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Child Gender-Related Vulnerability and Chronic Malnutrition in Burkina Faso: The Moderating Role of The Maternal Education

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Abstract

Background: Chronic malnutrition in children is a growth disorder resulting from a prolonged lack of nutrient intake. It is a widespread health issue in West and Central Africa where it affects one third (1/3) of children under five (05). This paper highlights the mitigation of child's gender-based chronic malnutrition risk through maternal education.

Methods: This paper uses data from the 2010 Demographic and Health Survey in Burkina Faso. Univariate and bivariate descriptive analysis techniques, multilevel logistic regression and interaction analyses were used. Analyses were conducted separately for children aged 0-5 months, 6-23 months and 24-59 months.

Results: The results showed that boys are at greater risk of suffering from chronic malnutrition than girls, even after considering control factors. This gender-based effect was observed in children in the 6-23 month and 24–59-month age subgroups. Furthermore, the interaction analysis showed that this gender effect is more pronounced in and even specific to children of uneducated mothers because of the latter's inappropriate hygiene and sanitation practices.

Conclusion: These results suggest that intensifying policies to encourage girls' schooling and strengthening hygiene and sanitation measures among children would reduce or even eliminate gender-based inequalities in chronic malnutrition among children in Burkina Faso.

Keywords: Chronic malnutrition; Maternal education; Child's gender; Interaction analysis

Introduction

Malnutrition in children is a pathological condition resulting from deficiency, excess or imbalance of food intake. Its most common form in West and Central Africa is chronic malnutrition, which affects one third of children under five [1]. Chronic malnutrition can be recognized in children by their relatively small size for their age, hence the term "stunting" used for the same condition. It has harmful short and long term health effects [2,3]. It reduces the physical and intellectual capacities of children, thus affecting their productivity even in adulthood [4]. These harmful consequences and the widespread of malnutrition have led Governments to commit to reduce the number of chronically malnourished children under five by 40% by 2025 (compared to 2012 levels) [5], and to eliminate it completely by 2030 [6]. A good knowledge of the factors associated with chronic malnutrition is essential to achieve these goals. A review of empirical studies shows that child,

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household, and community-related factors are associated with chronic child malnutrition [7-13]. Child gender is one of the factors associated with chronic malnutrition. The effect of gender most often leads to a higher risk of chronic malnutrition in boys compared to girls and is widely shared in West and Central Africa [10-13]. In previous studies, the reasons given to explain these gender inequalities are not always scientifically supported [14]. Among these reasons, it appears that the greater risk of chronic malnutrition among boys is partly related to a higher frequency of premature births (a major factor of poor health) among male births compared to female births, or to a higher prevalence of illnesses among boys in early life [11,15,16]. Thus, the fact that girls are less frequently ill than boys may explain why boys are more likely to be stunted. Mothers' level of education is also a critical factor in child health. In developing countries, more than half of the reduction in child mortality between 1990 and 2009 was attributed to improvements in the education of women of reproductive age [17]. Its effects on chronic child malnutrition have also been demonstrated in several studies. For example, for the period ranging from 2000 to 2021, we found thirteen studies showing that the mothers' low level of education is a risk factor for the occurrence of chronic malnutrition in children in West and Central African countries [11-13,18,19]. Through its action mechanism, maternal education would reduce children's vulnerability to disease. Indeed, compliance with good hygiene and sanitation practices reduces the frequency of diseases in children. Since educated mothers generally have good hygiene and sanitation practices, this could help reduce the incidence of disease in their children, both boys and girls [20]. Therefore, by helping to reduce the prevalence of disease, maternal education could mitigate the effects of a child's gender on his or her propensity to suffer from chronic malnutrition. A systematic review which showed that the gender effect on chronic malnutrition is only significant in children from disadvantaged socioeconomic backgrounds (including children of uneducated mothers) seems to support this assumption of the existence of a mitigating effect of maternal education [16]. However, to the best of our knowledge, this ability of maternal education to mitigate gender inequalities of chronic malnutrition has not yet been empirically proven, especially in Sub-Saharan Africa. In Burkina Faso, a previous study also found a higher risk of chronic malnutrition among boys compared to girls, but without analyzing the mechanisms of action [13]. This paper therefore aims at filling this knowledge gap by analyzing the moderating effect of maternal education on child's gender-related vulnerability to chronic malnutrition in Burkina Faso.

Methods

Study design and data source

This study used data from Demographic and Health Survey (DHS) in Burkina Faso. DHS is a cross-sectional study that is representative of the country, regions, and urban and rural areas. Burkina Faso, a West African country where nearly a quarter of children under five years of age are chronically malnourished [21]. The data is sourced from the DHS conducted in 2010, which is the latest DHS in the country for which data are available to date. DHS datasets are available for researchers through DHS at https://dhsprogram.com/data/available-datasets.cfm.

Variables

The dependent variable is child's chronic malnutrition. It is a dichotomous variable taking modality 1 (corresponding to "yes") if the height-age index is less than two standard deviations from the reference median. Otherwise, the variable takes the 0 modality (corresponding to "no"). This definition is consistent with the World Health Organization recommendations [22].

The independent variable is gender (male, female). Maternal level of education with three modalities ("none", "primary", "secondary and above") constitutes the interaction variable. We also mobilize several control variables consisting of the characteristics of the child (age, intergenic interval, feeding practices, vaccination status), of the mother (decision-making autonomy, nutritional status), the household (purchasing power, number of children under five, type of drinking water, type of toilet), the neighborhood (education rate of women in the neighborhood, proportion of wealthy households in the neighborhood). These control variables were identified based on a critical analysis of previous studies on chronic malnutrition that were carried out in contexts similar to those in Burkina Faso.

Statistical analyses

We conducted descriptive and logistic regression analyses. Logistic regressions were conducted separately for children aged 0-5 months, 6-23 months, and 24-59 months to account for factor specificity in each age group [23]. Given the hierarchical structure of the groups of variables, we opted for a multilevel logistic regression model where the first level represents the child's immediate environment (child, mother and household characteristics) and the second level is the neighborhood represented by the enumeration area. In addition to statistical considerations, choosing the enumeration area as a level of analysis has social significance. The enumeration area is a geographic unit that was created for census purposes. With roughly the size of a village, this area constitutes a cluster, an entity within which people interact with one another so that neighborhood effects can be observed in this space. This level of analysis has been considered in previous studies that have analyzed chronic malnutrition in Nigeria [7,24]. In addition, the DHS data we mobilize are representative at the enumeration area level.

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Analysis of moderator effects calls for interaction analyses. There are several methods for analyzing interaction effects, including analysis of variance[1] (ANOVA), multi-group regressions[2] and hierarchical multiple regressions. For this study, we use moderated multiple regression, which is a form of hierarchical multiple regressions [25]. In this method, the moderating effect of a Z variable on the relationship between an independent Xp variable and a dependent Y variable is assessed through the significance of the product of the two variables (Xp*Z). In practice, the analysis of the interaction effects was done during the logistic regression. After fitting the final model, we tested the significance of the interaction of maternal education with child's gender. When the interaction effect is significant, it is kept in the model. Otherwise, the variable without interaction is taken into account.

[1] The ANOVA in the context of an interaction analysis is only usable when the dependent variable is quantitative, the independent variable is categorical and the moderator variable is also categorical and at best dichotomous. Being simple, it only allows testing one link at a time and is not indicated for latent variables El Akremi, A. (2005). Chapitre 12. Analyse des variables modératrices et médiatrices par les méthodes d'équations structurelles. In Management des ressources humaines (pp. 325-348). De Boeck Supérieur. https://www.cairn.info/management-des-ressources-humaines--9782804147112-page-325.htm https://www.cairn.info/load_pdf.php?ID_ARTICLE=DBU_ROUSS_2005_01_0325 .

[2] This involves conducting regressions in each of the groups constituted by the moderator variable's modalities. The interaction effect is assessed through the variation in the R coefficient of determination. Its main limitation is the fragmentation of the sample following the constitution of the groups, which reduces the quality of the adjustments ibid..

Ethical considerations

This research uses secondary data only. The choice of data sources took into account the ethical requirements for data collection. Already anonymized data were provided. We obtained permission to access the Demographic and Health Survey databases through an online request on the Macro International website (www.dhsprogramm.com).

Results

Characteristics of the study population

The study involved 6,532 children, of whom 696 were in the 0-5 month age group, 2,039 in the 6-23 month age group, and 3,797 in the 24-59 month age group. For all age subgroups, there were as many girls as boys. Besides, children of uneducated mothers were in the majority (over 80%). On the other hand, children of mothers educated up to secondary school represented about 5% in each age subgroup (Table 1).

Table 1: Percentage of chronically malnourished children by gender, according to their mother's education level in 2010, Burkina Faso

Children Aged 0-5 Months								
Child gender	Mother's level of education							
	None		Primary		Secondary and above		Total	
	n	% (95% CI)	n	% (95% CI)	n	% (95% CI)	n	% (95% CI)
Male	303	10.7 (7.3, 14.6)	33	12.7 (3.4, 28.2)	20	22.1 (5.7, 43.7)	356	11.5 (8.4, 15.3)
Female	299	10.3 (7.1, 14.4)	40	8.4 (1.5, 20.4)	19	2.3 (0.0, 17.6)	358	9.7 (6.9, 13.3)
Total	**602**	**10.5** (8.1, 13.2)	**73**	**10.4** (4.8, 20.4)	**39**	**12.4** (4.3, 27.4)	**714**	**10.6** (8.5, 13.1)
Children Aged 6-23 Months								
Child	**Mother's level of education**							
gender	**No**		**Primary**		**Secondary and above**		**Total**	
	n	% (95% CI)	n	% (95% CI)	n	% (95% CI)	n	% (95% CI)
Male	866	36.1 (32.9, 39.4)	127	27.2 (20.0, 36.2)	61	16.2 (8.1, 28.1)	1055	33.9 (31.1, 36.9)
Female	824	29.0 (25.9, 32.2)	119	18.9 (12.0, 26.6)	52	4.4 (0.5, 13.2)	995	26.5 (23.8, 29.4)
Total	**1690**	**32.6** (30.4, 34.9)	**246**	**23.2** (18.0, 29.0)	**113**	**10.7** (5.6, 17.8)	**2050**	**30.3** (28.3, 32.3)
	Children from 24-59 Months							
Child gender	**Mother's level of education**							
	No		**Primary**		**Secondary and above**		**Total**	
	n	% (95% CI)	n	% (95% CI)	n	% (95% CI)	n	% (95% CI)
Male	1674	46.5 (44.0, 48.8)	218	31.5 (25.5, 38.3)	91	7.9 (10.4, 18.0)	1984	43.1 (40.9, 45.3)
Female	1612	42.4 (39.9, 44.8)	208	29.5 (23.2, 36.0)	90	13.1 (9.8, 17.7)	1912	39.6 (37.3, 41.8)
Total	3287	41.9 (41.0, 42.7)	427	29.1 (26.7, 31.5)	181	13.7 (11.1,16.5)	**3896**	41.4 (39.8, 43.0)

Note: The numbers used in table 1 are weighted, hence their difference with those used in tables 2, 3 and 4 for which the numbers have not been weighted.

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Table 2: Odds ratios (ORs) predicting chronic malnutrition in children aged 0-5 months, in Burkina Faso

Variables	0-5 Months			
	M0	M1	M2	M3
	OR (95% CI)	OR (95% CI)	OR (95% CI)	OR (95% CI)
Individual Factors				
Education (ref: none)				
Primary	1.06 (0.48, 2.34)	1.64 (0.64, 4.27)	1.72 (0.43, 6.83)	2.36 (0.44, 12.57)
High school and above	0.84 (0.28, 2.45)	1.62 (0.40, 6.53)	1.74 (0.30, 10.07)	2.87 (0.41, 20.26)
Gender (ref: male)				
Female	0.93 (0.57, 1.50)	0.81 (0.46, 1.42)	0.81 (0.46, 1.42)	
Gender (ref: male and uneducated mother				
Female and uneducated mother				0.93 (0.50, 1.70)
Female and mother educated up to primary school				0.51 (0.09, 2.78)
Female and mother educated up to secondary school				0.26 (0.02, 3.51)
Twinning (ref: singleton)				
Twin	4.22 (1,50, 11.86)	5.53 (1.49,0.51)	5.52 (1.49, 20.44)	5.19 (1.43, 18.80)
Size at birth (ref: not small)				
small	2.71 (1.51, 4.87)	2.95 (1.43, 6.10)	2.95 (1.43, 6.10)	2.97 (1.44, 6.10)
Intergenic interval (ref: >= 24 months)				
<24 months	0.80 (0.24, 2.73)	0.95 (0.24, 3.69)	0.94 (0.24, 3.67)	0.98 (0.25, 3.77)
Age (months)	1.10 (0.94, 1.28)	1.08 (0.90, 1.30)	1.09 (0.90, 1.31)	1.09 (0.90, 1.30)
Exclusive breastfeeding (ref: no)				
Yes	0.52 (0.26, 1.02)	0.53 (0.24, 1.15)	0.53 (0.24, 1.15)	0.52 (0.24, 1.15)
Involvement in decision making (ref: none)				
Average	1.69 (1.02, 2.79)	1.82 (1.03, 3.23)	1.80 (1.02, 3.20)	1.81 (1.02, 3.20)
Strong	0.82 (0.24, 2.84)	1.02 (0.25, 4.16)	1.03 (0.25, 4.16)	1.08 (0.27, 4.32)
Tolerance of violence (ref: none)				
Average	1.19 (0.71, 2.01)	1.37 (0.76, 2.47)	1.37 (0.76, 2.46)	1.37 (0.76, 2.46)
Strong	0.55 (0.22, 1.37)	0.56 (0.20, 1.55)	0.55 (0.20, 1.54)	0.55 (0.20, 1.54)
Maternal nutritional status (ref: BMI <18.5)				
18.5 <=BMI<25	0.71 (0.35, 1.43)	0.68 (0.30, 1.52)	0.67 (0.30, 1.50)	0.67 (0.30, 1.47)
BMI >=25	0.53 (0.15, 1.80)	0.71 (0.18, 2.85)	0.72 (0.18, 1.91)	0.72 (0.18, 2.88)
Household standard of living (ref: poor)				
Medium	1.50 (0.92, 2.46)	1.15 (0.61, 2.14)	1.14 (0.61, 2.13)	1.14 (0.61, 2.11)
Rich	0.83 (0.45, 1.55)	1.21 (0.39, 3.71)	1.39 (0.32, 5.96)	1.43 (0.34, 6.12)
Number of children under five in the household (ref: 1-2 children)				
3-4 children	0.87 (0.51, 1.47)	0.76 (0.41, 1.40)	0.76 (0.41, 1.40)	0.75 (0.41, 1.38)
5 children and more	0.84 (0.34, 2.08)	0.68 (0.24, 1.92)	0.67 (0.24, 1.91)	0.68 (0.24, 1.90)
Type of toilet (ref: improved)				
Unimproved	2.75 (1.41, 5.36)	4.34(1.49, 12.65)	4.25 (1.46, 12.45)	4.21 (1.44, 12.29)
Drinking water source (ref: improved)				
Unimproved	1.4 (0.36, 1.52)	1.25 (0.42, 3.71)	1.29 (0.43, 3.86)	1.27 (0.43, 3.75)
Place of residence (ref: urban)				
Rural	1.47 (0.36, 1.52)	0.94 (0.33, 2.69)	0.89 (0.30, 2.64)	0.90 (0.30, 2.65)
Contextual Factors				
Education rate	0.86 (0.34, 2.17)		0.92 (0.15, 5.56)	0.92 (0.15, 5.58)
proportion of wealthy households	0.56 (0.25, 1.25)		0.76 (0.13, 4.38)	0.73 (0.13, 4.19)
β_0		0.02 (0.01, 0.14)	0.02 (0.01, 0.16)	0.02 (0.01, 0.16)
Contextual variance	1.07	0.74	0.725	0.617
PCV (%)		30.84	2.03	14.9
n	696	696	696	696

PCV:, **CI**: Confidence Interval - **Source**: Author's calculation 2010 DHS data **M0**: Gross effects unadjusted OR; **M1**: Effects of individual characteristics, **M2**: Net effects of all individual and neighborhood characteristics, **M3**: Net effects of individual, neighborhood characteristics controlling for interactions

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Table 3: Odds Ratios (ORs) Predicting Chronic Malnutrition in Children Aged 6-23 Months in Burkina Faso

Variables	6-23 months			
	M0	M1	M2	M3
	OR (95% CI)	OR (95% CI)	OR (95% CI)	OR (95% CI)
Individual Factors				
Education (ref: none)				
Primary	0.76 (0.55, 1.03)	0.90 (0.64, 1.27)	0.94 (0.63, 1.39)	1.11 (0.68, 1.81)
Secondary and above	0.33 (0.20, 0.55)	0.46 (0.26, 0.83)	0.47 (0.25, 0.90)	0.64 (0.31, 1.31)
Gender (ref: male)				
Female	0.69 (0.57, 0.84)	0.61 (0.50, 0.75)	0.62 (0.50, 0.76)	
Gender (ref: male and uneducated mother)				
Female and uneducated mother				0.67 (0.53, 0.84)
Female and mother educated up to primary school				0.44 (0.24, 0.82)
Female and mother educated up to secondary school				0.27 (0.08, 0.93)
Twinning (ref: singleton)				
Twin	3.03 (1.75, 5.26)	2.39 (1.32, 4.33)	2.39 (1.32, 4.32)	2.37 (1.31, 4.30)
Size at birth (ref: not small)				
small	1.54 (1.14, 2.07)	1.41 (1.02, 1.95)	1.41 (1.02, 1.95)	1.41 (1.02, 1.94)
Intergenic interval (ref: >= 24 months)				
<24 months	1.28 (0.89, 1.84)	1.15(0.79, 1.68)	1.15(0.79, 1.68)	1.15 (0.79, 1.69)
Age (months)	1.12 (1.09, 1.14)	1.12 (1.09, 1.15)	1.12 (1.09, 1.15)	1.12 (1.09,1.15)
Vaccinated with DTP3 (ref: no)				
Yes	1.06 (0.78, 1.43)	0.93 (0.68, 1.28)	0.93 (0.68, 1.28)	0.92 (0.67, 1.27)
Minimum meal diversification (ref: no)				
Yes	0.80 (0.59, 1.08)	0.64 (0.46, 0.89)	0.64 (0.46, 0.89)	0.64 (0.46, 0.88)
Minimum frequency (ref: no)				
Yes	1.10 (0.88, 1.34)	1.14 (0.91, 1.43)	1.14 (0.93, 1.42)	1.14 (0.91, 1.44)
Involvement in decision making (ref: none)				
Average	0.96 (0.78, 1.20)	1.06 (0.86, 1.32)	1.06 (0.84, 1.33)	1.05 (0.83, 1.32)
Strong	0.69 (0.42, 1.13)	0.92 (0.55, 1.55)	0.92 (0.55, 1.56)	0.90 (0.53, 1.53)
Tolerance of violence (ref: none)				
Average	1.35 (1.08, 1.69)	1.24 (0.98, 1.57)	1.24 (0.98, 1.57)	1.24 (0.98, 1.57)
Strong	1.58 (1.17, 2.14)	1.29 (0.94, 1.78)	1.29 (0.93, 1.78)	1.29 (0.94, 1.79)
Maternal nutritional status (ref: BMI <18.5)				
18.5 <=BMI<25	0.56 (0.42, 0.75)	0.65 (0.48, 0.88)	0.65 (0.49, 0.88)	0.65 (0.48, 0.87)
BMI >=25	0.41 (0.25, 0.65)	0.63 (0.38, 1.04)	0.63 (0.38, 1.05)	0.61 (0.37, 1.02)
Household standard of living (ref: poor)				
Medium	0.95 (0.76, 1.21)	1.04 (0.81, 1.37)	1.04 (0.80, 1.35)	1.05 (0.81, 1.36)
Rich	0.56 (0.43, 0.74)	1.08 (0.72, 1.61)	1.04 (0.64, 1.69)	1.05 (0.65, 1.70)
Number of children under five in the household (ref: 1-2 children)				
3-4 children	1.36 (1.07, 1.71)	1.26 (0.98, 1.61)	1.26 (0.98, 1.61)	1.26 (0.98, 1.62)
5 children and more	1.33 (0.86, 2.08)	1.07 (0.67, 1.72)	1.07 (0.67, 1.71)	1.06 (0.66, 1.71)
Type of toilet (ref: improved)				
Unimproved	1.86 (1.47, 2.34)	1.48 (1.06, 2.06)	1.49 (1.07, 2.08)	1.48 (1.06, 2.07)
Drinking water source (ref: improved)				
Unimproved	0.57 (0.43, 0.77)	0.88 (0.59, 1.33)	0.88 (0.57, 1.34)	0.86 (0.56, 1.31)
Place of residence (ref: urban)				
Rural	1.84 (1.39, 2.43)	1.14 (0.76, 1.70)	1.16 (0.74, 1.80)	1.16 (0.74, 1.80)
Contextual Factors				
Education rate	0.37 (0.24, 0.58)		0.88 (0.45, 1.73)	0.91 (0.46, 1.80)
proportion of wealthy households	0.46 (0.34, 0.64)		1.12 (0.57, 2.24)	1.13 (0.57, 2.23)
β_0		0.08 (0.04, 0.16)	0.07 (0.03, 0.16)	0.07 (0.03, 0.16)
Contextual variance	0.391	0.342	0.34	0.345
PCV (%)	-	12.53	0.58	-1.47
n	2039	2039	2039	2039

PCV:, **CI**: Confidence Interval - **Source**: Author's calculation 2010 DHS data **M0**: Gross effects unadjusted OR; **M1**: Effects of individual characteristics, **M2**: Net effects of all individual and neighborhood characteristics, **M3**: Net effects of individual, neighborhood characteristics controlling for interactions

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Table 4: Odds Ratios (ORs) Predicting Chronic Malnutrition in Children Aged 24-59 Months in Burkina Faso

Variables	24-59 months			
	M0	M1	M2	M3
	OR (95% CI)	OR (95% CI)	OR (95% CI)	OR (95% CI)
Individual Factors				
Education (ref: none)				
Primary	0.61 (0.48, 0.77)	0.78 (0.61, 0.99)	0.83 (0.64, 1.07)	0.77 (0.54, 1.07)
Secondary and above	0.22 (0.15, 0.34)	0.38 (0.24, 0.60)	0.41 (0.26, 0.65)	0.32 (0.17, 0.62)
Gender (ref: male)				
Female	0.82 (0.71, 0.94)	0.81 (0.70, 0.93)	0.81 (0.70, 0.93)	
Gender (ref: male and uneducated mother				
Female and uneducated mother				0.78 (0.67, 0.91)
Female and mother educated up to primary school				0.92 (0.59, 1.42)
Female and mother educated up to secondary school				1.25 (0.54, 2.90)
Twinning (ref:singleton)				
Twin	1.51 (0.99, 2.27)	1.44 (0.95, 2.20)	1.45 (0.96, 2.21)	1.46 (0.96, 2.23)
Size at birth (ref:not small)				-
small	1. 34 (1.08, 1.66)	1.28 (1.03, 1.60)	1.29 (1.04, 1.60)	1.29 (1.04, 1.61)
Intergenic interval (ref: >= 24 months)				
<24 months	1.02 (0.84, 1.25)	0.98 (0.80, 1.20)	0.98 (0.80, 1.20)	0.97 (0.79, 1.19)
Age (months)	0.98 (0.97, 0.99)	0.98 (0.97, 0.99)	0.98 (0.97, 0.99)	0.97 (0.96, 0.98)
Vaccinated with DTP3 (ref: no)				
Yes	0.88 (0.73, 1.06)	0.88 (0.73, 1.06)	0.88 (0.73, 1.06)	0.88 (0.73, 1.06)
Involvement in decision making (ref: none)				
Average	0.81 (0.70, 0.95)	0.90 (0.77, 1.05)	0.90 (0.77, 1.05)	0.90 (0.76, 1.05)
Strong	0.58 (0.42, 0.79)	0.79 (0.57, 1.09)	0.79 (0.57, 1.09)	0.80 (0.58, 1.11)
Tolerance of violence (ref: none)				
Average	0.99 (0.84, 1.16)	0.90 (0.76, 1.06)	0.90 (0.76, 1.06)	0.90 (0.76, 1.06)
Strong	1.41 (1.13, 1.77)	1.26 (0.99, 1.58)	1.25 (0.99, 1.57)	1.24 (0.99, 1.57)
Maternal nutritional status (ref: BMI <18.5)				
18.5 <=BMI<25	0.78 (0.63, 0.96)	0.84 (0.68, 1.05)	0.85 (0.69, 1.05)	0.84 (0.68, 1.05)
BMI >=25	0.34 (0.24, 0.47)	0.53 (0.38, 0.75)	0.54 (0.38, 0.76)	0.54 (0.38, 0.76)
Household standard of living (ref: poor)				
Medium	0.86 (0.73, 1.01)	0.87 (0.73, 1.04)	0.87 (0.73, 1.04)	0.88 (0.73, 1.04)
Rich	0.42 (0.34, 0.51)	0.64 (0.48, 0.86)	0.65 (0.48, 0.89)	0.65 (0.48, 0.89)
Number of children under five in the household (ref: 1-2 children)				
3-4 children	1.48 (1.27, 1.74)	1.32 (1.12, 1.56)	1.31 (1.12, 1.56)	1.32 (1.12, 1.56)
5 children and more	1.85 (1.37, 2.51)	1.60 (1.18, 2.17)	1.59 (1.17, 2.16)	1.60 (1.17, 2.17)
Type of toilet (ref: improved)				
Unimproved	1.80 (1.53, 2.13)	1.05 (0.84, 1.33)	1.05 (0.84, 1.33)	1.05 (0.83, 1.32)
Drinking water source (ref: improved)				
Unimproved	0.51 (0.42, 0.63)	1.02 (0.77, 1.35)	1.04 (0.78, 1.39)	1.05 (0.79, 1.42)
Place of residence (ref: urban)				
Rural	2.31 (1.87, 2.83)	1.27 (0.96, 1.69)	1.19 (0.86, 1.64)	1.20 (0.87, 1.65)
Contextual Factors				
Education rate	0.18 (0.12, 0.28)		0.70 (0.40, 1.24)	0.70 (0.39, 1.25)
proportion of wealthy households	0.33 (0.26, 0.43)		0.99 (0.62, 1.62)	0.98 (0.60, 1.59)
β_0		2.35 (1.38, 4.02)	2.57 (1.44, 4.59)	2.60 (1.46, 4.65)
Contextual variance	0.396	0.28	0.276	0.275
PCV (%)	-	29.29	1.43	0.36
n	3797	3797	3797	3797

PCV:, **CI**: Confidence Interval - **Source**: Author's calculation 2010 DHS data **M0**: Gross effects unadjusted OR; **M1**: Effects of individual characteristics, **M2**: Net effects of all individual and neighborhood characteristics, **M3**: Net effects of individual, neighborhood characteristics controlling for interactions

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Descriptive analysis of chronic malnutrition

The descriptive analysis of chronic malnutrition is presented in table 1. It shows that the prevalence of chronic malnutrition seems to increase with the age of the child. From 10.6% among children aged 0-5 months, it reaches 30.3% in children aged 6-23 months and 41.4% among those aged 24-59 months. Moreover, the prevalence of chronic malnutrition decreases significantly according to the mother's level of education among children aged 6-23 months and in those aged 24-59 months. Among children in these two age groups, the prevalence of chronic malnutrition among children of uneducated mothers is nearly three times higher than among children of mothers with secondary education and above. In addition, this significant variation in the extent of chronic malnutrition according to the mother's level of education is not observed among children aged 0-5 months. In general, the prevalence of chronic malnutrition between boys and girls is not significantly different among children in the 0-5 month age group and among those aged 24-59 months. In these children, the lack of difference in prevalence exists regardless of their mother's education level. However, for children aged 6-23 months, there is a significant difference in the prevalence of chronic malnutrition between girls and boys of non-educated mothers. For children in this subgroup whose mothers have completed primary or secondary education, the difference is not significant.

Explanatory analysis of chronic malnutrition in children

Explanatory analysis shows that for children aged 0-5 months, there is no significant effect of maternal education on the propensity to be chronically malnourished. However, for the 6-23 month and 24-59 month age subgroups, the propensity to be chronically malnourished is higher for children of uneducated mothers compared with children of mothers educated up to secondary school (M2 Model in Tables 2, 3, and 4).

The explanatory analysis also reveals significant effects of the child's gender on their propensity to suffer from chronic malnutrition. Indeed, among children aged 6-23 months and 24-59 months, boys are significantly more likely to suffer from chronic malnutrition (M2 Model in Tables 3 and 4). By contrast, this gender-based effect is not significant for children aged 0-5 months (M2 Model in Table 2).

Furthermore, the interaction analysis shows that the effect of the child's gender also differs according to the mother's level of education. Among children aged 6-23 months, we observe that the risk of boys (compared to girls) suffering from chronic malnutrition decreases with the mother's level of education. In children aged 24-59 months, the higher propensity of boys (compared to girls) to suffer from chronic malnutrition is exclusive to children of uneducated mothers (Model M3 in Tables 2, 3 and 4). This effect is not significant for children of mothers with primary or secondary education.

Finally, we note that the effect of maternal education is still significant for children aged 24-59 months after accounting for interaction effects with the child's gender. However, this interaction effect was not significant for children aged 6-23 months.

Discussion

We found that boys are more likely to be chronically malnourished than girls. Other studies carried out recently in West Africa have found similar results [12,13,19]. The same is true for the findings of a systematic review conducted at the international level, which also found inequalities concerning acute malnutrition [14]. For some authors, boys are constitutionally more fragile and are much more frequently ill than girls [11,15,16]. This greater frequency of illness episodes in boys ultimately leads to a greater stagnation in their stature growth. Moreover, this greater propensity of boys to suffer from chronic malnutrition is more significant in or exclusive to children of uneducated mothers, as there is no significant difference in the risk of suffering from chronic malnutrition between boys and girls of mothers with up to secondary school level. This implies that maternal education mitigates the inequalities in chronic malnutrition between girls and boys. This mitigation of the child gender-based effects through maternal education takes place through a reduction in children (and especially boys) vulnerability to disease. Indeed, educated mothers generally comply with good hygiene, sanitation, and preventive care practices, which contribute to reducing the incidence of disease among their children, both girls and boys. Thus, there is little or no increased risk of disease for boys (compared to girls) when their mothers are educated. It is this reduction or absence of gender-specific vulnerability to illness among children of educated mothers that underlies the absence of gender-related inequalities in terms of chronic malnutrition risk. This mitigating effect of mothers' education is more noticeable with mother having secondary school level onwards. This demonstrates the need to pursue policies that encourage the enrollment of girls beyond the primary level, which will contribute to a considerable reduction in the magnitude and gender-specific inequalities of chronic child malnutrition. It is wothnoting that the effects of child gender and mother's education vary following the age subgroups of 0-5 months, 6-23 months and 24-59 months. For children under 6 months of age, the effects of maternal education as well as child gender were not significant. For children aged 6-23 months, its effect remains, after controlling for possible confounding factors but disappears after controlling for the effects of interactions with the child's gender. Finally, the direct effect of maternal education persists for children aged 24-59 months even after controlling for interactions. This

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variation in effects with age is partly related to changes in the child's immunity and feeding practices during their first five years of life. These results also support the appropriateness of our approach of conducting analyses stratified by the above-mentioned subgroups. Future studies on child malnutrition should consider these specificities and conduct analyses separately to uncover determinants specific to each subgroup. The strength of this study is that it shows that maternal education can mitigate the effects of child's gender on his/her propensity to suffer from chronic malnutrition in the setting of Burkina Faso. Its main limitation was the cross-sectional nature of the study design, which limited causal inference. Residual confounding is also possible because covariates describing some potential risk factors for malnutrition, such as illness, were not taken into account due to the nature of the data.

Conclusion

This research showed that maternal education mitigates the gender effect on the child's propensity to suffer from chronic malnutrition in Burkina Faso. This unprecedented result in the Sahelian Africa region calls for the integration of this gender dimension in programs to combat malnutrition among vulnerable populations. In practical terms, it calls for the reinforcement of hygiene and sanitation measures for children of uneducated mothers, which would make it possible to reduce or even eliminate gender-related inequalities in chronic child malnutrition.

Abbreviations

DHS: Demographic and Health Survey; ANOVA: analysis of variance; OR: Odd Ratio; CI: Confidence Interval; PCV: Proportional Change in Variance; BMI: Body Mass Index.

Author's contributions

PMS conceived the study. JFK and ETN helped to design the study. PMS analysed data and worked on the manuscript. JFK, ETN, SD and YO critically reviewed, commented on and revised the drafts. PMS had primary responsibility for final content of manuscript. All authors read and approved the final manuscript.

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Availability of data and materials

Databases used for analyses are publicly available on the Macro International website (www.dhsprogramm.com). All data generated or analysed during this study are available from the corresponding author on reasonable request.

Ethics approval and consent to participate

Not applicable.

Consent for publication

Not applicable.

Competing interests

The authors declare that they have no competing interests.

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