RESEARCH ARTICLE

Determining the I_x and estimating the force of mortality for children under five in Bangladesh [version 1; peer review: 2 approved with reservations]

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Abstract

Background: Under-five mortality is a health indicator in population health and the health sciences. Force of death is a more accurate measure of mortality than others, which indicates the situation of mortality when time tends to zero. The purpose of this research is to construct a simulation for I_x (the number of people living at exact age x) for under-five mortality in Bangladesh as a whole, and separately for rural and urban areas, and then estimating the mortality rate in regard to these matched models.

Methods: Secondary data were collected from Bangladesh Demographic and Health Survey 2007. A polynomial model was selected to match the I_x values. To prove the accuracy of the model, the rule of cross-validity was applied.

Results: It has been shown that fourth degree polynomial models can be adjusted to I_x values with explanation of more than 94% variation. It was noted that the mortality rate shows a rapidly decreasing pattern for people aged 0-20 months, a monotonically increasing pattern for those aged 20-53.5 months and then it begins to decrease. It is found that the mortality rate in rural areas is higher than in urban areas of all ages.

Conclusions: It has been shown that the mortality rate in rural areas is higher than for urban areas of all ages, except for those aged 53.5 months. The health situation should therefore be improved to reduce mortality in rural Bangladesh.

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Any reports and responses or comments on the article can be found at the end of the article.

Keywords

Children under five years, Force of mortality, Urban and rural mortality, F-test, Bangladesh

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Abbreviations

ANOVA, Analysis of variance; BDHS, Bangladesh Demographic and Health Survey; BBS, Bangladesh Bureau of Statistics; CVPP, cross validity prediction power; IMR, infant mortality rates; EA, enumeration area; MDG 4: Millennium Development Goal 4; NGO, non-governmental organization

Introduction

The mortality rate of infants is a reflection of the well-being and nutritional status of children, and also indicates the socio-economic progress in a given country or region. In truth, it reflects the well-being of mothers, the availability and standard of care for well-being, and how easy it is to receive support in the community and/or country. Child mortality rates and, in particular, infant mortality rates (IMRs) dropped sharply in developed countries, but over the past five decades it has been difficult to lower rates in developing countries such as Bangladesh. It has been found that 29,000 children under the age of five die every day in Bangladesh¹.

Five years of previous mortality studies of children under five (2010–2014) is 46 deaths per 1000 live births. Bangladesh achieved its Millennium Development Goal 4 (MDG 4) target for deaths under the age of five, decreasing the rate of child mortality to 48 per 1000 births by 2015. The current infant mortality rate is 38 deaths per 1000 live births, and the mortality rate for children is 8 per 1000 children. In childhood, the risk of death in the first month of life (28 deaths per 1000 live births) is almost three times higher than in the next 11 months (10 deaths per 1000 live births). It has also been found that mortality in the neonatal stage constitutes around 61% of all deaths under the age of five².

It was noted that in 2007, around 9.2 million live births resulted in death of the child before their fifth birthday³, but in the next twelve months this number fell to 8.8 million^{4,5}, with 41% of these deaths occurring in newborns⁵. The IMRs are 44.5 and 76 per 1,000 live births universal for more developed and less developed countries, respectively, indicating that infant death is still high in some vulnerable groups and areas, despite declining trends⁶. The highest under-five death rates are still observed in sub-Saharan Africa, while South Asia has the second highest rates in the world^{5,7}. Many countries have not reached MDG 4⁵, but Bangladesh is currently one of the few countries in the world, particularly in South Asia and sub-Saharan Africa, to have reached this goal. Bangladesh decreased death rates from 151 deaths per 1,000 live births in 1990 to 50 deaths per 1,000 live births in 2015⁸. Current studies have revealed that the mortality risk index is 45 per 1,000 live births⁶ and that under-five mortality is between 71⁹ and 65¹⁰ per 1,000 live births. Although the recent downward trend in infant mortality is notable¹¹, it remains high in Bangladesh due to the high incidence of malnutrition and childhood diseases. One child dies every three or four minutes, resulting in 14 child deaths every hour in Bangladesh¹². Deaths usually occur during the neonatal period¹³.

For this reason, a number of studies have been carried out on the mortality of infants and children and under five; however, in Bangladesh, there have been few studies

investigating the mortality rate of infants and children under the age of five. The polynomial model can be used to approximate a complex nonlinear relationship, which is related to the polynomial degree, which depends on the data pattern. In addition, the response variable is estimated at any time within the domain of the matched model in terms of the explanatory variable, i.e. the respondent's age. Furthermore, mortality is important because it is considered a mortal situation when time tends to zero, but age-specific mortality is the mortality rate within a specific age group. Therefore, the main purpose of this article is to match some models to I_x values for children under five in Bangladesh as a whole, as well as in rural and urban areas separately.

Methods

Data source

To achieve the above-mentioned goals of this study, secondary data on the I_x value for age (in months), i.e. the group data for children under five in Bangladesh as a whole and separately for rural and urban areas, are from Bangladesh Demographic and Health Survey (BDHS) 2007¹⁴. The 2007 BDHS was representative at national level and included the entire population that did not live in institutional housing units in the country. The survey was used as a sampling frame for the list of enumeration areas (EAs) prepared for the Population and Housing Census 2007, provided by Bangladesh Statistics Office (BBS). The BDHS study was conducted using a two-stage stratified sample of households. A total of 600 areas were initially selected, with 207 clusters in urban areas and 393 in rural areas. A complete list of households was then compiled in all selected areas to provide a sampling framework for the second phase of household selection. In the second phase of the sampling, a systematic sample of an average of 30 households per area was selected to provide statistically reliable estimates of the most important demographic and health variables for the country as a whole, for urban and rural areas individually, and for each of the seven divisions (Dhaka, Rajshahi, Rangpur, Chittagong, Khulna, Barisal and Sylhet). The total sample size is 8,721, of which 5,840 come from rural areas and 2,881 from urban areas during the ten years preceding the survey, in which the sample consists of eligible women, i.e. women who have ever been married and who are aged between 10 and 49 with at least one child. Their data are used as the raw data for this study.

Smoothing of age data

To better adjust the model, the age (in months) associated with the I_x values in Bangladesh and rural and urban areas was smoothed separately using the 4253H smoothing method twice¹⁵. The smoothing method was done using Minitab 12.1. It should be noted that the smoothing method is performed to remove age as well as reporting errors before model fitting for better performance as well as better prediction. There are various methods of smoothing, such as the free-hand curve method, the moving average method and 4253H, the double method. The free-hand curve method does not have a mathematical background and the moving average method loses some observations. For this reason, the 4253H method is used, a double method for better efficacy that does not lose any observations.

Model fitting

The l_x values for under-five mortality showed a non-linear distribution. Therefore, an n degree polynomial model is identified in this case and the model is given as:

$$y = a_0 + \sum_{i=1}^n a_i x^i + u \quad (1)$$

in which x represents the age in months that is used as explanatory variable in the model, y represents the l_x value, a_0 is a constant, a_i is the coefficient of the x^i ($i = 1, 2, 3, \dots, n$) and u is the error term of the model¹⁶. Here, a suitable n is chosen for which the sum of the squares of the error is the lowest. These models were built using SPSS 22.

Model validation procedure

Cross-validation is a technique used in model selection to better estimate the test error of a predictive model. The idea behind cross-validation is to create a better assessment of a model's predictive performance. For this, to check the legitimacy of these models over the population, the cross validity prediction power (CVPP), ρ_{cv}^2 , is employed at this juncture. The mathematical formula for the CVPP is specified below:

$$\rho_{cv}^2 = 1 - \frac{(n-1)(n-2)(n+1)}{n(n-k-1)(n-k-2)} (1 - R^2) \quad (2)$$

where n is the quantity of classes, k is the number of explanatory variables in the fitted model and R is the correlation between the observed and the fitted values of the response variable. The shrinkage coefficient of the fitted model is the absolute value of $(\rho_{cv}^2 - R^2)$; where ρ_{cv}^2 is the CVPP and R^2 is the proportion of variation of this model. Furthermore,

the stability situation of R^2 of this model is $(1 - \text{shrinkage})$. The estimated CVPP corresponding to R^2 and the results for the model fittings are summarized in Table 1. It has been shown that the CVPP can also be used as a model validation technique^{17–26}.

The F-test

To identify the overall significance level of the formulated model and the significance of R^2 of the model, the F-test is used in this paper. The formula for the F-test is given as:

$$F = \frac{\frac{R^2}{(p-1)}}{\frac{(1-R^2)}{(n-p)}} \text{ with } (p-1, n-p) \text{ degrees of freedom (df).}$$

where p is the number of parameters of the fitted model, n is the number of cases and R^2 is the coefficient of determination of the fitted model²⁷.

Instantaneous force of mortality (μ_x)

The instantaneous force of mortality at age x is defined as the ratio of the instantaneous rate of decrease in l_x to the value of l_x . It is denoted by μ_x and, in the limiting case, it is given using differential calculus by:

$$\mu_x = \lim_{t \rightarrow 0} \frac{l_{x+t} - l_x}{t \cdot l_x} = -\frac{1}{l_x} \frac{d}{dx}(l_x) = -\frac{d}{dx}(\ln l_x) \quad [28, 29].$$

In brief, it is also called the force of mortality. In fact, the force of mortality is a more accurate measure in mortality studies than age-specific death rates. It measures the mortality situation when time tends to zero. This is an instantaneous measurement, rather than an interval measurement.

Table 1. The results of CVPP and information on model fittings.

Models	n	K	Parameters	p-values	R^2	ρ_{cv}^2	Shrinkage	F-test (calculated and tabulated)
Model for Bangladesh	11	5	a_0 a_1 a_2 a_3 a_4	<0.0001 0.001102 0.007429 0.020427 0.038182	0.94553	0.821731	0.123798	26.08 and 9.15 with (4,6) df at 1% level of significance. Significant
Model for rural areas	11	5	a_0 a_1 a_2 a_3 a_4	<0.0001 0.001261 0.008829 0.023974 0.044073	0.94754	0.828309	0.11923	27.093 and 9.15 with (4,6) df at 1% level of significance. Significant
Model for urban areas	11	5	a_0 a_1 a_2 a_3 a_4	<0.0001 0.000799 0.005044 0.014332 0.027845	0.94241	0.811537	0.13088	24.548 and 9.15 with (4,6) df at 1% level of significance. Significant

CVPP, cross validity prediction power; df, degrees of freedom.

Results

The polynomial model is used to fit the age associated with the I_x values for children under five in Bangladesh in rural and urban areas, and these fitted models are presented (Figure 1, Figure 2, Figure 3) below:

- For Bangladesh, $y=950.1666-39.3148x+2.1053x^2-0.0449x^3+0.0003x^4$; t-value: (42.33616) (-5.84934) (3.96269) (-3.12604) (2.64699)
- For rural areas, $y=966.3290-26.1108x+1.3809x^2-0.0294x^3+0.0002x^4$; t-value: (63.16859) (-5.69949) (3.81335) (-3.00112) (2.54014)
- For urban areas, $y=984.0909-13.2389x+0.7251x^2-0.0155x^3+0.0001x^4$; t-value: (138.4389) (-6.2189) (4.3088) (-3.4093) (2.8858)

The results of the fitted models and the CVPP corresponding to the R^2 of these fitted models of I_x values for children under five in Bangladesh and in the rural and urban areas are presented in Table 2. It seems that the constructed models (i) to (iii) are cross-validated, and their shrinkages are also shown in Table 2. These imply that the fitted models (i) to (iii) are more than 81% stable, and this is demonstrated in Table 2.

In addition, it can be seen that the parameters of these models are significant, with more than 94% of the explained variance, which is also shown in Table 3. The stability position for R^2 of these matched models is over 87%. The calculated values for the F-test, i.e. the analysis of variance (ANOVA) for these matched models with (5, 7) df, are 26.08, 27.09 and 24.548 and are displayed in Table 2, while the corresponding tabular values are 9.15 for models (i) to (iii) at a significance level of 1%. Consequently, on the basis of these test

statistics, it is concluded that the F-test is highly significant, and therefore, that these models are highly significant. That is why the fitting of the models is good. Hence, forecasts based on these models are shown in Table 1.

It should be mentioned here that other more typical models, such as the linear model ($R^2 = 0.53$), exponential ($R^2 = 0.55$), square ($R^2 = 0.73$) and the cubic model ($R^2 = 0.85$), were also used for the Bangladesh data set, but they did not show a better fit due to the low coefficient of determination.

The ages associated with force of mortality for children aged under five in Bangladesh, and in rural and urban areas, are estimated from the fitted model of the I_x values that are presented in Table 3 and shown in Figure 4 to Figure 6.

In Table 3, as well as in the numbers described above, it can be seen that the mortality of children under five in Bangladesh, as well as in rural and urban areas, shows a rapidly decreasing pattern at 0–20 months, followed by a monotonically increasing pattern for age from 20 to 53.5 months and then it begins to decrease. In addition, it has been demonstrated that the mortality rate in rural areas is higher than for urban areas of all ages excluding those aged 53.5 months. All three cases show a similar pattern.

Discussion

Explanation of the empirical age patterns of death using these models is one of the most important topics in population studies, especially in demographics. In this study, the fourth degree polynomial models are well-suited to I_x values for children ages under five, with an explanation for the huge proportion of variation. The mortality of infants and children in Bangladesh is significantly reduced, but the future

Figure 1. Smoothed and predicted I_x values for children under five in Bangladesh. X axis represents age group and Y axis represents I_x .

Figure 2. Smoothed and predicted I_x values for children under five in rural areas in Bangladesh. X axis represents age group and Y axis represents I_x .

Figure 3. Smoothed and predicted I_x values for children under five in urban areas in Bangladesh. X axis represents age group and Y axis represents I_x .

increase in life expectancy requires an additional reduction in mortality³⁰. This study estimates how age is related to the mortality of children under the age of five in Bangladesh as a whole and in rural and urban areas separately. We expect these recent mortality findings to convince the government, non-governmental organizations and those responsible for policy planning of the

need for a planned increase in socio-demographic development and health care facilities. For this reason, the survival (I_x) function taken from the data is selected as the raw material in this study. The mortality force is the ratio between the instantaneous rate of decrease in I_x and the value of I_x , which is obtained from the functional dependence between I_x and age x .

Table 2. The observed, smoothed and predicted survival function (l_x values) for children under five in Bangladesh.

Age in Months	Bangladesh			Rural			Urban		
	Observed	Smoothed	Predicted	Observed	Smoothed	Predicted	Observed	Smoothed	Predicted
0	1000	992	950	1000	995	966	1000	997	984
1.5	835	871	896	888	913	930	947	958	966
4	787	791	824	855	860	882	932	932	942
7	751	752	764	834	834	842	917	918	922
10	733	733	726	822	822	816	911	912	910
14.5	725	723	700	815	813	798	910	909	902
20.5	714	713	700	805	804	796	909	909	904
31.5	702	701	717	794	794	805	908	907	912
41.5	686	688	699	784	784	791	902	904	908
53.5	677	678	657	775	776	762	902	902	895
60	669	669	679	770	770	776	899	899	903

Table 3. Instantaneous force of mortality for children under five in Bangladesh, in rural and in urban areas.

Age in Months	Bangladesh	Rural	Urban
0	0.041377	0.027021	0.013453
1.5	0.037172	0.023828	0.011562
4	0.029802	0.018618	0.008661
7	0.020994	0.012862	0.005672

Age in Months	Bangladesh	Rural	Urban
10	0.013058	0.007981	0.003283
14.5	0.004175	0.002719	0.000851
20.5	0.001050	0.000432	0.000426
31.5	0.003945	0.002020	0.001310
41.5	0.015448	0.007861	0.005014
53.5	0.024107	0.010886	0.008379
60	0.018265	0.006599	0.008007

Figure 4. Instantaneous force of mortality for children under five in Bangladesh. X axis represents age in months and Y axis represents force of mortality.

Figure 5. Instantaneous force of mortality for children under five in rural areas in Bangladesh. X axis represents age in months and Y axis represents force of mortality.

Figure 6. Instantaneous force of mortality for children under five in urban areas in Bangladesh. X axis represents age in months and Y axis represents force of mortality.

Mortality rate should be treated as the probability of death at a given moment, taking into account survival until that time. It was reported that the l_x values for the Bangladeshi male population are in line with the four-parameter cubic polynomial model³⁰ and it has been observed that the l_x values for the Bangladeshi population are consistent with the third degree polynomial model³¹. However, in this study, efforts were made to focus on which mathematical model best suits the relationship between age and l_x values for minors in Bangladesh as a whole, and in rural and urban areas separately. For this purpose, the polynomial model is chosen. It should be mentioned that a number of studies were carried out using the polynomial model^{32–35}. One of the limitations of the survey is that, except for a few questions, almost all information collected in BDHS surveys is subject to reporting errors.

Conclusions

In this study, it was found that the relationship between age and l_x values for children under five in Bangladesh results from a four-level polynomial model containing five parameters. The mortality rate shows a rapidly decreasing pattern at 0–20 months and a monotonically increasing pattern between 20 and 53.5 months, and then begins to decrease in all cases. This research result has fundamental strategic implications, especially for educational and awareness program requirements for a real decrease in child mortality and compliance with public health interventions. The researcher recommends additional research, taking into account these unobserved issues that are probably associated with the death of infants and

children, to better understand the relationship between family and public factors and the death of a child in Bangladesh. Intervention programs and policies should focus on this research to improve the health consequences for children, in order to achieve future improvement of the situation in Bangladesh as well as in other areas such as sub-Saharan Africa.

Ethical approval

Ethical approval for this study was not applicable, since ethical approval for the collection of data was previously approved for BDHS.

Data availability

Underlying data

The data from BDHS 2007 are free to access (https://dhsprogram.com/data/dataset/Bangladesh_Standard-DHS_2007.cfm?flag=0); however, before you can download data, users must register as a DHS data user for reasons laid out on the DHS website (<https://www.dhsprogram.com/data/Registration-Rationale.cfm>). Dataset access is only granted for legitimate research purposes (<https://dhsprogram.com/data/new-user-registration.cfm>).

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References

- Tadesse H, Deribew A, Woldie M: **Predictors of defaulting from completion of child immunization in south Ethiopia, May 2008: a case control study.** *BMC Public Health*. 2009; 9: 150–56.
[PubMed Abstract](#) | [Publisher Full Text](#) | [Free Full Text](#)
- Mitra SN and Associates: **Bangladesh demographic and health survey 2014.** National Institute of Population Research and Training (NIPORT), Dhaka, Bangladesh.
[Reference Source](#)
- UNICEF: **Millennium Development Goals, United Nations Children's Emergency Fund, 2009.** Dhaka, Bangladesh.
[Reference Source](#)
- Black RE, Cousens S, Johnson HL, *et al.*: **Global, regional, and national causes of child mortality in 2008: a systematic analysis.** *Lancet*. 2010; 375(9730): 1969–87.
[PubMed Abstract](#) | [Publisher Full Text](#)
- You D, Wardlaw T, Salama P, *et al.*: **Levels and trends in under-5 mortality, 1990–2008.** *Lancet*. 2010; 375(9709): 100–3.
[PubMed Abstract](#) | [Publisher Full Text](#)
- Population Reference Bureau: **World population data sheet, 2011.** Demographic data and estimate for the countries and religion of the world. Washington, DC.
[Reference Source](#)
- Srinivasan K, Prabhu GR: **A study of the morbidity status of children in social welfare hostels in Tirupati Town.** *Indian J Community Med*. 2006; 31(3): 170–72.
[Reference Source](#)
- El Arifeen S: **Child health and mortality.** *J Health Popul Nutr*. 2008; 26(3): 273–79.
[PubMed Abstract](#) | [Free Full Text](#)
- UNESCAP: **United Nation Economic and Social Commission for Asia Pacific.** 2009.
[Reference Source](#)
- Mitra SN and Associates: **Bangladesh demographic and health survey 2007.** National Institute of Population Research and Training (NIPORT), Dhaka, Bangladesh.
[Reference Source](#)
- Ahmed MK, Rahman M, van Ginneken J: **Epidemiology of child deaths due to drowning in Matlab, Bangladesh.** *Int J Epidemiol*. 1999; 28(2): 306–11.
[PubMed Abstract](#) | [Publisher Full Text](#)
- UNICEF: **Millennium Development Goals, United Nations Children's Emergency Fund, 2008.** Dhaka, Bangladesh.
[Reference Source](#)
- Habib H, Lohani M, Khan H, *et al.*: **Infant morbidity leading to infant mortality.** *Gomal Journal of Medical Sciences*. 2009; 7(2): 121–23.
[Reference Source](#)
- NIPORT M and ICF: **Bangladesh Demographic and Health Survey 2007.** National Institute of Population Research and Training (NIPORT), Dhaka, Bangladesh and ICF International, 2009.
[Reference Source](#)
- Velleman PF: **Definition and comparison of robust nonlinear data smoothing algorithms.** *J Am Stat Assoc*. 1980; 75(371): 609–15.
[Publisher Full Text](#)
- Montgomery DC, Peck EA: **Introduction to linear regression analysis.** John Wiley and Sons, New York. 1982.
[Reference Source](#)
- Islam MR: **Mathematical modelling of age and of income distribution associated with female marriage migration in Rajshahi, Bangladesh.** *Res J App Sci Eng Technol*. 2012; 4(17): 3125–29.
[Reference Source](#)
- Islam MR: **Modelling and projecting population for Muslim of urban area in Bangladesh.** *International Journal of Probability and Statistics*. 2012; 1(1): 4–10.
[Publisher Full Text](#)
- Islam MR: **Modelling age structure and ASDRs for human population of both**

- sexes in Bangladesh.** *International Journal of Anthropology.* 2013; **28**(1): 47–53.
[Reference Source](#)
20. Islam MR, Hossain MS: **Mathematical modelling of age specific adult literacy rates of rural area in Bangladesh.** *American Open Demography Journal.* 2013; **1**(1): 1–12.
 21. Islam MR, Hossain MS: **Mathematical modelling of age specific participation rates in Bangladesh.** *Int J Sci Innov Math Res.* 2013; **1**(2): 150–59.
[Reference Source](#)
 22. Islam MR, Ali MK, Islam MN: **Construction of life table and some mathematical models for male population of Bangladesh.** *American Journal of Computational and Applied Mathematics.* 2013; **3**(6): 269–76.
[Reference Source](#)
 23. Hossain MK, Islam MR, Khan MN, *et al.*: **Contribution of socio-demographic factors on antenatal care in Bangladesh: Modelling approach.** *Public Health Research.* 2015; **5**(4): 95–102.
[Reference Source](#)
 24. Hossain MS, Islam MR: **Age specific participation rates of Curacao in 2011: Modelling approach.** *American Open Computational and Applied Mathematics Journal.* 2013; **1**(2): 08–21.
[Reference Source](#)
 25. Islam MR, Hossain S: **Some standard physical characteristics of students in Seoul: Modelling approach.** *American Journal of Mathematics and Statistics.* 2015; **5**(5): 230–37.
[Reference Source](#)
 26. Islam MR, Hoque MN: **Mathematical modelling and projecting population of Bangladesh by age and sex from 2002 to 2031.** *Emerging Techniques in Applied Demography.* 2014; **4**: 53–60.
[Publisher Full Text](#)
 27. Gujarati DN: **Basic econometrics.** Third Edition, McGraw Hill, Inc., New York. 1998.
 28. Biswas S: **Stochastic processes in demography and applications.** Wiley Eastern Limited, New Delhi. 1988.
[Reference Source](#)
 29. Keyfitz N: **Introduction to the mathematics of population.** Addison Wesley Publishing Company, Reading, Massachusetts. 1968.
[Reference Source](#)
 30. Islam MR: **Construction of abridged life tables and indirect estimation of some mortality measures of Bangladesh in 2005.** *Journal of Population Indonesia.* 2007; **11**(2): 117–30.
 31. Islam MR: **Estimation of some mortality measures, modelling of I_2 and age associated with force of mortality of Bangladesh in 2007.** *Middle East Journal of Age and Ageing.* 2007; **4**(6): 32–38.
 32. Islam MR, Hossain MS, Faroque O: **U-Shaped pattern of employees' job satisfaction: Polynomial model approach.** *Int J Ecosyst.* 2014; **4**(4): 170–75.
[Reference Source](#)
 33. Islam MR: **Modelling of diabetic patients associated with age: Polynomial model approach.** *International Journal of Statistics and Applications.* 2011; **1**(1): 1–5.
[Publisher Full Text](#)
 34. Islam MR, Hossain MS: **Some models associated with age specific adult literacy rates of urban area in Bangladesh.** *Int J Ecosyst.* 2014; **4**(2): 66–74.
[Reference Source](#)
 35. Islam MR, Hossain MS: **Mathematical modelling of age specific adult literacy rates in Bangladesh.** *Advances in Life Sciences.* 2014; **4**(3): 106–13.
[Reference Source](#)

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Determining the I_x and estimating the force of mortality for children under five in Bangladesh

Review Comments:

Introduction:

- Introductory paragraphs focus on IMR whereas this analysis is on Child mortality. The citations are also mostly on IMR than under 5 child mortality.
- It has also been mentioned that “Child mortality rates and, in particular, infant mortality rates (IMRs) dropped sharply in developed countries, but over the past five decades it has been difficult to lower rates in developing countries such as Bangladesh” but the IMR and under 5 Child mortality rate trend of Bangladesh does not support this statement.
 - (Ref: <https://www.macrotrends.net/countries/BGD/bangladesh/infant-mortality-rate#:~:text=The%20infant%20mortality%20rate%20for,a%204.49%25%20decline%20from%20201>)
 - (Ref: <https://knoema.com/atlas/Bangladesh/Child-mortality-rate>).
- The statistics given regarding under five child mortality (“29,000 children under the age of five die every day in Bangladesh”) is from 2009. However, updated data on IMR and <5yrs mortality could have been cited. Generally, speaking this article referred to data in which most of the cases are old although, recent data were available.

Method:

- The analysis of this study was based on the BDHS data of 2007 whereas there were reports/data of 2014, 2017-18 on which this analysis could have been done.
- The observed smoothed, and predicted survival function (I_x values) for children under five in Bangladesh:
 - The model explained about 94%, which is a strength of this analysis

- Table 2: Smoothed and predicted survival function could have been shown for ages in months. At least at 6 months 12 months 18 months..... would be more practical.
- It seems that potential confounding variables were not considered in the best fit models.
- Some modifiable risk factors that could have been considered is the analysis of this study.

Results:

- Decreasing and increasing pattern have been shown at specific ages (in months) and also according to residential status. It would be better to show the results either for every month up to the age of 5yrs or at least at some specific ages like 6 months, 12 months, 18 months, so on... This type of presentation of the results might help policy makers to take policy decisions and the researchers to further undertake research to explore the reasons for such findings. As regards the rural/urban distribution, urban slum people are the most vulnerable therefore, breakdown analysis for the slum population would be more practical. However, if secondary data does not allow to do so then it should be stated as a limitation of the study under the discussion section.

Discussion:

- Discussion centered on the appropriateness of the modelling, however, some probable explanation(s) of the findings could have been discussed e.g., why a decreasing pattern was observed in ages 0-20 months and increasing trend in ages 20-53.5 months. Nothing has been mentioned about the methodological limitations of this study and the reason for using 2007 BDHS data where data of 2017-18 are available.

Conclusion:

Concluded on the relationship of age and force of child mortality but did not take into consideration of the rural/urban relationship though it was one of the objectives of this study.

Is the work clearly and accurately presented and does it cite the current literature?

Partly

Is the study design appropriate and is the work technically sound?

Partly

Are sufficient details of methods and analysis provided to allow replication by others?

Yes

If applicable, is the statistical analysis and its interpretation appropriate?

Yes

Are all the source data underlying the results available to ensure full reproducibility?

Yes

Are the conclusions drawn adequately supported by the results?

Partly

Competing Interests: No competing interests were disclosed.

Reviewer Expertise: I am a Medical Epidemiologist

I confirm that I have read this submission and believe that I have an appropriate level of expertise to confirm that it is of an acceptable scientific standard, however I have significant reservations, as outlined above.

Reviewer Report 03 July 2020

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Duah Dwomoh

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Abstract:

- The authors indicated in the results section that mortality rate was monotonically increasing for those aged 20-53.5 months but in the conclusion it is restricted to only those aged 53.5 months. Authors should revise that to reflect the findings as stated in the results

Introduction:

- The fact Bangladesh achieved the millennium development goal 4 has been repeated in the first and second paragraphs of the manuscript.
- Please provide a reference to this statement " ... it remains high in Bangladesh due to the high incidence of malnutrition and childhood diseases"

Methods:

- The statement " i.e. the group data for children under five in Bangladesh as a whole and separately for rural and urban areas, are from Bangladesh Demographic and Health Survey (BDHS) 2007". I think there is a word missing there. Perhaps are "obtained" from the Bangladesh Demographic and Health Survey (BDHS) 2007.
- The authors fitted a polynomial model explaining the number of people living at exact age x. The number of people living at the exact age group x is influenced by factors associated with their survival rate throughout the neonatal period. There are more critical factors such as multiple births, birth spacing, facility delivery, etc. that could influence the outcome measure of interest apart from age in a month. Authors should explain why these critical factors were omitted from the model. Can the addition of these key predictors improve the predictive power of the model?
- Authors conducted internal validation of the model using cross-validation which is good but they could have applied the developed model to a more recent Bangladesh DHS data to

validate the model. This could have provided a more rigorous assessment of the predictive performance of the model. In addition, the could have estimated Root Mean Square Percentage Error (RMSPE), Brier Score, and Mean Absolute Percentage Error to assess the predictive performance of the model especially when we have a typical count outcome.

Results:

- There should be a legend on the graph explaining which graph represents smoothed and predicted for readers who are not statistically inclined. This should go for all the graphs. However, for policy decisions, it could have been interesting to investigate the pattern of the outcome among the wealth quintile as well. I mean conduct similar analysis among various socioeconomic groups.

Is the work clearly and accurately presented and does it cite the current literature?

Yes

Is the study design appropriate and is the work technically sound?

Yes

Are sufficient details of methods and analysis provided to allow replication by others?

Yes

If applicable, is the statistical analysis and its interpretation appropriate?

Partly

Are all the source data underlying the results available to ensure full reproducibility?

Yes

Are the conclusions drawn adequately supported by the results?

Yes

Competing Interests: No competing interests were disclosed.

Reviewer Expertise: Statistical Methods and its application to health data, Mathematical Modeling of Infectious diseases

I confirm that I have read this submission and believe that I have an appropriate level of expertise to confirm that it is of an acceptable scientific standard, however I have significant reservations, as outlined above.

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