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Trend of Birth Spacing Impact on Physical Growth of Children under Age Five: An Analysis Based on Bangladesh Demographic and Health Surveys

Mithun Kumar Acharjee[1*], Md. Nuruzzaman Forhad[2] and Kumer Pial Das[3]

[1]Department of Statistics, Pennsylvania State University, PA 16802, USA.
[2]Research and Development Division, Prime Bank Limited, Head Office, Dhaka, Bangladesh.
[3]Research, Innovation and Economic Development, University of Louisiana at Lafayette, LA 70504, USA.

Authors' contributions

This work was carried out in collaboration between all authors. Author MKA designed the study, performed the statistical analysis and wrote the first draft of the manuscript. Author MNF also performed the statistical analysis, managed the literature searches and contribute to writing the manuscript. Author KPD rigorously checked and reviewed the design of the study, provide important suggestions during statistical analysis and extensively reviewed the manuscript. All authors read and approved the final manuscript.

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ABSTRACT

Physical growth and development of a young child is vital for quality of life, attaining good health, and national productivity. Physical growth and development during the first few years of life is influenced by many factors including birth spacing. This study was aimed to assess the impact of birth spacing on two indices of physical growth and development (stunting and underweight-also considered as malnutrition) of young children using the data from four of the most recent national-level demographic and health surveys in Bangladesh known as Bangladesh Demography and Health Surveys. Bivariate models have been employed to examine the impact of a number of background characteristics on stunting and underweight of children. These background characteristics include birth spacing, mother's age, education, BMI, wealth index, place of residence, access to media, ANC visit, and breastfeeding duration. To understand the potential

**Corresponding author: Email: mka86@psu.edu;*

confounding impact of these background characteristics on the relationship between birth spacing and physical growth and development of young children, two logistic regression models are considered. The adjusted odds ratios were estimated which provide ideas of the dynamics between the predictors. Moreover, time series analysis has been employed to predict the stunting and underweight status of young children in Bangladesh. The analysis of physical growth and development provides researchers and policymakers valuable tools to understand the nutritional status of young children. The analysis shows that variables such as mother's education, mother's age, wealth index, ANC visit, and breast feeding duration vastly influence both stunting and underweight. Available resources should be offered to address these covariates.

Keywords: Adjusted odds ratio, birth interval, physical growth, stunting, underweight.

1. INTRODUCTION

Birth Spacing (or birth interval) refers to the time interval from one child's birth date until the next child's birth date. Infant malnutrition is caused by numerous factors, but birth spacing is often ignored, even though it is strongly associated with two standard indices of physical growth, namely stunting and underweight. Stunting is defined in terms of height-for-age and underweight is defined in terms of weight-for-age. The Government of Bangladesh recommends a pregnancy interval of three years [1]. Bangladesh has witnessed large reductions in fertility [2] and as a result, there is a significant increase in median birth intervals (increasing from 35 months in 1993–1994 to 51.7 months in 2014) [3]. The Government of Bangladesh wants to achieve the stable population level by the year 2035. However, one of the primary obstacles to reaching the goal is marriage at a very early age, a large proportion of marriages still take place before the woman reaches her legal age which is 18 years. The 2014 BDHS found that 59 percent of women age 20-24 were married before age 18 that is a decline from 65 percent recorded in 2011. The median age at first birth which is approximately 18 years [3] across all years. These young women do not follow the recommended birth interval of 45 months rather they have birth intervals of only 27 months though the impact of the short and long intervals between pregnancies are independently associated with an increased risk of adverse maternal, prenatal, infant, and child outcomes, [3,4,5].

Interestingly, the length of the birth interval is associated with the demographic, socioeconomic and health related characteristics. Research shows that the mother's age at birth, birth order, survival status of the index child and maternal educations have a noticeable influence on the birth interval [6,7,8]. A cultural preference for sons over daughters is apparent in South East Asia [9,10,11] which has a significant impact on the birth spacing [6,7]. Nath et al. [12] studied the impact of wealth index on the birth interval. Also, the place of residence (rural and urban) and administrative divisions may play a vital role in the distribution of birth interval [13,14]. The mother's initial body mass index (BMI) is a key factor to consider, as it may be inversely related to the inter-pregnancy interval (a woman with higher BMI is likely to return to fertility sooner [15,16,17]). The spacing between pregnancies can have important health implications for her baby. A short birth interval should be avoided since a short birth interval increases the risk of intrauterine growth retardation and adversely affects infant nutrient stores at birth and nutrient delivery via breast milk [18, 19, 20]. Moreover, a new pregnancy often prompts weaning of the current child or at least a reduction in the volume of breast milk consumed [21,22,23]. Getting pregnant again within a year of giving birth usually increases the risk of low birth weight, uterine rupture, preterm birth and even infant death [24]. Thus, the above issues depict that low birth spacing is one of the primary reasons for the next birth to be stunted as well as underweight.

Although this birth spacing has an enormous impact on the stunting and underweight, very few studies have been conducted in Bangladesh to explore fact behind this. Our research has provided a conceptual framework needed to analyze the physical growth of children under five years of age as well as to measure the degrees of association of different determinants on physical growth. Also, the logistic regression model measures the impact of birth spacing on stunting and underweight. Finally, this paper has recommended a few steps addressing the stunting and underweight issues of young children in Bangladesh.

2. METHODS

2.1 Database

The study used the data of Bangladesh Demographic and Health Survey (BDHS), a nationally representative sample survey of men and women of reproductive age conducted every about 3 years since 1993-94. The survey is a collaborative effort of the National Institute of Population Research and Training (NIPORT), ICF International (USA), and Mitra and Associates. Data comes from the four most recent national level demographic and health surveys in Bangladesh known as Bangladesh Demography and Health Survey (BDHS) conducted in 2004, 2007, 2011, and 2014.

The methodology used in this study is repeated analysis of retrospective survey data of the BDHS program. The BDHS Individual record data file has 11,440, 10,996, 11,832, and 17,863 ever-married women respondents for the years 2004, 2007, 2011, and 2014 respectively. To assess the most recent impact of birth spacing on physical growth, the study considered the following steps for selecting an appropriate study sample:

Step I: Considering those respondents who experienced at least one live birth in the past five years.

Step II: Considering the main exposure “Birth Spacing”.

Step III: Matching all the background information’s of the respondents.

The calculation of the study sample for each BDHS survey is shown in Table 1.

The latest BDHS was conducted in 2017-2018; however, the DHS program has yet to publish any form of the dataset [25]. As a result, the analysis did include the data sets from 2004 to 2014 data.

2.2 Variables and Study Framework

The dependent variable is the physical growth, in the form of and underweight. All four BDHS used World Health Organization (WHO) cut-off points [26] for measuring stunting (height for age less than -2 Standard deviation (SD) of the WHO child growth standards median) and underweight (weight for age less than -2 SD of the WHO child growth standards median). SD values are available in BDHS dataset for stunting and underweight. For the aspiration of the analysis, we consider stunting (stunted and not stunted) and underweight (underweight and not underweight) as binary variables. The main exposure is the preceding birth interval (less than 24 months, 24 to 59 months, greater or equal to 60 months). Among the important covariates for modeling birth intervals that were reported in earlier studies [27, 28], those available in BDHS data are selected for this study. The study has considered covariates under three major headings: a) demographic, b) socioeconomic and c) health related variables, as shown in Fig.1. Mother’s BMI (underweight, normal, overweight, obese), mother’s height (less than 1.45 meters, equal or greater than 1.45 meters), mother’s age at the first birth (under 18, equal or greater than 18), number of antenatal visits during pregnancy (no visit, 1-3 times, more than 3 times), breastfeeding duration (less than 24 months, 24-35 months, more than 35 months), and media exposure (no, yes) are considered potentially important background factors for birth spacing. These factors are included in the analysis which takes into account the effect due to all the additional variables on the relationship between birth spacing and the physical growth of a young child, clearly shown in the study framework (Fig. 1).

2.3 Statistical Analysis

The univariate analysis shows the important features of the variables included in the study. Bivariate models (chi-square) have been

Table 1. Study sample

Year	Survey Sample	Step 1	Step 2	Step 3 (Study Sample)
2004	11,440	5,364	3436	2556
2007	10,996	4,856	2971	2364
2011	11,832	7,225	4302	3563
2014	17,863	6,926	2519	2100

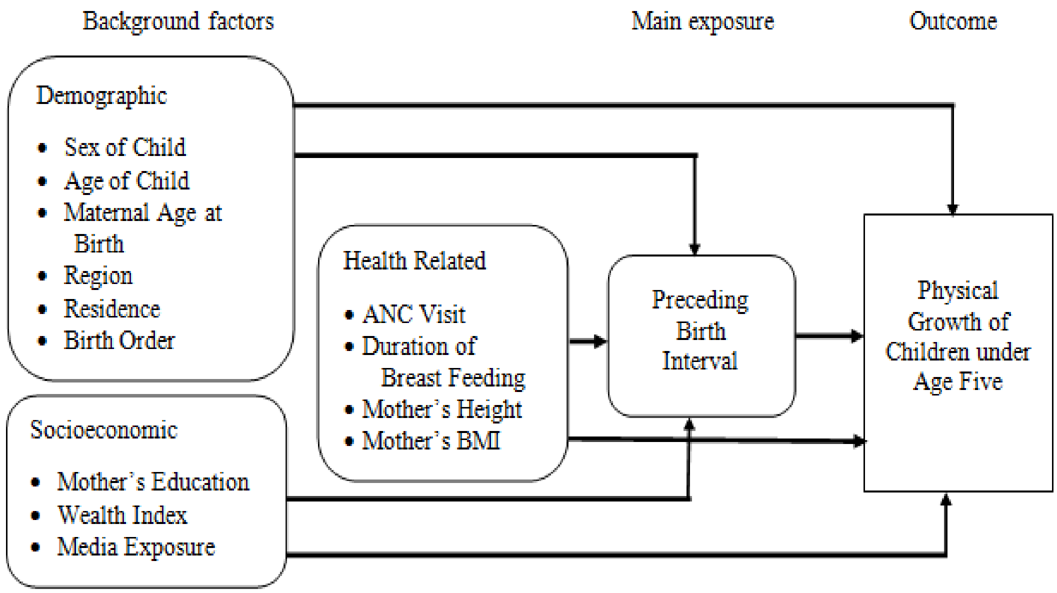

Fig. 1. Conceptual framework of the study

employed to examine the impact of a number of background characteristics on stunting and underweight of children. These background characteristics include birth spacing, mother's age, education and BMI, wealth index, place of residence, access to media, ANC visit and breastfeeding duration. To understand the potential confounding impact of these background characteristics on the relationship between birth spacing and physical growth and development of young children, two logistic regression models (Model I for stunting and Model II for underweight) are considered. After adjusting background characteristics, the adjusted odd ratios were estimated which provide ideas of the dynamics between the predictors. Moreover, time series analysis (Exponential smoothing) has been employed to predict the trend of stunting and underweight status of young children in Bangladesh. For the purpose analysis, the SPSS for Windows (IBM Corp., Armonk, N.Y., USA) is used. In traditional software packages including SPSS, a general assumption of analytical measures is that the observations in a data file are collected through a simple random sample from the population of interest. As a result, in this study, we used the "Complex Sample" option in SPSS that allows the selection of a sample according to complex design (BDHS based on a two stage stratified sample of households) and incorporates the design specifications into the data analysis. This complex sample is ensuring that the results are more valid.

3. RESULTS

3.1 Univariate Analysis

Descriptive statistics of the factors that influence a newborn baby's physical growth in Bangladesh are shown in Table 2.

Table 2 depicts that one third (33.7%) of children in the survey conducted in 2014 were stunted; these percentages were near 40% in all three previous surveys (2004, 2007, and 2011). Almost one third (31.8%) of children in 2014 were underweight; this is a significant decrease from previous surveys (45.1% in 2004, 39.8% in 2007, and 34.8% in 2011).

3.2 Bivariate Analysis

3.2.1 Stunting

In bivariate analysis, the degrees of influence of different determinants on child physical growth (Stunting and Underweight) have been found. The results in row-percentage by the sample with their corresponding *p*- values have been presented in Table 3 and Table 4.

Table 2. Frequency distribution of selected variables

Variable	Category	Year			
		2004	**2007**	**2011**	**2014**
Stunting	Stunted	1859 (39.2%)	1786 (40.9%)	2565 (39.6%)	848 (33.7%)
	Not stunted	2879 (60.8%)	2577 (59.1%)	3909 (60.4%)	1672 (66.3%)
Weighting	Underweight	2136 (45.1%)	1738 (39.8%)	2250 (34.8%)	801 (31.8%)
	Not underweight	2602 (54.9%)	2625 (60.2%)	4224 (65.2%)	1719 (68.2%)
Preceding Birth Interval	< 24 months	493 (14.4%)	376 (12.7%)	460 (10.7%)	273 (10.8%)
	24-59 months	2049 (59.6%)	1691 (56.9%)	2247 (52.2%)	1110 (44.1%)
	>= 60 months	894 (26.0%)	904 (30.4%)	1595 (37.1%)	1136 (45.1%)
Sex of Child	Male	2422 (51.1%)	2184 (50.1%)	3333 (51.5%)	1334 (52.9%)
	Female	2316 (48.9%)	2179 (49.9%)	3142 (48.5%)	1186 (47.1%)
Maternal age at Time of Birth	>= 18	4203 (88.7%)	3926 (90.0%)	5890 (91.0%)	2500 (99.2%)
	< 18	536 (11.3%)	437 (10.0%)	585 (9.0%)	20 (0.8%)
Mothers' Education	No Education	1703 (35.9%)	1107 (25.4%)	1224 (18.9%)	504 (20.0%)
	Primary	1457 (30.7%)	1363 (31.2%)	1961 (30.3%)	752 (29.9%)
	Secondary	1312 (27.7%)	1588 (36.4%)	2805 (43.3%)	1119 (44.4%)
	Higher	265 (5.6%)	304 (7.0%)	483 (7.5%)	144 (5.7%)
Number of ANC visit	No Visit	772 (16.3%)	919 (21.1%)	1554 (24.0%)	695 (27.6%)
	1-3 times	1904 (40.2%)	1744 (40.0%)	2640 (40.8%)	1192 (47.3%)
	4+ times	2061 (43.5%)	1699 (39.0%)	2280 (35.2%)	633 (25.1%)
Place of Residence	Urban	966 (20.4%)	937 (21.5%)	1503 (23.2%)	583 (23.1%)
	Rural	3772 (79.6%)	3426 (78.5%)	4971 (76.8%)	1937 (76.9%)
Parity	Poorest	1113 (23.5%)	940 (21.6%)	1437 (22.2%)	648 (25.7%)
	Poorer	972 (20.5%)	933 (21.4%)	1304 (20.1%)	504 (20.0%)
	Middle	935 (19.7%)	842 (19.3%)	1275 (19.7%)	468 (18.6%)
	Richer	892 (18.8%)	839 (19.2%)	1259 (19.5%)	495 (19.7%)
	Richest	825 (17.4%)	807 (18.5%)	1198 (18.5%)	404 (16.0%)
Mothers' Height	>=145 cm	3984 (84.4%)	3731 (85.7%)	5673 (87.6%)	2177 (86.4%)
	<145 cm	738 (15.6%)	621 (14.3%)	799 (12.4%)	343 (13.6%)
Breast Feeding Duration	< 24 months	2564 (54.1%)	2399 (55.0%)	3366 (52.0%)	1782 (70.7%)
	24-35 months	1442 (30.4%)	1308 (30.0%)	2093 (32.3%)	708 (28.1%)
	>= 36 months	732 (15.5%)	656 (15.0%)	1015 (15.7%)	29 (1.2%)

Variable	Category	Year			
		2004	2007	2011	2014
Child Age	0-11m	1137 (24.0%)	1041 (23.8%)	1486 (22.9%)	801 (31.8%)
	12-23m	1141 (24.1%)	1047 (24.0%)	1412 (21.8%)	914 (36.2%)
	24-35m	1027 (21.7%)	937 (21.5%)	1244 (19.2%)	806 (32.0%)
	36-47m	804 (17.0%)	753 (17.3%)	1314 (20.3%)	
	48-59m	631 (13.3%)	586 (13.4%)	1019 (15.7%)	
Mothers' BMI	Underweight	1755 (37.9%)	1394 (32.5%)	1744 (27.6%)	544 (22.2%)
	Normal	2603 (56.2%)	2539 (59.2%)	3797 (60.1%)	1449 (59.1%)
	Overweight	231 (5.0%)	313 (7.3%)	668 (10.6%)	393 (16.0%)
	Obese	38 (0.8%)	45 (1.1%)	110 (1.7%)	67 (2.7%)

Table 3. Association between selected variables and stunting with *p* values

Variables with Characteristics	Stunting Status							
	2004		2007		2011		2014	
	Stunted	*p* value	Stunted	*p* value	Stunted	*p* value	Stunted	*p* value
Preceding birth interval								
<24 months	45.2%	<0.001	50.4%	0.003	49.1%	<0.001	39.4%	0.023
24-59 months	43.0%		44.4%		44.2%		34.4%	
>=60 months	30.3%		38.4%		35.5%		31.5%	
Mother's education								
No Education	46.0%	<0.001	49.5%	<0.001	50.1%	<0.001	42.7%	<0.001
Primary	41.6%		46.3%		44.9%		37.8%	
Secondary	32.9%		34.2%		34.4%		29.2%	
Higher	14.3%		20.8%		21.6%		15.2%	
Child age								
0-11 months	17.2%	<0.001	21.9%	<0.001	20.2%	<0.001	14.3%	<0.001
12-23 months	50.7%		39.7%		49.4%		42.8%	
24-35 months	43.4%		52.8%		46.0%		42.9%	
36-47 months	45.3%		54.3%		43.8%			
48-59 months	43.7%		40.9%		41.2%			
Wealth index								
Poorest	50.1%	<0.001	51.5%	<0.001	51.4%	<0.001	42.6%	<0.001
Poorer	43.7%		47.1%		44.1%		38.3%	

Variables with Characteristics	Stunting Status							
	2004		2007		2011		2014	
	Stunted	*p* value	Stunted	*p* value	Stunted	*p* value	Stunted	*p* value
Middle	39.0%		40.7%		38.6%		32.8%	
Richer	37.0%		37.2%		35.5%		28.0%	
Richest	22.1%		25.7%		25.9%		21.4%	
Place of residence								
Urban	34.8%	0.025	34.6%	0.001	35.5%	0.004	31.1%	<0.027
Rural	40.4%		42.7%		40.9%		34.4%	
Access to media								
No	47.8%	<0.001	46.6%	<0.001	47.0%	<0.001	38.2%	0.002
Yes	35.4%		37.7%		35.6%		30.3%	
Mother's age								
Below 18 years	38.7%	0.082	40.7%	0.424	39.4%	0.370	49%	0.049
>=18 years	43.2%		43.1%		41.7%		33.3%	
Child sex								
Male	38.5%	0.384	41.4%	0.654	38.9%	0.309	35.7%	0.102
Female	40.0%		40.5%		40.4%		31.4%	
Mother's height								
<1.45 meters	35.3%	<0.001	37.3%	<0.001	36.8%	<0.001	51.8%	<0.001
>=1.45 meters	59.8%		62.7%		59.6%		30.8%	
Breast feeding duration								
<24 months	34.4%	<0.001	32.3%	<0.001	35.7%	<0.001	30.3%	<0.001
24-35 months	44.6%		50.0%		43.9%		43.1%	
>=36 months	45.7%		54.3%		43.8%		11.8%	
ANC visit								
No Visit	25.8%	<0.001	28.3%	<0.001	31.8%	<0.001	45.2%	<0.001
1-3 Times Visit	37.4%		40.6%		37.1%		32.8%	
>=4 Times Visit	45.9%		48.1%		47.9%		24.6%	
Mother's BMI								
Underweight	46.6%	<0.001	47.4%	<0.001	49.3%	<0.001	40.8%	0.004
Normal	36.1%		40.0%		38.3%		34.6%	
Overweight	19.7%		21.6%		24.9%		22.7%	
Obese	16.9%		19.0%		25.9%		23.8%	

Table 3 shows the relation among the variables with the stunting status of children aged less than five years. It is found that based on the 2014 data 31.5% of children are stunted in the case of mothers having a birth interval more than or equal to 60 months which remain in the range of lower to upper 30s for the last 10 years. In 2014, 34.4% of children are stunted for the respondents that have maintained a birth interval between 24 and 59 months, this is about a 10% improvement from 2011. About a similar (10% improvement) in 2014 over 2011 in the stunting rate for the mothers having a birth interval less than 24 months has also been observed. Stunting of a newborn baby is highly dependent on the mother's education in Bangladesh. In the case of higher educated mothers, only 15.2% of children are stunted which is about a 6% increase from 2011. On the other hand, 42.7% of children are stunted for uneducated mothers, also about 7% increase from 2011. Primary and secondary educated mothers are having 37.8% and 29.2% of stunted babies, respectively. In short, each of the upgrade in mother education categories results about 10% improvement in stunting rate over the period of 10 years. As expected, it has been observed that the stunting risk increases with the decrease of wealth status. Based on the 2014 data, the children of the poorest families have a higher proportion of being stunted (42.6%), whereas only 21.4% of children from the richest families are stunted. Over the period of 10 years, a higher rate of improvement in stunting has been observed among mothers in the lower wealth index compared to their peers (for example, about 8% improvement in the poorest category from 2004 to 2014 compared to a less than 1% improvement in the richest category over the same period.) The prevalence of stunting is always significantly higher in rural areas compared to urban areas in the past 10 years; however, the gap between urban and rural areas is shrinking almost steadily (it was 5.6% in 2004, 7.9% in 2007, 5.4% in 2011 and 3.3% in 2014) over the years. Access to media has been found to be statistically significant factor on stunting in each of the four surveys. The difference in stunting rate between these two groups (with and without media access) is about 8% in 2014 which is an improvement from previous surveys (it was about 10-12% in the other three surveys). Almost half (49%) of the children are stunted in under-18-year-old mothers in 2014. Most importantly, over the years the stunting rate for kids with mother's age under 18 is increasing whereas the stunting rate for kids with mother's age above 18 is decreasing which pinpoints the importance of the age of mother. The percentage of stunting is close among male children (35.7%) and female children (31.4%). A noteworthy relationship is found between the mother's height and the stunting status of her children. Mothers with a height less than 1.45 meters produced stunted babies in 51.8% of the cases, whereas mothers with a height more than or equal to 1.45 meters produced stunted babies in only 30.8% of the cases. This indicates that a mother's height is disproportionally related to the probability of the child's stunting. In the case of breastfeeding, mothers who feed their children 36 months or more have only 11.8% of stunted children. The study shows that 45.2% of stunted children are born in the families who do not visit the clinic for antenatal care during the pregnancy which is almost double to the stunting rate of children with families who visit a clinic for antenatal care four times or higher. It is observed that an underweight (a BMI of less than 18.5 is used to define thinness or acute under nutrition) mother's children are more prone to be stunted than normal-weighted participants. Among the underweight mother's children, the rate of occurrence of stunting is 40.8%, whereas it is 34.6% and 22.7% for the normal and overweight (a BMI of 25 or above usually indicates overweight) categories of BMI, respectively. All variable shows statistically significant association with stunted children except sex.

3.2.2 Underweight

The relation among the variables with the underweight status of under-five children is shown in Table 4. The duration between two births and the rate of underweight children are inversely related. Underweight children are only 30.1% in the case of mothers who have a birth interval more than or equal to 60 months. Of the mothers who had a child after 24-59 months from the previous child, 31.5% of their children are underweight, and 40% of children are underweight whose mothers had maintained only a less than 24-months birth interval. Underweight status shows the same relationship with mother's education as the stunting status, 17.6% and 42% of children are underweight for higher educated and uneducated mothers, respectively. The percentage of underweight children decreases with an increase of wealth status. In the poorest families, 44.2% of children are underweight while only 15.3% underweight in the richest families in 2014. These gaps between the poorest and the richest families in producing underweight children remain in the neighborhood of about 30% in all four surveys considered in this study. In rural families, 34.5% have underweight children compared to 23% in urban areas. Apparently, the gaps between urban and rural underweight children are increasing slightly over the years. As expected, there are more underweight children in families with no media access (38.7% in 2014) as opposed to families that have media access (26.7% in 2014) over the years and the percentages of underweight children are declining in all families (with media and without media); however, the rates of decrease in both groups of families are about the same rate which states that the influence of media is close to nothing in promoting children's nutritional health. Mother's age at birth happens to be a non-significant variable in this case. The gender of children shows the insignificant association with the levels of underweight (*p*- value is 0.879). Children are affected by their mother's height: 45.6% of children are underweight whose mothers are less than 1.45 meters, whereas 29.6% are underweight whose mother's height is more than or equal to 1.45 meters. A breastfeeding duration of 24-35 months results in 40.4% of underweight children; however, only 24.2% of children are underweight whose breastfeeding duration is more than 35 months. The pregnant mothers who visited the clinic more than three times for antenatal care had underweight babies in 22.9% of the cases, whereas 41.5% of children were underweight in the case of mothers who did not visit the doctor during the pregnancy. Over the years, the impact of ANC visits on children's weight is appeared to be increasing as the gap between a no visit and a more than 3 visits was about 9% in 2004 and about 19% in 2014. In the case of the mother's BMI, underweight mothers give birth to 45.9% of underweight children and 30.6% of children are underweight for normal mothers, whereas the rate is 19.5% for overweight mothers.

To sum up, bivariate analysis show that birth spacing, mother's education, wealth index, access to media, ANC visit, breastfeeding duration and mother's BMI significantly influence both stunting and underweight of children.

3.3 Regression Analysis

There are some factors that may potentially confound the relationship between the birth interval and the physical growth of a young child [29]. By including the confounding variables in the multiple logistic regression analysis we get the adjusted odds ratio which takes into account the effect due to all the additional variables included in the analysis. Birth-specific confounders include the age of the mother at birth, the sex of the child, the use of health care services, breastfeeding, the size of a child at birth, the mother's height, the mother's BMI, the region etc. Mother-specific confounders include the socio-economic status and the type of area of residence. The outcome of the analysis (Table 5) shows that the odds ratio (OR) has been statistically adjusted to incorporate the effect of the physical growth (stunting and underweight) of the children.

In Model I, the adjusted odds ratio (Adjusted OR) for the birth interval 24-59 in 2014 is found to be 1.126 with a 95% confidence interval (CI) (0.994, 1.468). This effect is statistically significant at a 10% level of significance, which implies that the prevalence of stunting is increased by 12.6% for those children who belong to the birth interval 24-59 months, compared to children having a birth interval of 60 months or more. These rates were 17.4%, 23.6% and 58.9% in 2011, 2007 and 2004 respectively. The rate of stunting increases dramatically with the decrease of the birth interval. In the case of a birth interval less than 24 months, the rate of stunting is increased to 32.2% (Adjusted OR: 1.322; CI (0.985, 2.174)), compared to the longest birth spacing (60 months or higher). Also, this effect is statistically significant at a 10% level of significance. These rates were 54.7%, 54.8% and 72.2% in 2011, 2007 and 2004 respectively. Overall, it can be concluded that the rate of increase in stunting in groups with less than 24 months birth interval compared to both the 24-59 months and 60+ months group is decreasing over the years.

In Model II, the adjusted odds ratio (Adjusted OR) was 0.991 for a birth interval of 24-59 months, with a 95% confidence interval (CI) (0.719, 1.368), which is statistically not significant at a 10% level of significance, stating that the percentage of underweight children is increased by 0.9% for the children having a birth interval of 24-59 months compared to the longest birth spacing group. These rates remain almost the same in 2007 and 2011 surveys; however, the rate has gone down significantly compare to the 2004 results where 29.7% more children were underweight with a 5% level of significance compare to the reference group (60 months or higher birth interval). Like stunting, the rate of underweight increases substantially (46.3%) in the case of a birth interval less than 24 months, compared to a birth interval 60 months or higher; however, this effect is happened to statistically insignificant. These rates were 30.8%, 33.8% and 53% in 2011, 2007 and 2004 respectively.

Logistic regression results indicate that in 2014 the prevalence of stunting is increased by 32.2% for those children who belong to the birth interval of less than 24 months, compared to children having a birth interval of 60 months or more. Likewise, the rate of underweight increases substantially (46.3%) in the case of a birth interval less than 24 months, compared to a birth interval of 60 months or higher.

The error bar chart (Fig. 2 and Fig. 3) indicates a steady decrease in the increase of prevalence rate over the years (2004-2014) for both birth intervals (24-59 months and <24 months) both in stunting and underweight category compared to birth intervals of more than 60 months; however, as expected the gaps in prevalence of underweight between the 24-59 months group and >60 months group have been decreasing faster than that between the <24 months and >60 months group. It can be concluded that birth spacing of less than 24 months remains as an important factor impacting physical growth of children under age 5 in Bangladesh. Thus, a special focus has been given to the children with the birth interval less than 24 months in time series analysis.

3.4 Time Series Analysis

Exponential Smoothing of time series has been used as the forecasting method. Exponential Smoothing assigns exponentially decreasing weights for newest to oldest observations which assures that the older data receives less priority and the newer data is seen as more relevant and is assigned more weight. Moreover, this algorithm performs smoothing by detecting seasonality patterns and confidence intervals. Exponential smoothing is usually used to make short-term forecasts.

Time series analysis predicts that the prevalence of stunting is expected to be increased by 10% in 2020 (about 22% decrease compared to the 2014 rate) for those children who will belong to the birth interval of less than 24 months compared to children having a birth interval of 60 months or more (Fig. 4). Similarly, (Fig. 5) time series graph predicts an increase of about 38% in the prevalence of underweight in 2020 for children with less than 24 months of birth spacing compared to the base group (>60 months of birth spacing).

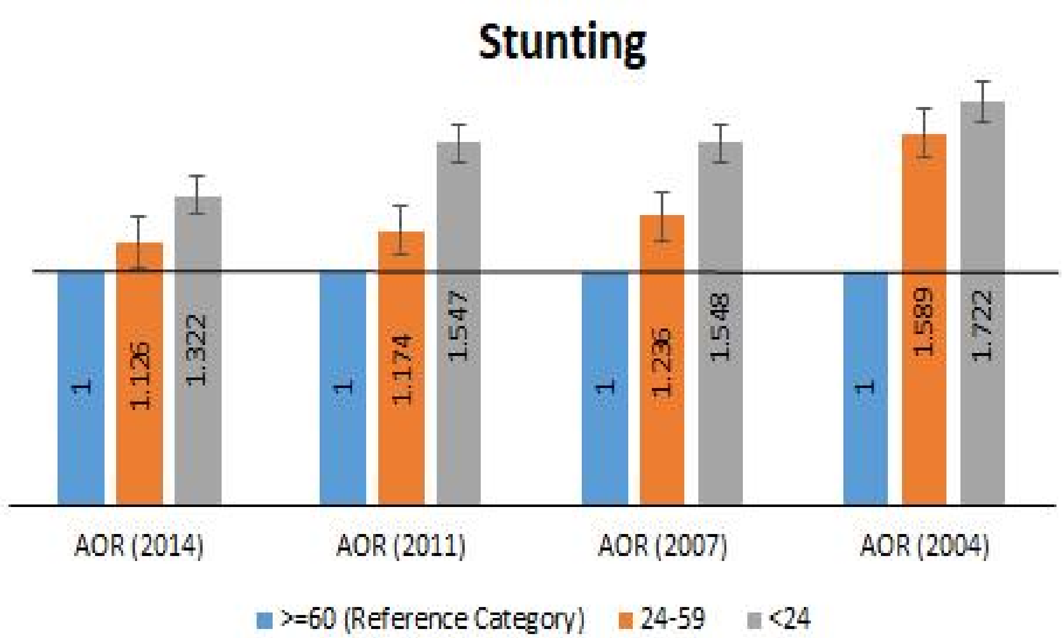

Fig. 2. Adjusted odds ratio of stunted children between 2004 and 2014

Table 4. Association between selected variables and underweight with *p* values

Variables with Characteristics	Weighting Status							
	2004		2007		2011		2014	
	Underweighted	*p* value	Underweighted	*p* value	Underweighted	*p* value	Underweighted	*p* value
Preceding birth interval								
<24 months	53.3%	<0.001	47.7%	0.015	43.6%	<0.001	40.0%	0.025
24-59 months	48.0%		42.7%		39.0%		31.5%	
>=60 months	37.3%		38.1%		31.8%		30.1%	
Mother's education								
No Education	53.1%	<0.001	46.7%	<0.001	48.7%	<0.001	42.0%	<0.001
Primary	46.1%		45.5%		40.8%		35.4%	
Secondary	39.0%		34.0%		27.6%		26.7%	
Higher	18.0%		20.0%		16.5%		17.6%	
Child age								
0-11 months	20.2%	<0.001	27.9%	<0.001	20.0%	<0.001	19.2%	<0.001
12-23 months	58.6%		38.7%		35.6%		37.2%	
24-35 months	55.4%		45.3%		38.8%		38.3%	
36-47 months	48.0%		47.2%		41.4%			
48-59 months	45.0%		44.8%		41.5%			
Wealth index								
Poorest	56.3%	<0.001	49.8%	<0.001	48.8%	<0.001	44.2%	<0.001
Poorer	52.5%		43.9%		40.7%		36.8%	
Middle	44.3%		41.9%		34.3%		30.3%	
Richer	40.5%		36.9%		26.3%		25.4%	
Richest	27.2%		24.6%		20.8%		15.3%	
Place of residence								
Urban	39.9%	0.007	32.2%	<0.001	27.0%	<0.001	23.0%	<0.001
Rural	46.4%		41.9%		37.1%		34.5%	
Access to media								
No	53.3%	<0.001	44.8%	<0.001	44.2%	<0.001	38.7%	<0.001
Yes	41.4%		37.0%		29.6%		26.7%	
Mother's age								
Below 18 years	44.7%	0.134	39.5%	0.274	34.3%	0.033	32.7%	0.847
>=18 years	48.6%		43.2%		39.3%		31.8%	

Variables with Characteristics	Weighting Status							
	2004		2007		2011		2014	
	Underweighted	***p* value**	**Underweighted**	***p* value**	**Underweighted**	***p* value**	**Underweighted**	***p* value**
Child sex								
Male	44.4%	0.358	38.8%	0.231	33.0%	0.009	31.6%	0.879
Female	45.8%		40.9%		36.6%		32.0%	
Mother's height								
<1.45 meters	42.0%	<0.001	37.0%	<0.001	32.5%	<0.001	45.6%	<0.001
>=1.45 meters	61.4%		56.8%		50.9%		29.6%	
Breast feeding duration								
<24 months	39.9%	<0.001	33.7%	<0.001	28.6%	<0.001	28.5%	<0.001
24-35 months	52.6%		44.9%		40.1%		40.4%	
>=36 months	48.5%		52.2%		44.0%		24.2%	
ANC visit								
No Visit	31.7%	<0.001	26.2%	<0.001	23.6%	<0.001	41.5%	<0.001
1-3 Times Visit	43.0%		38.6%		33.1%		31.9%	
>=4 Times Visit	52.1%		48.5%		44.3%		22.9%	
Mother's BMI								
Underweight	56.6%	<0.001	49.9%	<0.001	48.0%	<0.001	45.9%	<0.001
Normal	39.9%		37.4%		32.0%		30.6%	
Overweight	22.3%		18.2%		18.6%		22.7%	
Obese	14.2%		11.4%		18.7%		23.8%	

Table 5. Odds ratios and adjusted odds ratios (95% CI) of explanatory variables for the occurrence of stunting (Model I) and underweight (Model II) obtained from logistic regression model

2014				
Characteristics	**Model I (Stunting)**		**Model II (Underweight)**	
Preceding birth interval	**OR (95% CI)**	**Adjusted OR (95% CI)**	**OR (95% CI)**	**Adjusted OR (95% CI)**
>=60 months (Ref)	1.00	1.00	1.00	1.00
24-59 months	1.138 (1.092, 1.434)***	1.126 (0.994, 1.468)*	1.070 (1.014, 1.358)***	0.991 (0.719, 1.368)
<24 months	1.408 (1.081, 2.128)***	1.322 (0.985, 2.174)*	1.552 (1.011, 2.385)***	1.463 (0.880, 2.432)
2011				
Characteristics	**Model I (Stunting)**		**Model II (Underweight)**	
Preceding birth interval	**OR (95% CI)**	**Adjusted OR (95% CI)**	**OR (95% CI)**	**Adjusted OR (95% CI)**
>=60 months (Ref)	1.00	1.00	1.00	1.00
24-59 months	1.444 (1.242, 1.677)***	1.174 (0.997, 1.383)**	1.370 (1.176, 1.595)***	1.049 (0.871, 1.265)
<24 months	1.752 (1.379, 2.224)***	1.547 (1.147, 2.087)**	1.659 (1.300, 2.116)***	1.308 (0.951, 1.798)
2007				
Characteristics	**Model I (Stunting)**		**Model II (Underweight)**	
Preceding birth interval	**OR (95% CI)**	**Adjusted OR (95% CI)**	**OR (95% CI)**	**Adjusted OR (95% CI)**
>=60 months (Ref)	1.00	1.00	1.00	1.00
24-59 months	1.285 (1.042, 1.586)***	1.236 (0.937, 1.630)*	1.210 (1.004, 1.458)***	1.032 (0.823, 1.295)
<24 months	1.631 (1.211, 2.197)***	1.548 (1.038, 2.309)*	1.482 (1.130, 1.943)***	1.338 (0.922, 1.942)
2004				
Characteristics	**Model I (Stunting)**		**Model II (Underweight)**	
Preceding birth interval	**OR (95% CI)**	**Adjusted OR (95% CI)**	**OR (95% CI)**	**Adjusted OR (95% CI)**
>=60 months (Ref)	1.00	1.00	1.00	1.00
24-59 months	1.740 (1.437, 2.107)***	1.589 (1.255, 2.011)***	1.918 (1.478, 2.489)***	1.297 (1.001, 1.081)**
<24 months	1.901 (1.457, 2.480)***	1.722 (1.216, 2.440)***	1.555 (1.289, 1.875)***	1.530 (1.036, 1.624)**

*N.B.: *= p<0.1, **= p<0.05, ***= p<0.01*

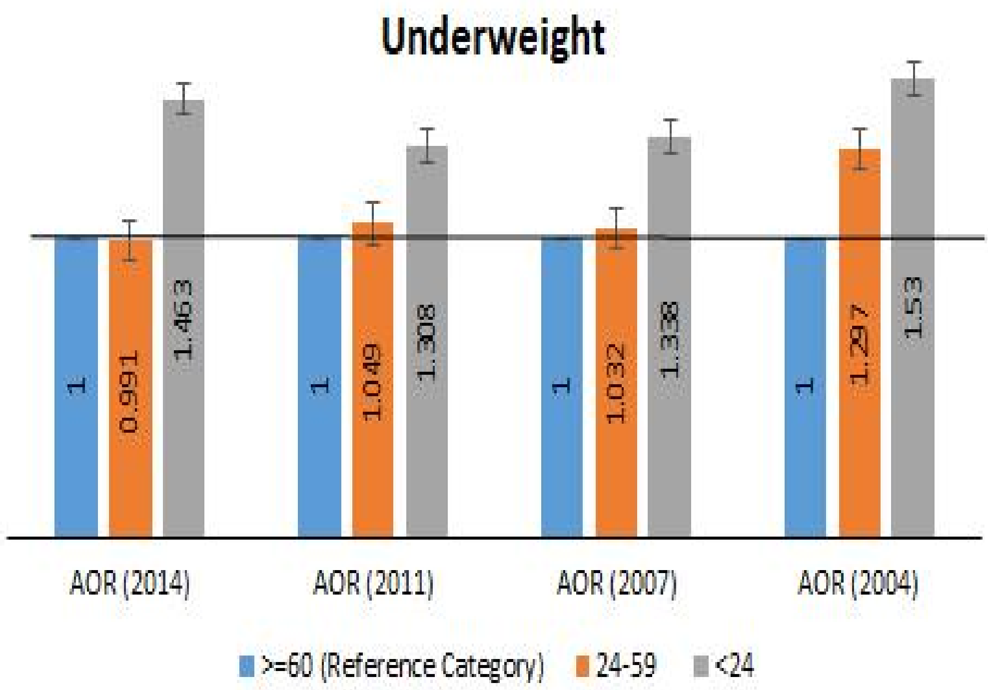

Fig. 3. Adjusted odds ratio of underweight children between 2004 and 2014

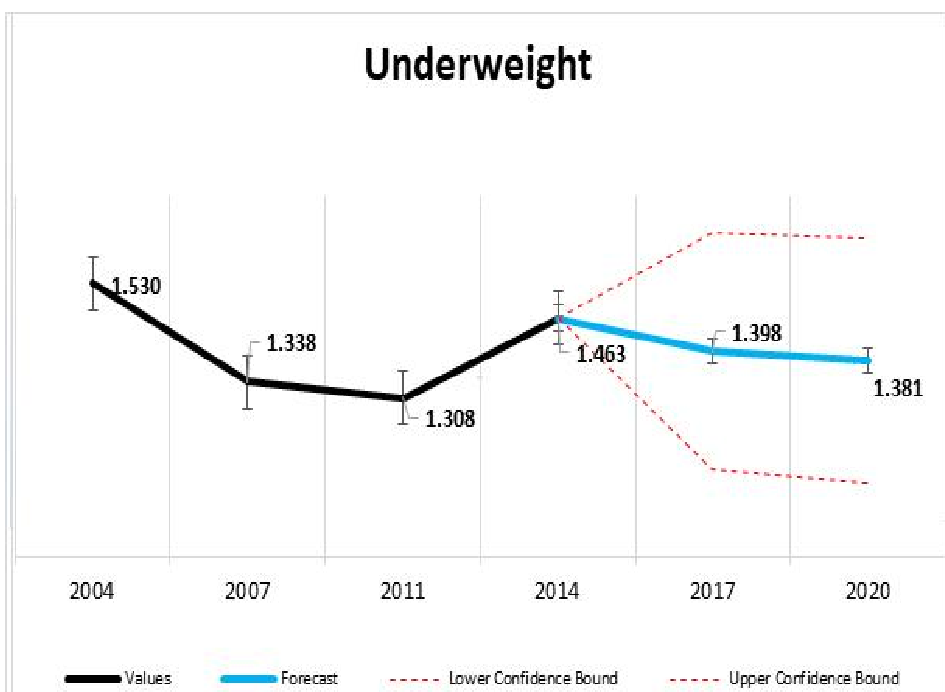

Fig. 4. Forecasting of adjusted odds ratio of stunted children for less than 24 months birth interval compared to more than 60 Months

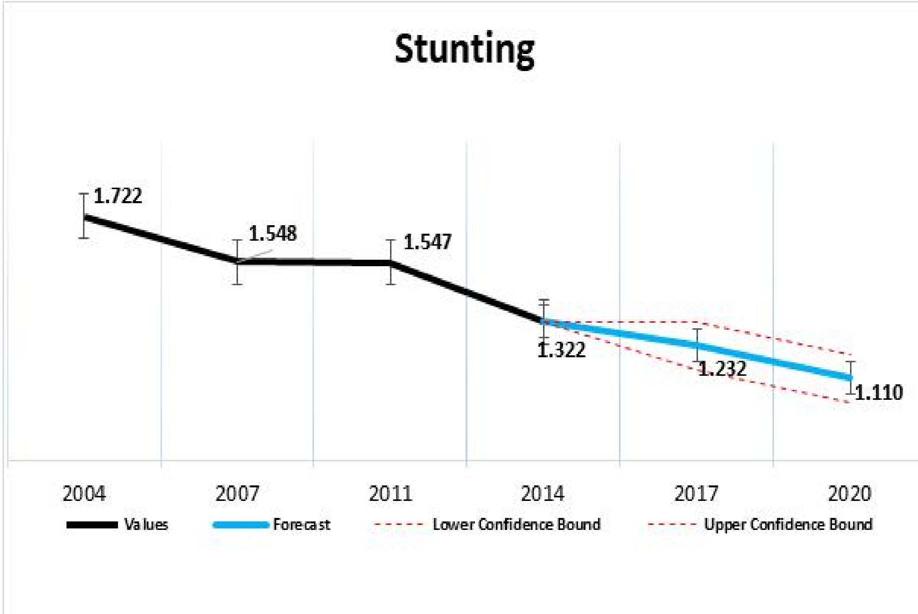

Fig. 5. Forecasting of adjusted odds ratio of underweight children for less than 24 months birth interval compared to More Than 60 Months

4. DISCUSSION

In the present study, a strong relationship between malnutrition (stunting and underweight) and the birth interval has been observed. Overall, the prevalence of stunting remained in around 39% from 2004 to 2011; however, an improvement is noticeable in the last two surveys (39.6 in 2011 to 33.7% in 2014). Multivariate analysis shows that preceding birth interval continues to be an important determinant for stunting and underweight. A birth interval of 24 months or less produce 32% more stunted children compare to the children whom born after a birth interval of 60 months or more. Even though, a significant improvement has been observed during the past 10 years more awareness has to be made so that a birth interval of at least two years is practiced. Mother's education, age, wealth index and ANC visit continue to be influential in determining the prevalence of stunting and underweight over the years. Even though about 1 in 3 child in Bangladesh is still underweight, the percentage of underweight children is going down almost linearly over the period of 10 years. The children with a birth interval of fewer than 24 months suffered more from different grades of malnutrition as compared to those with a birth interval of more than or equal to 60 months [30]. The prevalence of underweight in children with a birth interval fewer than 24 months was 46%, 30%, 34%, and 53% higher with a birth interval more than or equal to 60 months in 2014, 2011, 2007 and 2004 respectively.

5. CONCLUSION

From the above discussion, it is clear that children were at a higher risk of malnutrition when either previous or subsequent siblings were born within 24 months. So, it is expected that the additional benefits of birth spacing are likely to accrue. Physicians and family planning programs should be made aware of these benefits and counsel their patients accordingly.

One of the main advantages of this study is that it considers almost all possible concurrent determinants of short birth spacing and tries to visualize the relationship between birth spacing and physical growth. To understand those determinants, new programs could be introduced. Appropriate counseling to married couples of reproductive ages, about the importance of birth spacing, is needed.

The study concluded that there exists a mother's educational disparity in the incidence of malnutrition in children. Uneducated mothers should be the focus in policy formulation and child malnutrition elimination programs. The

Health, Nutrition, and Population Sector Program by the Government of Bangladesh should be expanded and specialized for uneducated, soon-to-be mothers.

DISCLAIMER

The products used for this research are commonly and predominantly use products in our area of research and country. There is absolutely no conflict of interest between the authors and producers of the products because we do not intend to use these products as an avenue for any litigation but for the advancement of knowledge. Also, the research was not funded by the producing company rather it was funded by personal efforts of the authors.

CONSENT

The written informed consent is obtained from the participants before participation in the study, and data collection was conducted confidentially.

ETHICAL APPROVAL

It is not applicable.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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