8
Descriptive data	14*	(a) Give characteristics of study participants (eg demographic, clinical, social) and information on exposures and potential confounders (b) Indicate number of participants with missing data for each variable of interest (c) <i>Cohort study</i> —Summarise follow-up time (eg, average and total amount)	8,9
Outcome data	15*	<i>Cohort study</i> —Report numbers of outcome events or summary measures over time <i>Case-control study</i> —Report numbers in each exposure category, or summary measures of exposure <i>Cross-sectional study</i> —Report numbers of outcome events or summary measures	9
Main results	16	(a) Give unadjusted estimates and, if applicable, confounder-adjusted estimates and their precision (eg, 95% confidence interval). Make clear which confounders were adjusted for and why they were included (b) Report category boundaries when continuous variables were categorized (c) If relevant, consider translating estimates of relative risk into absolute risk for a meaningful time period	10/12
Other analyses	17	Report other analyses done—eg analyses of subgroups and interactions, and sensitivity analyses	

**Discussion**

Key results	18	Summarise key results with reference to study objectives	12/15
Limitations	19	Discuss limitations of the study, taking into account sources of potential bias or imprecision. Discuss both direction and magnitude of any potential bias	15
Interpretation	20	Give a cautious overall interpretation of results considering objectives, limitations, multiplicity of analyses, results from similar studies, and other relevant evidence	15
Generalisability	21	Discuss the generalisability (external validity) of the study results	15

**Other information**

Funding	22	Give the source of funding and the role of the funders for the present study and, if applicable, for the original study on which the present article is based	
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\*Give information separately for cases and controls in case-control studies and, if applicable, for exposed and unexposed groups in cohort and cross-sectional studies.

**Note:** An Explanation and Elaboration article discusses each checklist item and gives methodological background and published examples of transparent reporting. The STROBE checklist is best used in conjunction with this article (freely available on the Web sites of PLoS Medicine at <http://www.plosmedicine.org/>, Annals of Internal Medicine at <http://www.annals.org/>, and Epidemiology at <http://www.epidem.com/>). Information on the STROBE Initiative is available at [www.strobe-statement.org](http://www.strobe-statement.org).