Title page

Title: Maternal high-risk fertility behavior and its association with chronic undernutrition among children under-5 in India, Bangladesh, and Nepal: do poor children have the higher risk?

Running head: High-risk fertility behavior and chronic undernutrition

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Key words: Fertility behaviors, mother's age at delivery, birth order, birth interval, South Asia

Number of Tables: 3; Number of Figures: 1; Main text (word count): 4,233; Abstract: 337

Abstract

Objectives: We aimed to examine (1) whether an association exists between maternal high-risk fertility behavior and chronic undernutrition among children under-5 and (2) exploring the relationship between poverty and high-risk fertility behavior and the relative roles they play as obstacles to reducing the risk of undernutrition among children

Methods: Analysis were based on response from married women aged 15 to 49 years living with at least one children under-5 years by considering three cross-sectional, nationally representative samples from India, Bangladesh, and Nepal.

Results: Maternal high-risk fertility behavior was associated with an increased risk of chronic undernutrition among children in India, Bangladesh and Nepal respectively. Multiple high-risk categories appeared to have more profound consequences on the outcome measured. Findings also demonstrated that for the risk of undernutrition, children among those mothers who were either poor or experienced high-risk fertility were not uniquely disadvantaged.

Conclusions: The results suggest that for the risk of chronic undernutrition, the negative effect of high-risk fertility behavior extends across all economic backgrounds and is not limited to children among those mothers who were either poor or experienced high-risk fertility.

Key words: Fertility behaviors, mother's age at delivery, birth order, birth interval, South Asia

Introduction

Despite economic growth, and a reduction in poverty over the past decade, chronic undernutrition among children under-5 is still rampant in South Asia (SA). Of the 175 million under-5 children, 45% are chronic undernourished, eclipsing even sub-Saharan Africa (SSA).¹ In India, Bangladesh, and Nepal, the proportion of chronic undernourished children is significantly higher than even the poorest countries of the SSA and are home to half of the world's undernourished children.¹ In 2012, the prevalence of child chronic undernutrition in India, Bangladesh, and Nepal were 48%, 43.2%, and 49.3% respectively.²

There is still not enough evidence and no clear assessment on why the rate of children undernutrition is so much higher in SA than anywhere in the world. While poverty is the main underlying cause of chronic undernutrition, the superior economic growth experienced by SA countries compared to those in SSA, has not translated to significant improvements in nutrition outcomes at a large. The child nutritional status continues to worsen in SA compared to SSA. The available evidence suggests a possible explanation for such high rate of undernutrition among children in SA as the 'Asian enigma'.³ These include: low status of women, lack of access to safe, clean drinking-water and basic sanitation, and rapid urbanization. Besides, other socio-economic factors including education have also some contribution to this difference but not as large as the others.⁴

Moreover there may be possibility on the effects of other bio-demographic factors such as high-risk fertility behavior defined as exposure of women to any of four demographic risks at their last

childbirth (age less than 18, more than three births, birth interval less than 24 months and age 35 or higher)⁵⁻⁷ for such higher rates of undernutrition among SA children. SA countries have higher proportions of teenage pregnancies, since early marriage is common and there is a family expectation to have a child soon after the marriage. In SA, nearly half (46%) of young women aged 20-24 years were married by their 18th birth day.⁸ Where as in SSA, nearly two out of five (37%) of young women aged 20-24 years were married by their 18th birthday.⁸ Within SA, teenage pregnancy rate is highest in Bangladesh (35%) followed by Nepal (21%), and India (15-21%).⁵ SA countries have also the higher parentage of birth with an interval of less than 24 months (26.6%) compared with SSA (19.9%).⁹

There is increasing evidences that various determinants of high-risk fertility behavior among SA women are associated with poor child nutritional outcomes. Investigators have documented association of child chronic undernutrition with short birth interval (<24 months)¹⁰⁻¹⁴ and with increasing birth order.¹⁴⁻¹⁷ In addition, investigators noted that women who get married and begin childbearing at a younger¹⁸⁻²⁰ or older age^{21, 22} are also more likely to have chronic undernourished children. Although such evidences supports the consideration of various exposure of high-risk fertility behavior as a high-priority maternal and child health concern within the region, no studies have assessed the relationship between combination of those exposure and major sources of child mortality. Generally, children may have greater probability of poor health outcomes if they are born to mothers who are too old or too young, if they are born after a short birth interval, or if they are of high birth order.²³ Therefore, analysis is needed for a clearer understanding of the separate and combined influences of maternal high-risk

fertility behavior and its association with child chronic undernutrition for the development of effective prevention programming for this region.

Moreover, the relationship between high-risk fertility behavior and child chronic undernutrition needs to be carefully examined in poorer settings because undernutrition are more common in those areas,^{15, 24-28} and such settings have also been associated with an increased risk of maternal high-risk fertility behavior.²⁹⁻³⁴ Women belonging to the poor household may be at a distinct disadvantage because an increased chance of high-risk fertility behavior^{29-33, 35-37} and impaired resources that can restrict education, job opportunities, proper housing, sanitation, food security, and higher level of depressive disorders³⁸ creating a favorable setting for child undernutrition. Therefore, a comparative assessment is needed to examine whether poverty, an indicator of economic status that has an independent association with maternal fertility behavior and/or risk of chronic undernutrition among children, plays a role in mediating the association between maternal high-risk fertility behavior and nutritional disadvantages among children.

To date, no research has been conducted in resource-poor settings to examine whether the children from poor households and whose mothers have experienced high-risk fertility behavior have a unique risk of chronic undernutrition. In this study, we aimed to further this important area of inquiry by (1) addressing whether an association exists between maternal high-risk fertility behaviors and chronic undernutrition among children under-5 and (2) exploring the relationship between poverty and high-risk fertility behaviors and the relative roles they play as obstacles to reducing the risk of child chronic undernutrition in three nationally representative samples from India, Bangladesh, and Nepal where chronic undernutrition is epidemic.

Methods

Data sources

The data for our study were from the 2005-2006 Indian National Family Health Survey (NFHS-3), 2011 Bangladesh Demographic Health Survey (BDHS), and 2011 Nepal Demographic Health Survey (NDHS). NFHS-3/BDHS/NDHS are nationally-representative household surveys conducted by ICF Macro/MEASURE DHS on behalf of Ministries of Health (MoH) with financial support from the United States Agency for International Development.³⁹ NFHS-3/BDHS/NDHS were designed to collect information on population health, nutrition, and fertility behaviors.⁵⁻⁷ NFHS-3/BDHS/NDHS used a probability-based multi-stage cluster sampling procedure. First, sampling frames were developed on the basis of non-overlapping units of geography (typically census enumeration areas) that cover the entire country. These geographic areas were identified as the primary sample units (PSU); samples of which were selected with probability proportional to population size. Next, within the selected PSU a list of all households was generated through field visits and a fixed proportion of households were selected using systematic sampling.⁵⁻⁷ Within selected households, all ever-married women aged 15–49 years were invited for interviews. The target number of women in this age group per PSU was typically 20–25 in urban areas and 30–40 in rural areas.

In 2005-2006 NFHS-3, of the 131,596 ever-married women 15 to 49 years old deemed eligible to complete the women's questionnaire on maternal and child health behaviors and outcomes, 124,385 did so (response rate=94.5%). The 2011 BDHS successfully interviewed 17,882 married

women, and the 2011 NDHS interviewed 12,674 married women. The overall response rate in 2011 BDHS and 2011 NDHS were 98.1% respectively. The questionnaires of NFHS-3/BDHS/NDHS were drafted in English and then translated into the national language of each specific country. In our analyses, we included only married women aged 15 to 49 years living with their last born children under-5 years of age (NFHS-3: n=29,713; BDHS: n=6,462; NDHS: n=1,829; for details on sample selection, see Table 1).

Measures

Child chronic undernutrition (stunting) was the outcome of this study. We classified children as chronically undernourished (stunted) if their height-for-age z score was 2 standard deviations below the median as per World Health Organization's reference population. Stunting was chosen because it reflects prolonged nutritional deficiency, on the other hand wasting or acute malnutrition is usually dependent on a recent set of events such as illness or food shortage. Therefore, chronic undernutrition, which is related to a nutritional deficiency over time, was determined to be more appropriate when defining exposure to high-risk fertility behavior as one or multiple events. We excluded the anthropometric observations outside the range +6 to -6 Z-scores.

Binary indicator of chronic undernutrition was used because their average values are easier to elucidate intuitively than continuous value. All NFHS-3/BDHS/NDHS studies stated that enumerators, including those collecting anthropometric data, received observed training and testing that included lecture and practical exercise components. Teams also often included personnel with advanced medical training.⁵⁻⁷

Maternal high-risk fertility behavior was the exposure of interest in this study. We applied the definition of “high-risk fertility behavior” adopted by the Demographic and Health Surveys.⁵⁻⁷ We considered three parameters: maternal age at the time of delivery, birth order, and birth interval to define the high-risk fertility behavior. Three exposure variables were defined for this analysis: 1) any high-risk fertility behavior versus none; 2) exposure to different categories of high-risk fertility behavior versus none (defined as exposure to single high-risk category versus none and multiple high-risk categories versus none); and 3) the specific types of high-risk fertility behavior versus none. The presence of any of the four conditions was termed as a single high-risk fertility behavior: i) mothers aged less than 18 years at the time of delivery; ii) mothers aged over 34 years at the time of delivery; iii) latest child born less than 24 months after the previous birth; and iv) latest child of order 3 or higher. Combinations of two or more single conditions were referred to as multiple high-risk categories.

This study also included the following maternal and child socio-demographic and health-related factors: respondents' education, age, sex, decision-making autonomy, employment status, place of residence, family size, height, body mass index (BMI), whether received ANC or not, pregnancy intention, presence of children younger than 2 years, initiation of breast feeding, whether children under-5 years were suffering from illness (1; combined fever, acute respiratory illness [ARI], and diarrhea) in the 2 weeks prior to the survey, and child gender. Information on diarrhea, ARI (defined as reports of cough accompanied by short, rapid breathing), and fever was gathered from women's NFHS-3/BDHS/NDHS questionnaire responses.⁵⁻⁷

We utilized the household wealth index as a surrogate indicator to estimate the poverty–wealth status of households. Principal component analysis was used to develop the NFHS-3/BDHS/NDHS wealth index by utilizing data on a household’s ownership of selected assets, such as televisions and bicycles, construction materials, and types of drinking water access and sanitation facilities.⁵⁻⁷ Each household was then weighted by the number of household members, and was divided into five groups: the first quintile (poorest), the second quintile (poorer), the third quintile (middle class), the fourth quintile (richer) and the fifth quintile (richest).⁵⁻⁷ We classified women as “poor” if they were belonged to the first wealth quintile and women belonging to any other wealth quintile were appointed as “non-poor”. We restricted the concept of “poor” to the very poorest in order to see more starkly the effect of being both poor and subject to high-risk fertility behavior.

Analytical methods

We run descriptive analyses first, to provide general information on the characteristics of the sample. We then created three fully adjusted logistic regression models to analyze our binary outcome variable for each country, with each model containing a different fertility risk predictor (any versus no risk; separate effects of single high-risk, multiple high-risk versus no risk; specific types of high-risk versus no risk). To see whether women either in poverty and high-risk categories were unique for the risk of child chronic undernutrition, we conducted logistic regression analyses to examine the adjusted association between high-risk fertility behavior and child undernutrition after stratification by household wealth level.

Since the size of the Indian population is larger than both the Bangladesh and Nepal populations and also the size of India also has several diverse regions, we therefore additionally conducted logistic regression analyses to examine the adjusted association between chronic undernutrition among children and high-risk fertility behavior after stratification by Indian state. We entered all the covariates simultaneously into the multiple regression models. Variance inflation factors (VIFs) was used to check the problem of multicollinearity and found no problem in our models. Significance for all analyses was set at $p < 0.05$. The proportion of child under chronic nutrition attributable to maternal high-risk fertility behavior was estimated from the frequency of any high-risk behavior and the odds ratios obtained in the multivariate model, using the following expression: $(p * [AOR - 1] / 1 + p * [AOR - 1]) * 100$, where p = prevalence of any high-risk fertility behavior and AOR = associated outcome effect size.⁴⁰ Sample weights were used for all analyses, and statistical testing was performed in Stata for Windows (Release 13.0, Stata Corporation, College Station, TX, USA).

Ethical considerations

All NFHS-3/BDHS/NDHS follow a standard protocol and were given blanket approval by the ORC Macro Institutional Review Board. Each survey that deviated substantially from the standard protocol was reviewed and approved separately. Each survey also received approval from an in-country ethical review board. Informed consent was obtained from each respondent for this survey. This study was considered to be exempt from full review as it was based on an anonymous public use of a secondary data set with no identifiable information on the survey participants.

Results

Table 2 shows the descriptive statistics of the participants. Key descriptive statistics highlighted some of the major differences between the countries. In the countries studied, a large proportion of mothers had no education; in India and Nepal the proportion was much lower than Bangladesh. More than two-thirds of the mothers lived in rural areas and more than one quarter of the women had no decision-making autonomy in all these countries. Regarding their occupation status, 30.0% and 57.3% of the women in India and Nepal had jobs; in Bangladesh the proportion was much lower. The proportion of underweight women (BMI <18.5) ranged from 19.4% to 38.3%, but was markedly higher in India.

Receiving ANC varied among countries. In Nepal more than 83% of women received ANC, whereas the corresponding figure for India and Bangladesh was 76.9% and 64.6%. In all these 3 countries, a large proportion of mothers had delivered normal birth and approximately one quarter of the births were unintended. Among children aged 0–59 months, the prevalence of stunting (HAZ less than -2 SD) was highest in India and was notably higher in all 3 countries in the SA region. In the countries studied, the proportion of women with low birth weight baby was higher in India, followed by Nepal and Bangladesh. In all these three countries, more than half of the mothers did not initiate early breastfeeding; in India the proportion was much higher.

In these 3 countries, among the latest children born in the five years preceding the survey, the prevalence of any risky fertility behavior among women was very high. The proportion of any risk categories ranged from 38.3% in Nepal and 44.9% in India. Approximately 32.0% of women

were in a single risk category in Bangladesh whereas this was reported by 34.4% and 27.2% of the mothers in India and Nepal. Regarding multiple risk categories, the prevalence ranged from 9.1% in Bangladesh to 11% in Nepal. The most common single risk category in Bangladesh were mothers' younger age at birth (younger than 18 years) followed by a birth order of three or higher. In India and Nepal the most common single risk category was birth order three or higher followed by preceding birth interval less than 24 months. The most common multiple risk categories in India and Bangladesh were preceding birth interval less than 24 months and birth order three or higher, whereas in Nepal the most common multiple risk categories were mothers' age at birth more than 34 years and birth order three or more.

Figure 1 show the prevalence of undernutrition according to household wealth by countries. In the countries studied, the prevalence of undernutrition was higher among the poor mothers compared with non-poor mothers and ranged from 51.5% in Bangladesh and 57.3% in India. Supplementary Table 1 shows the prevalence of chronic undernutrition among children under-5 according to Indian State. The proportion of undernutrition was lower in Goa and Kerala compared with other Indian states.

Supplementary Figure 1 shows the association between maternal high-risk fertility behavior with chronic undernutrition among children by Indian state. Maternal high-risk fertility behavior was associated with higher likelihood of having chronic undernourished children in Punjab, Rajasthan, Assam, West Bengal, Jharkhand, Orissa, Madhya Pradesh, Gujarat, Maharashtra, Andhra Pradesh, and Karnataka, respectively.

Table 3 shows the association between maternal risky fertility behavior with child chronic undernutrition. After adjusting all relevant covariates, maternal risky fertility behavior was associated with 29%, 25%, and 40% higher likelihood of having chronic undernourished children in India, Bangladesh, and Nepal respectively. Significant association was observed between single risk category and child undernutrition in India (adjusted odds ratio [AOR], 1.26; 95% CI, 1.17-1.35) and Bangladesh (AOR, 1.19; 95% CI, 1.04-1.36). Relative to women who were not fall in any risk categories, women who fall in multiple risk categories had 1.53 (95% CI, 1.35-1.74), 1.73 (95% CI, 1.34- 2.23), and 1.48 (95% CI, 1.06-1.79) times higher risk of having undernourished children in India, Bangladesh, and Nepal respectively. Regarding specific type of risk categories, mothers' younger age at birth only (younger than 18 years) or mothers younger age at birth, preceding birth interval less than 24 months or birth order three or higher, and mothers having birth order three or higher and birth interval less than 24 months were found to be associated with likelihood of undernutrition among children in these 3 countries. Significant association was observed between maternal ages at birth over 34 years, birth order three or higher or having birth interval less than 24 months and the likelihood of child undernutrition in India and Bangladesh. In addition, significant association was observed between preceding birth interval less than 24 months and the likelihood of undernutrition in India and Nepal.

Table 4 shows association between maternal high-risk fertility behavior with child chronic undernutrition by wealth. Non-poor women who were fall in any high risk-categories were more likely to report of having undernourished children in India (AOR, 1.38, 95 % CI,1.30–1.47), Bangladesh (AOR, 1.28, 95 % CI,1.10–1.50), and Nepal (AOR, 1.62, 95 % CI,1.20–2.18) than those women who did not fall in any high risk categories and were non-poor. Poor women who were fall in any high risk-categories were significantly more likely to report of having

undernourished children only in India than the poor women who did not fall in any high risk-categories. In all the three countries, multiple high-risk categories were found to be associated with the increased risk of child undernutrition for both poor and non-poor mothers. In addition, significant association was found between single high-risk category and the increased risk of child undernutrition among poor and non-poor mothers in India, whereas non-poor women who were fall in any single risk-category were more likely to report of having undernourished children in Bangladesh.

Population-attributable risk fractions

Calculations based on population-attributable risk estimates suggest that avoiding maternal high-risk fertility behavior could potentially reduce child chronic undernutrition by 11.5%, 9.2%, and 13.3% in India, Bangladesh, and Nepal respectively.

Discussion

To best our knowledge, this is the first study of the relation between separate and combined influences of high-risk fertility behavior and chronic undernutrition among children under-5 in SA region by considering three countries India, Bangladesh, and Nepal. Findings from these three large representative surveys indicate that over 44%, 40%, and 38% of married women in India, Bangladesh, and Nepal respectively who were living with at least one children under-5 were in at least one of the high-risk categories of fertility behavior. This extremely high

prevalence rate confirms that high-risk fertility behaviors are alarming common place in these impoverished SA nations, potentially affecting the health of a majority of Indian, Bangladeshi, and Nepalese women.

Generally, women in Muslim societies and communities face gender-based inequalities associated with the so-called “patriarchal gender system.”⁴¹ However, this study indicates 10-15% higher education of Bangladeshi women where Islam is the largest religion than Nepalese or Indian where Hinduism is the major religion, and more maternal autonomy in decision-making as well. The possible explanation is that, although India is dominated by the Hindu faith and Bangladesh is Muslim, however India is a nation split by castes and religions and there change comes slowly for religious diversity in India. An additional analysis was performed in our study to support this hypothesis, and Jain and Christian women in India have higher level of literacy and decision making autonomy compared to other religions.

This study also demonstrated that there are variations in the prevalence of undernutrition within India; the prevalence of undernutrition was found to be higher in the Central and East Indian state such as in Bihar and Uttar Pradesh where as the prevalence is lower in the states which are located in the coastal area. The possible explanation of such higher rate of undernutrition is due to low consumption of meat and fish in Bihar and Uttar Pradesh. In Bihar and Uttar Pradesh majority of the population are Hindus and vegetarian whereas in Goa and Kerala, while still mainly Hindu, has a relatively large proportion of people are Muslims and Christians and have the highest record of chicken/meat/fish consumption; fish consumption especially is particularly noteworthy in these states for a long time.⁴²

This study further reveals an elevated risk of chronic undernutrition among children of mothers who were in at least one of the high-risk categories of fertility behavior in India, Bangladesh, and Nepal respectively. Our findings of the association between maternal high-risk fertility behavior and child chronic undernutrition strongly suggest that high-risk fertility behavior threatens not only the health and well-being of women but also that of their young children. Importantly, because the present analyses were adjusted for potential confounders, these effects persist after consideration of demographic characteristics, multiple domains of socioeconomic status, household characteristics, and child characteristics that are strong confounders of fertility behavior and chronic undernourishment.

Our findings of the association between maternal high-risk fertility behavior and chronic undernutrition among children build on previous work that demonstrates a range of negative health consequences of certain fertility behavior on women⁴³⁻⁵⁷ and children¹⁰⁻²². Currently identified associations of maternal high-risk fertility behavior with childhood undernutrition provide a critical context for the elevated rates of infant and early childhood deaths demonstrated in prior work among women who are in at least one of the high-risk categories of fertility behavior⁴⁸⁻⁵¹ (ie, the currently documented increased rates of chronic undernutrition likely relate to increased risk of child death).

The mechanisms underpinning the association of maternal high-risk fertility behavior with undernutrition among children could be related to social and health related vulnerabilities among mothers who were in at least one of the high-risk categories of fertility behavior, including increased rates of poverty, maternal depression, and malnutrition.^{29-30, 32-33, 44-45, 52} Biological

vulnerability for adverse child nutritional outcome of early or too late motherhood, short birth interval or high birth order may also persist through pregnancy-induced hypertension,⁵³⁻⁵⁵ intra-uterine growth retardation,⁵⁶ congenital abnormalities,⁵⁷ iron-deficiency anemia,⁵⁸ prematurity and by competition for scarce nutrients between the mother and fetus.⁵⁵ Moreover, the observed association between fertility behavior and child nutritional outcome could be explained by the inadequate feeding practices, inadequate access to health care viz., incomplete infant vaccination schedules, lower use of ANC, skilled delivery care or through increased exposure to infectious pathogens.^{20,52, 59-60} Correlating with these findings, is also linked with poor maternal health outcomes, including pregnancy complications and maternal mortality, which in turn increase the likelihood of poor infant and child health outcomes.^{52, 59-60}

Another new important finding is that multiple high-risk categories appeared to have more profound consequences on the outcome that was measured. There seems to be a dose-response relationship observed between the types of high-risk fertility behavior and child chronic undernutrition. This is in line with previous observations according to which more victimization predicts higher levels of depressive symptoms, higher levels of biological vulnerability, receiving inappropriate preventive and curative services, and inadequate feeding practices,^{60,61} which may in turn facilitate child chronic undernutrition.

The findings also demonstrated that for the risk of chronic undernutrition, children among those mothers who were either poor and who were in at least one of the high-risk categories were not more uniquely disadvantaged. Therefore, it is the experience of maternal fertility behavior per se that disadvantages child nutritional outcome, whereas poverty does not uniquely disadvantage

the nutritional status of children among women who are in at least one of the high-risk categories. In fact, for chronic undernutrition single or multiple high-risk categories in the three countries under studied significantly affects children among women who are “wealthy” more than it does women who are “poor”. The importance of this finding therefore needs to be underscored. When the experience of high-risk fertility behavior adversely impacts a children’s risk of undernutrition, it does so whether the children is of a low economic status or not. For the risk of child undernutrition, the negative effect of high-risk fertility behavior extends across all economic backgrounds and is not limited to children among those mothers who were either poor or experienced high-risk fertility.

The strengths of the present study are: 1) This study used data of nationally representative sample of married women aged 15 to 49 years living with their last born children covering both rural and urban areas with a large number of subjects (NFHS-3: n=29,713; BDHS: n=6,462; NDHS: n=1,829), therefore the results represent the Indian, Bangladeshi, and Nepalese nationwide population; 2) The subjects were evaluated by interviewers and biomarker staffs (health technicians or nurses), who visited, interviewed, and collected data at households of the subjects; 3) A high participation rate was achieved through rigorous training of field staff and close supervision of the fieldwork, which provided the study with good statistical power

We note some important caveats to the findings presented here. First, our exposure variables were based on self-report, which is vulnerable to social desirability and recall biases. However, in order to avoid such biases, analyses were restricted to women who were living with their last children born in the five years preceding the survey. Second, analyses are cross sectional and causality cannot be assumed; however, as age at birth and birth interval occurred before the

assessed outcome, ordering of this exposure relative to child health events can be assumed. Nonetheless, prospective investigation is needed to better evaluate the effects of maternal high-risk fertility behavior on child health outcomes. Third, birth weight data were not available in BDHS survey. To extend assessment of infant birth weight, maternal reports of relative infant size at birth were included; this measure has questionable reliability and validity. Fourth, we used anthropometric method (height-for-age z score) to measure the nutritional status among the children. Although several studies have reported reliability scores of height-for-age z score,^{62,63} however, to obtain precise and accurate estimate the measurement of laboratory assessment are necessary. However because the subjects were a large number of people in communities and there is lack of trained personal and facilities, DHS/NFHS avoided to perform laboratory assessment. Fifth, although availability of food and custom are important determinants of undernutrition,^{64, 65} information on these variables was not available from DHS/NFHS. Several countries in South Asia such as Bangladesh, India and Nepal, although a variety of animal foods are used by economically privileged people, for a large section of the population animal foods do not constitute part of their diet due to economic reasons. In Nepal meat is either prohibitively expensive or not eaten for religious reasons. Most Nepalese are therefore restricted to a vegetarian diet for financial reasons. Therefore their diet is lack of sulfur amino acid which plays essential for human nutrition.⁶⁶ However, because the demonstrated associations between high-risk fertility behavior and child chronic undernutrition were so strong, it is unlikely that adding the variables food availability and custom into the model would result in an insignificant link between predicting probability of chronic undernutrition among children and maternal high-risk fertility behavior.

Finally, the study can be criticized for using an indirect measure of household wealth. However, because of the fact that in developing countries like Bangladesh it is hard to obtain reliable income and expenditure data, an asset-based index is generally considered a good proxy for household wealth status.

In spite of these limitations, our study brings to light important information that could serve as a basis to reduce the risk of child chronic undernutrition among women in SA region. Our results may also be relevant in other resource-limited settings where child undernutrition is common, and they may be of interest to clinicians assessing children with problems related to nutritional status.

Conclusions

High-risk fertility behaviors are shockingly frequent practices among women in SA region, which likely affects the health of their children. A woman's high-risk of fertility behavior is an important risk marker for the increased risk of undernutrition among children under-5. The results suggest that women who were from low economic strata and experienced high-risk fertility behavior were not unique in their child nutritional disadvantages. The results suggest that for the risk of chronic undernutrition, the negative effect of high-risk fertility behavior extends across all economic backgrounds and is not limited to children among those mothers who were either poor or experienced high-risk fertility. Our findings underscore the calls for avoiding high-risk fertility behavior largely in the form of short birth spacing, higher number of total live births,

and too early or too late childbearing patterns to reduce the risk of chronic undernutrition among children. Investigation of the causal link between high-risk fertility behavior and child nutritional outcome will be critical to developing interventions to improve child nutritional status, which is a public health research priority.

Competing interests: The authors declare that they have no competing interests.

Author Contributions: MR had full access to all of the data in the study and takes responsibility for the integrity of the data and the accuracy of the data analysis. *Study concept and design:* MR; *Acquisition of data:* MR; *Analysis and interpretation of data:* MR; *Drafting of the manuscript:* MR; *Critical revision of the manuscript for important intellectual content:* MR, SEH, MSZ, MJI, MMR, MA, MNH, AZI, MDH, MGM; *Statistical analysis:* MR. All authors commented on and approved the final draft.

Sources of Funding No external funding sources were provided for this study.

Acknowledgements We are grateful to the MEASURE DHS for providing us with the data set. In addition, we would like to acknowledge all individuals and institutions in Bangladesh involved in implementing the BDHS 2007.

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Table 1 Data cleaning and sample sizes

Data cleaning	India	Bangladesh	Nepal
Ever married women deemed eligible to participate	131,596	18,222	12,918
Declined to participate	-7,211	-340	-244
Had no child or having children ≥ 60 months	-88,815	-10,755	-8,709
Multiple births	-281	-61	-27
Children lived elsewhere	-163	-48	-24
Missing/flagged anthropometric data for children	-5,251	-520	-2081
Missing/flagged anthropometric data for women	-162	-36	-4
Total children anthropometric sample	29,713	6,462	1,829

Note: Analyses were restricted on last born children in the five years preceding the survey

Table 2: Socio-demographic, high-risk fertility behavior, and anthropometry characteristic of the study participants: Demographic and Health Surveys India, Bangladesh, and Nepal

Characteristics	India (n=29,713) (%)	Bangladesh (n=6,462) (%)	Nepal (n=1,829) (%)
Maternal age, years			
15-24	10,761 (40.8)	3137 (49.3)	744 (42.7)
25-34	15,798 (49.8)	2717 (41.7)	863 (45.2)
35-49	3,154 (9.4)	600 (9.0)	222 (12.1)
Data missing		8	
Maternal education			
No education	11,162 (46.7)	1,154 (19.0)	785 (43.9)
Primary education	4,264 (14.2)	1,934 (30.1)	361 (20.0)
Secondary and higher education	14,287 (39.1)	3,374 (50.9)	683 (36.1)
Maternal decision making autonomy, no. of aspects ^a			
0	7,080 (28.4)	1,688 (26.4)	561 (32.2)
1	4,932 (18.8)	1,014 (16.0)	327 (17.4)
2	5,695 (19.5)	970 (15.3)	260 (13.8)
3	12,006 (33.3)	2,790 (42.3)	681 (36.6)
Respondent employed			
No	20,858 (70.0)	5,818 (90.4)	676 (42.7)
Yes	8801 (30.0)	644 (9.6)	1,153 (57.3)
Data missing	54		
Area of residence			
Rural	18,355 (74.2)	4,404 (76.9)	1,436 (90.4)
Urban	11,358 (25.8)	2058 (23.1)	393 (9.6)
No. of household member, tertiles			
2-4	7,747 (23.7)	2,032 (31.7)	580 (31.2)
5-6	9,910 (33.1)	2,341 (36.2)	641 (35.3)
7+	12,056 (43.2)	2,089 (32.1)	608 (33.5)
Wealth index			
Poor	4,918 (23.8)	1,348 (22.2)	512 (23.6)
Non- poor	24,795 (76.2)	5,114 (77.8)	1,317 (76.4)
Maternal BMI category ^b			
Thin	9,543 (38.3)	1,744 (26.9)	311 (19.4)
Normal	17,007 (53.9)	3,878 (61.0)	1,333 (70.7)
Overweight/obese	3,163 (7.7)	840 (12.1)	185 (9.9)
Maternal height (cm)			
<145	3,299 (12.1)	831 (12.9)	216 (12.4)
≥145	26,414 (87.9)	5,631 (87.1)	1,613 (87.6)
Receiving antenatal care			
No	5,614 (23.1)	2,141 (35.4)	286 (16.7)
Yes	24,077 (76.9)	4,317 (64.6)	1,543 (83.3)
Data missing	22	4	
Types of delivery			
Normal	26,150 (90.4)	5,449 (85.3)	1,738 (94.9)
Cesarean	3,538 (9.6)	1,003 (14.7)	91 (5.1)
Data missing	25	10	
Pregnancy intention			
Unintended	6,523 (22.1)	1,894 (29.7)	476 (27.1)
Intended	23,187 (77.9)	4,568 (70.3)	1,353 (72.9)
Data missing	3		

(Continued...)

Characteristics	India (n=29,713) (%)	Bangladesh (n=6,462) (%)	Nepal (n=29,713) (%)
Child age, year			
<2	15,160 (52.0)	2,843 (44.0)	871 (48.9)
≥2	14,553 (48.0)	3,619 (56.0)	958 (51.1)
Child gender			
Female	13,739 (46.0)	3,124 (48.4)	861 (48.6)
Male	15,974 (54.0)	3,338 (51.6)	968 (51.4)
Initiation of breastfeeding			
Early	9,394 (23.8)	3,409 (46.2)	867 (45.2)
Late	20,313 (76.2)	3,042 (53.8)	962 (54.8)
Data missing	6	11	
Low birth weight baby			
No	23,405 (78.2)	5,366 (82.9)	1,487 (82.4)
Yes	6,307 (21.8)	1,095 (17.1)	342 (17.6)
Data missing	1	1	
Recent child illness			
No	22,224 (74.5)	3,792 (59.3)	1,243 (66.5)
Yes	7,483 (25.5)	2,667 (40.7)	586 (33.5)
Data missing	6	3	
Chronic undernutrition among children			
No	17,567 (54.9)	3,929 (60.3)	1,125 (63.3)
Yes	12,146 (45.1)	2,533 (39.7)	704 (36.7)
Any high-risk category			
No	17,295 (55.1)	3,833 (59.3)	1,131 (61.7)
Yes	12,418 (44.9)	2,629 (40.7)	698 (38.3)
Types of high-risk category			
No risk	17,295 (55.1)	3,833 (59.3)	1,131 (61.7)
Single high-risk category	9,536 (34.4)	2,045 (31.5)	495 (27.2)
Mother's age at birth <18 years	1,113 (4.8)	878 (13.7)	100 (5.9)
Mother's age at birth >34 years	368 (0.8)	111 (1.7)	17 (1.2)
Birth interval <24 months	3,442 (11.3)	245 (3.7)	143 (8.1)
Birth order >3	4,613 (17.6)	811 (12.5)	235 (12.0)
Multiple high-risk category	2,882 (10.6)	584 (9.1)	203 (11.0)
Age at birth <18 years and birth interval <24 months	141 (0.6)	65 (1.0)	13 (0.7)
Age at birth <18 years and birth order >3	7 (0.03)	2 (0.05)	--
Age at birth <18 years, birth interval <24 months, and birth order >3	21 (0.02)	--	--
Age at birth >34 years and birth interval <24 months	25 (0.07)	1 (0.02)	--
Age at birth >34 years and birth order >3	1,077 (3.7)	239 (3.7)	97 (6.7)
Age at birth >34 years, birth interval <24 months, and birth order >3	178 (0.6)	38 (0.5)	26 (1.2)
Birth interval <24 months and birth order >3	1,433 (5.4)	239 (3.8)	67 (3.4)

Note. BMI = body mass index (defined as weight in kilograms divided by the square of height in meters); Numbers are unweighted; percentages are weighted. ^aAspects of family decisions a woman participated alone or jointly in making. ^bBMI categories were thin (< 18.5), normal (18.5–24.9), or overweight/obese (≥25).

Table 3: Adjusted odds ratios for associations between different forms of high-risk fertility behavior among women and chronic undernutrition among children under five: Demographic and Health Surveys India, Bangladesh, and Nepal

Measure	Chronic undernutrition among children					
	India		Bangladesh		Nepal	
	AOR	95% CI	AOR	95% CI	AOR	95% CI
Any high-risk category						
No	1.00	--	1.00	--	1.00	--
Yes	1.29^a	1.21-1.39	1.25^b	1.10-1.43	1.40^c	1.08-1.81
Types of high-risk category						
No risk	1.00	--	1.00	--	1.00	--
Single high-risk category	1.26^a	1.17-1.35	1.19^c	1.04-1.36	1.38	0.92-2.41
Multiple high-risk category	1.53^a	1.35-1.74	1.73^a	1.34-2.23	1.48^c	1.06-1.79
Specific types of high-risk category						
No risk	1.00	--	1.00	--	1.00	--
Mother's age at birth <18 years	1.46^a	1.25-1.71	1.27^b	1.07-1.51	1.94^b	1.21-3.09
Mother's age at birth >34 years	0.86	0.59-1.24	1.24	0.76-2.03	0.71	0.21-2.39
Birth interval <24 months	1.32^a	1.20-1.46	1.24	0.89-1.75	1.49^c	1.04-2.16
Birth order >3	1.13	0.95-1.50	1.22	0.98-1.50	1.25	0.84-1.85
Age at birth <18 years and birth interval <24 months [†]	1.95^b	1.30-2.94	1.57^c	1.01-2.64	1.52^c	1.00-4.89
Age at birth >34 years and birth interval <24 months [‡]	1.20^c	1.01-1.24	1.76^c	1.13-2.75	1.07	0.56-2.07
Birth interval <24 months and birth order >3	1.50^a	1.29-1.74	1.82^a	1.33-2.49	2.28^b	1.29-4.04

Models were adjusted for maternal age, education, maternal decision-making autonomy, maternal occupation, residence, number of household members, wealth index, maternal BMI, maternal height, receiving ANC, types of delivery, pregnancy intention, child age, sex of child, initiation of breastfeeding, size of birth, and recent illness. [†]Includes the category age at birth <18 years and birth order >3 and age at birth <18 years, birth order >3 and birth interval < 24 months ; [‡]Includes the category age at birth > 34 years and birth order >3 and age at birth >34 years, birth order >3 and birth interval < 24 months. AOR adjusted odds ratio, CI confidence interval, ^ap<0.001, ^bp<0.01, ^cp<0.05

Table 4: Adjusted odds ratios for associations between different forms of high-risk fertility behavior among women and chronic undernutrition among children under-5 by wealth: Demographic and Health Surveys India, Bangladesh, and Nepal

Measure	Chronic undernutrition among children AOR (95% CI)					
	India		Bangladesh		Nepal	
	Poor	Non-poor	Poor	Non-poor	Poor	Non-poor
Any high-risk category						
No	1.00	1.00	1.00	1.00	1.00	1.00
Yes	1.21 (1.04-1.40)^c	1.38 (1.30-1.47)^a	1.15 (0.88-1.51)	1.28 (1.10-1.50)^b	1.10 (0.78-1.73)	1.62 (1.20-2.18)^b
Types of high-risk category						
No risk	1.00	1.00	1.00	1.00	1.00	1.00
Single high-risk category	1.17 (1.00-1.36)^c	1.35 (1.26-1.43)^a	1.08 (0.81-1.43)	1.23 (1.05-1.44)^c	0.99 (0.59-1.66)	1.52 (0.77-2.99)
Multiple high-risk category	1.42 (1.13-1.80)^b	1.63 (1.46-1.82)^a	1.68 (1.06-2.67)^c	1.73 (1.28-2.35)^a	1.39 (1.01-2.73)^c	1.66 (1.15-2.39)^b

Models were adjusted for maternal age, education, maternal decision-making autonomy, maternal occupation, residence, number of household members, maternal BMI, maternal height, receiving ANC, types of delivery, pregnancy intention, child age, sex of child, initiation of breastfeeding, size of birth, and recent illness. AOR adjusted odds ratio, CI

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Highlights for review

- Maternal high-risk fertility behavior was associated with an increased risk of chronic undernutrition among children under-5
- Multiple high-risk categories appeared to have more profound consequences on the outcome measured.
- For for the risk of undernutrition, children among those mothers who were either poor or experienced high-risk fertility were not uniquely disadvantaged