An Econometric Investigation of Infant Mortality Scenarios in Bangladesh

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Abstract: *In this paper, three econometric models (linear regression model, Reciprocal model & Double-log or log-linear regression model) comprised one outcome variable (infant mortality rate) and three explanatory variables (per capita gross domestic product, per capita health expenditure and mean age at marriage of female) have been considered over the period 1980 to 2007 for Bangladesh. At all stages of fitting model, it has been observed that at least one of the independent variables had significant effect on infant mortality rate. After removing multicollinearity and autocorrelation, two independent variables (per capita health expenditure and mean age at marriage of female) had significant effect on infant mortality rate in case of reciprocal model but per capita health expenditure had substantial effect on infant mortality rate in three econometric models. Results indicate for the policy makers at the national level for raising per capita health expenditure to decrease infant mortality rate.*

I. Introduction

Mortality is very responsive to social, economic and psychological factors. Infant Mortality estimates are disaggregated by socioeconomic characteristics, such as urban-rural residence, division, mother's education and wealth index and also by selected demographic characteristics to identify segments of the population requiring special attention.

Expectation of life at infant mortality rate is among the social indicators used by the World Bank to assess basic needs attainment in various societies. Historically, mortality has often been used as a barometer of welfare. Statistical studies in the nineteenth and twentieth centuries showed concern for socio-economic differences expressed as differential infant and crude mortality. Level of death rate; more importantly, infant mortality reflects a society's status of wellbeing. Such aspects can be taken as indicators of quality of life.

The infant mortality rate for the most recent time period (2010) is 52.54 deaths per 1,000 live births and which was 66 for the year 2003 and was 87 for the year 1989 (http://www.indexmundi.com/bangladesh/infant_mortality_rate.html). This means that, still 1 in 19 children now die in Bangladesh before reaching the first birthday although it is declining. To reduce infant mortality significantly, it is required to focus on reducing neonatal deaths since most infant deaths occur during the first month of life. There is very little difference in infant mortality levels in urban and rural areas, wide variations in mortality by division (BDHS 2004). Mother's

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level of education is inversely related to her child's risk of dying. Significant differentials have been observed by different years in Gross Domestic Product (GDP), and Per Capita Health Expenditure, Mean Age at Marriage of female, Literacy Rate of female and Source of pure drinking water attainment in mortality. The per capita GDP of our country shows a positive trend (which was Tk. 2393, Tk. 25926 and Tk.35775 in the year 1980, 2003 and 2008 respectively).

A good number of studies have been carried out about mortality in Bangladesh by M. N. Islam, M.M. Rahman, M. Kabir, Nitai Chakraborty, M. Ataharul Islam, MAzharul Islam and others. Their Different studies have examined this issue and identified different risk factors. Most of them, however, concentrated on studying the levels, trends, differentials and determinants of mortality using traditional tabular analysis. Earlier studies on infant mortality rate are mostly devoted to finding the determinants using binary logistic regression analysis. They have found possible linkages between infant and child mortality and subsequent fertility

Infant mortality rates reflect a country's level of socioeconomic development and quality of life and are used for monitoring and evaluating population and health programs and policies. The rates are also important for monitoring the progress of the United Nations Millennium Development Goal to reduce infant mortality. In this study a new attempt has been made to relate infant mortality rate with some economic indicator through econometric models.

II. Data and Methodology

Time-series data for the period of 1980 to 2007 were collected from statistical year book of Bangladesh published by Bangladesh Bureau of Statistics (BBS), International Centre on Diarrhea Disease Research, Bangladesh (ICDDR,B) and Bangladesh Demographic and Health Survey (BDHS 2007). Infant Mortality Rate has been taken as the dependent variable and GDP, Per Capita health expenditure, Mean age at Marriage of female are considered to be independent variables.

Analysis of infant mortality rate has commonly been carried out in terms of the "infant mortality rate" rather than the infant death rate, in order to approximate the probability of death among infants in a given year. The accuracy of the approximation varies from one situation to another but depends, in general, on the annual fluctuations in the number of births. The conventional infant mortality rate is defined as the number of infant deaths per year per 1,000 live births. Because of the very high level of mortality in the first hours, days and weeks of life and the difference in the causes accounting for infant deaths at the earlier and later ages of infancy, the conventional infant mortality rate may usefully be "broken up" into a rate covering the first month or so (**neonatal mortality rate**) and a rate for the remainder of the year **(post-neonatal mortality rate)**. The infant mortality data of the study have been carried out by the statistical packages SPSS and LIMDEP.

III. Specification of the Working Model

In this study an attempt has been made to establish relationship between infant mortality rates and some economic indicators through econometric models. The main concern is whether infant mortality can be studied independently of GDP, health expenditure and mean age at marriage. It is difficult to predict whether there will be a positive or negative dependence between them. But it is expected an average relation between them which can be studied correctly by regression modeling. Since there is no firm deterministic model to relate the demographic variables to economic indicators, the empirical investigation proposed the following 3 types of regression model to find the important economic variables which have substantial effect on reducing infant mortality rate in Bangladesh.

a) Linear Regression Model

$Y_t = \beta_0 + \beta_1 X_{1t} + \beta_2 X_{2t} + \beta_3 X_{3t} + u_t$ Where, t=1, 2,3,…,24 (years), β_0 is the intercept term, β_j (j=1,2,3) is the partial regression coefficient of Y on X_{jt} (t=1,2,3,…, 24) and β_j represents expected amount of change in Y for one unit change in X_{jt} (adjusting for the effect of other variables) Y_t = out put of the infant mortality rate for the different time periods.

X_1=per Capita Gross Domestic Product of Bangladesh. X_2 = per Capita health expenditure of Bangladesh. X_3 = mean Age at Marriage of female.

b) Reciprocal Model

$Y_t = \beta_0 + \beta_j (\frac{1}{X_{jt}}) + u_t$; Where, t=1, 2, 3,…, 24 (Years), β_0 is the intercept term, β_j (j=1, 2, 3) is the partial regression coefficient of Y on $\frac{1}{X_{jt}}$ and β_j represents expected amount of change in Y for one unit change in $\frac{1}{X_{jt}}$ (adjusting for the effect of other variables) Y_t = out put of the infant mortality rate for the different time periods. $\frac{1}{X_1}$ = inverse of Per Capita Gross Domestic Product of Bangladesh. $\frac{1}{X_2}$ = inverse of Per Capita health expenditure of Bangladesh. $\frac{1}{X_3}$ = Inverse of Mean Age at Marriage of female.

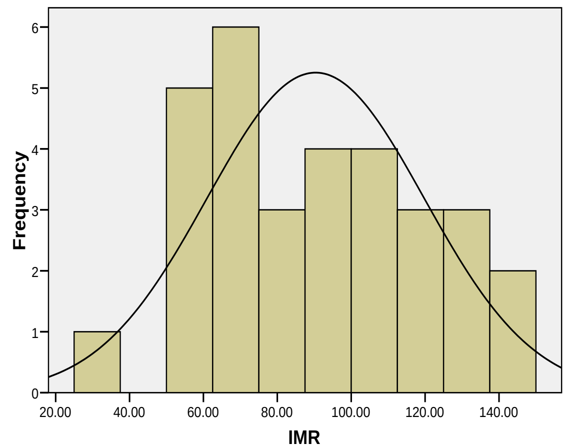
c) Log-linear Regression Model or Double-log Model

$\ln Y_t = \beta_0 + \beta_1 \ln X_{1t} + \beta_2 \ln X_{2t} + \beta_3 \ln X_{3t} + u_t$ Where, t=1, 2…24 (Years), β_0 is the intercept term, β_j (j=1, 2, 3) is the partial regression coefficient of $\ln Y_t$ on $\ln X_t$, β_j represents expected amount of change in $\ln Y_t$ for one unit change in $\ln X_t$ (adjusting for the effect of other variables, $\ln Y_t$ = Out put of the logarithm value of infant mortality rate for the different time periods, $\ln X_1$ = logarithm value of Per Capita Gross Domestic

Product of Bangladesh. $\ln X_2$ = logarithm value of Per Capita health expenditure of Bangladesh, $\ln X_3$ = logarithm value of Mean Age at Marriage of female.

IV. Econometric Justification

Firstly the normality assumption has been checked for infant mortality rate (IMR).The plotting almost satisfies the assumption.



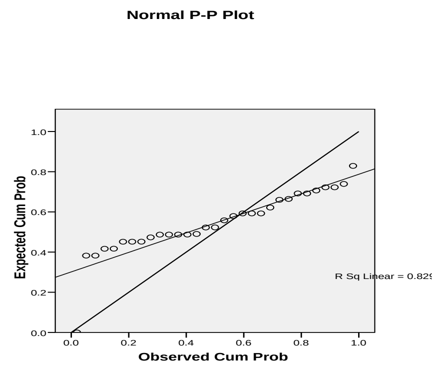


Fig: histogram with normal curve

Then the presence or absence of structural change has been examined. By structural change, it means that the values of the parameters of the model do not remain the same through the entire time period. For this, **Chow-test** for each model has been performed

Table: I Test results for Chow Test

Time period	RSS (1st Model)	RSS (2nd model)	RSS(3rd Model)	F	$F_{5\%}$
1980-1993	RSS_1 =0.00023	RSS_1 = 0.00046	RSS_1 = 0.029	1.95	3.34
1994-2007	RSS_2 =0.00022	RSS_2 = 0.00010	RSS_2 = 0.029	0.43	3.34
1980-2007	RSS_3 =0.00067	RSS_3= 0.00062	RSS_3 = 0.097	2.71	3.32

For performing Chow test three Regression models as mentioned earlier were fitted for 3 time periods as 1980-1993, 1994-2007 and 1980-2007. The results are given in table I.

Here the null hypothesis is: There is no structural change against the alternative hypothesis that there exists some structural change. From the test result we can conclude that there is no structural change in this model.

Detection of Multicollinearity: Multicollinearity has been detected by Variance Inflation Factor (VIF).

Table II: Results of testing the presence or absence of Multicollinearity among the explanatory variables in different models

		Before		After	
Model	**Variable**	**VIF**	**Tolerance**	**VIF**	**Tolerance**
Reciprocal Model	Inverse of Per Capita GDP	23.707	0.042		
	Inverse of Per Capita HE	25.066	0.040	3.694	0.271
	Inverse of MAMF*	3.722	0.269	3.694	0.271
Log linear regression Model	Log value of PCGDP*	20.671	0.048		
	Logarithm value of PCHE*	8.174	0.122	8.114	0.123
	Logarithm value of MAMF	15.241	0.066	8.114	0.123
Linear Regression Model	Per Capita GDP	8.561	0.117		
	Per Capita HE	22.498	0.044	7.082	0.141
	Mean Age at Marriage (F)	13.194	0.076	7.082	0.141

PCGDP=Per Capita GDP, PCHE= Per Capita Health Expenditure,

MAMF= Mean Age at Marriage of Female

To reduce multicollinearity, the remedial measure “Dropping Variables” procedure has been used (as here transformation of variable can not remove multicollinearity and other methods were not possible to apply. Also, per capita health expenditure is highly associated with GDP). For this purpose, per capita GDP in linear regression model, inverse of per capita GDP in reciprocal model and logarithm value of per GDP in double-log or log-linear model has been dropped. From the result (**Table II**), it is observed that for all models, the VIF of explanatory variables are less than 10. So for all models, the Multicollinearity among explanatory variables is not severe.

Secondly, the parameters were estimated irrespective of Multicollinearity and autocorrelation (**Table III**). It is seen that the value of adjusted R^2 are 0.946, 0.788 and 0.891 (when Multicollinearity and autocorrelation exist), but after removing Multicollinearity values of adjusted R^2 are 0.948,0.791 and 0.876 i.e. 94.8%,79.1% and 87.6% of total variation in Infant Mortality Rate is explained by the fitted **Linear Regression Model**, **Reciprocal Model and Double -log Model** respectively.

1) Linear Regression model: From the P-value it is observed that per capita health expenditure is highly significant and is negatively associated with infant mortality rate. So, this variable has an influence on decrease of Infant Mortality Rate with the increase of per capita health expenditure, i.e. for the increase of 1 taka per capita health expenditure, the infant mortality rate will decrease about 0.00054 times. It is also observed that mean age at marriage is significant and positive association with infant mortality rate. So, this variable has an influence on the increase in infant mortality rate with the increase in mean age at marriage of female. It indicates after certain age’s infant mortality increases with the increase of mean age at marriage of female.

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Table III: Parameter estimates and related statistics before and after removing multicollinearity:

		Multicollinearity & autocorrelation exist			After removing Multicollinearity		
Model	Variables	Coefficient	t-value	*p-value*	Coefficient	t-value	*p-value*
Linear Regression Model	Per Capita GDP	0.00000004	0.088	0.931			
	Per Capita Health Expenditure	-0.00054	-5.843	0.000	-0.0053	-7.774	0.000
	Mean age at Marriage	0.00726	2.145	0.044	0.007	2.198	0.039
Reciprocal Model	Inverse of Per Capita GDP	88.640	0.210	0.414			
	Inverse of Per Capita Health Expenditure	-0.141	3.476	0.836	0.37698	1.471	0.155
	Inverse of Mean age at Marriage	4.382	0.835	0.002	4.4722	3.358	0.002
Log linear regression Model	Log of Per Capita GDP	-0.223	-1.97	0.063			
	Log of Per Capita Health Expenditure	-0.082	-0.745	0.465	-0.251	-3.41	0.003
	Log of Mean age at Marriage	-0.907	-1.052	0.306	-1.0525	-1.148	0.264

2) Reciprocal Model: From the P-value it is observed that inverse value of mean age at marriage has highly significant effect and positive association with infant mortality rate. So, this variable has an influence on increase of Infant Mortality Rate with the increase in inverse of mean age at marriage or decrease in mean age at marriage of female

3) Double–logarithmic Model: From the P-value it is observed that logarithm value of per capita GDP (only at 10% level of significance) and of per capita health expenditure have significant effect and negative association with infant mortality rate. So these variables have an influence on increase of logarithm value of per capita GDP or increase of per capita GDP with the decrease of infant mortality rate.

Detection and removing of autocorrelation: Autocorrelation is detected by Durbin-Watson test. From the d-statistic (before) value it was found that, the problem of positive autocorrelation is present in all the three models. As the model is based on time series data, the problem of autocorrelation arises for three models. To get rid of the autocorrelation problem we have used the Cochran-Orcutt iterative procedure by computer software LIMDEP.

Model	**d statistic**	
	Before	**After**
Linear Regression Model	0.667	1.67436
Reciprocal Model	0.748	1.56
Log linear regression Model	0.558	1.62

From the value of d-statistic (after) it may concluded that the models are free from autocorrelation (positive or negative).

V. Discussions

The estimated results for Infant Mortality Rate are presented separately for three models in **Table IV**. These results are free from multicollinearity and autocorrelation.

1) Linear Regression Model

From the result it is observed that per capita health expenditure has highly significant effect and negative association with infant mortality rate. If per capita health expenditure increases by Tk.1000, then expected decrease in infant mortality rate is 0.403 assuming other variables constant.

2) Reciprocal Model

From the Table IV, it is observed that per capita health expenditure is highly significant and has positive association with infant mortality rate. So, this variable has a great influence on increase of Infant Mortality Rate with the increase of Inverse of per capita health expenditure or decrease of per capita health expenditure. It is also observed that inverse of mean age at marriage of female has significant and negative association with infant mortality rate. If the inverse of mean age at marriage decreases by one year, then the expected decrease in inverse of infant mortality rate is 2.198 assuming other things constant.

3) Double -log Model:

From the P-value, it is observed that logarithm value of per capita health expenditure is highly significant and negative association with infant mortality rate. So, this variable has a great influence on decrease in infant mortality rate with the increase of logarithm value of per capita health expenditure. If logarithm value of per capita health expenditure increases by Tk.1 then expected decrease in logarithm value of infant mortality rate is 0.347 assuming other things remain unchanged.

Table IV: Parameter estimates and related statistics after removing multicollinearity and autocorrelation

Model	Variable	Coefficient	t-statistic	p-value
Linear Regression Model	Intercept	0.11411	1.862	0.0627
	Per capita health expenditure	-0.000403	-5.755	0.000
	Mean Age at Marriage	0.000527	0.149	0.8813
Reciprocal Model	Intercept	-0.04772	-.982	0.3260
	Inverse of Per capita health expenditure	1.085	3.933	0.0001
	Inverse of Mean Age at Marriage	2.1987	2.249	0.0245

VI. Conclusion

The development of country and quality of life is indicated by crude death rate and more specifically by infant mortality rate. In this study an attempt has been made to relate infant mortality rate with some economic indicator through building econometric models. Linear, Reciprocal and Double Log or Log Linear models were applied for the indicators of infant mortality. In the data set, multicollinearity and autocorrelation were found. Multicollinearity is detected by Variation Inflation Factor (VIF) and removed by dropping variables procedure. Autocorrelation is detected by Durbin-Watson test and removed by Cochrane-Orcutt iterative procedure. In this study the models fit well showed by adjusted R^2. The study shows that there is no structural change in the models over the years. Per capita health expenditure has significant negative effect on infant mortality rate. Per capita GDP has significant effect on infant mortality rate. It indicates that with increase of per capita gross domestic product infant mortality rate decreases. Mean age at marriage of female has significant effect on infant mortality rate. It indicates infant mortality rate will be increased when mean age at marriage of female decreases. In linear regression model, mean age at marriage of female had positive association and significant effect (p-value=0.039) on infant mortality rate. It indicates after certain age, female are facing some complication during birth period which increases the infant mortality rate. After removing Multicollinearity and Autocorrelation two independent variables (per capita health expenditure, mean age at marriage of female) had significant effect on infant mortality rate in case of reciprocal model but per capita health expenditure had substantial effect on infant mortality rate in three econometric models. Results indicate that at the national level per capita health expenditure should be increased and mean age at marriage should not be too high or too low to decrease infant mortality rate.

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