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Adolescent Health: Parity And Nutritional Status Among Married Women What Is Unique For Adolescents And What Is Similar To Older Women?

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What is unique for adolescents and what is similar to older women?

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Abstract

Introduction
In Bangladesh, there is a high prevalence of child marriage, early initiation of childbirth, and high rates of undernutrition among adolescents. Pregnancy and childbirth pose unique risks for adolescents due to the intersection of reproductive and physical development.

Objective
This analysis sought to describe the relationship of parity and other reproductive exposures with nutritional outcomes for adolescents and older women ages 20-35 years, describing both the similarities and differences between the two age groups. The overall objective was to help inform improved adolescent health interventions and direct future needed research.

Methods
A secondary data analysis of the Bangladesh Demographic Health Survey 2011 was conducted. In all analyses, the complex survey design and appropriate weighting procedures were taken into account. The association of parity with anemia and underweight was described by bivariate analysis and logistic regressions, stratified by the age categories of adolescents and older women. Other reproductive exposures such as time since last birth, early adolescent versus later adolescent childbearing, and access to family planning were also assessed in relation to acute and chronic nutritional status using bivariate analysis and regression analysis. Adolescence was also evaluated as a possible effect modifier in all relevant analyses.

Findings
Of adolescents that were nulliparous, 32.4% (n=205) were underweight while 34.7% (n=286) of adolescents with one birth were underweight, and 44.8% (n=67) of adolescents with two births or more were underweight. The prevalence of underweight increased with parity for older women 20-35 years, similar to adolescents, but the absolute levels of underweight were much less. Parity was not found to be significant predictor of anemia or underweight for either adolescents or women ages 20-35 years. Adolescence was not found to be an effect modifier of the relationship of parity and anemia or underweight, but in the collapsed model for all women being an adolescent was associated with increased odds of being underweight of 76% (OR 1.76; 95% CI 1.47-2.11). For women 20-35 years, having given birth in the last 2 months was associated with an increased odds of anemia of 23% (OR 2.23; 95% CI 1.22-4.07). Among women ages 20-35, short stature was found to be significantly associated with a woman's first birth occurring when she was an adolescent 15-19 years (p=0.0008). For older women ages 20-35 years, access to family planning was associated with a lower prevalence of underweight, but access to family planning was not associated with underweight for adolescents.

Conclusions
This analysis suggests that the relationship of parity and associated reproductive exposures with the acute nutritional outcomes of underweight and anemia differ for adolescents than for older women. In addition, this analysis also suggests that married women who do become parous during adolescence, and especially during early adolescence, face possible long-term negative effects on attained height. Overall, this study suggests that there is a need to improve the nutritional status of adolescents in the preconception and periconception stage. Family planning providers may be one pathway to begin targeting adolescents with nutritional interventions, but additional research is needed to identify cost-effective nutrition interventions for adolescents.

Introduction

Bangladesh is a lower-middle income country that has made significant progress on reducing maternal and child mortality.[1, 2] Nonetheless, undernutrition remains one of the greatest health challenges for Bangladesh across the lifespan. Underweight, short stature, and essential vitamin and mineral deficiencies pose great risks for women and children, including being significant risk factors for adverse maternal and neonatal outcomes.[3] In 2011, the prevalence of under-five child stunting was 41%. [1] Unfortunately, female adolescents in Bangladesh experience a triple burden of high rates of undernutrition, child marriage, and teenage pregnancy. In a study conducted in rural Bangladesh in 2001,the most recent study specifically on adolescents, 46% of all female adolescents, married and unmarried, (12-16) were affected by severe underweight and 28% of females were affected by short stature.[4] Stunting is reflective of chronic malnutrition and growth failure, while underweight can be more reflective of acute nutritional definciencies[5] Moreover, in Bangladesh in 2011 more than 75% of marriages could be classified as child marriages, a marriage of an individual less than 18 years.[6] The mean age of marriage in 2011 was 15.7 years for females.[6] In Bangladesh, child marriage is associated with early initiation of childbirth as there is a cultural pressure for a woman to prove her fertility.[7] In 2011, the median age of first birth was 18.3 years among 20-24 year old females and 18.1 years among 25-49 year old females.[8] From the early 1990s to 2011, the adolescent fertility rate declined by 16%, but in 2014 the adolescent fertility rate remained high at 83 births per 1,000 women ages 15-19. [9,10]

Birth can be a biologically taxing event for a teenage mother who is still very much in a period of growth. Adolescence can be the second opportunity for catch up growth, especially in regions with high rates of undernutrition, since menarche is often delayed and thus growth spurts can occur later than expected.[11] The need for nutritional interventions in preconception and periconception periods is further supported by recent concerns about supplementation only during pregnancy. There is evidence that supplementation can support the growth of the fetus disproportionately to changes in height and weight of the mother, resulting in increased rates of cephalopelvic disproportion and obstructed labor.[12] There is also evidence that adolescence can be associated with a short cervix and small uterine volume, additional risk factors for preterm birth and adverse birth outcomes for the mother and child.[13] In adolescent maternal health, it is also important to differentiate the differences between early adolescent childbearing and late adolescent childbearing, since this time period of adolescence can be one of rapid change for females. [14] Early adolescent childbearing is often defined as age fifteen or less and has been shown to be associated with increased risk of adverse outcomes compared to even late adolescent childbearing.[13, 14]

Overall, adolescent health has gained new attention in recent years. In 2014, the WHO called for greater attention to the unique health needs of adolescents.[15] As noted previously, it is well known that being an adolescent is a risk factor for adverse maternal outcomes. [16] In Bangladesh, adolescence is a particularly critical period in a female's life because it can serve as a period of potential further growth missed earlier in life, but can also place further burdens on a female through the societal demands to marry and bear children. In looking at maternal health, it is important to recognize that adolescents are biologically different than older women. Therefore, understanding the nature of how nutritional status and parity, in addition to other reproductive exposures, varies between adolescents and older women will help to further direct improved interventions.

Overall, this analysis improves on the previous literature by describing how the relationship of parity and associated reproductive exposures with acute and chronic nutritional deficiency indicators varies for adolescents compared to older, more biologically mature women.

Objectives

1. The first objective of this analysis was to characterize the relationship of parity and nutritional indicators of anemia and undernutrition for adolescents in comparison with the same indicators of parity and nutrition for older women.
2. The second objective of this analysis was to investigate whether older women who first became parous in adolescence experience long-lasting, chronic effects on attained height.
3. The third objective of this analysis was to identify a potential pathway for improving nutritional interventions for adolescents. Thus, the results of this analysis can be used to encourage improved preconception, antenatal, and periconception nutritional counseling targeted at the unique sexual and reproductive needs of adolescents.

Methods

This study was a secondary data analysis using the Bangladeshi Demographic Health Survey (BHDHS) survey dataset. The sample for the 2011 BDHS is nationally representative and covers the entire population residing in non-institutional dwelling units in the country. For the overall DHS survey, five questionnaires were used in total.[17] This analysis incorporated findings from two of the surveys, the Women's Questionnaire and the Household Questionnaire.

BHDHS Sampling Design

The sampling design involved a two-stage sampling process. In the first stage, the sampling frame for this study was a list of enumeration areas (EAs) prepared for the 2011 Population and Housing Census, provided by the Bangladesh Bureau of Statistics (BBS). The primary sampling unit (PSU) for the survey is an EA that was created to have an average of about 120 households. In the first stage, 600 EAs were selected with probability proportional to the EA size, with 207 clusters in urban areas and 393 in rural areas. A complete household listing operation was then carried out in all the selected EAs to provide a sampling frame for the second-stage selection of households. In the second stage of sampling, a systematic sample of 30 households on average was selected per EA to provide statistically reliable estimates of key demographic and health variables for the country as a whole, for urban and rural areas separately, and for each of the seven divisions.[18]

BHDHS Study Population

The study population included all females living in Bangladesh during 2011 ages 15-35 years. The sample was comprised of all female respondents included in the nationally representative DHS survey. Sample weights were applied using the provided DHS weight variable from the downloaded dataset these weights were calculated based on the household weight multiplied by the inverse of the response rate for all women. All sample weights were divided by 1,000,000.

In total, the DHS data included 17,141 households and 17,842 females. This study was limited to married females since only married adolescents would be interviewed with the same questions as adult females under DHS protocol. Women who were currently pregnant at the time of the survey interview were excluded (N=1068).

Adolescence was defined as 19 years or less. The DHS survey population included 13 and 14 year olds, but the weight total of 13-14 year olds was zero. Thus, this study was limited to adolescents 15-19 years old. Adolescents were compared to women ages 20-35 years because being over 35 years is known to be associated with increased risk of adverse outcomes during pregnancy.[19]

Outcomes

Outcomes were mostly defined in binary terms since the purpose of this analysis is to advocate for additional adolescent nutritional interventions on a policy level. Binary outcomes allow simplified interpretation and clinical relevance but there exists a tradeoff with epidemiological value.

Height and weight were measured at the time of interview by DHS survey data collectors in centimeters. The DHS data collectors then calculated BMI measures using the collected height and weight measures defined by weight divided by height squared. For this analysis, underweight was defined as binary variable using a BMI cutoff of <18.5, according to WHO definitions.[5] A binary variable was chosen for ease of interpretation and for clinical significance.

Anemia was measured by blood fingerprick samples taken after consent was obtained from participating women. Anemia was defined by the DHS survey using the following classification system: hemoglobin levels 7.0 g/dl and less as severe, levels between 7.1g/dl and 9.9g/dl as moderate, between 10.0 g/dl and 11.9 g/dl as mild, with greater than 11.9 g/dl as normal. For this study, anemia was coded as a binary variable, with severe, moderate, and mild anemia being grouped together and normal levels being classified as no anemia. Anemia levels were adjusted for altitude. The DHS survey team reported 95% of the measurements to be complete and accurate. And collected anemia measurements from a third of eligible households.

Stunting is often the measure of choice used to capture long-term chronic malnutrition and is often used as an indicator for child health and also adolescent health. However, since this measure is based on a growth curve and adult women have completed height growth, stunting was not an appropriate measure in this study to compare adolescents and older women. To represent chronic effects of undernutrition, the measure of attained height was utilized instead. For clinical interpretation and consistency with the other outcomes of interest, a binary variable of short stature was defined as less than 150 cm (4 ft 11 inches). This height has been found to be associated with increased risk of adverse outcomes in childbirth, such as obstructed labor. [20, 21, 22, 23] However, attained height (cm) was also used as a continuous variable since height was found to be a normally distributed and understanding the relative magnitude of height difference could offer additional insights that can be lost using threshold measurements.

Exposure Variables

Parity was defined as the number of live births. Parity was categorized as 0 live births (nulliparous), 1 birth, and 2 or more births. In the preliminary analysis, nulliparous, gravid and nulligravid were two different categories, but the sample size for nulliparous, gravid adolescents was too small (N=64). As a result, these categories were collapsed.

Time since last birth was recorded in the DHs interviews as time in months between the respondent's reported last birth and when the interview was conducted.

Family planning access was measured based on reporting on three types of questions: whether certain facilities provided family planning services to the woman, whether the woman received family planning information from certain types of health workers, and reporting on current contraception methods. In this study, family planning access was only coded positively if the respondent indicated that she had received service or information from one of the sources or if she reported using a modern or traditional contraception method. Those who did not report receiving service or information on family planning were not considered to have access to family planning. There is no way to confirm the respondent utilized a provided method, so this variable was constructed to represent access to family planning and was coded binary.

In exploring potential exposures contributing to short stature, age at first birth was retrospectively looked at for women 20-35 years old. For these women, age at first birth during adolescence was constructed as a bivariate variable that was coded positive if the woman reported giving birth to her first child before 20 years of age. However, this relationship was further broken down by looking at differences in the relationship of short stature and age at first birth for women who were 15-16 years when they first gave birth compared to 18 or 19 years. The age of 17 years was excluded in order to gain a better sense of the extremes of adolescents. Only live births were considered for age at first birth.

Covariates

Potential cofounders were considered based on known mechanisms of influencing nutritional outcomes, represented in the conceptual framework displayed in *Figure 1.* This conceptual diagram was designed to represent the underlying determinants of adolescent nutritional status and the possible interventions to improve outcomes. However, the same determinants depicted as potential covariates would be relevant to the mechanisms determining the nutritional status of older women as well. Socioeconomic status was represented by a wealth index calculated by the BDHS survey team. This wealth index is based on principal component analysis and is a composite measure of a household's cumulative living standard based on ownership of selected assets. All interviewed households were separated into five quintiles.[17] Individual women retained the quintile assigned to their household. Educational status is represented by self-reported highest level of attained education including no education, primary, secondary, or higher education. Number of household members was categorized by five categories, one through four total people living in the household and 5 or more people in the household.

Indoor air pollution is also known to have adverse effects on the nutritional status.[24] Indoor air pollution was characterized by a binary variable, which was a composite outcome of both using an indoor cook stove and the use of a biomass fuel source. Similarly, poor sanitation and unclear water can lead to a cycle of infections that weaken the nutritional status of an individual and can have chronic long-term effects.[25, 26, 27] Sanitation was classified as a binary variable of improved and unimproved sanitation, grouping reported sanitation access based on definitions set by the WHO/UNICEF Joint Monitoring Program for Water Supply and Sanitation. Drinking-water source categories were classified similarly as a binary variable, differentiating reported drinking water sources by improved sources of drinking-water and unimproved sources of drinking-water established by the technical Joint Monitoring Program.

Data Analysis

Because a two stage clustering sampling procedure was used in the DHS sampling design, all analysis was conducted taking into account strata, clusters, and weights.

Nutritional outcomes were described with frequencies and percentages for both adolescents and women ages 20-35 years across parity. Bivariate analyses using Pearson's chi-squared test were performed to test for a significant association of parity with underweight and anemia. ANOVA testing was used to determine if there were significant differences across parity for adolescents and older women. Stratified unconditional logistic regression models were used to estimate the unadjusted and adjusted magnitude of the effect of parity on underweight and anemia for adolescents and older women. Adolescence was then assessed as an effect modifier in a collapsed logistic regression model for all women 15-35 years. The interaction term was tested at the $\alpha=0.1$ significance level. Odds ratios and confidence intervals are reported. Adjusted estimates accounted for potential confounding due to wealth index, attained education level, number of household members, access to water and sanitation[28], and indoor air pollution exposure.[29]

The relationship of anemia across different age groups was further investigated by looking at the bivariate association of anemia and time since last birth being 2 months or less. This analysis was stratified by parous adolescents and parous women 20-35 years who had given birth in the last five years. Time since last birth was used as a binary variable with a threshold of 2 months since the literature suggests that women are at increased risk of anemia 4-6 weeks postpartum.[30] Unadjusted and adjusted odds ratios are reported with confidence intervals. An interaction term between the variables adolescent and time since last birth was constructed and tested at the $\alpha=0.1$ significance level.

Because short stature and the effects of attained height play out over a long period of time, the relationship of short stature (height <150 cm) and age at first birth was explored in women 20-35 years. Bivariate associations were tested for short stature and age at first birth occurring in adolescence and the prevalence of short stature among older women whose age at first birth was 15 or 16 years versus 18 or 19 years. Because attained height was approximately normally distributed, linear regression was used to estimate the magnitude of the association between age at first birth being 18 or 19 years versus 15 or 16 years and attained height, accounting for potential confounders.

It was hypothesized that women who have access to family planning may also have received supplements or nutritional counseling if they displayed signs of undernutrition to the provider. Family planning promotion has been successful in Bangladesh and coverage is high compared to other countries at greater than 50% overall coverage for women 15-49 years.[31] Family planning is also an important exposure since it can delay parity. The association between family planning access and underweight, anemia and short stature was examined among adolescents and older women 20-35 years, using chi-square tests for bivariate analysis and unconditional logistic regression. Adolescence was tested as an effect modifier for the relationship between family planning access and nutritional outcomes in the logistic models. The interaction terms were evaluated at a significant level of $\alpha=0.1$.

All analyses were performed using SAS version 9.4. All analyses were conducted utilizing the appropriate survey weighting, taking into account both individual and household sampling weights. Only weighted totals and percentages are shown in the tables below. All significance testing was conducted at the 95% confidence level, except on interaction terms.

Results

Demographic Summary

All women included in the study were married and between the ages of 15-35 years. Of the women, 12.1% (n=1486) were adolescents ages 15-19 years while the other 87.9% (n=10759) were between the ages 20-35 years. There were significant differences in the parity of the adolescents and women ages 20-35 years. The majority of adolescents, 51.3% (n=825), had one previous birth at the time of the interview, 39.4% (n=633) were nulliparous and only 9.3% (n=149) had two or more births. On the other hand, 71.6% (n=6452) of the women 20-35 years had two or more births, 23.1% (n=2080) had one previous birth, and only 5.3% (n=479) were nulliparous. There were also significant differences across wealth index, education, number of household members, and sanitation and water access. The proportion of women with two or more births decreased with increasing wealth ($p<0.001$). Women who lived alone were more likely to be nulliparous (36.0%), while women who lived in a household size of three had the highest prevalence of parity of two or greater (80%). Increasing achieved education was also associated with decreasing parity, Of the 4,215 women without any attained education, 89.7% (n=3,783) had two or more children, compared to only 46.1% (n=545) of women who attained higher education. Parity of two or more was also more common among women with exposure to indoor air pollution and lack of access to improved sanitation than women without indoor air pollution exposure or with improved sanitation access ($p<0.001$). No significant differences across parity were found for women with unimproved versus improved water access (See Table 1 for all demographic information).

Underweight and Anemia across Parity for Adolescents

In the bivariate analysis, parity was associated with the prevalence of underweight among adolescents ($p=0.0431$) (Please see Table 2). As parity increased, the prevalence of underweight increased. Of adolescents that were nulliparous, 32.4% (n=205) were underweight while 34.7% (n=286) of adolescents with one birth were underweight, and 44.8% (n=67) of adolescents with two births or more were underweight. The prevalence of anemia also increased with parity. However, the bivariate association of parity and anemia was not found to be significant.

Underweight and Anemia across Parity of Women Ages 20-35 Years

Significant differences across underweight and anemia were found for this older group of women (p=0.0061) (See Table 3). The prevalence of underweight increased with parity, similar to adolescents, but the absolute levels of underweight were much less. For nulliparous women, 16.2% were underweight (n=78), compared to the 32.4% prevalence observed for adolescents. Women with one birth had a prevalence of underweight of 20.9% (n=436) while women with two or more births had a prevalence of underweight of 22.8% (n=1471). In addition, for these women, unlike for the adolescents, a significant association was observed between parity and anemia, but this association was different than for underweight. The women with two or more births had the highest prevalence of anemia (41.5%; n=43.8%), but nulliparous women (37.1%; n=60) and those with one birth (35.3%; n=227) had a lower prevalence of anemia, with the differences between these sub-groups relatively small.

Adolescence, Nutritional Outcomes, and Parity

The trend test for parity and underweight has significant (p-value for trend=0.019) for all women. Significant differences were found between mean BMI across parity for both adolescents and older women (p<0.001). However, in the stratified regression analysis, parity was not found to be significant predictor of anemia or underweight for either adolescents or women ages 20-35 years. Age of adolescence was not found to be an effect modifier of the relationship of parity and anemia or underweight, as both interaction terms were found to be non-significant in the collapsed model. However, in this collapsed model, it was observed that adolescence may be an independent predictor of nutritional outcomes. After adjusting for wealth index, attained educational level, number of household members, sanitation access, and indoor air pollution, adolescence remained significantly associated with being underweight. Being an adolescent was associated with increased odds of being underweight of 76% (OR 1.76; 95% CI 1.47-2.11).

Anemia and Time Since Last Birth

Since the number of births and being an adolescent were not found to be significantly associated with anemia prevalence in either age group, time since last birth was explored as another explanatory variable for anemia in adolescents and women ages 20-35. This particular analysis was limited to parous women since the variable time since last birth is dependent on parity. In addition, because many women in this study gave birth very young and have not given birth since adolescence, due to the young mean age at first birth, this analysis was also limited to women who have given birth in the last five years. For women 20-35 years, having given birth in the last 2 months at the time of the interview was associated with an increased odds of anemia of 23% (OR 2.23; 95% CI 1.22-4.07) compared to women ages 20-35 who had not given birth in the last 2 months, but had in the last 5 years (Please see Table 7). Adolescents who had given birth in the last two months at the time of interview were not at increased odds of anemia compared to those who had not and adolescence was not found to be an effect modifier of the relationship between anemia and time since last birth.

First Birth During Adolescence and Attained Height in Women 20-35 Years

Although underweight and anemia can be acute signals of undernutrition, short stature for women is often an indicator of long-term, chronic undernutrition. Among women ages 20-35, short stature was found to be significantly associated with a woman's first birth occurring when she was an adolescent 15-19 years (p=0.0008) (Table 8). In addition, women who first gave birth at 18 or 19 years compared to 15 or 16 years, were at an decreased odds of 22% of being of short stature (OR 0.78; 95% CI 0.63-0.97). In addition, when height was treated as a continuous outcome, it was found that women 20-35 years who gave birth at 18 or 19 years were on average 0.78 cm (SE=0.28; p=0.005) taller than women who gave birth at 15 or 16 years (Table 9), after adjusting for all relevant covariates.

Family Planning Access and Nutritional Status

Overall, 47.1% (n=4241) of women ages 20-35 years had access to family planning while 40.1% of adolescents (n=645) reported access. No association was found between family planning access and any nutritional outcome interest among adolescents (Tables 10). For older women ages 20-35 years, access to family planning was associated with underweight in the bivariate analysis (p=0.0382). Among women 20-35 years, 23.0% (n=1098) of those without family planning were underweight compared to 20.9% of those who reported access to family planning. No association was found among women 20-35 years between family planning access and anemia or short stature. Adolescence was not found to be an effect modifier of the relationship between family planning and underweight. Nonetheless, similar to with the relationship with parity, adolescence was found to be an independent predictor of underweight, even after adjusting for family planning access. Among adolescents reporting lack of access to family planning the prevalence of underweight was 34.2% (n=329), and among those with access the prevalence was 34.7% (n=558). The prevalence of underweight among adolescents with and without family planning access was higher than the prevalence of underweight in older women with or without family planning access.

Discussion

Adolescent health is a new and emerging field that is often caught between child health and women's health. Adolescence is its own unique time of human development, marked by rapid physical change and nutritional need. Overall, this analysis adds to what is known about adolescent maternal health, in terms of what is unique about the adolescent experience and what is similar to that of women who are more mature, particularly in the context of Bangladesh where child marriage and teenage pregnancy rates are high.

This analysis showed that both among adolescents and women 20-35 years, increasing parity is associated with increasing underweight. Adolescence was not found to be an effect modifier of the relationship between parity and underweight or anemia. However, adolescence was found to be a significant, independent predictor of underweight, and the prevalence of underweight was much greater for adolescents than for women 20-35 years. These findings suggest that there is both a need for preconception nutritional supplementation for adolescents to decrease the baseline underweight prevalence in nulliparous women, but also a need to recognize the importance of targeting parous adolescents for nutritional support, since almost half of adolescents with two or more children were found to be underweight. As adolescents continue to have more children their BMI may continue to decrease, placing their nutritional status even more at risk.

Adolescence was not found to be an effect modifier of the relationship between parity and anemia. In addition, unlike underweight, adolescence was not found to be a significant, independent predictor, suggesting adolescents do not face a greater risk of anemia than women 20-35 years. For women 20-35 years, having a birth within the last 2 months was significantly associated with decreased odds of anemia. However, this trend was not observed for adolescents. These findings could be due to the high-risk period of anemia 4-6 weeks postpartum not being applicable to adolescents. Because the overall prevalence of anemia in adolescents was high, the risk of anemia could remain high for adolescents regardless of parity and time since last birth. In comparison, these findings suggest that parity is not significant for women 20-35 years in establishing increased anemia risk but time since last birth should be monitored.

The existing literature is inconsistent regarding adolescent pregnancy and attained height. This analysis supports findings from a study in rural Bangladesh by Rah et al in 2008 that concluded pregnancy in adolescence was associated with ceased linear growth.[32] This analysis suggested that pregnancy in adolescence was associated with short stature later in life. However, other studies in different settings have suggested that reduced attained height in women who first gave birth in adolescence may depend on additional factors such as race/ethnicity or even the birth weight of the infant, possibly reflecting the relationship between weight gain and energy expenditure during pregnancy.[33, 34] In this analysis, having a child at 18 or 19 years was associated with greater attained height than having a child of 15 or 16 years, consistent with the adverse risks associated with early chilbearing compared to late adolescent childbearing.[13] These findings support that not only do teenage mothers face a higher prevalence of undernutrition around the time of birth, younger age at first birth is associated with long-term nutritional deficits. This realization further emphasizes the need to address the large degree of nutritional needs observed for adolescents.

Overall, this study suggests that there is a need to improve the nutritional status of adolescents in the preconception and periconception stage in order to ameliorate the short-term effects of undernutrition and prevent the long-term effects of short stature. There are great efforts to reduce teenage pregnancy altogether, but shifting social norms of child marriage and age of first birth will continue to take time, as slow progress has been observed compared to other countries with a higher prevalence such as India.[7] In the meantime, many adolescents are suffering from nutritional deficiencies.

The greatest limitation of this study is the use of cross-sectional data. No casual relationships can be inferred. In addition, the lack of longitudinal data further reduces the ability to generalize the findings. Many limitations exist due to variables of interest not being collected as part of the DHS survey instrument or measured in ways incompatible with this analysis. One variable not measured and captured in this analysis was age of first menarche. The day of first menarche could potentially distort the relationship between age and parity, since some adolescents may be married but may not have reached menarche yet, and therefore cannot get pregnant yet. This reality is likely exaggerated in an environment where onset of menarche is often delayed due to poor nutritional status. However, this limitation is slightly minimized by evidence that onset of menarche is slightly earlier among married women in Bangladesh.[35] Nonetheless, a further limitation is the use of the variable "time since last birth" in the DHS dataset, since this variable was only measured in months, rather than weeks. Most literature discusses postpartum anemia up to 6 weeks,[30, 36] so wide categories of one and two months possibly do not capture the nuanced time period of postpartum anemia. Other limitations exist due to the general nature of survey data collection methods, including recall bias for measures such as reported family planning access or possible measurement errors for biomarker and anthropological measurements. Moreover, this study also did not look at the nutritional intake of the respondents, so it is unknown what the root cause of undernutrition and underweight is, again emphasizing the observational nature of this analysis.

With the goal of improving undernutrition in adolescents, effectiveness and efficacy research must be conducted on possible nutritional interventions targeted specifically at adolescents. In 2013, Bhutta et al released a landmark study that performed a systematic review to identify 10 effective nutritional interventions for maternal and child health. The authors then used the Lives Saved Tool (LiST) to model the impact of scaling up these 10 interventions to 90% coverage in the 34 countries of the world with the highest burden of undernutrition.[37] Unfortunately, none of these identified interventions were specific to adolescents, either in preconception, prenatal care, or in the periconception period. The cost-effectiveness of the 10 interventions was evaluated based on cost per under-five child deaths averted. The cost-effectiveness of interventions aimed at reducing undernutrition in adolescents is equally important to begin to fully address undernutrition from a life course perspective. It is clear current maternal health programs, at 50% coverage in Bangladesh,[31] have less of an effect on reducing the burden of anemia and underweight in adolescents than in older women, contributing to possible long-term chronic effects as these adolescents continue to develop. However, the most appropriate, cost-effective interventions to address undernutrition in adolescents are largely unknown compared to reducing undernutrition in under-five children and older women.[37]

Family planning may be one possible area to begin targeting adolescents. Interestingly, this analysis found that older women with family planning access had a lower prevalence of underweight but no association was observed for adolescents. One of the key challenges of a rural, overwhelmingly poor setting like Bangladesh, is the lack of resources for health. In looking to enhance nutritional programming, looking to build on existing pathways could be beneficial. Bangladesh has had huge success with family planning in the past and this program is having effects for older women (even if modest), so looking to possibly train family planning providers on providing nutritional support to adolescents could be one way to reduce the nutritional burden, especially for the high-risk adolescents who begin having children.

Conclusion

Bangladesh is a country where child marriage and young childbearing are very prominent and rooted in engrained social norms. The health of millions of girls is put at risk when greater effort is not placed on their nutritional status, in case they do become pregnant and the unique risks they could face. Teenage pregnancy prevention is incredibly important, but this analysis shows that the nutritional needs of adolescents who begin having children can be exacerbated compared to women 20-35 years and appropriate preconception nutritional interventions are needed alongside family planning. In addition, the same trends are not necessarily observed for adolescents as are for older women, and these interventions may need to target adolescents in unique ways.

In summary, the trends observed were:

- Parity was not associated with underweight and anemia in adolescents or older women, after adjusting for potential confounders
- Adolescent age was not found to an effect modifier of the relationship between parity and underweight or anemia,
- **Adolescent age was a stronger predictor of underweight, as adolescents were at increased risk of underweight compared to older women**
- Adolescent age was not a strong predictor of anemia compared to older women, all women experience anemia at a high prevalence
- For older women, time since last birth was an important predictor of current anemia in women who had given birth in the last five years
- **No relationship between since last birth was observed for adolescents, suggesting married adolescents have a high prevalence of anemia across parity and time since last birth**
- **Becoming parous in adolescence was associated with shorter attained stature in women 20-35 years. In addition, the attained height of women whose age at first birth was 15 or 16 years was significantly less than even women whose age at first birth was 18 or 19 years**
- **Family planning access was associated with decreased underweight in older women but no effect was observed for adolescents**

This analysis suggests that the relationship of parity and associated reproductive exposures (time since last birth and access to family planning) with acute nutritional status outcomes of underweight and anemia differ for adolescents than for older women. The analysis presented did not identify the determinants of undernutrition in Bangladeshi, married adolescents. However, this analysis did identify that the same assumptions about the patterns of nutritional status with increasing births or in time periods before or after pregnancy cannot be presumed to be equivalent for all married women who bear the societal role of childbearing in Bangladesh. Married adolescents experience a higher prevalence of undernutrition than older women and many of the same relationships commonly understood in maternal health, time since last birth for anemia for example, did not appear to hold for adolescents in this study. Nonetheless, it is apparent that married women who do become parous during adolescence face long-term nutritional consequences. Greater attention must be given to understanding the underlying mechanisms of adolescent development. The intersections between maternal and reproductive health and physical development relevant to young childbearing women must be further prioritized on the research agenda.

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Table 1. Demographic Characteristics of Study Population by Parity					
			Parity		
	Nulliparous n(%)	**1 birth** n(%)	**2+ births** n(%)	**Total** n(%)	**p-value**
Totals[1]	**1168 (7.7)**	**3120 (19.9)**	**11262 (72.4)**	15550 (100.0)	
Age					<0.001
Adolescent	633 (39.4)	825 (51.3)	149 (9.3)	1607 (100.0)	
Ages 20-35 years	479 (5.3)	2080 (23.1)	6452 (71.6)	9012 (100.0)	
Wealth Index					<0.001
Poorest 20%	137 (5.0)	412 (14.9)	2211 (80.1)	2760 (100.0)	
Second 20%	201 (6.7)	540 (17.9)	2281 (75.5)	3023 (100.)	
Middle 20%	232 (7.4)	613 (19.5)	2301 (73.2)	3146 (100.0)	
Fourth 20%	297 (9.1)	695 (21.3)	2274 (69.6)	3266 (100.0)	
Richest 20%	329 (9.8)	834 (24.7)	2210 (65.5)	3373 (100.0)	
Education					<0.001
No education	123 (2.9)	309 (7.3)	3783 (89.7)	4215 (100.0)	
Primary	243 (5.2)	688 (14.6)	3766 (80.2)	4697 (100.0)	
Secondary	611 (11.2)	1679 (30.7)	3183 (58.2)	5474 (100.0)	
Higher	219 (18.5)	417 (35.3)	545 (46.1)	1181 (100.0)	
Number of Household Members					<0.001
1	200 (36.0)	118 (21.2)	238 (42.8)	555 (100.0)	
2	322 (6.0)	1321 (24.5)	3743 (69.5)	5364 (100.0)	
3	337 (6.1)	717 (12.9)	4503 (81.0)	5538 (100.0)	
4	196 (8.3)	493 (20.9)	1672 (70.8)	2364 (100.0)	
5+	141 (8.3)	444 (26.0)	1122 (65.7)	1752 (100.0)	
Sanitation					<0.001
Unimproved	400 (6.1)	1166 (17.7)	5021 (76.2)	6587 (100.0)	
Improved	757 (8.8)	1834 (21.3)	6036 (70.0)	8627 (100.0)	
Water					0.625
Unimproved	4 (8.6)	11 (24.6)	31 (66.8)	46 (100.0)	
Improved	1192 (7.7)	3106 (19.9)	11214 (72.5)	15514 (100.0)	
Indoor Household Pollution					<0.001
No	989 (7.6)	2553 (19.5)	9535 (72.9)	13077 (100.0)	
Yes	60.0 (5.5)	172 (15.9)	851 (78.6)	1514 (100.0)	

[1]These totals have row percentages reported. All other reported percentages refer to column percentages

Table 2. Association of Parity and Underweight and Anemia in Adolescents					
	Parity				
	Nulliparous n(%)	**Parous (1 birth)** n(%)	**Parous (2+ births)** n(%)	**Total** n(%)	**p-value**
Underweight					0.0431
No	428 (67.6)	539 (65.3)	82 (55.2)	1049 (65.3)	
Yes	205 (32.4)	286 (34.7)	67 (44.8)	558 (34.7)	
Anemia					0.4023
No	123 (62.7)	152 (58.0)	26 (50.7)	300 (59.1)	
Yes	73 (37.3)	110 (42.0)	25 (49.3)	208 (40.9)	

Table 3. Association of Parity and Underweight and Anemia in Women 20-35 Years					
	Parity				
	Nulliparous n(%)	**Parous (1 birth)** n(%)	**Parous (2+ births)** n(%)	**Total** n(%)	**p-value**
Underweight					0.0061
No	402 (83.8)	1645 (79.1)	4982 (77.2)	7028 (78.0)	
Yes	78 (16.2)	436 (20.9)	1471 (22.8)	1984 (22.0)	
Anemia					0.0024
No	102 (62.9)	415 (64.7)	1130 (56.2)	1647 (58.5)	
Yes	60 (37.1)	227 (35.3)	879 (43.8)	1166 (41.5)	

Table 4. Unadjusted and Adjusted Odds of Anemia and Underweight for Adolescents				
	Anemia		Underweight	
	Unadjusted OR (95% CI)	*Adjusted** OR (95% CI)	*Unadjusted* OR (95% CI)	*Adjusted** OR (95% CI)
Parity				
Nulliparous	Ref	Ref	Ref	Ref
Parous-1	1.22 (0.79-1.88)	1.18 (0.73-1.91)	1.11 (0.87-1.41)	1.09 (0.83-1.43)
Parous-2+	1.63 (0.74-3.61)	1.90 (0.78-4.66)	1.69 (1.11-2.57)	1.15 (0.71-1.86)

* Adjusted for indoor air pollution, wealth index, attained education, sanitation, water access, and number of household members

Table 5. Unadjusted and Adjusted Odds of Anemia and Underweight for Women Ages 20-35 Years				
	Anemia		Underweight	
	Unadjusted OR (95% CI)	*Adjusted** OR (95% CI)	*Unadjusted* OR (95% CI)	*Adjusted** OR (95% CI)
Parity				
Nulliparous	Ref	Ref	Ref	Ref
Parous-1	0.93 (0.63-1.35)	0.80 (0.49-1.30)	1.11 (0.87-1.41)	1.09 (0.83-1.43)
Parous-2+	1.32 (0.91-1.91)	1.07 (0.67-1.72)	1.69 (1.11-2.57)	1.15 (0.71-1.86)

* Adjusted for indoor air pollution, wealth index, attained education, sanitation, water access, and number of household members

Table 6. Unadjusted and Adjusted Odds of Anemia and Underweight Among All Women				
	Anemia		Underweight	
	Unadjusted OR (95% CI)	*Adjusted** OR (95% CI)	*Unadjusted* OR (95% CI)	*Adjusted** OR (95% CI)
Parity				
Nulliparous	Ref	Ref	Ref	Ref
Parous-1	1.00 (0.76-1.33)	0.96 (0.68-1.34)	0.97 (1.81-1.16)	1.02 (0.82-1.27)
Parous-2+	1.32 (1.02-1.71)	1.28 (0.89-1.85)	1.53 (1.15-2.03)	0.88 (0.69-1.11)
Age				
Ages 20-35	Ref	Ref	Ref	Ref
Adolescent	0.98 (0.79-1.22)	1.08 (0.81-1.44)	1.89 (1.66-2.14)	1.76 (1.47-2.11)

* Adjusted for indoor air pollution, wealth index, attained education, sanitation, water access, and number of household members

Table 7. Anemia and Time Since Last Birth for Women 20-35 Years (Last Birth in the Last 5 years)		
	Anemia	
	Unadjusted OR (95% CI)	*Adjusted* OR (95% CI)*
Time Since Last Birth		
>2 months	Ref	Ref
<u><</u>2 months	2.64 (1.60-4.35)	2.23 (1.22-4.07)

* Adjusted for indoor air pollution, wealth index, attained education, sanitation, water access, and number of household members

Table 8. Association of First Birth as an Adolescent (15-19 yrs) and Short Stature in Women 20-35 Years				
	First Birth as an Adolescent (15-19 Years)			
	No n(%)	Yes n(%)	Total n(%)	P-value
Short Stature (<150 cm)				0.0008
No	1196 (61.4)	3996 (56.6)	5193 (57.6)	
Yes	753 (38.6)	3066 (43.4)	3819 (42.4)	

Table 9. Effect of Teenage Pregnancy at 15 or 16 Years vs 18 or 19 Years on Attained Height of Women 20-35 Years				
	Attained Height (cm)			
	Unadjusted β (SE)	p-value	*Adjusted** β (SE)	p-value
Pregnancy at 15 or 16 Years	0.76 (0.22)	<0.001	0.78 (0.28)	0.005

* Adjusted for indoor air pollution, wealth index, attained education, sanitation, water access, and number of household members

Table 10. The Association of Family Planning Access and Nutritional Outcomes Among Adolescents				
	Family Planning Access			
	No n(%)	Yes n(%)	Total n(%)	P-value
Underweight				0.5964
No	633 (65.8)	416 (64.4)	1049 (65.3)	
Yes	329 (34.2)	229 (35.6)	558 (34.7)	
Anemia				0.6042
No	167 (58.0)	134 (60.5)	300 (59.1)	
Yes	121 (42.0)	87 (39.5)	208 (40.9)	
Short Stature				0.8478
No	550 (57.2)	372 (57.7)	645 (57.4)	
Yes	412 (42.8)	273(42.3)	922 (42.6)	

Table 11. The Association of Family Planning Access and Nutritional Outcomes Among Women 20-35 Years				
	Family Planning Access			
	No n(%)	Yes n(%)	Total n(%)	P-value
Underweight				0.0382
No	3672 (77.0)	3356 (79.1)	7028 (78.0)	
Yes	1098 (23.0)	885.4 (20.9)	1984 (22.0)	
Anemia				0.1124
No	831 (56.8)	816 (60.4)	1351 (48.0)	
Yes	632 (43.2)	535 (39.6)	1692 (58.4)	
Short Stature				0.3863
No	2726 (57.1)	2467 (58.2)	5193 (57.6)	
Yes	2045 (42.9)	1774 (41.8)	3819 (42.4)	

Figure 1. Conceptual Diagram of Determinants and Interventions Influencing Nutritional Status of Adolescents