USAID
FROM THE AMERICAN PEOPLE

DHS WORKING PAPERS

Reducing Child Malnutrition through Mother's Birth Spacing: Evidence from Ghana

Gloria Essilfie
Raymond Elikplim Kofinti
Emmanuel Ekow Asmah

2023 No. 193

DEMOGRAPHIC AND HEALTH SURVEYS

Auguts 2023

This document was produced for review by the United States Agency for International Development.

DHS Working Papers No. 193

Reducing Child Malnutrition through Mother's Birth Spacing: Evidence from Ghana

Gloria Essilfie[1]
Raymond Elikplim Kofinti[1]
Emmanuel Ekow Asmah[1]

ICF
Rockville, Maryland, USA

August 2023

[1] School of Economics, University of Cape Coast, Cape Coast, Ghana

Corresponding author: Gloria Essilfie, Department of Applied Economics, School of Economics, University of Cape Coast, Cape Coast, Ghana; phone: +233246605496; email: gloria.essilfie@ucc.edu.gh

Acknowledgments: The authors wish to express their profound gratitude to the United States Agency for International Development (USAID) for providing the necessary financial assistance for this research work through the Demographic and Health Survey Program implemented by ICF. We extend this appreciation to our facilitators, Drs. Shireen Assaf, Sara Riese, and Emma Shuvai Chikovore, for their immense contributions during the conceptualization and development of the research paper. Our gratitude also goes to the reviewers, Drs. Rukundo Benedict and Shireen Assaf, our editors, and formatters. We also thank the School of Economics, University of Cape Coast, and the entire university community for their support.

Editor: Diane Stoy
Document Production: Joan Wardell

This study was conducted with support from the United States Agency for International Development (USAID) through The DHS Program (#720-OAA-18C-00083). The views expressed are those of the authors and do not necessarily reflect the views of USAID or the United States Government.

The DHS Program assists countries worldwide in the collection and use of data to monitor and evaluate population, health, and nutrition programs. For additional information about The DHS Program, contact: DHS Program, ICF, 530 Gaither Road, Suite 500, Rockville, MD 20850, USA; phone: +01 301-572-0950; fax: +01 301-407-6501; email: reports@dhsprogram.com; internet: www.dhsprogram.com.

Recommended citation:

Essilfie, Gloria, Raymond Elikplim Kofinti, and Emmanuel Ekow Asmah. 2023. *Reducing Child Malnutrition through Mother's Birth Spacing: Evidence from Ghana.* DHS Working Papers No. 193. Rockville, Maryland, USA: ICF.

CONTENTS

TABLES AND FIGURE

ABSTRACT

Although research has focused on the impact of birth spacing on maternal health, inadequate maternal repletion due to shorter birth intervals could also affect the health of the child. However, limited studies exist on the linkage between birth spacing and child nutrition. This study examines the association between birth spacing and child stunting and underweight using the 2014 Ghana Demographic and Health Survey. The study employed descriptive statistics and logistic regressions to establish the association between birth spacing and child stunting and underweight. The analyses reveal that childbirth spacing between 24 to 35 months (*OR* = 0.6, 95% CI [0.4, 1.0]; $p < .1$), 36 to 47 months (*OR* = 0.4, 95% CI [0.3, 0.7]; $p < .01$), and beyond 47 months (*OR* = 0.5, 95% CI [0.3, 0.9]; $p < .05$) have lower odds of child stunting than children with birth spacing less than 24 months. Children with birth spacing between 24 to 35 months (*OR* = 0.5, 95% CI [0.3, 1.0]; $p < .05$), 36 to 47 months (*OR* = 0.4, 95% CI [0.2, 0.9]; $p < .05$) and beyond 47 months (*OR* =0.5, 95% CI [0.3, 0.9]; $p < .05$) have lower odds of being underweight than those with birth spacing less than 24 months. The findings reveal a negative association between shorter birth spacing and child stunting and underweight, which suggests that shorter birth spacing is associated with higher odds of child malnutrition. The study recommends that Ghana Health Service and other healthcare providers should educate mothers on the gains of birth spacing of at least 2 years for their children.

Key words: birth spacing, stunting, under 5, underweight, Ghana

1 INTRODUCTION

Despite the concerted efforts of world leaders to reduce child malnutrition, about 22% (149.2 million) of children under the age of 5 were stunted in 2020.[1] The prevalence of stunting and underweight among children under 5 varies across continents and regions and is of great concern in Africa. For example, about 90% of all stunted children worldwide are found in Africa and Asia.[1–4] Stunting affected 30.7% of under-five children in Africa, while sub-Saharan Africa reported an incidence of 24.1%.[5] This means that sub-Saharan Africa has the highest incidence of malnutrition on the continent of Africa. Sub-Saharan Africa is the home of one-quarter of children affected by wasting in 2020, with comparable numbers for children affected by severe wasting.[6,7] Malnutrition contributes to an increase in healthcare costs, a decrease in work efficiency, and a slowdown in economic development, which accelerates the cycle of poverty and disease.

Although Ghana has impressive achievements in reducing the burden of malnutrition among children under 5, child stunting and underweight remain a significant concern. For example, 19% and 11% of children under 5 were stunted and underweight according to the 2014 Ghana Demographic and Household Survey (GDHS). National statistics reveal that stunting peaks in children between 24 to 35 months of age (28.2%).[8,9] Stunting, or being excessively short for one's age, is a sign of the effects of nutritional and non-nutritional variables that impede children's cognitive and physical growth, and also raise their risk of dying from common infections. Unlike stunting, underweight accounts for acute as well as chronic malnutrition and reflects children who are stunted, wasted, or both.[1,4,5,10–12]

To accelerate progress toward the 2030 target of eradicating malnutrition and hunger, undernutrition reduction initiatives and all efforts aimed at improving the nutritional status of children under 5 must be enhanced. The World Health Organization (WHO) is creating a strategic plan that directs governments and development partners to combat all types of malnutrition through enhanced service delivery, strengthened regulations, and better data utilization. Such an effort can succeed only through coordinated and complementary efforts.[1] One complementary effort identified in the literature as a way to influence child malnutrition is birth spacing. The interval between births is a domestic decision that affects not only the health of the mother but also that of the child.[13–14] Waiting at least 2 to 3 years between pregnancies is advised by the WHO to lower newborn and child mortality and enhance maternal health.

There are several reasons why a gap between births is necessary. The likelihood of many adverse health consequences, notably poor health, and mortality for mothers and children has been linked to having children too close together.[13–14] Intrauterine growth retardation, preterm birth, low birthweight, and anemia are less common in women with longer birth intervals.[15] While a plethora of research has focused on the impact of a mother's characteristics—such as education, income, age, and other household characteristics on improving child health—less attention has focused on the impact of birth spacing on the nutritional status of children under age 5 in Ghana. Prior research conducted in sub-Saharan Africa and low- and middle-income countries (LMICs) has suggested that the period between one birth and the next, or the preceding birth interval, is related to the health outcomes of the child.[16–18]

The extant literature revealed that a preceding birth spacing of at least 36 months was related to a 10% to 50% reduction in stunting, whereas birth intervals of fewer than 12 months and 12–23 months were linked with greater stunting risk than a birth interval between 24–35 months.[19–20] A 2009 study by Gribble, Murray, and Menotti revealed that birth intervals of less than 24 months and 24–35 months significantly raise the risk of stunting compared to intervals of 36 to 59 months.[21] A short duration between pregnancies can be dangerous if the mother's nutrient stores run low, which can raise the risk of intrauterine growth retardation and negatively affect the infant's nutrient reserves and availability.[22–23]

In this study, we address the following research objectives: (1) to investigate the association between birth spacing and child stunting, and (2) to examine the association between birth spacing and child underweight. Investigating birth spacing and child malnutrition in children under 5 in Ghana is a major step toward determining resource investments in policy interventions that can improve maternal and child health outcomes. This will also help to inform the Ministry of Health and Maternal Health Service providers to implement specific birth spacing recommendations and policies that improve the health status of children. The insights from this study may contribute to the realization of SDG target 2.2, which focus on ending all forms of malnutrition, and includes achieving, by 2025, internationally agreed targets for stunting in children under 5 years.

1.1 Research Question

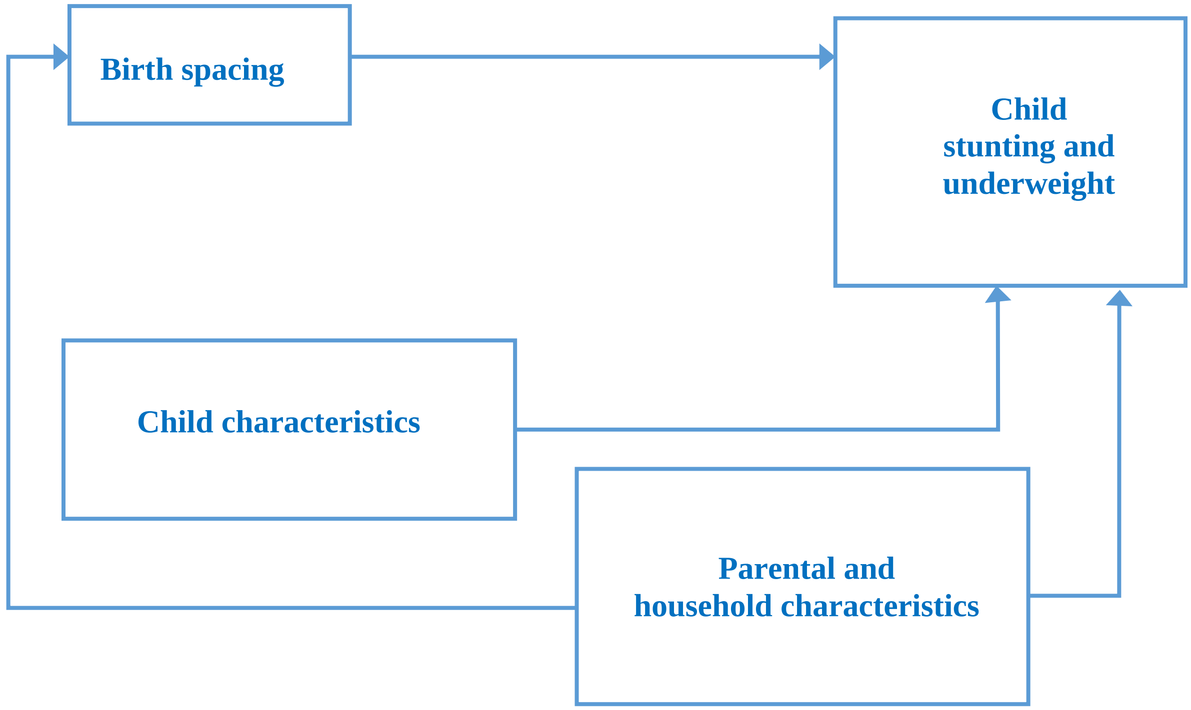
The study seeks to address the following research questions:

- Is there an association between birth spacing and stunting among children under 5?
- Is there an association between birth spacing and underweight among children under 5?

1.2 Conceptual Framework

A systematic review identified several outcome measures for parental, child, and household characteristics that influence child malnutrition. Figure 1 highlights the interconnected system of variables that influences a child's nutritional status (stunting and underweight). The first association is the link between birth spacing (preceding birth interval) and child stunting and underweight. The literature found a negative relationship between shorter birth intervals and child nutrition. This is based on the observation that a longer repletion period is beneficial for both the mother and the child.[19,23–24] As shown in the conceptual framework, we anticipate a negative association between birth spacing, child stunting, and underweight. The conceptual framework also underscores the importance of parental characteristics such as maternal attributes (education, age, employment status, BMI, contraceptive use, and marital status); a partner's characteristics (level of education); household characteristics (household size, place of residence, wealth quintile, and region); and child's characteristics (sex, age, birth order, perceived size of child at birth) in affecting child stunting and underweight. All variables in the conceptual framework are based on existing literature and data availability.[19] Hence, data analysis and interpretation of findings have been guided by the conceptual framework.

Figure 1 Conceptual framework of the study



2 DATA AND METHODS

2.1 Data

This study utilizes the most current Ghana Demographic and Health Survey (GDHS), undertaken in 2014. The GDHS is a nationally representative cross-sectional sample survey. Over the years, six rounds of GDHS have been undertaken in Ghana—in 1988, 1993, 1998, 2003, 2008, and 2014. The 2014 GDHS was based on a two-staged stratified sample frame with systematic sampling and probability proportional to size in identifying enumeration areas from which households were selected from the 2010 Population and Housing Census. The GDHS provides data on key population and health issues that include fertility, family planning, infant and child mortality, maternal health, nutrition of children and women, and malaria. The sample for the study focuses on children under 5 with anthropometric information on height for age (HAZ) *z* scores and weight-for-age (WAZ) *z* scores, whose mothers are between the ages 20 to 49. The sample size of the under 5s with HAZ and WAZ outcomes was further constrained with those with information on birth spacing. Thus, our analyses focused on second births and beyond. After the regression analysis, the final weighted analytical sample was 1,904 children age less than 59 months.

2.2 Variables

2.2.1 Dependent variables

Two outcome variables are used for the study—child stunting and underweight. Child stunting is defined as children with a HAZ score less than −2 SD, while underweight children are those with less than −2 WAZ scores. The two outcome variables are dichotomous and are standard measures of child nutritional status as proposed by the WHO in 2006.[25]

2.2.2 Independent variables

As shown in our conceptual framework, there are a number of independent variables that influence child nutrition. These variables are grouped into three broad categories: child, parental, and household characteristics. The child characteristics include birth spacing, the primary variable, which is categorized into four: <24 months, 24–35 months, 36–47 months, and above 47 months. This categorization follows the convention in the 2014 GDHS report. In addition to birth spacing, four additional variables—age, sex, birth order, and perceived size at birth—are used to control for other child-level correlates of child nutrition. The parental characteristics include five variables, which includes the mother's BMI status, age, employment status, contraceptive usage, and the partner's educational level. Household characteristics included four main household-level variables: wealth index, place of residence, region of residence, and family size. The independent variables are recoded into binary or categorical variables. The names and measurements of the variables are provided in the Appendix in Table A1.

2.3 Statistical Analysis

The study employed two main analytical procedures—descriptive and inferential analyses. The descriptive statistics describe the distribution of the dependent and independent variables as well as bivariate analyses of the dependent variable across all the independent variables. The inferential analysis involved establishing the association between birth spacing and the two dependent variables: child stunting and underweight. Given the dichotomous nature of the two dependent variables, the study employed binary logistic models using adjusted and unadjusted models. The unadjusted and adjusted odds ratios are presented using 95% confidence intervals (CI) and the associated p values to denote statistical significance. Hence, the estimates were considered statistically significant at $p < .05$. Additional analysis ensured the internal consistency of the logistic models, such as checking the correlation coefficients among the independent variables and applying the appropriate survey weight, which accounted for the multi-stage sampling and stratification design of the DHS Program Data.

3 RESULTS

3.1 Distribution of Children Under 5 by Child, Mother, and Household Characteristics

As a prelude to the logistic regression analysis, summary background statistics on the distribution of the under-5 children, their mothers, and household are presented in Table 1. For the child-level variables and their nutritional status, we observe that roughly one-in-five under-5 children (19%) were stunted in Ghana, while about one-in-ten children (11%) were reported to be underweight. The main explanatory variable in this study is the birth interval between two successive births. Table 1 shows that approximately 12% of the under 5s were born following short birth intervals of less than 24 months, 29% between 24 and 35 months, and 20% after 36 to 47 months. Birth intervals greater than 47 months were observed among 38% of the sampled population.

Table 1 Percent distribution of children under 5 by child, mother, and household characteristics

Variables	Percent	Number
Child characteristics		
Stunting		
No	81.5	1,552
Yes	18.5	351
Underweight		
No	89.5	1,705
Yes	10.5	199
Preceding interval		
<24	12.0	229
24–35	29.1	554
36–47	20.9	397
>47	38.0	724
Age in months		
<6	11.3	215
6–11	10.3	197
12–23	22.1	421
24–35	19.7	374
36–47	19.6	374
48–59	17.0	323
Sex of child		
Female	47.0	895
Male	53.0	1,009
Birth order		
2nd child	47.8	910
3rd child	42.1	802
4th and above	10.1	192
Size at birth		
Very small	3.9	74
Small	9.5	181
Average or larger	86.6	1,649
Parental characteristics		
Mother's BMI categories		
Thin	4.2	80
Normal	54.3	1,035
Overweight	25.6	488
Obese	15.8	301
Mother's educational level		
No education	34.4	654
Primary	20.0	382
Secondary or higher	45.6	868

Continued...

Table 1—*Continued*

Variables	Percent	Number
Mother's age groups		
20–29	32.1	611
30–39	54.0	1,027
40–49	13.9	265
Mother is currently working		
No	17.6	334
Yes	82.4	1,570
Mother is currently in a union		
No	5.6	106
Yes	94.4	1,797
Contraceptive usage		
None	72.7	1,384
Traditional	3.4	65
Modern	23.9	454
Partner's educational level		
None	27.0	514
Primary	10.4	197
Secondary	54.2	1,032
Higher	8.4	160
Household characteristics		
Wealth Index		
Lowest	25.4	484
Second	22.9	436
Middle	18.5	352
Fourth	17.1	326
Highest	16.0	305
Place of residence		
Urban	42.3	806
Rural	57.7	1,098
Region of residence		
Western	9.9	188
Central	11.8	225
Greater Accra	13.2	251
Volta	8.0	153
Eastern	9.1	172
Ashanti	16.8	320
Brong Ahafo	9.5	181
Northern	14.8	282
Upper East	4.3	81
Upper West	2.7	52
Family size		
1–2	1.7	33
3–4	25.7	489
5–6	41.1	782
7 or more	31.5	600
Total	**100.0**	**1,904**

Table 1 shows the distribution of children according to their age and sex. In the analytical sample, most children were in the 12–23 age group (22.1%), were second birth order (47.8%), and were perceived by their mothers as average or larger at birth (86.6%). The mothers of the children were classified as having normal BMI (54.3%), had some form of secondary or higher education (45.6%), were between age 30 to 39 (54%), resided in rural areas (57.7%), and had some form of formal employment (83.1%). A greater percentage of the mothers were married (94.4%), had partners with secondary education (54.2%), and were not using any form of contraceptives (72.7%). The data also revealed an average family size between 5 and 6 (41.1%).

3.2 Bivariate Analysis of Independent Variables by Child Malnutrition

Table 2 shows the association between stunting and underweight of children under 5 by background characteristics of the children, mother, and household in Ghana based on the Pearson chi-squared test. For the child variables in the model, we observe that the child's age and perceived size of child at birth were significantly associated with both child stunting and underweight. Stunting and being underweight increased with child's age and then decreased after 35 months. Preceding birth interval and birth order were significantly associated with stunting, but not with underweight. Stunting decreased with increasing preceding birth interval and increased with increasing birth order. With parental characteristics, mother's BMI and educational level of the mother were significantly associated with both child stunting and underweight. For example, children of mothers with no education had a higher incidence of stunting (25.7%) and underweight (13.7%). While marital status and partner's educational level were only significant for child stunting, contraceptive usage and mother's employment were only significant for child underweight. With household characteristics, place of residence, region of residence, and family size were significantly associated with child stunting and underweight, while the wealth index was significant for only stunting and showed a pattern of a decreasing level of stunting with increasing wealth quintile.

Table 2 Association between malnutrition of children under 5 by child, maternal, and household characteristics

	Stunting			Underweight		
Variables	**%**	**CI**	***p* value**	**%**	**CI**	***p* value**
Child characteristics						
Preceding interval			.001			.066
<24	28.7	[21.1, 37.7]		16.6	[10.1, 26.2]	
24–35	20.8	[17.0, 25.2]		11.2	[8.2, 15.1]	
36–47	16.7	[12.9, 21.3]		9	[6.3, 12.5]	
>47	14.4	[11.5, 17.8]		8.8	[6.7, 11.4]	
Age in months			.001			.016
<6	6.4	[2.7, 14.3]		3.2	[1.7, 6.1]	
6–11	8.3	[5.0, 13.4]		10.6	[6.8, 16.2]	
12–23	18.3	[14.4, 23.1]		13.5	[10.4, 17.4]	
24–35	28.1	[22.7, 34.2]		12.5	[8.0, 19.0]	
36–47	23.5	[17.9, 30.2]		11.4	[7.8, 16.3]	
48–59	15.8	[11.8, 20.9]		7.8	[5.2, 11.6]	
Sex of child			.050			.823
Female	16.4	[14.0, 19.2]		10.6	[8.4, 13.4]	
Male	20.2	[17.4, 23.4]		10.3	[8.3, 12.7]	
Birth order			0.001			.271
2nd child	15.1	[12.1, 18.6]		9.5	[7.1, 12.5]	
3rd child	20.9	[17.7, 24.4]		10.9	[8.8, 13.3]	
4th and above	24.2	[18.3, 31.4]		13.6	[9.2, 19.5]	
Size at birth			.001			.001
Very small	38.0	[27.2, 50.3]		26.3	[16.4, 39.3]	
Small	21.8	[16.5, 28.3]		18.5	[12.5, 26.5]	
Average or larger	17.2	[15.0, 19.7]		8.9	[7.2, 10.9]	
Parental characteristics						
Mother's BMI categories			.001			.001
Thin	22.0	[13.5, 33.7]		21.5	[12.7, 34.0]	
Normal	23.3	[20.2, 26.7]		14.3	[11.6, 17.5]	
Overweight	13.7	[10.5, 17.8]		6	[4.0, 8.8]	
Obese	8.6	[5.8, 12.5]		1.5	[0.6, 4.0]	
Mother's educational level			.001			.020
No education	25.7	[22.3, 29.5]		13.7	[10.9, 17.2]	
Primary	19.2	[15.0, 24.1]		10.1	[7.4, 13.7]	
Secondary or higher	12.7	[10.0, 15.9]		8.2	[5.8, 11.3]	

Continued...

Table 2—*Continued*

Variables	Stunting %	Stunting CI	Stunting *p* value	Underweight %	Underweight CI	Underweight *p* value
Mother's age groups			.428			.864
20–29	17.4	[14.0, 21.4]		10.5	[7.9, 13.8]	
30–39	18.2	[15.0, 21.8]		10.3	[7.8, 13.4]	
40–49	22.0	[16.9, 28.0]		11	[7.5, 16.0]	
Mother is currently working			.199			.022
No	15.2	[10.6, 21.2]		10.8	[7.0, 16.4]	
Yes	19.1	[16.9, 21.6]		10.4	[8.6, 12.5]	
Mother is currently in a union			.011			.309
No	29.2	[20.6, 39.6]		18.3	[11.1, 28.6]	
Yes	17.8	[15.6, 20.2]		10	[8.3, 12.0]	
Contraceptive usage			.187			.003
None	18.6	[16.1, 21.4]		11	[9.1, 13.2]	
Traditional	7.7	[3.2, 17.2]		3.1	[0.7, 12.5]	
Modern	19.6	[14.8, 25.5]		9.8	[6.1, 15.5]	
Partner's educational level			.001			.115
None	24.6	[20.9, 28.8]		14.8	[11.6, 18.7]	
Primary	20.7	[15.0, 27.9]		13.7	[8.6, 21.2]	
Secondary	16.2	[13.3, 19.5]		8.5	[6.3, 11.3]	
Higher	10.4	[6.2, 17.0]		5.3	[2.7, 10.3]	
Household characteristics						
Wealth Index			.001			.123
Lowest	23.7	[20.2, 27.7]		13.8	[10.8, 17.5]	
Second	24.9	[20.3, 30.2]		12.4	[9.3, 16.4]	
Middle	16.4	[12.2, 21.7]		8.6	[5.7, 12.8]	
Fourth	13.2	[9.1, 19.0]		10.2	[6.6, 15.5]	
Highest	8.8	[4.3, 17.0]		4.8	[1.4, 14.9]	
Place of residence			.001			.020
Urban	14.0	[10.9, 17.8]		8.7	[6.1, 12.2]	
Rural	21.7	[19.0, 24.6]		11.8	[9.7, 14.2]	
Region of residence			.001			.017
Western	18.6	[12.4, 26.8]		9.5	[6.0, 14.7]	
Central	21.1	[15.7, 27.7]		13	[9.1, 18.3]	
Greater Accra	9.6	[5.1, 17.3]		6	[2.5, 13.6]	
Volta	19.2	[12.2, 28.7]		9.2	[6.1, 13.8]	
Eastern	16.5	[11.5, 23.0]		7.9	[4.5, 13.7]	
Ashanti	14.9	[9.3, 23.0]		10.7	[5.7, 19.0]	
Brong Ahafo	14.7	[10.5, 20.1]		5.5	[3.3, 9.1]	
Northern	32.1	[26.9, 37.7]		18	[13.6, 23.4]	
Upper East	14.0	[9.8, 19.6]		10.9	[7.2, 16.0]	
Upper West	22.0	[17.0, 28.1]		11	[7.3, 16.2]	
Family size			.001			.005
1–2	19.0	[7.8, 39.3]		8.5	[2.7, 24.0]	
3–4	13.4	[10.1, 17.6]		6.6	[4.6, 9.5]	
5–6	16.8	[13.6, 20.5]		10	[7.9, 12.7]	
7 or more	24.7	[20.6, 29.4]		14.3	[10.6, 18.9]	

The Northern Region had the highest levels of stunted and underweight children compared with other regions (32% and 18% respectively), while Greater Accra had the lowest levels at 10% and 6%, respectively.

3.3 Association between Birth Spacing and Child Stunting—Multivariate Analysis

The results of the logistic regression of the association between birth spacing and child stunting, controlling for other independent variables, are shown in Table 3. We present the results of both the adjusted odds-ratio (*aOR*) and unadjusted odd-ratios (*OR*) together with confidence intervals and *p* values. In the adjusted model, the results indicate that compared with the birth interval of less than 24 months, increasing birth interval is associated with lower odds of being stunted. For example, birth spacing above 47 months is associated with 50% lower odds of stunting in comparison to children with birth spacing less than 24 months (*aOR* = 0.5, 95% CI [0.3, 0.8], $p < .01$). Similar results were found within the unadjusted results. With the association of the child's age, the adjusted results show that children in the age categories of 12 months or above had approximately three times the odds or higher of being stunted compared to children less than 6 months old.

When we examine the association between the sex of child and stunting, we find that male children had significantly higher odds of being stunted in both the unadjusted and adjusted models compared to females (*aOR* = 1.4, 95% CI [1.1, 1.8], $p < .01$). As shown in Table 3, children who are perceived to be average or large have 60% lower odds of becoming stunted, compared with those who were perceived to be very small (*aOR* = 0.4, 95% CI [0.2, 0.7]). Birth order was significantly associated with child stunting, but only within the unadjusted model.

With the parental variables in the model, the adjusted results show that mothers with secondary or higher level of education have 40% lower odds of having stunted children compared to those without education (*aOR* = 0.6, 95% CI [0.4, 0.9], $p < .05$). Marital status was found to be significantly associated with lower odds of being stunted. The mother's nutritional status, her age, employment status, contraceptive use, and partner's education level were not found to be significantly associated with child stunting.

Table 3 Unadjusted and adjusted logistic regression results for child stunting

	Unadjusted		Adjusted	
	OR	**CI**	***OR***	**CI**
Child Characteristics				
Preceding interval				
<24				
24–35	0.7	[0.4, 1.0]	0.6*	[0.4, 1.0]
36–47	0.5**	[0.3, 0.8]	0.4***	[0.3, 0.7]
>47	0.4***	[0.3, 0.7]	0.5**	[0.3, 0.8]
Age in months				
<6				
6–11	1.3	[0.4, 4.0]	1.5	[0.5, 4.7]
12–23	3.3*	[1.2, 8.9]	4.1**	[1.5, 10.9]
24–35	5.8***	[2.2, 15.4]	7.5***	[2.7, 20.5]
36–47	4.5**	[1.8, 11.2]	5.3***	[2.1, 13.8]
48–59	2.8*	[1.1, 7.2]	2.7*	[1.0, 7.2]
Sex of child				
Female				
Male	1.3*	[1.0, 1.6]	1.4**	[1.1, 1.8]
Birth order				
2nd child				
3rd child	1.5*	[1.1, 2.1]	1.1	[0.7, 1.7]
4th and above	1.8**	[1.2, 2.8]	0.8	[0.4, 1.6]
Size at birth				
Very small				
Small	0.5*	[0.2, 0.8]	0.6	[0.3, 1.2]
Average or larger	0.3***	[0.2, 0.6]	0.4**	[0.2, 0.7]
Parental characteristics				
Mother's BMI categories				
Thin				
Normal	1.1	[0.6, 2.0]	1.2	[0.7, 2.3]
Overweight	0.6	[0.3, 1.1]	0.9	[0.4, 1.8]
Obese	0.3**	[0.2, 0.7]	0.5	[0.2, 1.2]

Continued...

Table 3—*Continued*

	Unadjusted *OR*	CI	Adjusted *OR*	CI
Mother's educational level				
No education				
Primary	0.7*	[0.5, 1.0]	0.9	[0.6, 1.3]
Secondary or higher	0.4***	[0.3, 0.6]	0.6*	[0.4, 0.9]
Mother's age groups				
20–29				
30–39	1.1	[0.7, 1.5]	1.1	[0.7, 1.8]
40–49	1.3	[0.9, 2.0]	1.2	[0.6, 2.3]
Mother is currently working				
No				
Yes	1.3	[0.9, 2.0]	1.0	[0.7, 1.6]
Mother is currently in a union				
No				
Yes	0.5*	[0.3, 0.9]	0.5*	[0.3, 0.9]
Contraceptive usage				
None				
Traditional	0.4*	[0.1, 0.9]	0.4	[0.2, 1.0]
Modern	1.1	[0.7, 1.6]	1.0	[0.6, 1.5]
Partner's educational level				
None				
Primary	0.8	[0.5, 1.3]	1.3	[0.8, 2.4]
Secondary	0.6***	[0.4, 0.8]	1.3	[0.9, 2.0]
Higher	0.4***	[0.2, 0.6]	1.2	[0.6, 2.3]
Household characteristics				
Wealth Index				
Lowest				
Second	1.1	[0.8, 1.5]	1.5*	[1.0, 2.3]
Middle	0.6*	[0.4, 0.9]	1.2	[0.7, 2.2]
Fourth	0.5**	[0.3, 0.8]	1.0	[0.5, 2.1]
Highest	0.3**	[0.1, 0.7]	0.8	[0.3, 2.1]
Place of residence				
Urban				
Rural	1.7**	[1.2, 2.4]	0.9	[0.5, 1.4]
Region of residence				
Greater Accra				
Western	2.2	[0.9, 4.9]	1.6	[0.7, 3.9]
Central	2.5*	[1.2, 5.5]	1.9	[0.8, 4.6]
Volta	2.2	[0.9, 5.3]	1.2	[0.5, 3.3]
Eastern	1.9	[0.8, 4.1]	1.1	[0.5, 2.8]
Ashanti	1.7	[0.7, 3.9]	1.3	[0.5, 3.2]
Brong Ahafo	1.6	[0.7, 3.5]	1.2	[0.5, 2.8]
Northern	4.5***	[2.2, 9.2]	3.0*	[1.2, 7.6]
Upper East	1.5	[0.7, 3.4]	1.1	[0.4, 2.8]
Upper West	2.7*	[1.3, 5.7]	1.8	[0.7, 4.5]
Family size				
1–2				
3–4	0.7	[0.2, 1.9]	0.9	[0.3, 3.1]
5–6	0.9	[0.3, 2.4]	1.1	[0.3, 3.7]
7 or more	1.4	[0.5, 4.0]	1.5	[0.4, 5.4]
N	**1,904**		**1,904**	

*** $p < .001$, ** $p < .01$, * $p < .05$

Analysis of the association between the various categories of wealth quintiles and child stunting in the adjusted model shows that women within the second wealth quintile had 1.5 times the odds of having stunted children compared to women in the lowest quintile (*aOR* = 1.5, 95% CI [1.0, 2.3], $p < .05$). In the unadjusted model, the remaining wealth categories were found to be significantly associated with child stunting but they lost significance in the adjusted model. Furthermore, both the adjusted and unadjusted models revealed that children of mothers who reside in the Northern Region had greater odds of being stunted compared to the mothers who reside in the Greater Accra Region (*aOR* = 3.0, 95% CI [1.2, 7.6], $p < .05$). The remaining regions were not significantly different from Greater Accra in stunting. Place of residence and family size were not significantly associated with stunting in the adjusted models.

3.4 Association between Birth Spacing and Child Underweight—Multivariate Analysis

Table 4 reports estimates of the multivariable logistic regression of the association between birth spacing and child underweight, after controlling for other independent variables at the child, parental and household levels. The results from the adjusted model show that birth spacing is significantly associated with lower odds of child underweight. Children with a preceding interval of 24 months or more have between 50% to 60% lower odds of being underweight compared to children with a birth interval of less than 24 months. Specifically, children with birth interval of 24 to 35 months (*aOR* = 0.5, 95% CI [0.3, 1.0], $p < .05$), 36–47 months (*aOR* = 0.4, 95% CI [0.2, 0.9], $p < .05$), and beyond 47 months (*aOR* = 0.5, 95% CI [0.3, 0.9], $p < .05$) had lower odds of being underweight. All the children's age categories in both the adjusted and unadjusted models were found to be significantly associated with higher odds of being underweight, compared with children aged less than 6 months. Furthermore, children who were perceived to be average or large have significantly (70%) lower odds of being underweight, compared to children perceived to be very small, as shown in the adjusted and unadjusted model results. The child's sex and birth order were not significantly associated with underweight. Similar to what was found for stunted children in the adjusted model results, women who are married had 60% lower odds of having underweight children compared with their non-married counterparts. Except for the partner's level of education and the middle wealth quintile, which were found to be significantly associated with child underweight within the unadjusted model, all the remaining parental and household variables (mother's age, employment status, level of education, contraceptive usage, partner's level of education, place of residence, region of residence and family size) were found not to be statistically associated with child underweight in both the adjusted and unadjusted model results.

Table 4 **Unadjusted and adjusted logistic regression results for child underweight**

	Unadjusted *OR*	CI	Adjusted *OR*	CI
Child characteristics				
Preceding interval				
<24				
24–35	0.6	[0.3, 1.2]	0.5**	[0.3, 1.0]
36–47	0.5*	[0.2, 1.0]	0.4**	[0.2, 0.9]
>47	0.5*	[0.2, 0.9]	0.5**	[0.3, 0.9]
Age in months				
<6				
6–11	3.6***	[1.8, 7.0]	3.7***	[1.8, 7.5]
12–23	4.7***	[2.2, 9.8]	5.5***	[2.7, 11.4]
24–35	4.3***	[1.9, 9.9]	5.0***	[2.3, 10.8]
36–47	3.9**	[1.7, 8.8]	4.2**	[1.8, 10.0]
48–59	2.5*	[1.2, 5.5]	2.5*	[1.1, 5.6]
Sex of child				
Female				
Male	1.0	[0.7, 1.3]	1.1	[0.8, 1.6]
Birth order				
2nd child				
3rd child	1.2	[0.8, 1.7]	0.8	[0.5, 1.4]
4th and above	1.5	[0.9, 2.5]	0.7	[0.3, 1.5]
Size at birth				
Very small				
Small	0.6	[0.3, 1.2]	0.9	[0.4, 1.8]
Average or larger	0.3***	[0.1, 0.5]	0.3**	[0.2, 0.7]
Parental characteristics				
Mother's BMI categories				
Thin				
Normal	0.6	[0.3, 1.2]	0.7	[0.3, 1.3]
Overweight	0.2***	[0.1, 0.5]	0.3**	[0.1, 0.7]
Obese	0.1***	[0.0, 0.2]	0.1***	[0.0, 0.2]
Mother's educational level				
No education				
Primary	0.7	[0.5, 1.1]	1.1	[0.7, 1.9]
Secondary or higher	0.6*	[0.4, 0.9]	0.9	[0.5, 1.6]
Mother's age groups				
20–29				
30–39	1.0	[0.6, 1.5]	1.2	[0.7, 2.2]
40–49	1.1	[0.6, 1.8]	1.3	[0.6, 3.0]
Mother is currently working				
No				
Yes	1.0	[0.6, 1.6]	0.8	[0.5, 1.3]
Mother is currently in a union				
No				
Yes	0.5*	[0.3, 0.9]	0.4**	[0.2, 0.8]
Contraceptive usage				
None				
Traditional	0.3	[0.1, 1.2]	0.3	[0.1, 1.2]
Modern	0.9	[0.5, 1.6]	0.9	[0.5, 1.5]
Partner's educational level				
None				
Primary	0.9	[0.5, 1.7]	1.3	[0.6, 2.5]
Secondary	0.5**	[0.3, 0.8]	0.9	[0.5, 1.5]
Higher	0.3**	[0.2, 0.7]	0.7	[0.3, 1.8]
Household characteristics				
Wealth Index				
Lowest				
Second	0.9	[0.6, 1.4]	1.3	[0.7, 2.4]
Middle	0.6*	[0.3, 1.0]	1.2	[0.5, 2.7]
Fourth	0.7	[0.4, 1.2]	1.4	[0.5, 3.8]
Highest	0.3	[0.1, 1.1]	0.8	[0.2, 3.6]

Continued…

Table 4—*Continued*

	Unadjusted *OR*	CI	Adjusted *OR*	CI
Place of residence				
Urban				
Rural	1.4	[0.9, 2.2]	0.8	[0.5, 1.5]
Region of residence				
Greater Accra				
Western	1.6	[0.6, 4.6]	1.3	[0.4, 4.5]
Central	2.3	[0.9, 6.3]	2.1	[0.7, 6.7]
Volta	1.6	[0.6, 4.4]	0.9	[0.3, 2.9]
Eastern	1.4	[0.5, 4.0]	0.8	[0.2, 2.6]
Ashanti	1.9	[0.6, 5.8]	1.5	[0.4, 5.2]
Brong Ahafo	0.9	[0.3, 2.6]	0.7	[0.2, 2.3]
Northern	3.4*	[1.3, 9.0]	1.8	[0.5, 6.1]
Upper East	1.9	[0.7, 5.2]	1.0	[0.3, 3.7]
Upper West	1.9	[0.7, 5.3]	1.3	[0.4, 4.3]
Family size				
1–2				
3–4	0.8	[0.2, 2.6]	1.3	[0.4, 5.0]
5–6	1.2	[0.3, 4.2]	2.2	[0.6, 8.9]
7 or more	1.8	[0.5, 6.3]	2.9	[0.7, 12.1]
N	1,904		1,904	

*** $p < .001$, ** $p < .01$, * $p < .05$

4 DISCUSSION

Multisectoral strategies are key to continuing the progress that Ghana has made in improving child undernutrition. In this study, we explored the association between birth spacing, child stunting, and underweight. The results showed that longer birth spacing was associated with lower odds of stunting and underweight. Several other child, parental, and household characteristics were also significantly associated with lower stunting and underweight.

The first finding is the positive association between birth spacing and a child's nutritional status. Specifically, the findings indicate that birth spacing of at least two years is associated with a lower risk of child stunting and underweight. These findings suggest that mothers need at least two years to replenish themselves and have healthy children. Other studies corroborate our findings. For example, in India, it was observed that birth spacing of less than 24 months increases the risk of stunting by 28%.[20] A systematic review of 58 observational studies suggested that shorter birth spacing has adverse consequences on child health outcomes. The study cited maternal nutritional depletion, and folate depletion as potential transmission mechanisms.[22] Other studies in sub-Saharan Africa and LMICs also identified the adverse consequences of short-term birth spacing on a child's nutritional outcome.[16–18] Our study confirms WHO's advice about waiting at least two to three years between pregnancies because this leads to lower newborn and child mortality and enhances maternal health. In addition, according to a study funded by USAID in 2002, having children at a birth interval of 3 to 5 years is preferable and may lead to a reduction in infant mortality in under-developed nations if there were no births within 36 months of previous birth.[13] This pattern will help to inform the decisions of the Ministry of Health and Health Service Providers in Ghana to institute policy prescriptions that encourage birth spacing of at least two years for mothers between age 20 to 49.

Several factors at the child, parental and household level were found to influence child stunting and underweight. With stunting, diverse factors make a compelling case for a multisectoral approach to its reduction. At the child level, the study identified age of the child, sex of the child, and perceived size at birth as significant predictors of stunting. The findings on the age of the child suggest that the risk of stunting peaks for children age 24 to 35 months. This is confirmed by the 2014 GDHS report, which also indicated that the risk of stunting is heightened for children between age 24–35 months. The results also indicate that male children have higher odds of being stunted than female children. This finding is supported by previous studies on child stunting in Ghana.[9,26]

It was also observed that average or larger perceived size at birth was associated with lower odds of stunting. Larger birth sizes are reflective of high birth weight, which is negatively correlated with stunting.[2] These variables at the child level imply that within the Ghanaian context, interventions focused on child stunting should emphasize age cohorts, specifically age 24–35 months, the male child, and children with relatively lower birth weight. At the parental level, the mother's level of education and marital status were the predictors of child stunting. The findings indicated that mothers with secondary or higher education have a lower risk of having a stunted child. This could imply that educated mothers are more likely to engage in health-seeking behaviors, such as adequate nutrition and formal healthcare practices focused on improving the health status of their children.[27–29]

Mothers who are currently married had lower odds of having a stunted child. It is possible that marriage settings create a support system for both the mother and the child, which guarantees household food security. This has consequences on the nutritional outcomes of the household, including that of the child.[30] At the household level, the findings revealed that children in the second wealth quintile have a higher risk of being stunted. Our finding on the negative association between child stunting and household wealth index corroborates other research findings. For example, some studies have shown that children from impoverished homes tend to be more undernourished than their counterparts from affluent homes.[31–33] This may be attributed to the fact that wealthy parents have the ability to provide their children with nutritious food, clean water, and a safe environment, which helps to improve their health status. The region of residence showed that children in the Northern Region have higher odds of child stunting. This finding is not surprising given that the Northern Region of Ghana has the highest proportion of poor households compared to Greater Accra.[8]

The findings on child underweight also revealed significant predictors at the child, parental, and household levels. At the child's level, the age of the child and perceived size at birth were identified as significant covariates. Unlike stunting, the risk of being underweight peaks among children age 12 to 23 months. The study also revealed that average or larger size at birth is associated with lower odds of child underweight. High birth weight has an adverse association with underweight. This finding concurs with a study in Pakistan that revealed that birth size is negatively associated with child underweight.[34] With parental characteristics, the mother's BMI and marital status were significant correlates of child underweight. The study also observed that obese/ overweight and married mothers had lower odds of having underweight children. The significant association between marital status and child underweight could imply that marriage helps create a pool of resources that ensure income stability at the household level, which has a potential positive association with child nutrition, including underweight. Unlike stunting, none of the household factors were identified as significant correlates of child underweight. In spite of this, the variables at the child's and parental level imply that within the Ghanaian context, interventions focused on reducing child underweight should emphasize child-specific factors, such as age of the child between 12 to 23 months, perceived size at birth, and marital status.

Our study makes an important contribution by examining a reproductive intervention (birth spacing) on two important child health indicators—stunting and underweight. Although previous studies have focused on the association between birth spacing and maternal health, the current study focuses on the association between birth spacing, child stunting, and underweight. This is because inadequate maternal repletion due to shorter birth intervals can transcend the health of the mother and affect the child. The study also identified several other child, parental, and household characteristics that Ghana can use to continue the progress towards reducing child stunting and underweight.

Our results highlight the urgent need for the Ministry of Health and Ghana Health Services, as well as the Planned Parenthood Association of Ghana, to increase measures that reduce child stunting and underweight with emphasis on birth spacing. In addition, the representativeness of the GDHS across the regional geographies of the country makes our findings generalizable. However, our study has some limitations which should be taken into consideration when interpreting our results. The 2014 GDHS is a cross-sectional survey that does not lend itself to causal inference. Our study also excludes mothers between age 15–19 because of the small sample size for computing the mother's BMI categories. Future research may focus on repeated cross-sectional or pseudo panel analyses, and more current GDHS data to fill in these important gaps.

5 CONCLUSION

The findings from the study support existing findings on the effect of birth spacing on child stunting and underweight. The study reveals that mothers with a birth spacing of at least two to three years compared to their counterparts with less than two years of birth spacing have lower odds of having a stunted and underweight child under age 5. Our results underscore the role of birth spacing as one of the critical indicators that can reduce the odds of having stunted and underweight children age under 5. Our study recommends that the Ministry of Health, Planned Parenthood Association of Ghana, and both public and private maternal health organizations should educate women within the reproductive age (20–49) on the need to space births at least two to three years apart because this can help to reduce the prevalence of child stunting and underweight among children under age 5.

REFERENCES

1. Food and Agriculture Organization of the United Nations (FAO). *The State of Food Security and Nutrition in the World 2022*. FAO; 2022. https://www.fao.org/documents/card/en/c/cc0639en

2. Kofinti RE, Koomson I, Paintsil JA, Ameyaw EK. Reducing children's malnutrition by increasing mothers' health insurance coverage: A focus on stunting and underweight across 32 sub-Saharan African countries. *Econ Model.* 2022; 117:106049. https://doi.org/10.1016/j.econmod.2022.10604

3. Katoch OR. Determinants of malnutrition among children: a systematic review. *Nutrit.* 2021; 96:111565. https://doi.org/10.1016/j.nut.2021.111565

4. World Health Organization (WHO). *Malnutrition.* WHO; 2021. https://www.who.int/news-room/fact-sheets/detail/malnutrition

5. WHO. *Global Nutrition Targets 2025—Childhood Overweight Policy Brief*. WHO; 2014. https://apps.who.int/iris/bitstream/handle/10665/149021/WHO_NMH_NHD_14.6_eng.pdf

6. UNICEF. *Child Malnutrition*. UNICEF; 2022. https://data.unicef.org/topic/nutrition/malnutrition/

7. Jornayvaz FR, Vollenweider P, Bochud M, Mooser V, Waeber G, Marques-Vidal P. Low birth weight leads to obesity, diabetes and increased leptin levels in adults: the CoLaus study. *Cardiovasc Diabetol.* 2016; 15(1). https://doi.org/10.1186/s12933-016-0389-2

8. Ghana Statistical Service (GSS), Ghana Health Service (GHS), and ICF International. *Ghana Demographic and Health Survey.* GSS, GHS, and ICF International; 2014. https://dhsprogram.com/pubs/FR307/FR307.pdf

9. Essilfie G, Sebu J, Annim SK. Women's empowerment and child health outcomes in Ghana. *Afr Dev Rev.* 2020; 32(2):200-215. https://doi.org/10.1111/1467-8268.12428

10. FAO. *The State of Food Security and Nutrition in the World 2020: Transforming Food Systems for Affordable Healthy Diets.* FAO; 2020. https://www.fao.org/publications/home/fao-flagship-publications/the-state-of-food-security-and-nutrition-in-the-world/en

11. Bhutta ZA, Berkley JA, Bandsma RHJ, Kerac M, Trehan I, Briend A. Severe childhood malnutrition. *Nat Rev Dis Primers.* 2017; 3(1):1-18. https://doi.org/10.1038/nrdp.2017.67

12. Leroy JL, Frongillo EA. Perspective: What does stunting really mean? A critical review of the evidence. *Adv Nutr.* 2019; 10(2):196-204. https://doi.org/10.1093/advances/nmy101

13. Nti CA, Gadegebeku C, Ofosu B, Akoto E, Agbi-Dzorkar M. Knowledge, attitude and practice of birth spacing among Ghanaian mothers: Implications for maternal and child nutritional status. *World Appl Sci J.* 2014;31 (11): 1971-1978. https://www.idosi.org/wasj/wasj31(11)14/19.pdf

14. Costello A, Osrin D, Manandhar D. Reducing maternal and neonatal mortality in the poorest communities. *BMJ.* 2004; 329(7475):1166-1168. https://doi.org/10.1136/bmj.329.7475.1166

15. Sharma D, Shastri S, Sharma P. Intrauterine growth restriction: Antenatal and postnatal aspects. *Clin Med Insights: Pediatr.* 2016; 10: CMPed.S40070. https://doi.org/10.4137/cmped.s40070

16. Yaya S, Uthman OA, Ekholuenetale M, Bishwajit G, Adjiwanou V. Effects of birth spacing on adverse childhood health outcomes: Evidence from 34 countries in sub-Saharan Africa. *Journal of Matern-Fetal Neonatal Med.* 2019;33(20):3501-3508. https://doi.org/10.1080/14767058.2019.1576623

17. Kozuki N, Walker N. Exploring the association between short/long preceding birth intervals and child mortality: Using reference birth interval children of the same mother as comparison. *BMC Public Health.* 2013; 13(Suppl 3): S6. https://doi.org/10.1186/1471-2458-13-s3-s6

18. Cheslack Postava K, Winter AS. Short and long interpregnancy intervals: Correlates and variations by pregnancy timing among *U.S. women. Perspect Sex Reprod Health.* 2015; 47(1):19-26. https://doi.org/10.1363/47e2615

19. Dewey KG, Cohen RJ. Does birth spacing affect maternal or child nutritional status? A systematic literature reviews. *Matern Child Nutr.* 2007; 3(3):151-173. https://doi.org/10.1111/j.1740-8709.2007.00092.x

20. Chungkham HS, Sahoo H, Marbaniang SP. Birth interval and childhood undernutrition: Evidence from a large-scale survey in India. *Clin Epi Glob Health.* 2020;8(4):1189-1194. https://doi.org/10.1016/j.cegh.2020.04.012

21. Gribble JN, Murray NJ, Menotti EP. Reconsidering childhood undernutrition: Can birth spacing make a difference? An analysis of the 2002-2003 El Salvador National Family Health Survey. *Matern Child Nutr.* 2009; 5(1):49-63. https://doi.org/10.1111/j.1740-8709.2008.00158.x

22. Conde-Agudelo A, Rosas-Bermudez A, Castaño F, Norton MH. Effects of birth spacing on maternal, perinatal, infant, and child health: A systematic review of causal mechanisms. *Stud Fam Plann*. 2012; 43(2):93-114. https://doi.org/10.1111/j.1728-4465.2012.00308.x

23. Dewey KG. Energy and protein requirements during lactation. *Ann Rev Nutr.* 1997; 17:19-36. https://doi.org/10.1146/annurev.nutr.17.1.19

24. Manun'ebo, MN, Haggerty PA, Kalengaie M, Ashworth A, Kirkwood BR. Influence of demographic, socioeconomic and environmental variables on childhood diarrhoea in rural area of Zaire. *J Trop Med Hyg.* 1994; 97:31-38. https://europepmc.org/article/MED/8107171

25. WHO. *WHO Child Growth Standards: Length/height-for-Age, Weight-for-Age, Weight-for-Length, Weight-for-Height and Body Mass Index-for-Age: Methods and Development.* WHO; 2006. https://www.who.int/publications/i/item/924154693X

26. Darteh EKM, Acquah E, Kumi-Kyereme A. Correlates of stunting among children in Ghana. *BMC Public Health.* 2014; 14(1). https://doi.org/10.1186/1471-2458-14-504

27. Bicego GT, Boerma JT. Maternal education and child survival: A comparative study of survey data from 17 countries. *Soc Sci Med.* 1993; 36(9): 1207–27. https://doi.org/10.1016/0277-9536(93)90241-U

28. Adekanmbi VT, Kayode GA, Uthman OA. Individual and contextual factors associated with childhood stunting in Nigeria: A multilevel analysis. *Matern Child Nutr.* 2013; 9: 244-259. https://www.ncbi.nlm.nih.gov/pmc/articles/PMC6860873/

29. Muhangi L, Lule SA, Mpairwe H, Ndibazza J, Kizza M, Nampija M. Maternal HIV infection and other factors associated with growth outcomes of HIV-uninfected infants in Entebbe, Uganda. *Public Health Nutr.* 2013; 16: 1548-1557. https://doi.org/10.1017/S1368980013000499

30. Dallmann D, Marquis G, Colecraft E, Dodoo N, Addy N. Marital status and support for women's and chidren's wellbeing: Perspective of rural Ghanaian women. *Curr Dev Nutr.* 2019; 3:3131686. https://doi.org/10.1093/cdn/nzz051.P04-038-19

31. Zere E, McIntyre D. Inequities in under-five child malnutrition in South Africa. *Int J Equity Health.* 2003;2(1). https://doi.org/10.1186/1475-9276-2-7

32. Thang NM, Popkin BM. Patterns of food consumption in Vietnam: Effects on socioeconomic groups during an era of economic growth. *Eur J Clin Nutr.* 2003; 58(1):145-153. https://doi.org/10.1038/sj.ejcn.1601761

33. Hong R, Banta JE, Betancourt JA. Relationship between household wealth inequality and chronic childhood under-nutrition in Bangladesh. *Int J Equity Health.* 2006; 5(1):1-10. https://doi.org/10.1186/1475-9276-5-15

34. Siddjga M, Shah GH, Mayo-Gamble TL, Zubair A. Determinants of child stunting, wasting, and underweight: Evidence from 2017 to 2018 Pakistan Demographic and Health Survey. *J Nutri Metab.* 2023; 2023: 1-12. https://doi.org/10.1155/2023/2845133

APPENDIX

Table A1 Independent variables and their measurements

Explanatory variables	Measurement
Child characteristics	
Preceding interval	Preceding birth interval recoded as: 1 = <24 months; 2 = 24–35 months; 3 = 36–47 months; 4 = >47 months
Age in month	Age in months recoded as 1 = less than 6 months; 2 = 6–11 months; 3 = 24–35 months; 4 = 36–47 months; and 5 = 48–59 months
Sex of child	Dummy variable: 0=female; and 1=male
Birth order	Categorical variable: 2 = 2nd child; 3 = 3rd child; and 4 = 4th child
Size at birth	Perceived size at birth is recorded as: 1 = very small; 2 = small, and 3 = average or larger
Parental characteristics	
Mother’s BMI categories	Categorized as thin if BMI is less than 18.5; normal if BMI is 18.5 to 24.99; overweight if BMI is 25.0 to 29.99 and obese if 30.0 to 60
Mother’s educational level	Categorical: 0=no education; 1 = 1 primary; and 2 = 2 secondary or higher.
Mother’s age groups	Categorical: 1 = 20–29; 2 = 2 30–39; and 3 = 3 40–49.
Mother’s employment status	Dummy variable: 0 = not working; and 1 = working
Marital status of the mother	Dummy variable: 0 = never in union/widowed/divorced/no longer living together/separated; and 1 = married/living with a partner
Contraceptive usage	Categorical variable: 0 = not using; 1 = traditional contraceptive; and 2 = modern contraceptive
Partner’s educational level	Categorical variable: 0 = none; 1 = primary; 2 = secondary; and 3 = higher
Household characteristics	
Wealth index	Categorical variable: 1 = Lowest, 2 = Second; 3 = Middle; 4 = Fourth and 5 = Highest
Place of residence	Dummy variable: 1 = Urban; and 0 = Rural
Region of residence	Categorical variable: 1 = Western; 2 = Central; 3 = Greater Accra; 4 = Volta; 5 = Eastern; 6 = Ashanti; 7 = Brong Ahafo; 8 = Northern; 9 = Upper East; and 10 = Upper West
Family size	Categorical variable: 1 = 1–2 members; 2 = 3–4 members; 3 = 5–6 members; and 4 = 7 or more