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Impact of Maternal Anemia and Household Wealth Index on Children Anemia in Bangladesh: Multilevel Logistic Regression Analysis

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Abstract

Anemia is a public health problem especially among children in developing countries and it is one of the important predictors for growth and development. The aim of this study was to determine the impact of maternal anemia and household wealth index on anemia among pre-school children (6-59 months) in Bangladesh after removing cluster effect and after controlling the effects of selected confounders on children anemia with 95% confidence interval (CI). Data for this study was extracted from the 2011 Bangladesh Demographic and Health Survey (BDHS-2011). BDHS-2011 used a two-stage stratified cluster sampling technique for selecting households. Theanemia status of pre-school children was the outcome variable of this study. Chi-square (χ^2) test and two level logistic regression model were used in this study for finding the impact of maternal anemia and household wealth index on children anemia. Population attributable fraction (PAF) was utilized for calculation the contribution of maternal anemia and household wealth index on children anemia. Parents' socio-economic, demographic, children age, birth weight, nutritional status were considered as cofounding variables. The total number of 2071 children aged 6-59 months were considered to examine their anemia status and it was observed that the prevalence of child anemia being overall 52.10%, of which 48.27% where in urban environments and 53.73% in rural areas in Bangladesh. The prevalence of mild, moderate and severe anemia was 29.60%, 21.70% and 0.80% respectively among anemic children in this country. The two level logistic regression model demonstrated that anemic mothers' children were more prone for getting anemia than non-anemic mothers' children ($p<0.01$). When controlled the effect of other variables, it was also found that anemic mothers were more likely to get anemic children ($p<0.01$). It was noted that children living in poor family who was more probable to get anemia than who lived in rich family ($p<0.01$). After controlling the effect of other variables, it was found same result but comparatively lower odds ratio [Adjusted odds ratio (AOR)=1.708]. When we compared middle family children with rich family, it was found that children who lived in middle family had more chance to have anemic than rich family children for both unadjusted and adjusted ($p<0.01$). Finally, population attributable risk percent (PAR%) demonstrated that the individual contribution of anemic mothers for getting anemic children by 20.65% for unadjusted, and for adjusted it was by 19.35%. In case of unadjusted, the individual contribution for poor family among their children anemic was 18.20% and for adjusted was 17.70%. It was found the contribution of middle family for having

anemic children by 4.65% and 4.43% for unadjusted and adjusted cases respectively. A high prevalence of anemia among pre-school children (age, 6-59 months) was found in Bangladesh. This study suggests the presence of modifiable factors associated with child anemia. Our selected multilevel model provided that anemic mothers and poor family children were vulnerable for getting anemia in Bangladesh. These two groups are correlated, and PAF shows that these two groups together can put contribution by more than one third (38.85%) for children anemia in this country. Consequently, anemia can be considered as the major problem for children in Bangladesh, and Government and Non-government health organizations can consider our findings for societal intervention to reduce its incidence.

Keywords: Anemia, Pre-school children, Bangladesh, Prevalence, Multilevel regression.

Mathematics Subject Classification: 62J12.

1. Introduction

Prevalence of child anemia is a serious public health problem especially in developing countries (DeMaeyer and Adiels-Tegman, 1985). About 48% of children under five years of age are anemic in global terms (McLean, Cogswelland Egli, 2009). Many studies have been conducted on child anemia in a worldwide context because anemia interrupts the proper development of their mental, physical growth and social behavior (Burdam, Hakimi and Thio, 2016; Challa and Amirapu, 2016; Mannan, Ahmed and Akhtar, 2016; McCarthy, NíChaoimhand Hourihane, 2017). It also causes a variety of complications including negative behavioral and cognitive effects resulting in poor school performance and work capacity in later life (Villalpando, Shamah-Levy and Ramírez-Silva, 2003). Hemoglobin (Hb) level is considered the standard measurement for screening anemia, if the hemoglobin level of a child (<5 years) is below than 11.0 g/dl, then that child is considered as anemic (Benoist, McLean and Egli, 2008).

Children can be considered as the future leaders of a nation, and an unhealthy child is more likely to be unhealthy adult, and it is difficult to properly lead a country or nation with unhealthy persons. Attention therefore should be paid to pre-school children (6-59 months) due to their unique role in the future of populations. It is therefore important to investigate the prevalence of anemia and determine their risk factors among children.

In Bangladesh, some studies have been conducted of anemia among Bangladeshi women (Bishwajit, Yayaand Tang, 2016; Ghose, Yayaand Tang, 2016; Kamruzzaman, Rabbani and Saw, 2015; Merrill, Shamim and Ali, 2011). Some studies have on anemia been found with Bangladeshi rural children (Faruque, Khan and Malek, 2006; Helen Keller International/ Institute of Public Health Nutrition, 2002). One study has found on anemia among rural pre-school children in Bangladesh with only children in Dhaka city (Ahmed, 2000). It is very essential to investigate on anemia level of Bangladeshi pre-school children (6-59 months) using nationally representative sample. More recently, Khan et al. studied on anemia among pre-school children in Bangladesh, they used nationally representative data which was collected by Bangladesh Demographic and Health Survey (BDHS) using stratified cluster sampling (Khan, Awanand Misu, 2016). They did not consider cluster effect of their dataset though they used hierarchy structural data. There was a great chance to have cluster effect in BDHS dataset and without removing cluster effect; entire analysis might be misleading (Khan and Shaw, 2011).

In the present study, we used data that was collected in the name of BDHS, 2011. BDHS-2011 selected sample using by two stages stratified cluster sampling which was a nationally representative hierarchy structural data.

The aim of this study was to determine the prevalence of anemia among pre-school children and to investigate the effect of maternal anemia and wealth index on children anemia in Bangladesh after removing cluster effect.

2. Methods

A total of 2071 pre-school children (6-59 months) were considered as the sample in the present study. The data were extracted from Bangladesh Demographic and Health Survey (BDHS-2011), 2011. In BDHS-2011 collected data from each selected household from all over Bangladesh. Socio-economic, demographic, health and lifestyle information were collected from each selected subject in the BDHS-2011 (BDHS, 2013). It is a nationally representative survey in Bangladesh and it was carried out from July 2011 to December 27, 2011. In addition, BDHS-2011 collected blood from women in reproductive age and children (6-59 months) to test the hemoglobin level as a measure of anemia. Moreover, height and weight of women and pre-school children were also measured in the BDHS-2011 for calculating their nutritional status. All information with respect to the collection of data from the selected subjects such as sampling technique, survey design, survey instruments, measuring system, subject consent, ethics statement, quality control have been described elsewhere (BDHS, 2013).

BDHS-2011 collected blood from 2353 pre-school children (6-59 months) in Bangladesh for measuring anemia. The presence of outliers in the dataset was checked by the present authors. After removing unusual and missing data, the data set was reduced to 2071 for the analysis in the current study.

2.1 Sampling

BDHS-2011 used a two-stage stratified cluster sampling technique for selecting households. In the first stage, 600 enumeration areas (EAs) (207 from urban and 393 from rural) were selected for the BDHS-2011 using random sampling with proportional allocation. In the second stage, they selected 30 households from each selected EA using systematic sampling, and covered the whole country. A total of 18000 residential households were selected for completing interviews with about 18000 ever-married women. In addition, one-third of the selected households were considered as a sub-sample and these were selected using systematic sampling for collecting blood from women and their pre-school children (6-59 months) to measure their anemia.

2.2 Outcome variable and independent variables

The anemia status of pre-school children was the outcome variable of this study. The standard method for diagnosing anemia was to measure the level of hemoglobin (Hb) in blood; low Hb levels indicate anemia. The sample was first classified into two groups: anemic children (Hb level<11.0g/dl) and non-anemic children (Hb level≥11.0 g/dl). Anemic children were then subdivided into three subgroups such as mild anemia (Hb level 10.0 to 10.9 g/dl), moderate anemia (Hb level 7.0 to 9.9 g/dl) and severe anemia (Hb level <7.0 g/dl) (BDHS, 2013).

The independent variables used in this study were: administrative divisions (Barisal, Chittagong, Dhaka, Khulna, Rajshahi, Rangpur, Sylhet), residence (urban/rural), mother education (none,

primary, secondary, higher), sex of child (male/female); mother age (age≤20, 21≤age≤29, 30≤age≤39, age≥40 years), total born children (1-2 children, 3-5 children, 6 and more children); toilet facility (unhygienic/hygienic); maternal anemia level (non-anemic, anemic); place of birth/delivery (home, hospital/clinic); religion (non-Muslim/Muslim); wealth index (poor, middle, rich); birth weight (low birth weight, average, larger than average); children age group (age <2 year, 2≤age<3year, 3≤age<4 year, 4≤age< 5 years) number of family member group (member≤4, member 5-10, member11≥), child nutritional status (under weight, normal weight, over weight and obese). Child nutritional status was measured by weight for age (z-score). More detail on these variables is available in the 2011 BDHS surveys report (BDHS, 2013).

2.3 Statistical analysis

The association between anemia status of pre-school children and their parents' socio-economic, demographic and anthropometric variables were checked by Chi-square (χ^2) test. The significantly associated factors that were generated by the χ^2-test were to be used as independent variables in multilevel logistic models. two level logistic regression model were used in this study for finding the impact of mother anemia and household wealth index on children anemia. Population attributable fraction [PAF= P_b(OR-1)/OR; P_b is the proportion of risk group of independent factors, here our case we considered the proportion of anemic mothers, and children who lived in poor and middle family] was utilized for calculation the contribution of mother anemia and household wealth index on children anemia. For case of interpretation, we presented the PAF as population attributable risk percent (PAR%) multiplying PAF by 100. We calculated 'crude PAR%' using odds ratio (OR), and adjusted contribution was measured by adjusted odds ratio (AOR). Parents' socio-economic, demographic, children age, birth weight, nutritional status were considered as cofounding variables. In this study, we wanted to determine the impact of mother anemia and household wealth index after controlling the effects of selected confounders on children anemia with 95% confidence interval (CI).Statistical significance was accepted at $p<0.05$. Statistical analyses were carried out using STATA (version 13) and SPSS software (version IBM 20).

3. Results

A total number of 2071 pre-school children (6-59 months) in Bangladesh were considered as subjects in the present study. This study revealed that the prevalence of anemia among Bangladeshi children (6-59 months) was 52.1%. The prevalence of anemia among rural children (53.7%) was more than urban (48.3%), also the percentage of anemic boys (53.0%) was higher than girls (51.0%) (Figure 1). Among the anemic children, it was noted that a remarkable number of children (21.7%) had been suffering from moderate anemia; however, only 0.8% of the children presented with severe anemia. Approximately 30% Bangladeshi pre-school children were mildly anemic (Table 1).

Table 1: Prevalence of severe, moderate, mild anemic pre-school children in Bangladesh

Categories of anemia	**Frequency, N (%)**
Severe (Hb<7.0 g/dl)	17 (0.8%)
Moderate (7-9.9 g/dl)	449 (21.7%)
Mild (10.0-10.9 g/dl)	612 (29.6%)

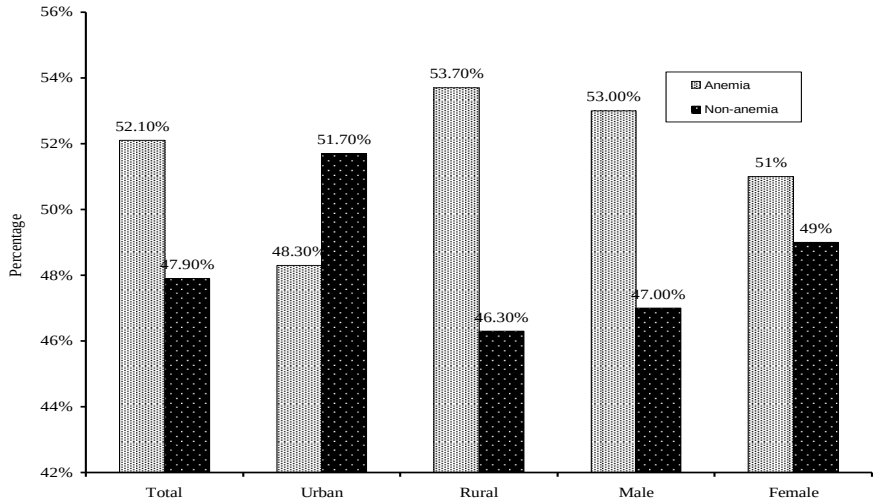

Fig. Prevalence of anemia among children by residence and gender

The χ^2-test demonstrated that living location (geographic divisions), place of residence, mother education level, mother age, religion, wealth index, children age group, toilet facilities at home, child nutritional status and maternal anemia level were significantly associated factors with child anemia (Table 2). These factors were considered as independent variables in the two level logistic regression model.

Table 2: Association between socio-economic and demographic factors with child anemia status in Bangladesh

Variables	Chi-square value	p-value
Children anemia versus Division	16.063	0.013
Children anemia versus Place of residence	5.864	0.015
Children anemia versus Mothers' education	14.329	0.002
Children anemia versus Children's sex	0.837	0.360
Children anemia versus Mother's age (year)	23.797	0.001
Children anemia versus Total number of children	1.567	0.457
Children anemia versus Religion	8.417	0.004
Children anemia versus Household wealth index	34.772	0.001
Children anemia versus Maternal anemia status	57.191	0.001
Children anemia versus Place of delivery	1.543	0.214
Children anemia versus Children's birth weight	0.223	0.894
Children anemia versus Children's age (year)	164.437	0.001
Children anemia versus Family members	0.055	0.973
Children anemia versus Toilet facilities	10.301	0.001
Children anemia versus Children's nutritional status	24.816	0.001

The two level logistic regression model demonstrated that anemic mothers' children were more prone for getting anemia than non-anemic mothers' children [Unadjusted, odd ratio (OR)=1.954; 95% CI:1.636-2.333; $p<0.01$]. When controlled the effect of other variables, it was also found that

anemic mothers were more likely to get anemic children [Adjusted odds ratio (AOR)= 1.843; 95% CI:1.526-2.226; p<0.01]. It was noted that children living in poor family who was more probable to get anemia than who lived in rich family [Unadjusted, odd ratio (OR)=1.743; 95% CI:1.448-2.098; p<0.01]. After controlling the effect of other variables, it was found same result but comparatively lower odds ratio [Adjusted odds ratio (AOR)=1.708; 95% CI:1.396-2.098; p<0.01]. When we compared middle family children with rich family, it was found that children who lived in middle family had more chance to have anemic than rich family children for unadjusted [Unadjusted, odd ratio (OR)=1.348; 95% CI:1.064-1.708; p<0.01] and adjusted [Adjusted odd ratio (AOR)=1.348; 95% CI:1.064-1.708; p<0.01]. (Table 3).

Table 3: The effect of maternal anemia on their children anemia in Bangladesh

Variable	Group	Unadjusted OR (95% CI)	*Adjusted OR (95% CI)
Maternal anemia	Yes Vs No[R]	1.954 (1.636-2.333)	1.843 (1.526-2.226)
Household wealth index	Poor Vs Rich [R]	1.743 (1.448-2.098)	1.708 (1.396-2.089)
	Middle Vs Rich [R]	1.348 (1.064-1.708)	1.348 (1.064-1.708)

* Adjusted the effect of other variables such as children nutritional status, children age group, household wealth index, living location (division) and religion.

Finally, PAR% demonstrated that the individual contribution of anemic mothers for getting anemic children by 20.65% (95% CI: 16.40%-24.15%) for unadjusted, and for adjusted it was by 19.35% (95% CI: 14.58%-23.30%). The individual contribution of poor family for their children anemic by 18.20% (95% CI: 13.21%-22.35%) for unadjusted, and for adjusted by 17.70% (95% CI: 12.11%-22.26%). It was found the contribution of middle family for having anemic children by 4.65% (95% CI: 1.08%-7.46%) and 4.43% (95% CI: 0.51%-7.46%) for unadjusted and adjusted cases respectively (Table 4).

Table 4: Crude and adjusted population attributable risk percent (PAR%) of maternal anemia on their children anemia

Variable	Group	Crude PAR% (95% CI)	*Adjusted PAR% (95% CI)
Maternal anemia	Yes	20.65 (16.40-24.15)	19.35 (14.58-23.30)
Household wealth index	Poor	18.20 (13.21-22.35)	17.70 (12.11-22.26)
	Middle	4.65 (1.08-7.46)	4.43 (0.51-7.46)

* Adjusted the effect of other variables such as children nutritional status, children age group, household wealth index, living location (division) and religion.

4. Discussions

This study determined the prevalence of anemia and investigated associated factors of child anemia in Bangladesh. In the present study, all the Bangladeshi children (6-59 months) were considered as a population and a sample was selected using a two-stage stratified cluster sampling. Data was extracted from the BDHS-2011 dataset. Some previous studies in Bangladesh have determined the prevalence and investigated the associated factors of anemia among pre-school children in rural area (Ahmed, 2000; Faruque, et al. 2006; Helen Keller International/ Institute of Public Health Nutrition, 2002). They did not use nationally representative sample of the nation. However, one study has been found on anemia among pre-school children in Bangladesh, in this study authors used nationally representative hierarchy structural data (BDHS dataset) (Khan, et al.

2016). They applied single level logistic regression analysis for determining effect of socio-economic and demographic factors on child anemia. The dataset of BDHS is hierarchy structural data, and single-level statistical model would not be appropriate for analyzing such kind of nested data (Khan and Shaw, 2011). Multilevel regression models had been already used to BDHS dataset for different articles (Kamruzzaman, et al. 2015; Kamruzzaman, Mamun and Bakar, 2017; Khan and Shaw, 2011; Khan, Islam and Shariff, 2017). In the present study, we used two level logistic regression models for determining the effect of socio-economic and demographic factors on pre-school children in Bangladesh. Moreover, median odds ratio (MOR) was used in this study, and it was found the value of MOR was 1.293; there was a variation of child anemia level among 600 enumeration areas (clusters).

The prevalence of anemia in this study population was 52.10% (rural 53.70% and urban 48.30%), which was higher than the global anemia level of 29%. Based on WHO criteria, anemia among children can be considered as a severe public health problem (prevalence greater than 40%) in Bangladesh (McLean, et al. 2009). Higher prevalence rates of child anemia were observed in other countries besides Bangladesh, such as Indonesia (58.7%) (Semba, de Pee and Ricks, 2008), Benin (82%) and Mali (83%) (Ngnie-Teta, Receveur and Kuate-Defo, 2007) and Ghana (78.4%) (Ewusie, Ahiadeke and Beyene, 2014). The prevalence rate of the present study was higher than in other studies around the world including; Pakistan (33.2%) (Habib, Black and Soofi, 2016), India (31.4%) (S, T and Ramachandran, 2015), Haiti (38.8%) (Ayoya, Ngnie-Teta and Seraphin, 2013) and Brazil (32.8%) (Leal, Batista and Lira, 2011).

As we mentioned earlier, a dataset was used in this study that was collected from the BDHS-2011 using a two-stage stratified cluster sampling. To the best of our knowledge, this is the first study that determined the risk factors for child anemia after removing the cluster effect present in a large dataset collected from all over Bangladesh. This model provided more accurate risk factors for child anemia in Bangladesh. This study identified the undernourished child as more likely to get anemia than the normal or over-nourished child. The BDHS-2011 data showed that the prevalence of stunted, wasted and underweight children of under age 5 were 41%, 16% and 36% respectively, and most of the undernourished pre-school children were living in poor family environments (BDHS, 2013). This study also noted that the wealth index was an important predictor of child anemia, and the decreasing tendency of the rate of child anemia was observed with increasing family wealth index. A poor family in Bangladesh is not able to provide adequate nutritional food to family members. Poor nutrition affects all family members but women and children are especially vulnerable because of their unique physiology and socioeconomic characteristics, as a result children become underweight and anemic. These results were in agreement with those of Mali (Ngnie-Teta, et al. 2007) and Indonesia studies (Semba, et al. 2008). The present study reveled that the mother's anemia level was one of the major risk factors for child anemia. Anemic mothers had a greater chance to get an anemic child and this risk factor was also found in studies of anemia in Pakistani (Habib, et al. 2016) and in Haiti pre-school children (Ayoya, et al. 2013). In Bangladesh, 42% of ever-married women age 15-49 were anemic, with most of them living in poor family environments (BDHS, 2013). Some studies of anemia such as in Pakistani children (Habib, et al. 2016), children in Haiti (Ayoya, et al. 2013) and in Brazil (Leal, et al. 2011) reported that younger children were more vulnerable to anemia than comparatively older children. The same result was found in this study. The present study demonstrated that children who were living in the Dhaka division were less likely to get anemia than in other divisions such as Barisal and Rangpur. Among the administrative divisions in Bangladesh, people living in Dhaka were more likely to fall into the highest wealth quintile than people living in other divisions (BDHS, 2013).

The results of multivariable logistic models in Khan et al. study showed that water source, wealth index, maternal anemia, age of the children, stunting and division were risk factors for pre-school children in Bangladesh (Khan, et al. 2016). More risk factors such as child's nutrition and religion were found in our study after removing cluster effect.

From the above discussion one can recognize that all associated factors of childhood anemia are also related to poverty. It is observed that the family wealth quintiles and school attendance have been increasing in Bangladeshi during last decade; as a result there has been an improvement in childhood nutritional status over this period. The level of stunting among children under age 5 has declined from 51% in 2004 to 36% in 2014. Wasting increased to 17% in 2007 from 15% in 2004 and has gradually declined since then, to 14% in 2014. The level of underweight has declined from 43% in 2004 to 33% in 2014 (BDHS, 2014). Unfortunately, the trends in anemia among pre-school children in Bangladesh were not observed because BDHS collected anemia data for children and mothers only for 2011 and not for 2014; thus, child anemia data for the whole country was not available in Bangladesh.

5. Limitation of this study

Secondary data was used in this study. Some of the selected socio-economic and demographic factors were chosen with the intention of identifying their effect on child anemia, but it was not possible to look at other possibly important factors that may also be related to child anemia, such as diabetes mellitus, environmental factors and sedentary lifestyle, etc. Clearly, more research is required.

6. Conclusions

In this study, anemia among 2071 pre-school children (6-59 months) was investigated in Bangladesh. The prevalence of anemic children was more than 50%. In this study, a two-level logistic regression model was utilized to remove the cluster effect of child anemia among the 600 clusters, which were selected from overall Bangladesh. This study suggests the presence of modifiable factors associated with child anemia. Our selected multilevel model provided that anemic mothers and poor family children were vulnerable for getting anemia in Bangladesh. These two groups are correlated, and PAF shows that these two groups together can put contribution by more than one third (38.85%) percent for children anemia in this country. Consequently, anemia can be considered as the major problem for children in Bangladesh, and Government and Non-government health organizations can consider our findings for societal intervention to reduce its incidence.

Abbreviations

AOR: Adjusted Odds Ratio; BDHS: Bangladesh Demographic and Health Survey; CI: Confidence Interval; EA: Enumeration Area; g/dl: Grams Per Decilitre; Hb: Hemoglobin; IBM: International Business Machines; MOR: Median Odds Ratio; NIPORT: National Institute of Population Research and Training; SE: Standard Error; SPSS: Statistical Package for the Social Science Software; WHO: World Health Organization; χ^2: Chi-Square.

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