HSI Health Sciences Investigations Journal

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ISSN Online 2704-4890 | ISSN Print 2720-7609

Online first publication

Original Research Article

HSI Journal (2021) Volume 2 (Issue 1): https://doi.org/10.46829/hsijournal.2021.6.2.1.166-172

Open Access

Multilevel analysis of risk factors associated with severe underweight among children under 5 years: evidence from the 2014 Ghana Demographic and Health Survey

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Received January 2021; Revised March 2021; Accepted April 2021

Abstract

Background: Undernutrition among children < 5 yr. is a global public health problem, especially in developing countries like Ghana. Undernutrition increases the risk of child morbidity and mortality. There is paucity of data on household-level effects on severe underweight and associated factors.

Objective: The study investigated the risk factors associated with severe underweight among children < 5 yr. in Ghana and examined unobserved differences across households based on the 2014 Ghana Demographic and Health surveys (GDHS) data.

Methods: Data from a population-based cross-sectional study was obtained from the 2014 Ghana Demographic and Health Survey. Data on 2720 children nested within 1972 households was extracted for analysis. Our regression analysis used data on 2716 children with complete data on the outcome and risk factors. Children with weight-for-age Z-score below -3 standard deviations were classified as severely underweight based on the 2006 WHO child growth standards. We applied random intercept multilevel logistic regression to examine whether severe underweight status in children differ across households while simultaneously identifying potential risk factors.

Results: A total of 2720 children had valid weight-for-age z-score and 53 (1.95%) of them were identified as severely underweight. In the univariate model, child level variables such as multiple birth [odds ratio (OR), 4.03; 95% confidence interval (CI): 1.85 - 8.76] and child born average (OR, 2.17; 95% CI: 1.09 - 4.32) or small (OR, 4.08; 95%C I: 2.01 - 8.28) in size at birth are associated with increased odds of severe underweight. Maternal/household level variables such as increase in number of children below 5 yr. (OR, 1.61; 95%CI: 1.28 - 2.04), poorest households (OR, 4.85; 95% CI: 1.14 - 20.59) and increase in number of births in last 5 yr. (OR, 1.80, 95% CI: 1.24 - 2.60) were associated with increased odds of severe underweight. Increase in maternal years of education (OR, 0.89; 95% CI: 0.83 - 0.95) was associated with reduced odds of severe underweight. In the multilevel logistic model, only type of birth (OR, 1.61; 95% CI: 1.28 - 2.04), size of child (average: OR, 2.12; 95% CI: 1.04 - 4.33; small: OR, 3.87; 95% CI: 1.80 - 8.33) at birth, and maternal education (OR, 0.92; 95% CI: 0.84 - 1.00) were independently associated with severe underweight. There were no significant residual household-level variations in severe underweight status.

Conclusion: Our findings suggest that improving maternal education, socioeconomic conditions of families, and family planning are critical in addressing severe underweight.

Keywords: Child malnutrition, severe underweight, risk factors, Ghana Demographic and Health Survey

INTRODUCTION

Child nutritional status is a strong indicator of overall child health and strongly linked with child survival [1]. Recent estimates indicate that about 50% of all global child deaths are as a result of malnutrition [2]. Malnutrition has also been linked with frequent infections and morbidity among children under 5 yr. [2]. Although child undernutrition remains a global problem, it is linked with weak economies or lower country Gross Domestic Product (GDP) [3,4]; thus, Africa and Asia have the highest burden. It is of global interest to improve health and survival of populations by ensuring adequate nutrition for all. This is evidenced by the promulgation of the second Sustainable development goal, "End hunger and improve nutrition for all by 2030" which seeks to eliminate malnutrition of all forms, including that among children under 5 yr. Several efforts have been made globally to facilitate the realisation of this ambitious goal including the Scaling Up Nutrition

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(SUN) movement, Baby Friendly Hospital Initiative (BFHI) as well as other tested interventions [5]. Evidence from the Ghana Demographic and Health Surveys (GDHS) generally show declining trends in under 5 yr. undernutrition in Ghana although regional variations still persist [6]. Underweight prevalence in Ghana reduced from 18% in 2003 to 11% in 2014. Current estimate of severe underweight among under 5 yr. in Ghana is 1.7% with the least prevalence (0.8%) among children under 6 mos and the highest prevalence (2.7%) among children 18 - 23 mos, based on the 2014 GDHS [6]. Our earlier study using the 2008 GDHS data showed older age of child, longer breastfeeding duration, multiple births, diarrhoeal history, small size at birth, maternal body mass index (BMI) and years of formal education as significant determinants of undernutrition in children under 5 yr. [7]. Similar risk factors of child undernutrition have been reported in the sub-Saharan African sub-region [8-12]. However, evidence on the determinants of severe undernutrition among children under 5 yr. based on nationally representative data is limited. Furthermore, the few studies available on severe undernutrition are dominated by stunting and wasting, with very little evidence on severe child underweight.

Although underweight prevalence in Ghana is generally lower than that reported for stunting; but higher than that estimated for wasting among children under 5 yr. [13], underweight is of primary interest in this study due to its ability to capture both chronic and acute influences of undernutrition. Ghana in response to the global goals of reducing childhood undernutrition has taken both nutrition-sensitive and nutrition-specific actions. Amongst these are growth monitoring and promotion, the Baby friendly hospital initiative, Vitamin A supplementation, universal salt iodisation, biofortification of foods, breastfeeding law, ensuring biodiversification in rural and undernutrition endemic areas, and Community management of severe acute malnutrition (CMAM) [14]. Generating evidence on the risk factors for severe underweight as well as evidence on the existence of differences across households will be invaluable in Ghana's efforts at preventing child undernutrition. Secondly, child growth monitoring in Ghana uses the anthropometric indicator of 'weight-for-age' and providing clear evidence on risk factors for severe underweight presents an excellent opportunity for immediate intervention at the primary care level as well as informing implementation of both the growth monitoring and promotion, and Ghana's Infant and young child feeding programme strategies. The study investigated the risk factors associated with severe underweight among children under 5 yr. in Ghana and examined unobserved differences across households based on the 2014 GDHS data.

MATERIALS AND METHODS

Study setting

This study is based on data from a population-based cross-sectional study obtained from the 2014 GDHS. The data is freely available online upon request at DHS MEASURE Program website [15]. Data on maternal and child health, their nutritional status through anthropometric measurements, awareness and use of family planning methods, childhood mortality were collected and detailed description of the 2014 GDHS methods is published elsewhere [6]. The inclusion of anthropometric measurements among children under 5 yr. provides a unique opportunity to conduct population-based studies aimed at monitoring the nutritional status of children and identification of risk factors associated with under-five malnutrition prevalence in several developing countries like Ghana. Data on 2720 children nested within households with plausible for weight-for-age z-scores (WAZ) (an indicator used to measure underweight status) was extracted for analysis.

Outcome variable

The outcome variable of interest in this study is severe underweight measured by WAZ. Generally, weight-for-age, height-for-age and weight-for-height are the 3 main indicators used for assessing nutritional status of children in stable situations [16]. Among the 3 indicators, weight-for-age is considered to provide a good overall index of understanding the nutritional outcome of children under 5 yr. and also serve as a composite index of height-for-age and weight-for-height [6,17,18]. Thus, weight-for-age serves as an overall indicator of population's health. This study therefore used only weight-for-age to assess severe underweight among children under 5 yr. A child is identified as severely underweight if his or her WAZ is below -3 standard deviations (SD) from the median of the reference population based on the 2006 WHO child growth standards [17].

Risk factors

Potential risk factors considered in this study are those established in the literature as significant predictors of nutritional status among children under 5 years, especially in developing countries [7,19-22]. Among others, the variables explored in this study include child age and sex, place of birth, breastfeeding, type of birth (singleton or multiple birth), size of child at birth (as perceived by the mother and not based on the actual birthweight), maternal education, total children ever born, number of children under-five in households, household wealth status, number of births in last 5 yr., maternal age, place of residence, type of toilet facility in household and maternal national health insurance status.

Statistical analysis

Regression analyses were performed on 2716 children nested within 1972 households with complete weight and age measurements as well as complete measurements on risk factors considered in the final models. Standard logistic and multilevel logistic regression analysis were applied to analyze risk factors for severe underweight among children under 5 yr. The extension of the standard logistic model to the multilevel logistic regression model is crucial due to the hierarchical structure of the GDHS dataset where we have children clustered within households. Specifically, we

applied random intercept multilevel logistic regression model to examine whether severe underweight status in children differ across households while simultaneously identifying potential risk factors. Thus, the multilevel modelling approach [23] in this study places particular emphasis on household level differences in the odds of severe underweight status among children and the extent of clustering of severe underweight status within a household which cannot be achieved through the standard logistic regression analysis. The household-level Variance Partition Coefficient (VPC) [24] which measures the amount of variation in severe underweight status among children from the random intercept multilevel logistic regression model is given by "VPC = household-level variance / (household-level variance + child-level variance)". Using the random intercept multilevel logistic regression, this quantity also coincides with the Intra-household Correlation Coefficient which measures similarity in severe underweight status among children belonging to the same household. The child-level residual was assumed to follow a standard logistic distribution with mean zero and variance $\pi^{2/3}$, where $\pi = 3.14$ [25].

We performed univariate logistic regression on the set of potential risk factors for child nutritional status where factors with $p < 0.10$ were retained and considered candidate set for inclusion in the multiple logistic regression models. Our final models adjusted for type of birth, size of child at birth, maternal education, number of children under 5 yr. in households, household wealth status, total children ever born and number of births in last 5 yr. We used maximum likelihood estimation approach to obtain parameters in our models and among competing covariance structures, identity structure provided a good fit to the data in the random intercept multilevel logistic model. All the analyses in the study were performed using STATA Statistical Software (Version 14, StataCorp LLC, College Station, TX) [26]. A $p < 0.05$ was used to declare statistical significance.

RESULTS

A total of 2720 children had valid WAZ and 53 (1.95%) of them were identified as severely underweight (WAZ < -3 SD). However, regression analysis were done on 2716 due to missing data on size of child at birth, an important risk factor for child nutritional status to consider in our model [7,20].

Risk factors for severe underweight

The univariate logistic results showed that multiple birth [odds ratio (OR), 4.03; 95% confidence interval (CI): 1.85 - 8.76] compared to singleton; child born average (OR, 2.17; 95% CI: 1.09 - 4.32) or small (OR, 4.08; 95% CI: 2.01 - 8.28) in size compared to those born large; number of children below 5 yr. (OR, 1.61, 95% CI: 1.28 - 2.04); poorest households (OR, 4.85; 95% CI: 1.14 - 20.59) compared to those from very rich households; and number of births in last 5 yr. (OR, 1.80; 95% CI: 1.24 - 2.60) are associated with increased odds of severe underweight. Maternal years of education (OR, 0.89; 95% CI: 0.83 - 0.95) decreases the odds of severe underweight. Risk factors independently associated with severe underweight in the multiple logistic regression are multiple births (OR, 2.73; 95% CI: 1.13 - 6.59), size of child (average: OR, 2.10; 95% CI: 1.05 - 4.21; small: OR, 3.81; 95% CI: 1.86 - 7.80) at birth, maternal years of education (OR, 0.92; 95% CI: 0.84 - 1.00) and number of children below 5 yr. (OR, 1.37; 95% CI: 1.00 - 1.87). In the multilevel logistic model, only type of birth, size of child at birth and maternal years of education are independently associated with severe underweight. The odds of severe underweight increases among children born multiple (OR, 2.76; 95% CI: 1.10 - 6.96) compared to those born singleton; and child born average (OR, 2.12; 95% CI: 1.04 - 4.33) or small (OR, 3.87, 95% CI: 1.80 - 8.33) in size compared to those born large; while increase in maternal years of education (OR, 0.92; 95% CI: 0.84 - 1.00) is protective of severe underweight (Table 1).

Residual household level variation analysis

From the random intercept multilevel logistic regression model presented in Table 1, the VPC is given as "VPC = 0.18 / (0.18+3.29) = 0.0519." Thus, 5.19% of variation in severe underweight among children could be attributable to residual household-level differences. This also means that the correlation of severe underweight among children from the same household is about 0.05. We performed a statistical test to establish whether the household-level variance of 0.18 (Table 1) represent a large household effect on the outcome using likelihood ratio test. A p of 0.23 associated with the test suggests that this effect is not statistically significant. Thus, severe underweight among children does not differ significantly across households in Ghana after adjusting for type of birth, size of child at birth, maternal education, number of children under-five in households, household wealth status, total children ever born and number of births in the last 5 yr.

DISCUSSION

This study sought to investigate household differences in severe underweight prevalence as well as the risk factors for severe underweight among children under-five years in Ghana. Prevalence of severe underweight was 1.95% and showed no significant differences across households after adjusting for child, maternal and household level factors. Our study found both child and maternal factors to be associated with severe underweight. Significant child factors were multiple birth and small or medium size of child at birth; significant maternal factors being years of formal education and number of children below 5 yr. old. Our findings confirm results of an earlier study that used national level data from 2008 survey in Ghana [7] and evidence from Nigeria [27]. Although children under 5 yr. undernutrition has been generally associated with male sex, rural residence, child age, breastfeeding status, birth interval and duration of breastfeeding [7,27,28], our data only supported significant associations with type of birth,

Table 1. Regression analysis of risk factors associated with severe underweight status among children under 5 years (n=2716).

Characteristics	Univariate logistic model UOR (95% CI)	multiple logistic model AOR (95% CI)	Multilevel logistic model AOR (95% CI)
Type of birth			
Single birth	ref	ref	ref
Multiple birth	4.03*** (1.85, 8.76)	2.73* (1.13, 6.59)	2.76* (1.10, 6.96)
Size of child			
Large	ref	ref	ref
Average	2.17* (1.09, 4.32)	2.10* (1.05, 4.21)	2.12* (1.04, 4.33)
Small	4.08*** (2.01, 8.28)	3.81*** (1.86, 7.80)	3.87** (1.80, 8.33)
Education in years	0.89** (0.83, 0.95)	0.92* (0.84, 1.00)	0.92* (0.84, 1.00)
Number of children <5 years	1.61*** (1.28, 2.04)	1.37* (1.00, 1.87)	1.38 (0.99, 1.91)
Wealth index			
Very rich	ref	ref	ref
Rich	2.94 (0.61, 14.27)	2.09 (0.41, 10.57)	2.11 (0.41, 10.74)
Average	1.97 (0.39, 9.81)	1.34 (0.26, 7.03)	1.34 (0.25, 7.07)
Poor	3.56 (0.79, 16.00)	2.05 (0.42, 9.95)	2.06 (0.42, 10.17)
Poorest	4.85* (1.14, 20.59)	1.94 (0.39, 9.61)	1.96 (0.39, 9.77)
Total children ever born	1.11 (0.99, 1.25)	0.96 (0.83, 1.10)	0.96 (0.83, 1.11)
Number of births in last 5 years	1.80** (1.24, 2.60)	1.18 (0.72, 1.94)	1.18 (0.71, 1.96)
Household-level variance	-	-	0.18(1.33[a])
Child-level variance	-	-	$\pi^2/3 \approx 3.29$

UOR, unadjusted odds ratio; AOR, adjusted odds ratio; CI, confidence interval; Ref: reference category: ***, $p < 0.001$; **, $p < 0.01$; *, $p < 0.05$; [a] standard error associated with household-level variance.

child size at birth, and maternal education level, after taking into account possible household level differences. This may be due to some successes of child growth monitoring and promotion in the country, which likely addresses predisposing factors that result in group differences. The lack of association between severe underweight and sex in this study has also been reported in India [29].

Chattergee and colleagues [29] concluded that poverty was the single most important predictor of child underweight in India after they assessed socioeconomic determinants of inequities in child undernutrition. Also, a review of maternal and child interventions in Ghana by Zere et al. [30] observed inequities in stunting and underweight prevalence spelling a disadvantage to the poorest in Ghana. Evidence from the northern region of Ghana showed that caregiver occupation strongly predicted poor nutritional status among children under 5 yr. with higher risk of undernutrition among children of farming parents compared to traders [31]. Furthermore, previous work by authors of this current work [19] showed spatial differences in risk of chronic malnutrition in Ghana which could also be explained by socioeconomic differences across different parts of the country. It is possible that efforts at improving child nutrition through growth monitoring and Infant and young child feeding programmes are likely able to use nutrition counselling to successfully attenuate modifiable aspects of risks of undernutrition imposed by poverty but less successful when abject poverty is indicated. The positive effects of maternal education on child health and nutrition outcomes have well been documented in low- and middle-income countries [32].

Our findings, showing less odds of severe underweight among children under 5 yr. with higher educated mothers is consistent with Ghanaian studies [7]. The influence exerted by maternal education could be through an increased capacity to access and utilize available nutrition information, increased capacity to earn income or have access to resources as well as generally improved socioeconomic status. Our study found that small size at birth of child was associated with severe underweight, ant this finding is consistent with earlier studies [7,11,27]. Small size of child at birth (a proxy for low birth weight) as perceived by the mother could partly reflect sub-optimal intrauterine nutrition during pregnancy [2]. It is estimated that about 15% of infants born globally have low birth weight [33]. The 2014 estimate of low birth weight for Ghana is 9.8%, a slight reduction from 10% in 2008 [13].

Undernourishment in the womb often leads to a diminished potential for growth, reduced cognitive abilities, reduced muscle strength, increased risk for non-communicable diseases, increased morbidity, and severity of infections as well as high mortality [34]. It is therefore necessary that efforts towards improving preconception nutrition be intensified. Improvement in maternal nutritional status before pregnancy will improve birth outcomes. Although our study did not examine the relationship between maternal BMI and severe underweight, low maternal BMI has been reported to be significantly associated with both low birth weight and severe child underweight (10).

Our finding of a significant association between type of birth and severe underweight, with children of multiple birth having higher odds of severe underweight is consistent with literature [35,36]. Multiple birth is linked with undernutrition via resultant low birth weight, preterm birth, or medical complications which likely occur with multiple births and can also interfere with breastfeeding. Other predisposing factors to undernutrition include special challenges of mothers to initiate and sustain breastfeeding and inadequate support for mothers in areas of organization, feeding, individualization and stress management [2]. The child growth monitoring booklet used in Ghana already indicates multiple birth as a risk factor for sub-optimal growth and thus given more attention during routine nutrition counselling that is offered as part of growth monitoring and promotion. However, evidence from a retrospective cohort study of child welfare clinic attendance in urban Ghana showed that only 13.6% of infants achieved the recommended nine or more visits in a 12 mos period of investigation [37]. Furthermore, the report said that attendance reduced from the first month of the year (75%) to a low of 16%. Poor patronage of child growth monitoring and promotion programmes interrupts this readily available nutrition counselling offered as part of the programme; limiting the effectiveness of interventions targeted at the first 1,000 days window of opportunity within which improvements may be made in child nutrition.

Our study also found severe underweight to be higher in households that had more children under 5 yr. The link between larger household size and specifically households with a higher proportion of children has been well documented [28,38]. Food insecurity and inadequate care are the main vehicles through which undernutrition occurs among households with increasing number of children under 5. Inadequate care for children can directly lead to child undernutrition; and care is known to get poor with increasing number of children in the household. Family planning utilization has been linked with reduced odds of child undernutrition [28,39,40] and has been a major intervention promoted to address a wide array of issues pertaining to maternal and child survival. As part of Ghana's community-based management of severe acute malnutrition, severely malnourished children are routinely linked up to nutritional support services. However, there is need to also link up parents of severely malnourished children under 5 yr. to other available services like family planning and livelihood support services to help address risks due to extreme poverty and high-risk fertility. While our data generally confirmed increased odds of severe underweight in households with increased number of children under 5 yr. in multiple logistic regression analysis, this association was lost after taking household differences into account during multilevel analysis. Our finding of the loss of statistical association between severe undernutrition and number of children under 5 yr. during multilevel analysis in the light of existing evidence, suggests that issues with family planning may be entrenched in some households and definite targeting of households with family planning programmes will be key in addressing issues of severe undernutrition among children under 5 yr. in Ghana.

Conclusion

Results of this study clearly show that both child and maternal factors are associated with severe underweight among children under 5 yr. in Ghana. While nutrition specific interventions like the CMAM are helpful in addressing undernutrition among children, there is a need to intensify existing nutrition sensitive interventions targeted at improving household food security, maternal education, and family planning among women to prevent or reduce the burden of severe undernutrition. Further research in the form of multinomial ordered logistic regression model is required to investigate how the predictors of underweight categories of severe underweight, underweight and normal weight compare.

DECLARATIONS

Ethical considerations

The study used an anonymized publicly available secondary data set with permission from the MEASURE DHS programme. No ethical approval was required for analysis.

Consent to publish

Both authors agreed to the content of the final paper.

Funding

None

Competing Interests

No potential conflict of interest was reported by the authors.

Author contributions

JMKA conceived and designed the study, extracted the data and prepared it for analysis. JMKA analyzed and interpreted the data. JMKA and DOA drafted the manuscript. JMKA and DOA critically reviewed and revised the manuscript. Both authors approved the final version of the manuscript.

Acknowledgements

The authors acknowledge the MEASURE DHS for granting access and permission to use the dataset for this study.

Availability of data

Data supporting the conclusions of this article are freely available at URL: https://dhsprogram.com/data/available-datasets.cfm upon sending a request to the DHS Program.

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