

Rural-Urban Differentials of Childhood Malnutrition in Bangladesh

Azizur Rahman^{1,*} and Md. Sazedur Rahman²

¹*School of Computing and Mathematics, Charles Sturt University, Wagga Wagga, NSW 2678, Australia*

²*Statistics Discipline, Khulna University, Khulna-9208, Bangladesh*

Abstract: Malnutrition is a major health problem in developing countries and it affects childhood growth. Data from the 2014 Bangladesh Demographic and Health Survey were used in this study to explore the rural-urban disparities of malnutrition in children aged 0-59 months. Findings revealed that the prevalence of stunting, underweight and wasting were respectively as 39.6%, 35.7% and 16.7% for the rural children and 32.4%, 27.9% and 13.0% for the urban children. Both moderate and severe malnutrition were significantly higher in rural than urban community, and rural children ran about 1.3 times higher risk of becoming malnourished than their urban counterparts. The height and weight of children, mother's BMI, parents' education and family wealth index were found to be the significant factors associated with differentials at rural-urban malnutrition. Appropriate socioeconomic development, antenatal care in pregnancy and poverty reduction programs with a special emphasis on rural community would reduce the overall rural-urban inequality.

Keywords: Rural-urban comparison, Bangladesh, severe and moderate malnutrition, stunting, underweight and wasting.

INTRODUCTION

Child malnutrition still remains one of the most serious health problems in developing countries [1-3]. Malnutrition is responsible for 45% of all deaths among under-5 children [4]. It is reported that the prevalence of various forms of malnutrition such as stunting (height-for-age), wasting (weight-for-height), and underweight (weight-for-age) in pre-school children were 159 million (24.7%), 50 million (7.8%), and 95 million (15.1%), respectively in 2014 worldwide [5, 6]. Malnutrition affects the children's physical growth, cognitive development, mortality, morbidity, physical and mental work capacity [6-8]. It prevents them from reaching their full physical and mental potentiality and growth, also causes lower intellectual and physical abilities in adult life [4]. The mother's BMI, household wealth, parental education, media exposure, number of preschool siblings, size at birth, duration of breast feeding, mothers' height and measles vaccination are the factors associated with childhood malnutrition [9, 10].

In South-Asian countries, economic improvements have not been adequately reflected in improvements in child nutrition [8, 11]. The absolute number of stunted children are much higher in this region than anywhere else in the world, and over 50% of South-Asian children are underweight, comparing to 30% in Africa [12]. In South-Asia, Bangladesh is one of the most populous countries with 160 million people and about 31.5% of

its total population suffering from intense poverty [13]. Poverty, hunger, malnutrition and disease are interlinked factors. About 31.5% of the population lives below the national poverty line in Bangladesh and for every 1000 babies born, 31 die before their first birthday [14]. Two-thirds of childhood deaths occur as a consequence of malnutrition in Bangladesh [12, 15]. The rate of malnutrition in Bangladesh is almost double that of Somalia or Mozambique and somewhat is equal to that of Ethiopia [16].

Although the rate of child malnutrition have been decreasing in recent years due to initiatives implemented by the Bangladesh government and national and international organizations, present rates of child malnutrition are still alarming. Between the 2007 and 2014 Bangladesh Demographic and Health Surveys, the total prevalence of stunting decreased by 7%- from 43% to 36%, the underweight rate declined by 8% and the total prevalence of wasting decreased by only 3%-from 17% to 14% in under-5 children [17, 18]. According to WHO, the level of stunting and underweight levels are both above the threshold 'very high' prevalence [19]. These malnourished children are at greater risk of dying, deficit disorder, memory deficiency, cognitive development, physical and mental work capacity, learning disabilities, impairing school performance, etc. [20-22].

Nutritional status can vary from community to community. Region is a significant determinant of child malnutrition [23]. It is found from a study of 47 developing countries that there are significant differences in child nutrition outcomes in rural and urban areas [24]. It revealed that, on average, child

*Address correspondence to this author at the School of Computing and Mathematics, Charles Sturt University, Wagga Wagga, NSW 2678, Australia; Tel/Fax: +61269334744; E-mail: azrahman@csu.edu.au

health outcomes are better in urban areas, but the urban poor have higher rate of under-5 child malnutrition than their rural counterparts. A study of 749 pupils - 366 of whom are drawn from rural communities and 383 whom are drawn from urban communities in Nigeria shows that the mean nutritional status was significantly lower among the rural pupils than the urban pupils ($p < .001$) [23]. Research comparing the nutritional status of urban to rural areas helps to create appropriate nutritional policy. Since Bangladesh has experienced significant socio-economic growth in recent years [25-27], it is important to determine the present differentials in urban and rural malnutrition. Although, there are some recent studies about the determinants of malnutrition, researchers have not directed their attention toward a comparison of under-5 child malnutrition between rural and urban areas in Bangladesh. This study aims to measure and compare the rural-urban differentials in childhood malnutrition status, to observe some of their key determinants, and to help policy makers achieve the goal of a two-third reduction in childhood mortality by reducing the overall burden of malnutrition.

The outline of this paper is as follows. The next section provides information about the research materials and methods. Then overall analyses are presented and described in the results section. A detailed discussion about the significant findings is provided in the discussion section. The conclusion section highlights some final remarks with policy implications.

MATERIALS AND METHODS

Data from the 2014 Bangladesh Demographic and Health Survey (BDHS) were extracted for this analysis. The survey was conducted by The National Institute of Population Research and Training (NIPORT) of the Ministry of Health and Family Welfare of Bangladesh and one of specific objectives of this survey was to measure nutritional status of under-5 children. Two-stage stratified sampling method was used in where out of 17,989 chosen households, interviews were effectively done in almost 98% of total households [28]. A total sample of 7,131 children (age <5), 4879 (68.4%) from the rural and 2252 (31.6%) from the urban areas of the country were studied. The malnourished children were identified by three anthropometric indicators: height-for-age (stunted), weight-for-height (wasted) and weight-for-age (underweight) measures used widely for measuring malnutrition. Each indicators was categorized into three

groups, "Nourished", "Moderately malnourished" and "Severely malnourished".

To be more specific, on the basis of Z-score of height-for-age (HAZ), weight-for-height (WHZ) and weight-for-age (WAZ), a child was classified as severely malnourished, moderately malnourished and nourished if his/her Z-score for each indicator (HAZ/WHZ/WAZ) was respectively exposed in the ranges: Z-score < -3.0, $-3.0 \leq$ Z-score < -2.0 and Z-score \geq -2.0). The WAZ, HAZ and WHZ were calculated by using the WHO AnthroPlus Software (version 3.2.2, 2011) [29] from the age, height and weight of the children.

A set of demographic and socioeconomic factors of child malnutrition also selected as covariates for comparing results between rural and urban areas. The factors were: parents' age and education level, mother's body mass index (BMI) and family wealth index. Data were analyzed using Statistical Package for the Social Sciences (SPSS-23) software. The mean differences were compared using student's *t*-distribution while chi-square (χ^2) test was used for comparing ratios, rates and proportions. The level of significance was set at $p < 0.05$.

RESULTS

The study analyze a total of 7,131 children data among them 68.4% children were from rural communities. Table 1 compares the prevalent rates of nutritional status of children by in the rural and urban areas. Results demonstrate statistically significant differentials in that the prevalence rates of stunting, wasting, and underweight for the rural and urban children. In particular, the overall estimated prevalence rates of stunting, wasting and underweight were 39.6%, 35.7% and 16.7% respectively for the rural area, which are significantly higher than the estimated figures of 32.4%, 27.9% and 13.0% respectively for the urban area.

Both moderate and severe stunting were significantly higher in rural areas than urban areas ($\chi^2 = 34.41$, $df = 2$ and $p < 0.001$). The prevalence of moderate and severe stunting were 25.8% and 13.8% in rural areas. Whereas, these rates were 21.5% and 10.9% in urban areas. Also the total stunting rate was about 7.2% higher in rural than in urban community ($t = 5.85$, $p < 0.0001$).

Results of the wasting and underweight indices also reveal significant rural-urban differentials. In particular,

Table 1: Differentials of Childhood Nutrition in Rural and Urban Areas of Bangladesh, 2014

| Characteristics | Number of participants [†] | |
|---------------------------------------|-------------------------------------|----------------------|
| | Rural child (n= 4879) | Urban child (n=2252) |
| Stunting (Height-for-age)** | | |
| Nourished | 2946 (60.4) | 1522 (67.4) |
| Malnourished: Severe | 672 (13.8) | 246 (10.9) |
| Moderate | 1261 (25.8) | 484 (21.5) |
| Wasting (Weight-for-height)** | | |
| Nourished | 4065 (83.3) | 1959 (87.0) |
| Malnourished: Severe | 190 (3.9) | 90 (4.0) |
| Moderate | 624 (12.8) | 203 (9.0) |
| Underweight (Weight-for-age)** | | |
| Nourished | 3134 (64.2) | 1624 (72.1) |
| Malnourished: Severe | 441 (9.0) | 161 (7.1) |
| Moderate | 1304 (26.7) | 467 (20.7) |

***p*-value < 0.01; [†]Percentage in the parentheses.

about 16.7% of the rural children had severe or moderate wasting compare to their urban counterparts' estimate of 13.0% ($t = 3.98$, $p < 0.0001$). The total prevalence of underweight was about 7.9% higher in rural than in urban areas ($t = 6.58$, $p < 0.0001$). Additionally, the moderate and severe underweight rates were respectively 26.7% and 9.0% for rural and 20.7% and 7.1% for urban children. Both of these estimates were significantly higher in the rural community than the urban community ($\chi^2 = 43.11$, $df = 2$ and $p < 0.001$).

Table 2 presents results for the comparisons of some selected demographic and socioeconomic characteristics between rural and urban children. Several risk factors for childhood malnutrition such as weight and height of children, BMI of mother, education level of parents and wealth index of family demonstrate statistically significant differentials. Data reveal that estimates of the mean weight (10.31 ± 3.0 kg) and height (82.50 ± 13.27 cm) of rural children is significantly lower than that of urban children (with $p < 0.001$). Mother's BMI shows a significant difference between the mean estimates (rural: 21.24 ± 5.38 vs. urban: 23.06 ± 6.13 ; $t = 12.68$, $p < 0.001$) indicating a poor health status of mother, especially mothers in rural areas.

The level of mother education was found to be a statistically significant factor ($\chi^2 = 214.79$, $df = 3$ and $p < 0.001$). The rate of uneducated mothers was higher in rural areas (16.8%) than urban community (12.5%).

Around 46.2% mothers in both rural and urban communities have secondary education. Primary level of education was higher among rural mothers (30% vs. 23.2%) while higher education estimate was about 10.8% lesser in rural mothers. Almost a similar pattern is observed for father education variable. The secondary and higher education percentages were much larger in urban fathers though.

The wealth indexed of family was better in urban areas and found to be statistically significant at $p < 0.001$. Most of the rural children belonged to poor families (51.9%) while the highest percent of urban children (69.9%) belonged to rich families. The children of the middle income family were found as higher in rural areas (22.4%) than in urban areas (13.7%) though.

The multiple logistic regression results reveal that most of the selected characteristics were significantly associated with different forms of severe and moderate malnutrition (see, Table 3). For instance, children lived in poor and middle wealth indexed family are respectively 1.87 times and 1.44 times more likely to be stunted than children lived in rich family. Similar result found for moderate stunting, i.e. children in poor as well as middle wealth-households are roughly in a one and half times higher risk of becoming moderately stunted than their rich family counterparts. The poor family children were 2.08 times and 1.54 times and the middle wealth-family children were 1.52 times and 1.34 times more likely to be severely and moderately wasted than

Table 2: Comparisons of Rural-Urban Differentials by Selected Attributes of the Study Children

| Characteristics | Mean \pm SD or number of participants [†] | | p-value |
|----------------------|--|----------------------|---------|
| | Rural child (n= 4879) | Urban child (n=2252) | |
| Weight of child (kg) | 10.31 \pm 3.0 | 10.76 \pm 3.39 | < 0.001 |
| Height of child (cm) | 82.50 \pm 13.27 | 83.71 \pm 13.95 | <0.001 |
| Age of father (year) | 34.20 \pm 8.49 | 33.88 \pm 7.166 | 0.122 |
| Age of mother (year) | 25.53 \pm 5.92 | 25.65 \pm 5.71 | 0.417 |
| BMI of mother | 21.24 \pm 5.38 | 23.06 \pm 6.13 | < 0.001 |
| Mother's education | | | <0.001 |
| No education | 818 (16.8) | 281 (12.5) | |
| Primary | 1462 (30.0) | 523 (23.2) | |
| Secondary | 2249 (46.1) | 1042 (46.3) | |
| Higher | 350 (7.2) | 406 (18.0) | |
| Father's education | | | < 0.001 |
| No education | 1354 (27.8) | 418 (18.6) | |
| Primary | 1591 (32.6) | 561 (24.9) | |
| Secondary | 1429 (29.3) | 742 (32.9) | |
| Higher | 504 (10.3) | 530 (23.5) | |
| Wealth Index | | | < 0.001 |
| Poor | 2531 (51.9) | 369 (16.4) | |
| Middle | 1093 (22.4) | 308 (13.7) | |
| Rich | 1255 (25.7) | 1575 (69.9) | |

[†]Percentage in the parentheses.

the rich family children. Also, the children of poor family ran a 1.54 times and 1.30 times higher risk of becoming severely and moderately underweight than their rich counterparts.

The children of nutritionally at-risk (i.e. underweight mothers with BMI \leq 18.50 kg/m²) mothers were more likely to be malnourished compared to the children whose mother had an overweight (i.e. BMI > 20.50 kg/m²). Statistics reveal that the children of underweight mothers ran a 1.63 times and 1.35 times, 2.98 times and 1.75 times as well as 1.81 times and 1.85 times higher risk of becoming severely and moderately stunted, wasted as well as underweight respectively than than their better-fed counterparts. Somewhat similar results were also observed for children whose mothers had a normal BMI range from 18.50-20.50 kg/m² when compared to children whose mother had a nutritional overweight. Also, decreased level of mothers' education significantly enhanced the risk of both severe and moderate stunting and wasting.

Moreover, father education has a large impact on stunting and wasting. The results revealed that the

children of illiterate father had the highest risk of severe stunting and wasting and they were 2.05 times and 2.31 times more likely to be severely stunted and wasted than the children whose father had higher than a secondary education. Children whose father had 'no', 'primary' and 'secondary' educations respectively ran a 1.84 times, 1.70 times and 1.33 times higher risk of becoming moderately stunted than children whose father had more than secondary education. Analysis also shows that measures of malnutrition or stunting, wasting and underweight were high in rural areas and significantly associated with this residential differential factor. The children resided in rural areas were approximately 1.3 times higher risk in each form of malnutrition (except the severe underweight) than their urban counterparts.

DISCUSSION

The analyses of this study show that overall about 36%, 37% and 14% children in Bangladesh were stunted, underweight and wasted respectively. These rates are slightly lower than the estimates from recent years BDHS data. Statistics demonstrate that the rates

Table 3: Effects of Sociodemographic and Community Characteristics on Severe and Moderate Stunting, Wasting and Underweight of Under-5 Children in Bangladesh, 2014 (n = 7,131)[‡]

| Characteristic | Odds ratio of Stunting | | Odds ratio of Wasting | | Odds ratio of Underweight | |
|--------------------|------------------------|----------|-----------------------|----------|---------------------------|----------|
| | Severe | Moderate | Severe | Moderate | Severe | Moderate |
| Wealth Index | | | | | | |
| Poor | 1.87** | 1.59** | 2.08** | 1.54* | 1.54* | 1.30* |
| Middle | 1.44** | 1.42** | 1.52** | 1.34* | 1.21 | 1.14 |
| Rich (\$) | | | | | | |
| Mother's BMI | | | | | | |
| Underweight | 1.63** | 1.35** | 2.98** | 1.75** | 1.81** | 1.85** |
| Normal | 1.42** | 1.21* | 1.79** | 1.33* | 1.41* | 1.47** |
| Overweight (\$) | | | | | | |
| Mother's Education | | | | | | |
| No education | 2.48** | 1.37** | 1.83** | 1.44** | 0.68 | 1.27 |
| Primary | 2.16** | 1.28* | 1.67* | 1.47** | 0.89 | 1.25 |
| Secondary | 1.35* | 1.11 | 1.44* | 1.16 | 0.76 | 1.29 |
| Higher (\$) | | | | | | |
| Father's education | | | | | | |
| No education | 2.05** | 1.84** | 2.31** | 1.12 | 1.06 | 0.74 |
| Primary | 1.54* | 1.70* | 1.64* | 1.14 | 1.22 | 0.77 |
| Secondary | 1.16 | 1.33* | 1.01 | 0.94 | 1.04 | 0.77 |
| Higher (\$) | | | | | | |
| Region | | | | | | |
| Rural | 1.29** | 1.25** | 1.30** | 1.31** | 1.02 | 1.32** |
| Urban (\$) | | | | | | |

[‡]Reference category of dependent variable is well-nourished children; [§]Reference category of independent variables.
*p-value<0.05; ** p-value<0.01.

of stunted, underweighted and wasted children somewhat declined from the estimated rates of 43%, 45% and 17% respectively in 2007 to 41%, 33% and 16% respectively in 2011. Then the rate for the underweight soared by nearly 4%, while the rates for the stunting and wasting further declined by around 5% and 2% respectively from 2011 to 2014. Thus the prevalence of stunting in Bangladesh shows an overall noteworthy declining trend, yet the fall in prevalence has not been as rapid as the rise in the population. Such an overall improvement could be due to various interventions program of the government and private sectors [30]. However, the overall prevalent rates of malnutrition are still high in the country.

The rural-urban trends in prevalence rates of malnourished children in Bangladesh from 2007 – 2014 are depicted in Figure 1. Between the 2007, 2011 and 2014 BDHS surveys, the prevalence of stunting in rural areas decreased by almost 10% – from 49.5% to 39.6% – in children under the age of five. The level of

stunting in urban areas also decreased by about 9% – from 41.5% to 32.4%. Although the stunting curve shows a moderately decline trend over this time period for the urban children, it shows a relatively slow decline trend for the rural children between the 2011 and 2014 surveys. Moreover, the level of underweight decreased rapidly by 12% in urban areas and moderately by 8% in rural areas between the 2007 and 2011 BDHSs. The prevalence rates are fairly constant in both urban and rural areas between the 2011 and 2014 BDHSs though. The level of wasting in rural areas of Bangladesh decreased by only about 3% – from 19.2% to 16.0% between 2007 and 2011, but then it raised again by 1% in 2014 survey. In the period 2007-2014, on an average the prevalence of stunting, underweight and wasting was respectively 7%, 9% and 3% higher in rural areas than that in urban areas. This findings support the existence of rural-urban nutritional and health disparities in under-5 children in the developing country Bangladesh.

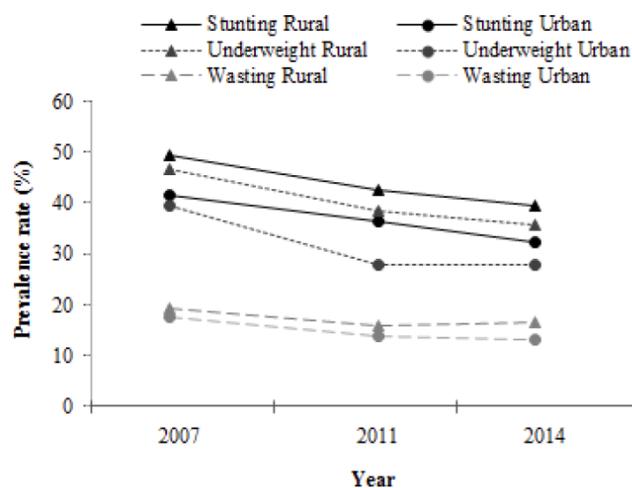


Figure 1: Rural-urban trends in prevalence of malnourished children in Bangladesh, 2007 – 2014.

The results demonstrate that rural children are more vulnerable to be malnourished than urban children. This is an agreement with the findings of other studies in the developing nations [24, 31-32]. It is also apparent in the results that there are significant rural-urban inequalities exist in the country in terms of demographic, socio-economic and community status – such as – weight and height of children, BMI of mother, parents' educational status, family wealth index and residential status of children. Some recent studies have found these variables as significant factors for child malnutrition in Bangladesh [25-27]. However, in this study, these variable were found to be major contributors of rural-urban childhood nutritional disparities.

Education is the powerful tools to progress and provides a source of knowledge. More educated mothers can make better use of health services, provide better childcare, have increased knowledge of appropriate child rearing, have more hygienic household practices and personal habits and also have higher status in the family [9]. In this study, children of uneducated or primary educated mothers had a higher risk of severe and moderate stunting and wasting. Lower maternal education has also been identified as a key risk factor for malnutrition in rural areas [10]. Both severe and moderate stunting as well as severe wasting are strongly associated with father's education. In Bangladesh, father's education should be more closely related to household income than mother's education. For example, the father's education is a prerequisite for sufficient access to food in a household and contributes a higher proportion of wealth to children's welfare, and better economic conditions

increase the living standards of families, allowing them to take essential care of the children, and provide support to the mother for baby care-giving. All of this depends on the father's education because the main household earner in the country is predominantly male. There is a large gap between mother's and father's education between rural and urban areas of the country. The educational status among urban parents have found better than rural parents. This finding is consistent with few studies conducted in Bangladesh [9, 10, 32]. From this study it is found that, a decreasing level of parental education elevated the prevalence of child malnutrition in both rural and urban communities which is an agreement of other research [22, 25, 27, 33-35]. Over the last two decades, Bangladesh has made an improvements in accessing education, especially in women's education through various programs including the Female Secondary Stipend (FSS) program, a conditional cash transfer program and free education for girls. These programs seem enhanced the rural literacy rate in the country. Hence, these sort of government and non-government educational programs must continue and should place a special emphasis on rural education to remove the educational gap for reducing rural-urban nutritional inequality.

Findings of the study suggest that the mother's nutritional status (i.e. mother's BMI) is better in urban areas than rural areas, which has also a significant effect on rural-urban disparities. Healthier mothers are more likely to have healthier babies [36]. The low BMI mothers' children have a significantly high likelihood of becoming malnourished compared to the children whose mother has a BMI > 20.50 kg/m². The problem of maternal malnutrition in a country like Bangladesh is a complex one with several underlying causes [9]. Poverty is a direct cause of maternal undernutrition because mothers from rural and poor families are nutritionally deprived during childhood and adolescence, and this does not improve after marriage. Social causes, like early marriage, frequent childbirth, lack of proper birth spacing, and discrimination of intra-household food distribution in a male-dominated family, all exacerbate the poor state of maternal malnutrition. Besides this, undernourished mothers usually have little or no education and probably cannot breast-feed their children adequately, which can contribute to the poor nutrition of their children and they usually give birth to low birth weight babies [9]. This analysis suggests that the factors influencing maternal nutrition as discussed above would be more pronounced since

the nutritional status of mothers emerges as one of the key determinant of their children's nutritional status, and there is a significant difference observed between rural-urban maternal nutrition. So, for reducing childhood malnutrition, the good nutritional status of the mother in pregnancy period should be ensured. Policy makers should give more importance in rural areas for improving rural mothers' nutritional status throughout their lifecycle and during pregnancy.

Rural-urban differentials in malnutrition have found for the family wealth index. The difference of family income is the most important factor in explaining rural-urban disparities [32]. Most of the households (51.9%) in the rural areas were in the poor group, while this estimate in urban area was only 16.4%. A number of studies have revealed that children from poor families are more likely to be malnourished than middle income or rich families, [26-28, 33-35]. which is also truth for this present study. Results of the regression analysis have depicted that the children in poor or middle wealth indexed family are more likely to be severely and moderately malnourished compared to children in rich family. This finding suggests the continued need of comprehensive poverty reduction social and economic policies with a specific attention to the rural community.

CONCLUSIONS

This paper examined rural-urban differentials in under-5 children nutritional outcomes in Bangladesh using the Z score-based anthropometric measures – such as – stunting, wasting and underweight. The prevalence of childhood malnutrition is significantly higher among rural children than their urban counterparts. Also for both rural and urban areas, the prevalence of stunting, wasting and underweight is still high and remains fairly constant during the period between the 2011 and 2014 BDHSs. The study suggests that severe and moderate malnutrition is a public health problem among children in Bangladesh. The key factors such as the low level of height and weight of children, inadequate maternal nutrition, no or low level of parental education, and poor wealth index of households are found to be significantly associated with disparities in malnutrition rates between rural and urban children. Consequently it is recommended that policymakers at the public and private sectors should give attention to improving those factors to rapidly reduce the overall level of malnutrition and rural-urban differentials. Furthermore a prospective study is needed to find out the specific set of geospatial determinants of child and maternal nutrition since the two are strongly linked.

DECLARATION OF CONFLICTING INTERESTS

The authors declared no conflicts of interest with respect to the research, authorship, and/or publication of this article.

ACKNOWLEDGEMENTS

The authors wish to acknowledge the help of the National Institute of Population Research and Training (NIPORT) of Bangladesh for supplying the data used in this study. They are grateful to the Data Science Research Unit (DSRU) of the School of Computing and Mathematics at the Charles Sturt University, Australia for assistance in reviewing the manuscript. Sincere thanks are also due to the anonymous reviewers and the editor for their valuable comments which were used to improve the paper.

ETHICS STATEMENT

There is no ethics approval required for this study and it analyzed the 2014 Bangladesh Demographic and Health Survey data.

REFERENCES

- [1] Das S, Rahman RM. Application of ordinal logistic regression analysis in determining risk factors of child malnutrition in Bangladesh. *Nutrition Journal* 2011; 10(1): 124. <https://doi.org/10.1186/1475-2891-10-124>
- [2] Rahman A, Biswas SC. Nutritional status of under-5 children in Bangladesh. *South Asian Journal of Population and Health* 2009; 2(1): 1-11.
- [3] Kramer CV, Allen S. Malnutrition in developing countries. *Paediatrics and Child Health* 2015; 25(9): 422-427. <https://doi.org/10.1016/j.paed.2015.04.002>
- [4] Black ER, Victora GC, Walker PS, Bhutta AZ, *et al.* Maternal and child undernutrition and overweight in low-income and middle-income countries. *Lancet* 2013; 382(9890): 427-451. [https://doi.org/10.1016/S0140-6736\(13\)60937-X](https://doi.org/10.1016/S0140-6736(13)60937-X)
- [5] WHO. World Health Statistics 2014. Geneva, Switzerland: World Health Organization 2014.
- [6] UNICEF/WHO/World Bank. Joint Child Malnutrition Estimates by UNICEF, WHO & World Bank 2014. (Accessed at <http://data.worldbank.org/child-malnutrition> on 25 June 2018).
- [7] Rahman A, Chowdhury S, Hossain D. Acute malnutrition in Bangladeshi children: levels and determinants. *Asia Pacific Journal of Public Health* 2009; 21(3): 294-302. <https://doi.org/10.1177/1010539509335399>
- [8] Fakir MSA, Khan RWM. Determinants of malnutrition among urban slum children in Bangladesh. *Health Economics Review* 2015; 5(1): 22-22. <https://doi.org/10.1186/s13561-015-0059-1>
- [9] Rahman A, Chowdhury S. Determinants of chronic malnutrition among preschool children in Bangladesh. *Journal of Biosocial Science* 2007; 39(2): 161-173. <https://doi.org/10.1017/S0021932006001295>
- [10] Rahman A, Chowdhury S, Karim A, Ahmed S. Factors associated with nutritional status of children in Bangladesh: A multivariate analysis. *Demography India* 2008; 37(1): 95-109.

- [11] Das Gupta M. Death clustering, mothers' education and the determinants of child mortality in rural Punjab, India. *Population Studies* 1990; 44(3): 489-505. <https://doi.org/10.1080/0032472031000144866>
- [12] Rahman A. Significant risk factors for childhood malnutrition: evidence from an Asian developing country. *Science Journal of Public Health* 2016; 4(1): 16-27.
- [13] Chowdhury AM, Bhuiya A, Chowdhury ME, Rasheed S, Hussain Z, Chen LC. The Bangladesh paradox: exceptional health achievement despite economic poverty. *The Lancet*. 2013; 382(9906): 1734-1745. [https://doi.org/10.1016/S0140-6736\(13\)62148-0](https://doi.org/10.1016/S0140-6736(13)62148-0)
- [14] Rahman A, Chowdhury BS. Nutritional status of under-5 children in Bangladesh. *South Asian Journal of Population and Health* 2009; 2(1): 1-11.
- [15] Ahmed T, Hossain M, Sanin KI. Global burden of maternal and child undernutrition and micronutrient deficiencies. *Annals of Nutrition and Metabolism* 2012; 61(Suppl. 1): 8-17. <https://doi.org/10.1159/000345165>
- [16] Alam N, Wojtyniak B, Rahaman MM. Anthropometric indicators and risk of death. *The American Journal of Clinical Nutrition* 1989; 49(5): 884-888. <https://doi.org/10.1093/ajcn/49.5.884>
- [17] Megabiaw B, Rahman A. Prevalence and determinants of chronic malnutrition among under-5 children in Ethiopia. *International Journal of Child Health and Nutrition* 2013; 2(3): 230-236. <https://doi.org/10.6000/1929-4247.2013.02.03.5>
- [18] BDHS. National Institute of Population Research and Training (NIPORT), Mitra and Associates, and Macro International, Calverton, Maryland: Bangladesh Demographic and Health Survey (BDHS); 2007.
- [19] Das S, Gulshan J. Different forms of malnutrition among under five children in Bangladesh: a cross sectional study on prevalence and determinants. *BMC Nutrition* 2017; 3(1): 1-1. <https://doi.org/10.1186/s40795-016-0122-2>
- [20] Martins VJ, Toledo Florêncio TM, Grillo LP, Do Carmo P Franco M, Martins PA, Clemente AP, Santos CD, Vieira MD, Sawaya AL. Long-lasting effects of undernutrition. *International Journal of Environmental Research and Public Health* 2011; 8(6): 1817-1846. <https://doi.org/10.3390/ijerph8061817>
- [21] Martorell R, Ho TJ. Malnutrition, morbidity, and mortality. *Population and Development Review* 1984; 10: 49-68. <https://doi.org/10.2307/2807955>
- [22] Ahamed A, Das S, Rahman A, Rahman ST. On selection of a robust multilevel model for child nutrition measure in Bangladesh. In Proceedings of the Bangladesh Statistical Association Conference, Dhaka 2017; pp. 1-22.
- [23] Oninla SO, Owa JA, Onayade AA, Taiwo O. Comparative study of nutritional status of urban and rural Nigerian school children. *Journal of Tropical Pediatrics* 2006; 53(1): 39-43. <https://doi.org/10.1093/tropej/fml051>
- [24] Van de Poel E, O'Donnell O, Van Doorslaer E. Are urban children really healthier? Evidence from 47 developing countries. *Social Science & Medicine* 2007; 65(10): 1986-2003. <https://doi.org/10.1016/j.socscimed.2007.06.032>
- [25] Das S, Rahman A, Ahamed A, Rahman ST. Multi-level models can benefit from minimizing higher-order variations: an illustration using child malnutrition data. *Journal of Statistical Computation and Simulation* 2018; 1-21. <https://doi.org/10.1080/00949655.2018.1553242>
- [26] National Institute of Population Research and Training - NIPORT/Bangladesh, Mitra and Associates/Bangladesh, and ICF International. Bangladesh Demographic and Health Survey 2014. Dhaka: NIPORT, Mitra and Associates, and ICF International; 2016. (Accessed at: <https://dhsprogram.com/pubs/pdf/FR311/FR311.pdf> on 25 June 2018).
- [27] WHO. Anthro for personal computers, version 3.2.2, 2011: software for assessing growth and development of the world's children. Geneva: WHO; 2011. (Accessed at: <http://www.who.int/childgrowth/software/en/> on 20 June 2018).
- [28] Yunus RM, Rahman A. Factors associated with nutritional status of children in low and middle income countries in Southeast Asia – A multilevel analysis. In Proceedings of the 42nd Annual Conference of the Australian & New Zealand Regional Science Association International (pp. 1-7). Australian & New Zealand Regional Science Association International (ANZRSI); 2018.
- [29] Fotso JC. Urban-rural differentials in child malnutrition: trends and socioeconomic correlates in sub-Saharan Africa. *Health & Place* 2007; 13(1): 205-223. <https://doi.org/10.1016/j.healthplace.2006.01.004>
- [30] Srinivasan CS, Zanella G, Shankar B. Rural-urban disparities in child nutrition in Bangladesh and Nepal. *BMC Public Health* 2013; 13(1): 581. <https://doi.org/10.1186/1471-2458-13-581>
- [31] Nahar B, Ahmed T, Brown KH, Hossain MI. Risk factors associated with severe underweight among young children reporting to a diarrhoea treatment facility in Bangladesh. *Journal of Health, Population, and Nutrition* 2010; 28(5): 476.
- [32] Kuddus A, Rahman A. Affect of urbanization on health and nutrition. *International Journal of Statistics and Systems* 2015; 10(2): 165-175.
- [33] Janevic T, Petrovic O, Bjelic I, Kubera A. Risk factors for childhood malnutrition in Roma settlements in Serbia. *BMC Public Health* 2010; 10(1): 509-509. <https://doi.org/10.1186/1471-2458-10-509>
- [34] Negash C, Whiting SJ, Henry CJ, Belachew T, Hailemariam TG. Association between maternal and child nutritional status in Hula, rural Southern Ethiopia: a cross sectional study. *PLoS One* 2015; 10(11): e0142301. <https://doi.org/10.1371/journal.pone.0142301>
- [35] Islam MA, Rahman MM, Mahalanabis D. Maternal and socioeconomic factors and the risk of severe malnutrition in a child: a case-control study. *European Journal of Clinical Nutrition* 1994; 48(6): 416-424.