Projection of Life Expectancy at Birth for the Population of Urban Area in Bangladesh

Background: Life expectancy at birth (LE) reflects the overall mortality of a population and it is also used as one of the indicators of the health status of population. Objective: The main purpose of this study is to project LE for the population of male, female and both sexes of urban region in Bangladesh by using polynomial model. Data and Methodology: For this purpose, the data is obtained from Statistical Year Book (SYB) of Bangladesh of 2012. Quasi Newton Method is used to build up these models using the Statistical software STATISTICA. Furthermore, t-test statistics, F-test statistics and cross validity prediction power (CVPP) are applied to identify the correctness of these model. Results: It is found that LE for the population of urban region of Bangladesh follow simple linear regression model. Based on t-stats, coefficient of determination, shrinkage coefficients and F-stats these models are seemed to be well fitted. So, these models can be used for better prediction. Then, these LE are projected during 2012-2051 using the fitted time trend models. It is observed that the LE for the population of male, female and both sexes of urban region of Bangladesh in 2051 are 75, 84.1 and 78 years respectively. Conclusion: Urban population of Bangladesh are going to be aged population dramatically. Proper planning for the allocation of public and private resources may be taken for the better lifestyle of urban population.

Keywords: *Life expectancy at birth (LE), Polynomial model, t-test statistics, F-test statistics, Cross validity prediction power (CVPP), Bangladesh*

Introduction

Life expectancy is demarcated as the average number of supplementary years that a person of a specific age group will live, if the current age-specific mortality schedules remain constant over the course of the individual's lifetime (Chiang, 1968). Life expectancy is an indirect measure of mortality and it is also the main indicator of health status of a society or a country or a region. On the other hand, education and health are the leading sectors for socio-economic development for the developing countries like Bangladesh. Life expectancies in urban and rural areas for the population of male, female and both sexes from 1994 to 2011 show the shortest life expectancy of those living in rural area than that of urban areas (BBS, 2014). Life expectancy at birth (LE) in Bangladesh is poor in international comparisons with median of LE for male and female are 70 and 76 years respectively in 2011 (WHO, 2013). Life expectancy is not the measure of the aged population, but it shows the present situation of socio-economic development of a country. Moreover, it is found that LE of Bangladesh is increasing with the increase of time (BBS, 2013). Like many other nations, in Bangladesh female live lengthier than male and this gender difference in the LE has been increasing with passing of time. The longer LE of female population does not necessarily provide that the female are healthier

than male. Studies on self-reported health status measure specify higher prevalence of functional restrictions and poor health among female (Parahyba et al., 2005; Lima et al., 2009; Zunzunegui et al., 2009 and Szwarcwald et al., 2011), suggesting that the additional years cannot essentially be lived in hale and hearty life. LE is increasing every year that means aged population is increasing in Bangladesh. So, especially government and policy makers should have clear concept about the number of aged population to ensure them with healthy environment. For this, correct information of LE in the future years is needed to take several steps for development of education, health, environment and others socioeconomic related sectors of Bangladesh. For this reason, mathematical model is selected to observe the trend of LE for the population of urban areas in Bangladesh. To do so, polynomial model has been chosen in this study. It is mentioned here that polynomial model was applied in a number of studies like as (Islam, 2004, 2005a; 2005b; 2007a and 2011; Islam et al., 2004 and 2014; Islam and Hossain, 2014a and 2014b). Therefore, the fundamental aims of this study are to construct some models to LE for the population of male, female and both sexes of urban region in Bangladesh and then to project LE for them employing these fitted models for the period 2012-2051.

Source of Data

A data on LE for the population of men, women and both sexes of urban region in Bangladesh during 2002-2011have been obtained from SYB of Bangladesh of 2012 (BBS, 2013) which are shown in Table 1.To fulfill the above objectives, these LE data are used in this study.

Table 1. *Observed LE for Male, Female and Both Sexes of the Population of Urban Area in Bangladesh during 2002-2011*

Year	Male	Female	Both Sexes
2002	67.0	67.3	67.2
2003	67.3	67.9	67.6
2004	67.5	68.1	67.8
2005	67.6	68.1	67.9
2006	67.7	68.7	68.1
2007	67.7	68.7	68.1
2008	67.9	68.8	68.3
2009	68.2	69.2	68.7
2010	68.3	69.5	68.9
2011	68.9	71.1	69.9

Source: BBS (2013) Statistical Year Book of Bangladesh 2012.

Methods

Data Smoothing

In this paper, it is found that there are some kinds of unexpected distortions in the data set if LE is dotted on a graph paper. For that reason, an adjustment is imperative and needed to abate these unexpected distortions before going to construct model to these data. In this situation, the data of LE for the population of men, women and both sexes of are smoothened by the Package Minitab Release 12.1 by smoothing technique named "4253H, twice" (Velleman, 1980). After that, these smoothed data are taken to build models and these smoothed data are presented in the Table 2.

Table 3. *Smoothed and Predicted LE for Male, Female and Both Sexes of the Population of Urban Area in Bangladesh during 2002-2011*

Year	Male		Female		Both Sexes	
	Smoothed	Predicted	Smoothed	Predicted	Smoothed	Predicted
2002	67.0	67.0	67.4	67.3	67.2	67.2
2003	67.3	67.2	67.8	67.6	67.6	67.4
2004	67.5	67.3	68.1	68.0	67.8	67.7
2005	67.6	67.5	68.3	68.3	67.9	67.9
2006	67.7	67.6	68.5	68.7	68.0	68.1
2007	67.7	67.8	68.7	69.0	68.1	68.3
2008	67.9	68.0	69.1	69.3	68.3	68.5
2009	68.1	68.1	69.5	69.7	68.6	68.8
2010	68.4	68.3	69.9	70.0	69.0	69.0
2011	68.7	68.5	71.0	70.4	69.6	69.2

Model Building

The polynomial model is chosen to fit model (using the scattered plot of Fig.1-Fig.3) to LE for the population of men, women and both sexes in urban region of Bangladesh. Therefore, the configuration of n degree polynomial model is addressed by

$$y_t = a_0 + \sum_{i=1}^{n} a_i t^i + u$$

where, t represents time (years); y_t represents LE; the coefficient of t^i is a_i, a_0 is the constant term and u is the error term of the model. In this case, n is chosen so that the error sum of square is minimum. Moreover, it is noted that actually disturbance term (u) of the model is normally as well as independently distributed with mean zero and constant variance, that is, $u_i \sim NID(0, \sigma^2)$ (Gujarati, 1998). In this case, it is found that if n=1, i. e., the polynomial model of degree one becomes simple linear regression model fitted to these data sets.

It is noted that these models are built using the Statistical software STATISTICA.

Model Validation Procedure

To verify how a large amount of these models on LE are stable, the cross validity prediction power (CVPP), ρ^2_{cv}, is used for the urban area of Bangladesh. Here

$\rho^2_{cv} = 1 - \frac{(n-1)(n-2)(n+1)}{n(n-k-1)(n-k-2)}(1-R^2)$; where, n indicates the number of cases, k specifies the number of predictors for the model and the cross validated R denotes the correlation between observed and predicted values of the response variable (Stevens, 1996). The positive value of (ρ^2_{cv} -R^2) mentions the shrinkage coefficient of the model; where ρ^2_{cv} is CVPP and R^2 is the coefficient of determination of the model as well as the stability of R^2 of the model is (1-shrinkage). The results on model fittings and estimated CVPP are presented in Table 3. A number of studies have been used this technique as validation (Islam, 2006a; 2006b; 2006c; 2007b; 2007c; 2008; 2012a; 2012b; 2013; Islam &Hossain, 2013a; 2013b; Hossain& Islam, 2013; Islam et al., 2013; Islam and Hoque, 2015).

F-test statistics

The F-test is employed to corroborate the measurement of overall significance of the model. The mathematical shape for F-test is specified under:

$$F = \frac{R^2 / (k-1)}{(1-R^2) / (n-k)}$$

where k represents the number of parameters of the model, n is the number of cases and $\mathbf{R^2}$ is the coefficient of determination of the fitted model (Gujarati, 1998). These results are exposed in Table 4.

Results

Table 1 and Table 2 represent the observed, smoothed and predicted LE for the population of men, women and both sexes of urban area in Bangladesh during 2002-2011. To see the level and trend of observed LE for the population, the data have been presented in graph paper shown in Fig. 4. It is investigated that the trend of LE for the population of men, women and both

sexes are showing upward. It is also seen that LE for female is higher than male during 2002-2011. Observed, smoothed and predicted LE for the population of men, women and both sexes during 2002-2011 are plotted in the Fig.1 toFig.3 respectively.

Figure 1. *Observed, Smoothed and Predicted LE for Male Population of Urban Area in Bangladesh During 2002-2011. X: Years and Y: LE*

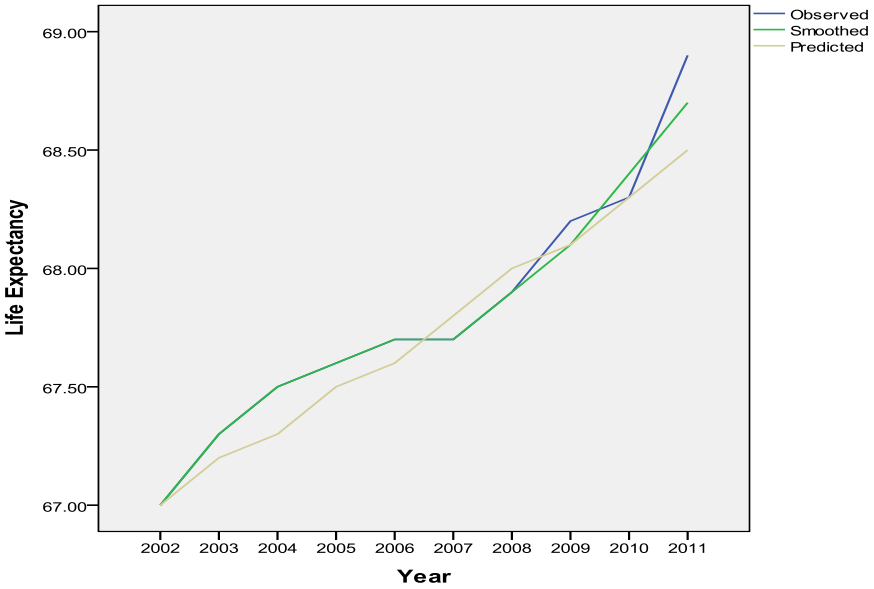


Figure 2. *Observed, Smoothed and Predicted LE for Female Population of Urban Area in Bangladesh During 2002-2011. X: Years and Y: LE*

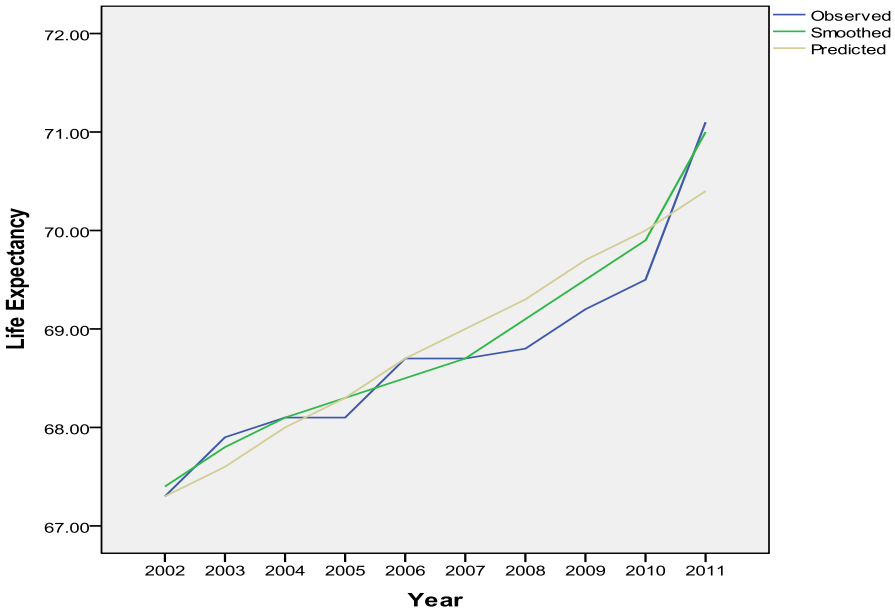
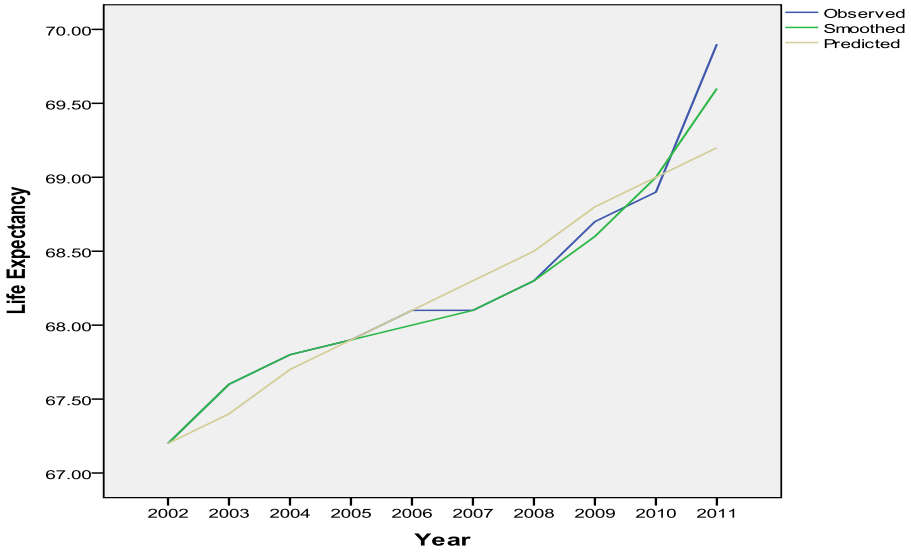


Figure 3. *Observed, Smoothed and Predicted LE for Both Sexes of the Population of Urban Area in Bangladesh During 2002-2011. X: Years and Y: LE*



The model, that is, two parameters linear regression model is constructed to LE for the population of male, female and both sexes of urban area in Bangladesh and the constructed models are as follows:

y_t = -259.330+ 0.163tfor male (1)
t-stat (-9.7387) (12.2845)
P-value (0.0000) (0.0000)

y_t = -620.676 +0.344t for female (2)
t-stat (-9.6447) (10.7143)
P-value (0.0000) (0.0000)

y_t = -378.084 +0.222t for both sexes (3)
t-stat (-8.212) (9.693)
P-value (0.0000) (0.0000)

The enumerated CVPP, ρ_{cv}^2 related to their R^2 are demonstrated in Table 3. From the table it is observed that the constructed models are highly cross-validated and their shrinkages coefficients are very lowest. In the table, it is found that the constructed models (1) – (3) are stable more than 92%, 90% and 91% respectively. Moreover, all the parameters of the constructed models (1) – (3) are significant explaining large proportion of variance. The stabilities of R^2 of these constructed models are more than 97%.

Table 3. *Information on Model Fittings and Estimated CVPP of the Predicted Equations*

Models	N	k	R^2	ρ_{cv}^2	Shrinkage	Variance explained (%)
Equation 1	10	1	0.94966	0.928805	0.02085514	94.966
Equation 2	10	1	0.93485	0.907859	0.02699071	93.485
Equation 3	10	1	0.92154	0.889035	0.032505	92.15

From these statistics of Table 4, it is also decided that all these fitted models are highly significant. For this reason, the fits of all these models are good. Then, the projected values of LE are estimated by applying these constructed regression models that are exposed in Table 5. After plotting these LE of men, women and both sexes of the population of urban area during 2012-2051 in the Fig.4, it shows a upward trend due to time like the trend during 2002-2011.These projections of LE give an idea regarding the future size of the oldest population in Bangladesh.

Table 4. *Information of Calculated and Tabulated Values of F-statistics of the Predicted Equations*

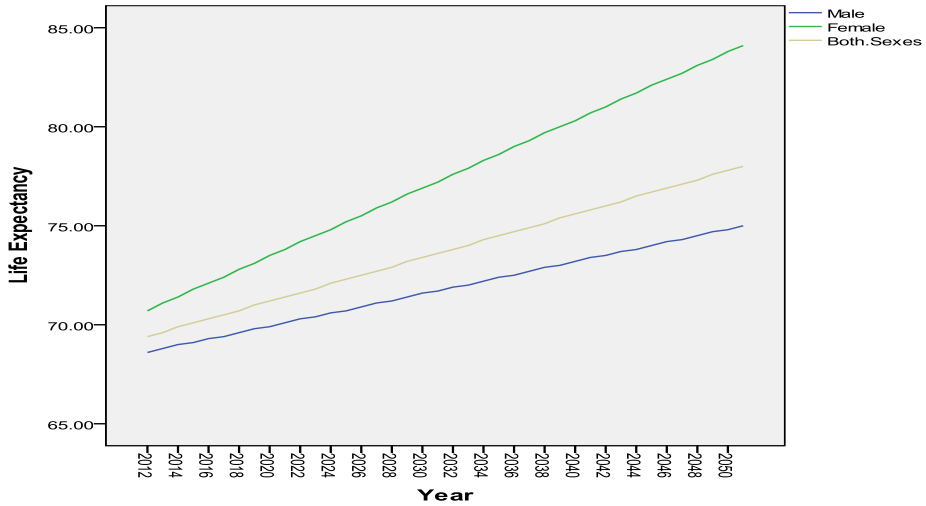
Models	n	K	Cal. F	Tab.F (at 1% level)
Equation 1	10	2	150.92	11.3 with (1,8) d.f.
Equation 2	10	2	114.79	11.3 with (1,8) d.f.
Equation 2	10	2	93.96	11.3 with (1,8) d.f.

Table 5. ***P****rojected LE for Male, Female and Both Sexes of the Population of Urban Area in Bangladesh during 2012-2051*

Year	Male	Female	Both Sexes
2012	68.6	70.7	69.4
2013	68.8	71.1	69.6
2014	69.0	71.4	69.9
2015	69.1	71.8	70.1
2016	69.3	72.1	70.3
2017	69.4	72.4	70.5
2018	69.6	72.8	70.7
2019	69.8	73.1	71.0
2020	69.9	73.5	71.2
2021	70.1	73.8	71.4
2022	70.3	74.2	71.6
2023	70.4	74.5	71.8
2024	70.6	74.8	72.1
2025	70.7	75.2	72.3
2026	70.9	75.5	72.5
2027	71.1	75.9	72.7
2028	71.2	76.2	72.9

2029	71.4	76.6	73.2
2030	71.6	76.9	73.4
2031	71.7	77.2	73.6
2032	71.9	77.6	73.8
2033	72.0	77.9	74.0
2034	72.2	78.3	74.3
2035	72.4	78.6	74.5
2036	72.5	79.0	74.7
2037	72.7	79.3	74.9
2038	72.9	79.7	75.1
2039	73.0	80.0	75.4
2040	73.2	80.3	75.6
2041	73.4	80.7	75.8
2042	73.5	81.0	76.0
2043	73.7	81.4	76.2
2044	73.8	81.7	76.5
2045	74.0	82.1	76.7
2046	74.2	82.4	76.9
2047	74.3	82.7	77.1
2048	74.5	83.1	77.3
2049	74.7	83.4	77.6
2050	74.8	83.8	77.8
2051	75.0	84.1	78.0

Figure 4. *Projected LE for Male, Female and Both Sexes of the Population of Urban Area in Bangladesh during 2012-2051. X: Years (Time) and Y: Projected LE*



Discussion

In the current study, the core objective was to project the LE of the urban populations of Bangladesh by sex. The simple linear regression model was employed as a method of projecting the LE. The projections were accomplished

up to the year 2051. The results revealed that the LE of the urban populations of Bangladesh by sex increase in accordance with time and female tend to live longer than male and it clearly exhibited the differences in LE between male and female. These findings conform to the study of Malaysian population (Islam et al., 2017). In this study, actually the LE was treated as the average number of years of a person who can expect to live provided existing mortality patterns. The LE is treated as the most commonly used measurement of health status of population as well as, in fact, mortality. Nonetheless, LE should be familiar as a measure of length of life rather than quality of life, on the contrary, it does not count the full burden of illness and disability.

In 2002, the LE in the urban populations of Bangladesh was 67.2 (male, 67; female, 67.3) years (BBS, 2013), on the other hand, by 2051, it would be increased as 78 (male, 75; female, 84.1) years (projected). The long life can be attributed by a number of various types of factors together with rising living standards, enhanced lifestyle and improved quality education, as well as greater access to quality as well as available health services which are significantly increased LE in Bangladesh, especially in the urban area of Bangladesh. Therefore, the demographic and socioeconomic changes, and availability of health facilities persuade LE (Mondal and Shitan, 2013, 2014; Mondal et al, 2015). In Bangladesh, the expansion of population and the demographic transition since the 1971 were accompanied by major socioeconomic development. LE is affected by different factors such as socioeconomic status, social factors, genetic factors and environmental factors like income, education, the quality of the health system, health behaviors such as tobacco and alcohol consumption, poor nutrition, overcrowded housing, lack of clean drinking water, adequate sanitation, lack of exercise.

After the long years of socioeconomic development, Bangladesh had transformed into middle income country. accordingly, the socioeconomic development determines the improvements in social sectors and increases LE. Increases in LE have also been attributed by the substantial improvements in sanitation and the availability as well as easy access to clean drinking water (Mondal and Shitan, 2015). The sanitation system in Bangladesh has been improving radically which is imperatively as well as significantly high as the developing nations. An increase in LE was driven mainly by the enhancement in sanitation in the time of the nineteenth and early twentieth century's (Oeppen and Vaupel, 2002). Environmental quality is a very important factor affecting health and morbidity: air and water pollution, depletion of natural resources, soils deterioration are all capable of increasing humanmortality that mean reducing life expectancy (Elo and Preston, 1992; Pope, 2000; Pope et al.,2004 and Evans and Smith, 2005)

In deaths and LE, the sex differences vary from country to country or any region to region. But, in most countries, generally male live shorter lives than that of female, sometimes by a margin of as much as 5-10 years. This study was investigated that the LE for female would be higher compared to male in Bangladesh. The deaths for women were found lower than that of men for all ages. In general, more boys than girls die in infancy period and during each

subsequent years of life,; mortality for male exceed than that of female (Islam, 2003). As a consequence, the gender difference would be more broadened in the future of the country.

Conclusions

In this paper, it is observed that LE for the population of urban area in Bangladesh follow a simple linear regression model. It is investigated that the significance of these constructed models is very soaring because of test statistics-F. Then, LE for the population of male, female and both sexes of urban area in Bangladesh are projected using these models during 2012-2051. It is also observed that people in Bangladesh tend to have substantial longer life expectancy rate. These might be used as predicted LE for the population of male, female and both sexes of urban area in Bangladesh for 2012-2051 for further higher study. The LE for the population of male, female and both sexes of urban area in Bangladesh in 2051 will be 75, 84.1 and 78 years respectively which exhibits that the urban population of Bangladesh are radically tending to be old aged population. Proper planning for the allocation of public and private resources may be taken based on the findings of this study for the better lifestyle of urban residents. More research study should be needed in this arena.

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