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Estimation of Childhood Mortality in Bangladesh: Indirect Approach

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Abstract Childhood mortality is one of the sensitive indices of health as well as development which often reveal a country's image in the world. Moreover, in Bangladesh, it is considered as an interesting topic for academician as well as researcher because of high childhood mortality. The objective of this study is to estimate the childhood mortality through Trussel technique using data classified by duration of marriage of mothers taken from Bangladesh Demographic and Health Survey (BDHS)-2004. From the results of estimated mortality levels for the national level, rural level and urban level, it is seen that the probability of dying (qx) are increasing with increase of marital duration, but for the male of urban level, these probabilities are decreasing from the marital duration 0-4 to 10-14 and then again increasing up to the last marital duration group. In all cases, the probability of dying is higher for male than that of female at each duration. It is observed that age specific average parities per woman for three cases follow simple linear regression model with explaining large proportion of variance.

Keywords Data Classified by Duration of Marriage of Mothers, Children Ever Born (CEB), Children Dead, Trussel's Technique, Regression Model, Cross Validity Prediction Power (CVPP), F-Test , Bangladesh

1. Introduction

In any country, childhood mortality is a reflection of the nation's health as well as the nutritional status of children which also indicates the socio-cultural and economic progress. Childhood mortality rates especially infant mortality rate (IMR) in developed countries is swiftly decreased but till now it is a problem in developing nations like Bangladesh during the last fifty years. Tadesse *et al.* (2009) reported that 29000 children were died in every day before completing their fifth birth day in the world[1]. It was mentioned that in 2007, 9.2 million children born alive all over the world died before their fifth birth day[2] but after one year, it was decreased to 8.8 million[3, 4], of which, 41% of deaths occurred in neonates[4]. In accordance with PRB (2011), IMR is 44, 5 and 76 per 1000 live births in world, more developed and least developed countries in that order[5]. In spite of decreasing childhood mortality, it still remains high in some vulnerable groups and areas. It was indicated that the highest rates of under-five mortality continue to occur in sub-Saharan Africa and South Asia has the second highest rate in this globe[4]. Besides, most of these children live in these regions and died from a disease or a combination of diseases or sickness[6]. Any way, many countries are not on track to reach the target of Millennium Development Goal-4 (MDG-4)[4], but Bangladesh is currently one of the some countries in the world particularly in South Asia and Sub-Saharan Africa, which is on target for reaching the MDG-4 regarding to child mortality. The aim for Bangladesh linked to MDGs is to lessen under five mortality from 151 per 1000 live births in 1990 to 50 in 2015[7]. In recent times, a number of studies reported that IMR is 45 per 1000 live births[5] and under five mortality is 71[8] and 65[9] in this country, which clarify that Bangladesh is on the track to reach MDG-4. Even if, the recent decline in childhood mortality is notable[10], but it still remains high in Bangladesh owing to high prevalence of malnutrition, childhood diseases and illness. UNICEF (2008) reported that one neonate dies in every three to four minutes, making 14 neonates deaths every hour in Bangladesh[11]. Habib *et al.* (2009) reported that deaths usually occur in the neonatal period[12]. Therefore, it is the topic of interest to population and health researchers to evaluate the causes, levels and trends of mortality in Bangladesh. But, due to lack of vital registration system, it is quite impossible to identify the exact mortality level and their causes. In addition, the contributory relationship and differentials between under-five mortality and its socio-economic, demographic and other characteristics is not well recognized in this

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country. Therefore, the objective of this study is to estimate the childhood mortality using data classified by duration of marriage group of mothers in Bangladesh through indirect technique.

2. Sources of Data

The data classified by duration of marriage of mothers for fulfilling the aforementioned objective of this study are presented in Table 1 taken from Bangladesh Demographic and Health Survey (BDHS) 2004[13], for the ten year period preceding the survey, having an eligible woman (ever married and aged 10-49) with at least one or more children (with a total sample size 8721, of whom 5840 from rural and 2881 from urban areas), which were conducted by Mitra and Associates under the authority of the National Institute of Population Research and Training (NIPORT), Ministry of Health and Family Welfare, Bangladesh.

3. Methodology

3.1. Trussel Technique

The well-established Trussel technique (1975)[14] is employed to estimate the childhood mortality in this study when the data are classified by duration of marriage group of mothers. The multipliers, k_i, required to adjust the proportion of dead, D_i, for the effect of the age pattern of childbearing are calculated from the ratio P_1/P_2 and P_2/P_3, by using the following equation:

$$k_i = a_i + b_i(P_1/P_2) + c_i(P_2/P_3)$$

It is assumed that the West family of Model Life Tables is an adequate representation of mortality in Bangladesh, so, values of the coefficients, ai, bi and ci, for estimation of child mortality multipliers, Trussell variants are used, when data are classified by duration of marriage of mothers.

Each probability of dying before exact age x, denoted by q_x is calculated by using the following formula:

$$q_x = k_i \times D_i$$

The probability of surviving denoted by l_x, from birth to exact age x, for each duration group is obtained by using the following formula:

$$lx = 1\text{-}qx$$

3.2. Model Fitting

If marriage specific average parities per woman are plotted in the graph paper, then, it appears from the Fig. 4 to Fig. 6 that these are, more or less, linearly distributed. So, in this case, linear regression model is treated and the model is

$$y = a_0 + a_1 x + u \qquad [15]$$

In which, x represents the mid value of marriage duration in years, y represents marriage specific average parities per woman, a_0 is the constant; a_1 is the coefficient of x and u is the error term of the model. It is to be noted that these models are built using the software STATISTICA.

3.3. Model Validation Procedure

To check the legitimacy of these models, the CVPP, ρ^2_{cv}, is employed at this juncture. The mathematical formula for CVPP is given below:

$$\rho^2_{cv} = 1 - \frac{(n-1)(n-2)(n+1)}{n(n-k-1)(n-k-2)}(1-R^2).$$

Wherein, n is the number of classes, k is the number of explanatory variables in the fitted model and the cross-validated R is the correlation between observed and predicted values of the dependent variable[16]. The shrinkage of the model is the absolute value of (ρ^2_{cv} - R^2); where ρ^2_{cv} is CVPP and R^2 is the proportion of variation of the fitted model. Furthermore, the stability of R^2 of the model is (1-shrinkage). The estimated CVPP corresponding to their R^2 and information on model fittings are summarized in Table 2. It was informed that CVPP was also employed by Islam (2006)[17], Islam et al. (2003)[18] and Khan and Ali (2004)[19] as model validation method.

3.4. The F-Test

To identify the overall assessment of significant level of the formulated model as well as the significance of R^2, the F-test is employed in this paper. The formula for F-test is given as

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

Wherein, p = the number of parameters is to be estimated in the fitted model, n is the number of cases and R^2 is the coefficient of determination of the model[20].

4. Results and Discussion

4.1. Estimation of Child Mortality for National Level of Bangladesh

The required data are summarized in Table 1. The sex ratios of the reported number of children ever born (CEB) are examined for consistency check of the data. A complete set of these sex ratios are presented in the last column of Table 1. The values of these ratios for different marriage durations are expected to reasonably stable and to be close to 1.05.

Average parities, P_i, are calculated at national level for male, female and both sexes and these are shown in Table 2. The results indicate that the average parities per woman, i.e., the mean number of male CEB are higher than the female CEB. It is also observed that average parities are increasing with the increase of marriage duration of the mother.

The proportion of children dead (D_i) for each marriage duration group of mother for male, female and both sexes are

shown in Table 2. The values of k_i are obtained by substituting the average parities ratios P_1/P_2 and P_2/P_3 and the coefficients taken from West families of Model Life Tables in the Coale-Demeny System and presented in Table 2.

The estimates of q_x values are presented in Table 2 and the results are also presented in Figure 1. From the figure, it is observed that the probability of dying is increasing with the increase of marriage duration and the probability is higher for male than that of female at each duration.

Table 1. Children Ever Born and Children Surviving by Sex and Duration of Marriage of Mother of National Level, Bangladesh, 2004

Duration of marriage (in years)	Total women	Male		Female		Sex ratio of CEB
		CEB	Dead	CEB	Dead	
National level						
(1)	(2)	(3)	(4)	(5)	(6)	(7)
0-4	2042	600	46	582	31	1.03093
5-9	2052	1807	158	1699	129	1.06357
10-14	1781	2536	274	2431	222	1.04319
15-19	1348	2503	316	2533	266	0.98816
20-24	854	2057	336	2100	313	0.97952
25-29	393	1156	227	1186	220	0.97470
30-34	251	815	172	920	185	0.88587
Total	8721	11474	1529	11451	1366	1.00201
Rural level						
(1)	(2)	(3)	(4)	(5)	(6)	(7)
0-4	1349	404	29	392	24	1.03061
5-9	1341	1213	104	1143	89	1.06124
10-14	1177	1732	206	1683	159	1.02911
15-19	910	1745	230	1784	196	0.97814
20-24	570	1445	236	1422	234	1.01617
25-29	291	897	182	888	167	1.01014
30-34	202	684	138	768	146	0.89063
Total	5840	8120	1125	8080	1015	1.00495
Urban level						
(1)	(2)	(3)	(4)	(5)	(6)	(7)
0-4	693	196	17	190	7	1.03158
5-9	711	594	54	556	40	1.06835
10-14	604	804	68	748	63	1.07487
15-19	438	758	86	749	70	1.01202
20-24	284	612	100	678	79	0.90265
25-29	102	259	45	298	53	0.86913
30-34	49	131	34	152	39	0.86184
Total	2881	3354	404	3371	351	0.99496

Note: 35-39 age group is included in 30-34 age group

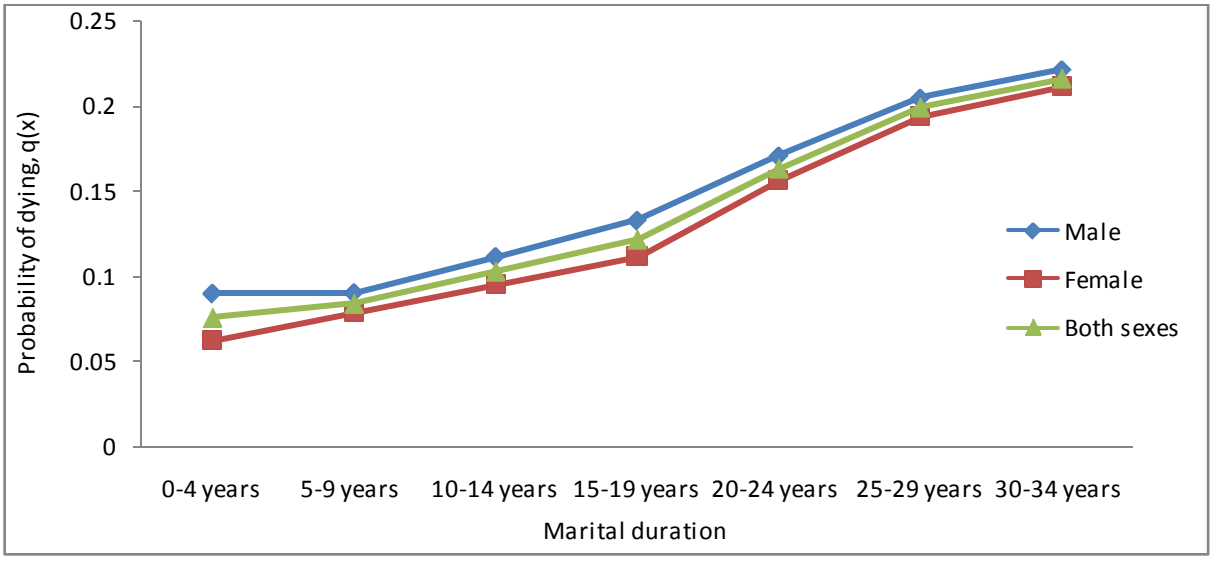

Figure 1. Patterns of child mortality for national level of Bangladesh

Table 2. Estimates of Probabilities of Dying and Surviving by Sex, Derived from Child Survival Data Classified by Duration of Marriage, Trussel Variant-West Model, National Level of Bangladesh, 2004

Sex	Marriage duration (in years)	Average parities per woman P_i	Proportion of children dead D_i	Multipliers k_i	Exact age	Estimates of q_x	Probability of surviving l_x
	(1)	(2)	(3)	(4)	(5)	(6)	(7)
Male	0-4	0.29383	0.07667	1.16893	2	0.08962	0.91038
	5-9	0.88060	0.08744	1.02863	3	0.08994	0.91006
	10-14	1.42392	0.10804	1.02912	5	0.11119	0.88881
	15-19	1.85682	0.12625	1.04953	10	0.13250	0.86750
	20-24	2.40867	0.16334	1.04265	15	0.17031	0.82969
	25-29	2.94148	0.19637	1.04043	20	0.20431	0.79569
	30-34	3.24701	0.21104	1.04705	25	0.22097	0.77903
		P_1/P_2				0.33367	
		P_2/P_3				0.61844	
Female	0-4	0.28501	0.05326	1.16271	2	0.06193	0.93807
	5-9	0.82797	0.07593	1.02652	3	0.07794	0.92206
	10-14	1.36496	0.09132	1.03347	5	0.09438	0.90562
	15-19	1.87908	0.10501	1.05697	10	0.11099	0.88901
	20-24	2.45902	0.14905	1.04893	15	0.15634	0.84366
	25-29	3.01781	0.18550	1.04444	20	0.19374	0.80626
	30-34	3.66534	0.20109	1.05129	25	0.21140	0.78860
		P_1/P_2				0.34423	
		P_2/P_3				0.60659	
Both sexes	0-4	0.57884	0.06514	1.16591	2	0.07595	0.92405
	5-9	1.70858	0.08186	1.02761	3	0.08412	0.91588
	10-14	2.78888	0.09986	1.03124	5	0.10298	0.89702
	15-19	3.73591	0.11557	1.05317	10	0.12171	0.87829
	20-24	4.86768	0.15612	1.04572	15	0.16326	0.83674
	25-29	5.95929	0.19086	1.04240	20	0.19895	0.80105
	30-34	6.91235	0.20576	1.04913	25	0.21587	0.78413
		P_1/P_2				0.33879	
		P_2/P_3				0.61264	

4.2. Estimation of Child Mortality for Rural Level of Bangladesh

In the same way, child mortality for rural level of Bangladesh are estimated and presented in Table 3. The probability of dying between birth and exact age x (q_x) for male, female and both sexes are presented in Table 3 and the results are plotted in Figure 2. From the Figure, it is indicated that the probability of dying is increasing with the increase of marriage duration and the probability of dying is higher for male than that of female at each duration.

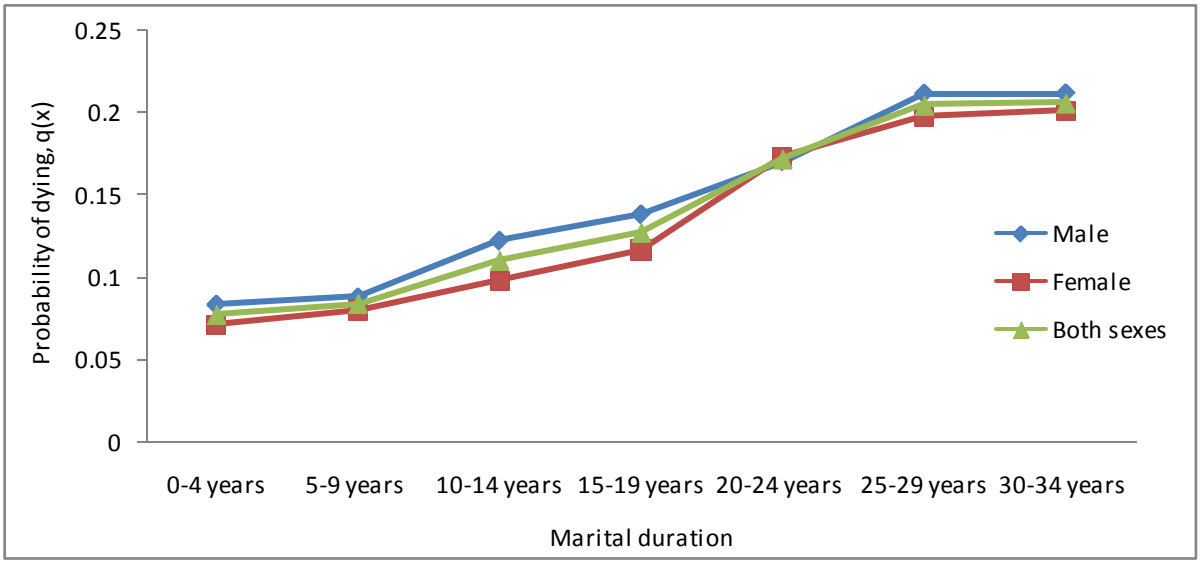

Figure 2. Patterns of child mortality for rural level of Bangladesh

Table 3. Estimates of Probabilities of Dying and Surviving by Sex, Derived from Child Survival Data Classified by Duration of Marriage, Trussel Variant-West Model, Rural Level of Bangladesh, 2004

Sex	Marriage duration (in years)	Average parities per woman P_i	Proportion of children dead D_i	Multipliers k_i	Exact age	Estimates of q_x	Probability of surviving l_x
	(1)	(2)	(3)	(4)	(5)	(6)	(7)
Male	0-4	0.29948	0.07178	1.16974	2	0.08396	0.91604
	5-9	0.90455	0.08574	1.02975	3	0.08829	0.91171
	10-14	1.47154	0.11894	1.03041	5	0.12256	0.87744
	15-19	1.91758	0.13181	1.05120	10	0.13856	0.86144
	20-24	2.53509	0.16332	1.04475	15	0.17063	0.82937
	25-29	3.08247	0.20290	1.04285	20	0.21159	0.78841
	30-34	3.38614	0.20175	1.04956	25	0.21175	0.78825
		P_1/P_2				0.33108	
		P_2/P_3				0.61470	
Female	0-4	0.29059	0.06122	1.16312	2	0.07121	0.92879
	5-9	0.85235	0.07787	1.02845	3	0.08009	0.91991
	10-14	1.42991	0.09447	1.03716	5	0.09798	0.90202
	15-19	1.96044	0.10987	1.06210	10	0.11669	0.88331
	20-24	2.49474	0.16456	1.05474	15	0.17357	0.82643
	25-29	3.05155	0.18806	1.05047	20	0.19755	0.80245
	30-34	3.80198	0.19010	1.05755	25	0.20104	0.79896
		P_1/P_2				0.34092	
		P_2/P_3				0.59609	
Both sexes	0-4	0.59007	0.06658	1.16651	2	0.07767	0.92233
	5-9	1.75690	0.08192	1.02913	3	0.08431	0.91569
	10-14	2.90144	0.10688	1.03373	5	0.11049	0.88951
	15-19	3.87802	0.12071	1.05656	10	0.12754	0.87246
	20-24	5.02982	0.16393	1.04967	15	0.17207	0.82793
	25-29	6.13402	0.19552	1.04662	20	0.20464	0.79536
	30-34	7.18812	0.19559	1.05351	25	0.20606	0.79394
		P_1/P_2				0.33586	
		P_2/P_3				0.60553	

4.3. Estimation of Child Mortality for Urban Level of Bangladesh

In the similar process is adopted for the estimation of child mortality for urban level of Bangladesh and presented in Table 3. The estimates of q_x values are presented in Table 4. The results indicate that the estimate of the probability of dying increase with the increase of marriage duration for male, female and both sexes but excepting for male in the duration of 0-14 years that are showed in Figure 3. Moreover, the probability of dying is higher for male than that of female at each duration.

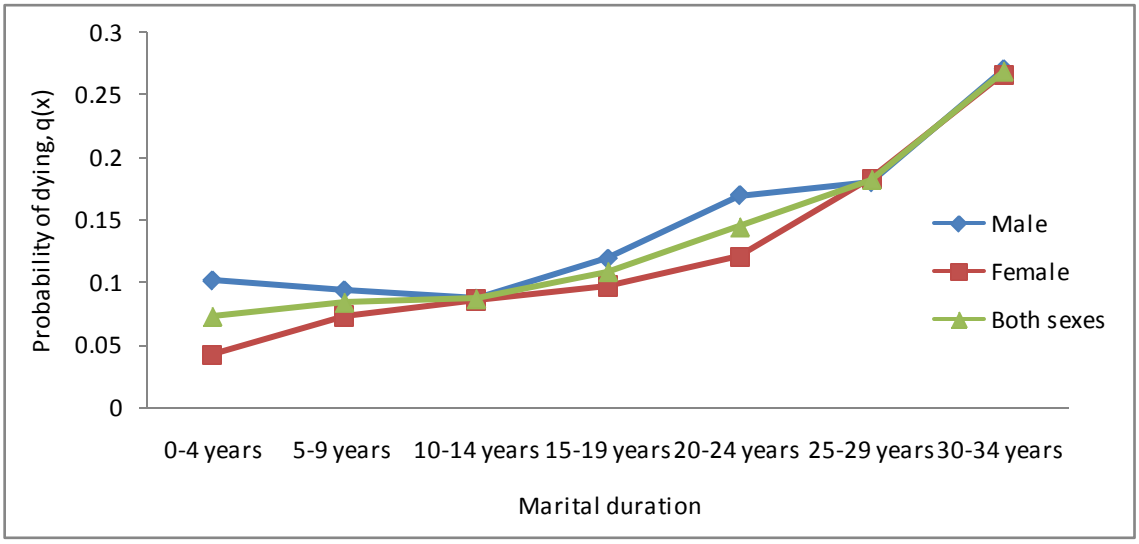

Figure 3. Patterns of child mortality for urban level of Bangladesh

Table 4. Estimates of Probabilities of Dying and Surviving by Sex, Derived from Child Survival Data Classified by Duration of Marriage, Trussel Variant-West Model, Urban Level of Bangladesh, 2004

Sex	Marriage duration (in years)	Average parities per woman P_i	Proportion of children dead D_i	Multipliers k_i	Exact age	Estimates of q_x	Probability of surviving l_x
	(1)	(2)	(3)	(4)	(5)	(6)	(7)
Male	0-4	0.28283	0.08673	1.16764	2	0.10127	0.89873
	5-9	0.83544	0.09091	1.02635	3	0.09331	0.90669
	10-14	1.33113	0.08458	1.02592	5	0.08677	0.91323
	15-19	1.73059	0.11346	1.04528	10	0.11860	0.88140
	20-24	2.15493	0.16340	1.03753	15	0.16953	0.83047
	25-29	2.53922	0.17375	1.03477	20	0.17979	0.82021
	30-34	2.67347	0.25954	1.04118	25	0.27023	0.72977
		P_1/P_2				0.33854	
		P_2/P_3				0.62762	
Female	0-4	0.27417	0.03684	1.16241	2	0.04282	0.95718
	5-9	0.78200	0.07194	1.02238	3	0.07355	0.92645
	10-14	1.23841	0.08422	1.02471	5	0.08630	0.91370
	15-19	1.71005	0.09346	1.04467	10	0.09763	0.90237
	20-24	2.38732	0.11652	1.03520	15	0.12062	0.87938
	25-29	2.92157	0.17785	1.03045	20	0.18327	0.81673
	30-34	3.10204	0.25658	1.03676	25	0.26601	0.73399
		P_1/P_2				0.35060	
		P_2/P_3				0.63145	
Both sexes	0-4	0.55700	0.06218	1.16511	2	0.07245	0.92755
	5-9	1.61744	0.08174	1.02443	3	0.08374	0.91626
	10-14	2.56954	0.08441	1.02533	5	0.08655	0.91345
	15-19	3.44064	0.10352	1.04499	10	0.10818	0.89182
	20-24	4.54225	0.13876	1.03641	15	0.14381	0.85619
	25-29	5.46078	0.17594	1.03268	20	0.18169	0.81831
	30-34	5.77551	0.25795	1.03904	25	0.26802	0.73198
		P_1/P_2				0.34437	
		P_2/P_3				0.62947	

4.4. Results of Model Fittings

The simple linear regression model is assumed to fit to age specific average parities per woman by duration of marriage for Bangladesh, rural and urban areas and these fitted models are described below:

For Bangladesh, $y=0.095482+0.211291x$ i)

For Rural, $y=0.090888+0.219120x$ ii)

For Urban, $y=0.258944+0.180821x$ iii)

The estimated CVPP and results on model fittings for these models are exposed in Table 5 and Table 6 respectively. It seems from these tables that the fitted models (1) - (3) are highly cross-validated and their shrinkages are very small shown in the same table. These imply that the fitted models (1) - (3) will be stable more than 99% and these are demonstrated in the Table 5. Moreover, it is seen that the parameters of these models are highly significant with more than 99% of variance explained and the stability for R^2 of these models is more than 99%. The calculated values of F statistic for these fitted models are displayed in the last column of Table 6 in which from these statistics it is concluded that F-test is highly significant and hence, these models are highly statistically significant. Therefore, the fit of these models are better well.

Table 5. The Results of CVPP

Models	n	K	R^2 (%)	ρ_{cv}^2	Shrinkage	Stability of R^2
Bangladesh	7	2	99.95	0.998571	0.000928571	0.999071
Rural	7	2	99.97	0.999143	0.000557143	0.999443
Urban	7	5	99.91	0.997429	0.001671429	0.998329

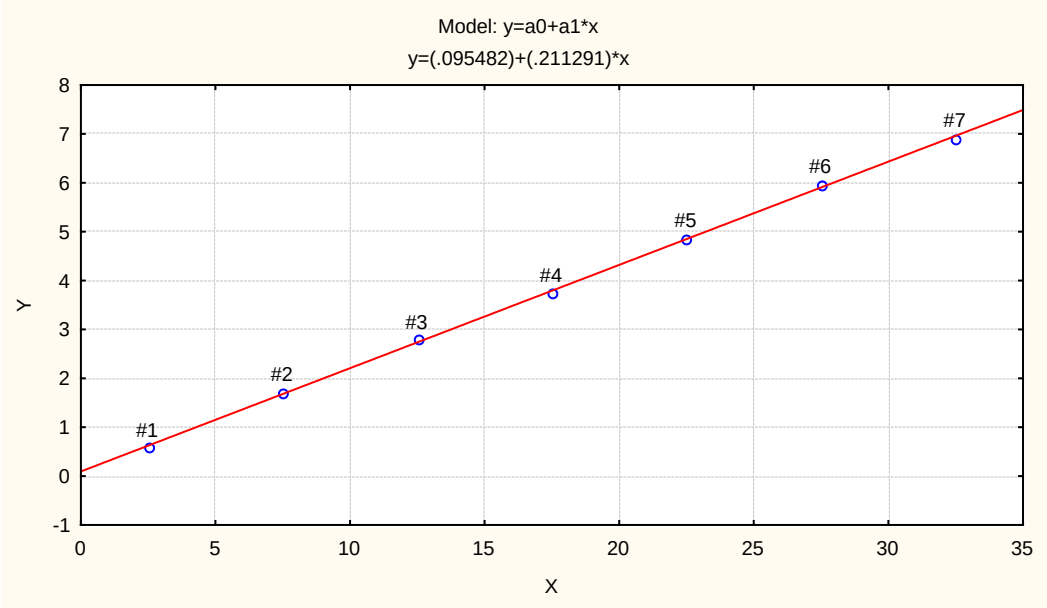

Figure 4. Observed and fitted marriage specific average parities per woman for Bangladesh. X axis represents duration marriage and Y axis represents average parities per woman

Table 6. Information on Model Fittings

Models	R^2	Para meters	Estimate	Standard	t-value	p-level	Lower Conf.	Upper Conf.	Calculated F with d.f (p-value)
Bangladesh	99.95	a0	0.095482	0.041024	2.3275	0.067424	-0.009974	0.200938	10776.47 with d.f (1, 5) (0.000)
		a1	0.211291	0.002035	103.8098	0.000000	0.206059	0.216523	
Rural	99.97	a0	0.090888	0.036069	2.5198	0.053187	-0.001831	0.183607	14992.63 with d.f (1, 5) (0.000)
		a1	0.219120	0.001790	122.4444	0.000000	0.214520	0.223720	
Urban	99.91	a0	0.258944	0.172025	1.50527	0.192596	-0.183260	0.701147	448.86 with d.f (1, 5) (0.000)
		a1	0.180821	0.008535	21.18626	0.000004	0.158881	0.202760	

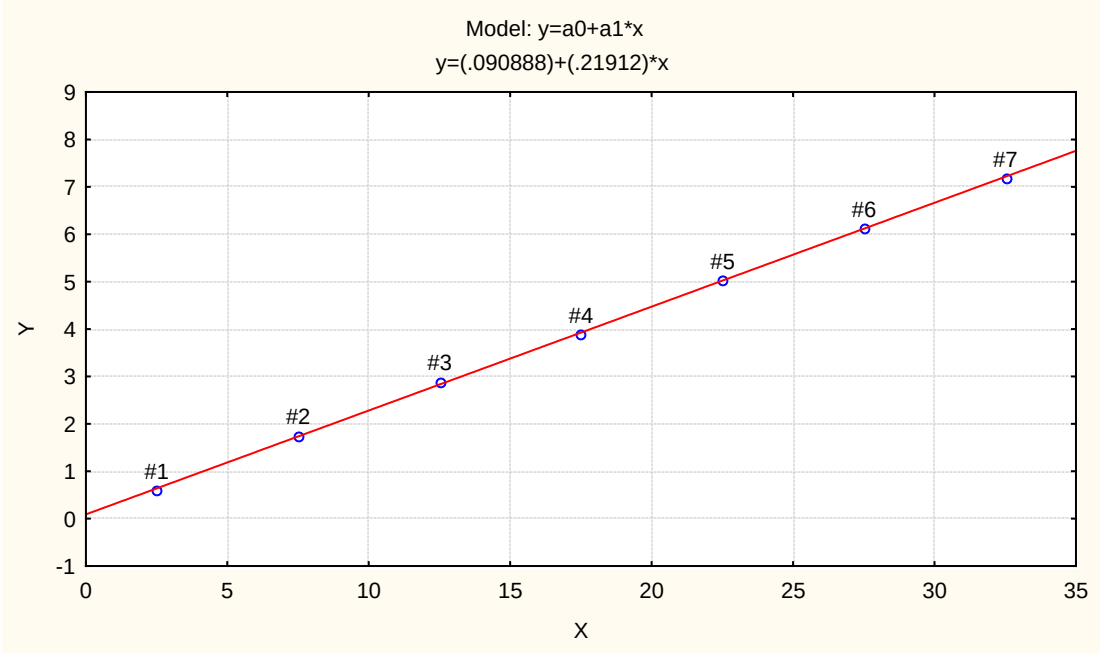

Figure 5. Observed and fitted marriage specific average parities per woman for Rural level of Bangladesh. X axis represents duration marriage and Y axis represents average parities per woman

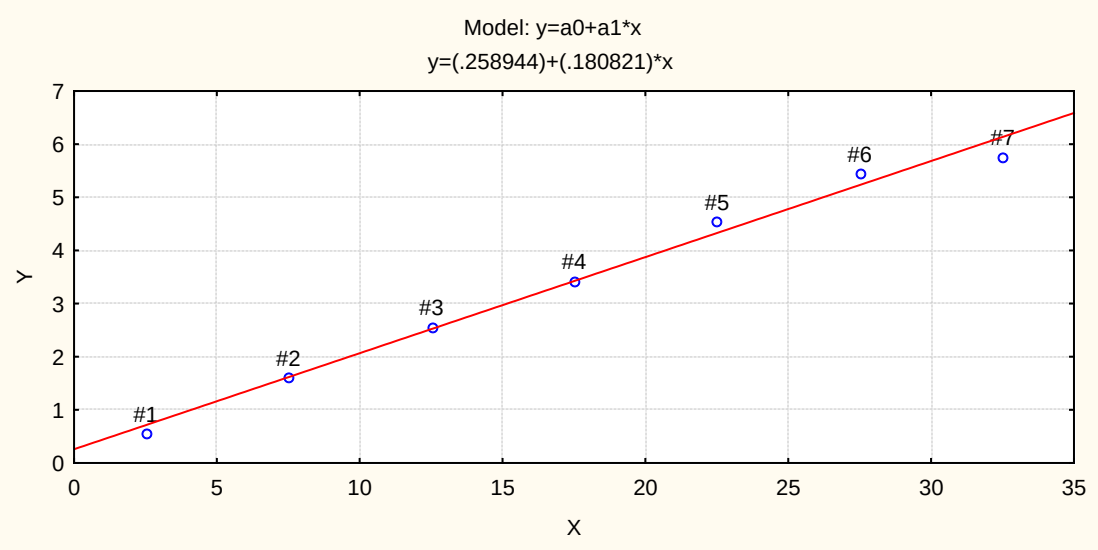

Figure 6. Observed and fitted marriage specific average parities per woman for Urban level of Bangladesh. X axis represents duration marriage and Y axis represents average parities per woman

5. Conclusions

In this study, the average parities are increasing monotonically with the duration of marriage and the proportions of children dead are also increasing with marital duration. From the results of estimated mortality levels for the national level, rural level and urban level, it is observed that the probability of dying is increasing due to increase of marital duration, but for the urban level of male, these probabilities are decreasing in the marital duration 0-14 years and then again increasing up to the last marital duration group. The probability of dying is higher for male than that of female at each duration of marriage. It is investigated that age specific average parities per woman for three cases follow simple regression model with explaining more than 99% variation. In addition, it is expected that this study for measuring the childhood mortality through indirect technique would be very helpful for policy makers, program designers and /or planners to design or redesign program(s) or existing program(s) for lessening under-five mortality and for reaching MDGs. Moreover, for the estimation of adult mortality, these probabilities of surviving in this study may be used for the applications of Widowhood method or any other methods.

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