Dhaka Univ. J. Sci. 59(1): 9-15, 2011 (January)

Analysis of Birth Interval in Bangladesh Using Product-Limit Estimate and Accelerated Failure Time Regression Model

Sharif Mahmood and Begum Zainab

Institute of Statistical Research and Training (ISRT), Dhaka University, Dhaka-1000, Bangladesh

Received on 07. 06. 2009. Accepted for Publication on 30. 06. 2010

Abstract

This paper presents the present condition of birth interval in Bangladesh and different demographic and socio-economic factors that affect the birth interval using product-limit estimate and accelerated failure time regression model. Determination and identification of the factors causing variation in length of birth interval is of great importance for its direct relation to fertility. We have found that mother's education, mother's age and place of residence have a great influence for variation in birth interval. This study demonstrates how the factors affect the parents for having successive children in Bangladesh.

I. Introduction

A birth interval, defined as the length of time between two successive live births, indicates the pace of childbearing. Information on birth intervals provides insight into birth-spacing patterns, which have far-reaching impact on both fertility and child mortality levels. Research has shown that children born too soon after a previous birth are at increased risk of dying at an early age. The number of children a woman may produce during her whole reproductive period depends on the length of intervals she gives between births. Thus for a women, longer birth intervals imply lower level of fertility.

Differences in a country's fertility levels can be attributed to the differences in the length of the reproductive life of women and differences in the length of time between births when women are exposed to the risk of conception. Analysis of those factors influencing the span and those affecting the spacing of fertility has proven useful, since in many cases they appear to vary quite substantially across populations [Rodriguez et.al.1984].

The 2004 BDHS survey shows that median birth interval is 39 months. This is slightly longer than the median birth interval of 35 months reported in the 1999-2000 BDHS survey and 37 months in the 1996-1997 BDHS survey. Younger women have shorter birth intervals than older women, presumably because they are more fecund and want to build their families. The median birth interval for women age 15-19 is 27 months compared with 48 months for women over age 40. The median birth interval is slightly shorter if the previous child was a girl than if it was a boy. Birth intervals are much shorter if the previous child died (28 months) than if the previous child survived (40 months). In part, this reflects the shortening of postpartum amenorrhea that occurs when the preceding child dies in infancy and breast-feeding stops prematurely [Shah,1990]. Women are also less likely to use contraception to postpone fertility if the previous child died and they want to replace the dead child.

Very few studies have been conducted so far in Bangladesh on birth interval dynamics; those that do deal with typical data and do not represent the whole country. Different studies have examined this issue and identified different risk factors contributing to the length of birth intervals. Zenger [1993] studied Siblings' neonatal mortality risks and birth spacing in Bangladesh. Nitai et al.[1996] studied the differential patterns of birth interval in Bangladesh. This study makes an attempt to evaluate the effect of some selected determinants of the birth interval using product limit estimate and accelerated failure time regression model.

II. Data and Methodology

The 2004 BDHS survey was conducted under the authority of the National Institute for population Research and Training (NIPORT) of the Ministry of Health and Family Welfare. The survey was implemented by Mitra and Associates, a Bangladeshi research firm located in Dhaka. In this paper, we have analyzed the open birth intervals initiated by birth during the five-year period 1999-2004, because complete birth and death histories are available only for those births occurring after 1999. In this study, closed birth intervals are defined as the length of the interval between the birth of the index child and the birth of the subsequent child; Open birth intervals are defined the length of a birth interval between the birth of index child and the date of interview. Total subsequent birth intervals in this five-year period amounted to 7,034 intervals, of which 1,613 were closed intervals. Six explanatory variables for birth spacing have been selected for evaluation. These variables are maternal age at birth of the indexed child, Birth order of the indexed child (parity), mother's education, sex of the index child, place of residence and Division.

We have presented the distribution of open subsequent birth interval for different subgroups of explanatory variables and examined the differentials. At the second stage of the analysis, product limit (P-L) approach is used. This technique is appropriate for the analysis of the birth interval because all intervals, closed as well as open, can be included in the analysis, thereby avoiding the bias towards short intervals if only closed intervals are examined. The estimate of proportion of women not having another child within any given period subsequent to a live birth was obtained by product limit method. The estimate for median birth intervals were then obtain on the basis of P-L estimate for the survival function to take account of censoring (open birth intervals). The advantage of using the P-L method is that censoring is taking into account in estimating the survivor functions. The P-L method is utilized in this study to take account of the issue of censoring in the birth intervals. The Accelerated failure time regression model estimates in the specific group that lives longer than t (time) equals the percentage of subjects in the reference group that lives longer than a constant multiple of time.

III. Product Limit Estimate Analysis

The P-L method of the survival function [Kaplan and Meier, 1958] may be obtained as follows:

$$\hat{S}(t_i) = \prod_{j=1}^{i} \left(1 - \frac{d_j}{n_j} \right)$$

The P-L method is widely applicable when the data consists of censoring [Lawless, 2003]. This technique is appropriate for the analysis of the birth interval because all intervals, closed as well as open, can be included in the analysis, thereby avoiding the bias towards short intervals if only closed intervals are examined. The estimate of proportion of women not having another child within any given period subsequent to a live birth was obtained by product limit method. The estimate for mean birth intervals were then obtain on the basis of P-L estimate for the survival function to take account of censoring (open birth intervals).

Table. 1. Product limit estimate of the probability of not having a subsequent birth within given interval by different demographic and socio-economic characteristics

Characteristics	Level	Level of subsequent birth interval (in month)								
		Num -ber	≤ 12	≤ 18	≤ 24	≤ 30	≤ 36	≤ 42	≤ 48	≤ 54	≤59
Mother's age at birth of index child	≤24	3457	0.977	0.931	0.839	0.743	0.630	0.540	0.466	0.413	0.358
	25 – 34	2862	0.976	0.939	0.875	0.798	0.723	0.661	0.608	0.568	0.533
	≥35	715	0.973	0.948	0.888	0.838	0.795	0.755	0.715	0.710	0.664
Residence	Rural	4927	0.975	0.936	0.855	0.764	0.667	0.593	0.531	0.488	0.445
	Urban	2107	0.975	0.940	0.875	0.816	0.755	0.694	0.646	0.619	0.577
Mother's education	None	2599	0.975	0.936	0.846	0.756	0.658	0.585	0.520	0.481	0.440
	Primary	2189	0.978	0.938	0.863	0.776	0.683	0.602	0.551	0.521	0.463
	Secondary	1846	0.978	0.938	0.879	0.808	0.744	0.693	0.636	0.593	0.575
	Higher	400	0.968	0.928	0.885	0.843	0.809	0.753	0.709	.	.
Parity	≤ 2	3846	0.976	0.930	0.847	0.763	0.665	0.591	0.526	0.481	0.431
	3 – 5	2460	0.977	0.946	0.882	0.802	0.724	0.656	0.602	0.569	0.526
	≥6	728	0.978	0.943	0.863	0.788	0.734	0.678	0.642	0.614	.
Sex of index child	Girl	3450	0.978	0.939	0.864	0.772	0.690	0.618	0.558	0.523	0.481
	Boy	3584	0.975	0.935	0.859	0.787	0.696	0.629	0.572	0.531	0.489
Division	Barisal	770	0.928	0.959	0.901	0.832	0.755	0.707	0.632	0.601	0.495
	Chittagong	1542	0.977	0.937	0.855	0.745	0.641	0.554	0.483	0.434	0.393
	Dhaka	1555	0.979	0.945	0.867	0.789	0.711	0.636	0.569	0.527	.
	Khulna	877	0.979	0.928	0.888	0.851	0.788	0.741	0.687	0.635	.
	Rajshahi	1329	0.980	0.948	0.880	0.819	0.758	0.714	0.682	0.652	.
	Sylhet	961	0.961	0.897	0.779	0.655	0.521	0.414	0.354	0.346	0.273

Result Using Product Limit Estimate

The purpose of this model is to show the birth interval depends upon different factors. We now interpret the results for variables (factors) of this model.

Mother Age at Birth of Index Child

Mother age is often considered to be an important factor causing variation in birth interval. Younger women have shorter birth intervals than older women, presumably because they are more fecund and want to build their families.

In our study, maternal age at birth also shows a consistent positive relationship with birth spacing. Table 1 shows that for women less than 25 years of age, the probability of not a subsequent child within 42 months is 0.54. Again for women aged 35 or higher probability of not a subsequent birth within 42 months is 0.755 (Fig: 1). Differences in birth spacing by age of mother at the birth of the child are relatively small in the early interval in Bangladesh.

Birth Order of the Index Child

The birth order of the index child that initiates the birth interval could also be an important determinant of the birth interval.

In our study, results show weaker but positive association between birth order and subsequent birth interval. For women having 2 or fewer children, the probability of not having a subsequent birth within 42 months is 0.591. Again for women having 6 or more children, the probability of not having a subsequent birth within that 42 months is 0.678.

The birth spacing pattern of women with children 3-5 years of age is quite similar to that of higher parity of women (See Figure-2).

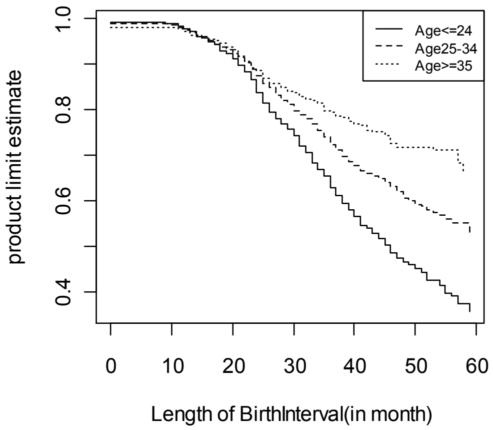

Fig. 1. Estimated probability of not having a subsequent birth with in a given interval by mother's age.

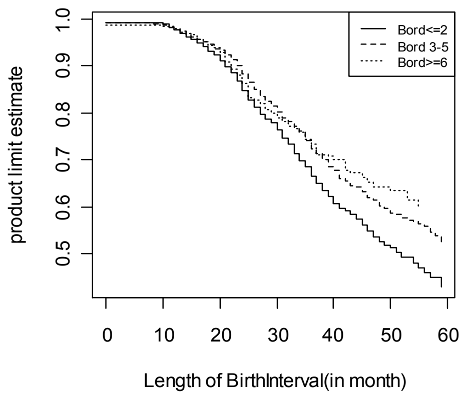

Fig. 2. Estimated probability of not having a subsequent birth with in a given interval by birth order.

Mother's Education

Education is a key variable in explaining birth interval differentials. Education is expected to have a negative impact on fertility and birth spacing through a change in the socio-cultural and reproductive behavior of married women including child loss, knowledge and practice of contraception as well as through changes, in family size norms.

In the no education category, the probability of not having a subsequent birth within 42 months is 0.585. In primary education category, the probability of not having a subsequent birth within 42 months is 0.602. However, there is not much difference in birth spacing between the no education and primary education category .But in higher education category, the probability of not having a subsequent birth within 42 months is quite higher which is 0.753 (See Figure 3).

Sex of the Index Child

The strong preference for having at least one living son in Bangladesh is well known. In a society such as Bangladesh, where parents typically highly value a son as an economic asset and old-age insurance as well as the bearer of the family name, it is less likely that they will accept contraception or other methods of fertility control until they have had at least one son [Ahmed, 1981]. Thus, the sex of the index child could be regarded as a determinant of the birth interval.

The PL estimates also show a similar pattern of longer birth spacing among women having a son as the index child. Mother's having a son as the index child, the probability of not having a subsequent birth within 48 months is 0.572, whereas Mother's having a daughter as the index child, the probability of not having a subsequent birth within 48 months is 0.558.(Fig: 4).

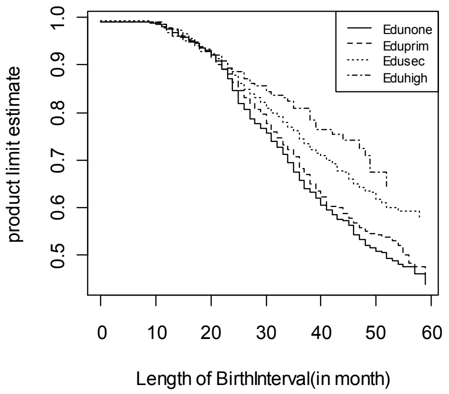

Fig. 3. Estimated probability of not having a subsequent birth with in a given interval by mother's education.

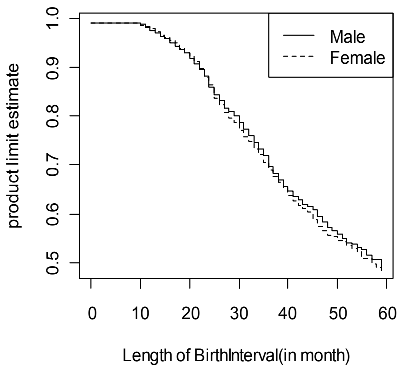

Fig. 4. Estimated probability of not having a subsequent birth with in a given interval by sex of index child.

Place of Residence

Place of residence is also found to have an important impact on the birth interval. The urban environment provides new ideas, a technological setting altering the costs and benefits of children, and usually provides greater access to modern health care and family planning services.

The result of our study shows an expected pattern of shorter birth intervals for rural women than that for urban women.

For urban women, the probability of not having a subsequent birth within 42 months is 0.694 whereas for rural women, the probability of not having a subsequent birth within 42 months is 0.593 (Fig: 5).

Division

It is often account for variation in birth spacing due to differences in economic condition, social and cultural practices, availability of family planning facilities, etc. So division might have an important impact on the birth interval.

The results of our study shows that for the mother's of sylhet, the probability of not having a subsequent birth within 42 months is 0.414 (which is smallest among all the divisions) whereas for the mother's of khulna, the probability of not having a subsequent birth within 42 months is 0.741 (which is largest among all the divisions).

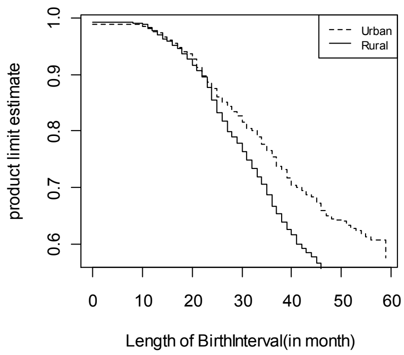

Fig. 5. Estimated probability of not having a subsequent birth with in a given interval by place of residence.

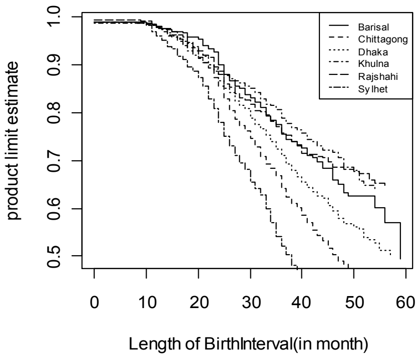

Fig. 6. Estimated probability of not having a subsequent birth with in a given interval by division.

IV. Distribution Fitting for Birth Ineterval Data

A technique closely related to P-P and Q-Q plot is used with parametric models for which the survivor or distribution function can be "linearized". This means that some transform of $S(t;\theta)$ is a linear function of t or of some function of t, that is, $g_1[S(t;\theta)]$ is a linear function of $g_2(t)$ for some function g_1 and g_2. The idea is then plot $g_1(\hat{S}(t))$ versus $g_2(t)$; if the parametric family is appropriate the result should be roughly linear. For Birth interval data we have the following figure:

Table. 2. Median birth intervals by different demographic and socio-economic characteristics based on P-L Method for birth interval data:

Characteristics	Level	Number	Median
Mother's age at birth of index child	age ≤ 24	3457	46
	age 25 – 34	2862	NM*
	age ≥ 35	715	NM*
Birth order of Child	Bord ≤ 2	3846	52
	Bord 3-5	2460	NM*
	Bord 6+	728	NM*
Mother's Education	None	2599	52
	Primary	2189	56
	Secondary	1846	NM*
	Higher	400	NM*
Sex of index Child	Boy	3584	59
	Girl	3450	57
Place of Residence	Urban	2107	NM*
	Rural	4927	53
Division	Barisal	770	59
	Chittagong	1542	47
	Dhaka	1555	57
	Khulna	877	NM*
	Rajshahi	1329	NM*
	Sylhet	961	38

*Not Measurable (see section V)

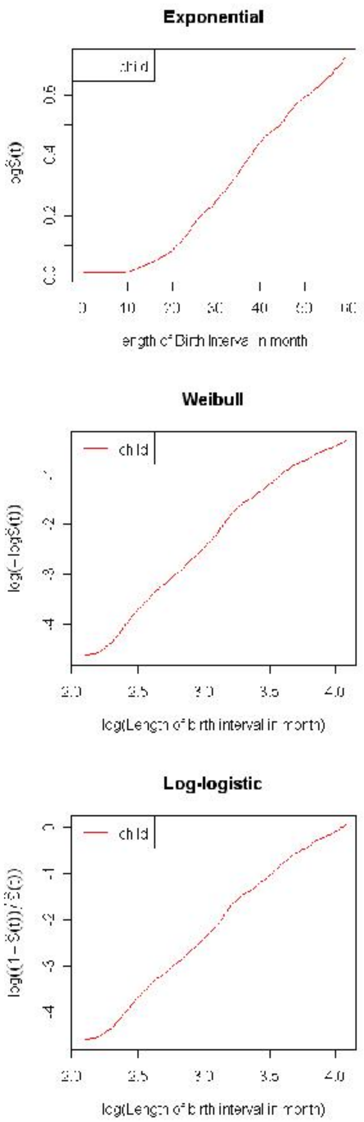

Fig. 7. Exponential, Weibull and Log-logistic probability plots for Birth interval data.

The main reason of the parametric model is that it provides a confidence interval for the quantiles for each category, whereas the nonparametric method cannot do this because of degree of censoring. From the figure 7, we see our birth interval data follows Log-logistic distribution very well.

V. Accelerateed Failure Time Regression Model

Let us consider the AFT model,

$$\mathbf{Y} = U(\mathbf{x}) + b\mathbf{Z}$$

Where

$U(\mathbf{x}) = \mathbf{X'B}$
$\mathbf{Y}$ = log(Birth interval)
$\mathbf{B}$ = Vector of regression coefficient
$\mathbf{X}$ = Vector of covariates
$\mathbf{Z}$ = random variable follows standard logistic
b = scale parameter of logistic

The family of the models for which Z has a standard logistic distribution is a frequent basis of regression analysis. The covariates effectively alter the time (birth interval) scale. Different covariate vector x1 and x2 give functions that are transformation of one another, they have the same shape but are separated by a location U(X1)-U(X2). In particular if exp(U(X)) >1, the effect of the covariate vector is to decelerate birth interval, and if exp(U(X)) <1, the effect is to accelerate it.

The accelerated failure time regression model is an alternative where proportional hazards assumption does not hold. In contrast to the proportional hazards model, the accelerated failure time model is best characterized in terms of survival function. Let us consider a simple example with $S_{X1}(t)$ and $S_{X2}(t)$ the survival functions in the treated and the control population, the accelerated failure time regression model specifies that, with $\varphi>0$,

$$S_{X1}(t)=S_{X2}(\varphi t)$$

The interpretation is as follows: the percentage of subjects in the treatment group that lives longer than t equals the percentage of subjects in the control group that lives longer than φt. The parameter φ is called the acceleration factor; values below one are in favor of the treatment, as the survival time is then prolonged under the treatment.

An alternative interpretation is in terms of the median survival time. With M_{X1} and M_{X2} the median survival times in the treated and control group, we have that

$$S_{X1}(M_{X1})=S_{X2}(M_{X2})=0.5$$

From the accelerated failure time assumption it follows that

$$S_{X1}(M_{X1})=S_{X2}(\varphi M_{X1})=0.5$$

And therefore $\varphi M_{X1}=M_{X2}$. For $\varphi<1$ the median survival time in the treatment group is larger than the median survival time in the control group.

Table 3 shows the dependency of birth interval upon different factors. Column 3, 4, 5 and 6 indicates the estimated values of coefficients for different factors, standard deviation, the values of z statistic and the p-values of the test statistic respectively. As we have obtained a parametric regression model we can find the corresponding median survival time as well as we could make confidence interval for the estimated parameters

VI. Conclusion

The data show that birth intervals are affected by different socio-economic and demographic factors in Bangladesh. The data is consists of 7034 births which we have haul out from national representative data BDHS 2004. Thus this study has a great importance for national policies related to fertility. This study reveals how the factors affect the parents for having successive children. Again it differs from previous studies (Nitai et al.[1996]; Khan, H.T.A, and Roesside, R. [1998]) since we have considered open and closed birth intervals, which is considered as survive or failure in survival analysis.

Table. 3. Fitted Log-logistic value model for birth interval data by different demographic and socio-economic characteristics

Variable	Coefficient	Value	Std. Error	Z	P
	Intercept	3.928	0.049	79.586	0.000
Mother's age	β_{12} (age25-34)	0.203	0.029	7.094	0.000
	β_{13}(age 35+)	0.456	0.053	8.572	0.000
Birth order (parity)	β_{22}(3 to 6)	0.033	0.030	1.095	0.024
	β_{23}(more than 6)	- 0.019	0.052	-0.384	0.073
Mother's education	β_{31}(Primary)	0.063	0.027	2.369	0.002
	β_{32}(Secondary)	0.181	0.031	5.802	0.000
	β_{33}(Higher)	0.182	0.061	2.691	0.000
Sex of index child	β_{42}(Female)	-0.014	0.022	-0.64	0.513
Residence	β_{52}(Rural)	- 0.129	0.026	-5.001	0.000
Division	β_{62}(Chittagong)	-0.219	0.042	-5.211	0.000
	β_{63}(Dhaka)	-0.093	0.043	-2.161	0.032
	β_{64}(Khulna)	0.053	0.051	1.033	0.301
	β_{65}(Rajshahi)	0.038	0.046	0.281	0.411
	β_{66}(Shylet)	-0.364	0.045	-8.174	0.000

As expected, younger women have shorter birth intervals than older women, presumably because they are more fecund and want to build their families. We have observed in PL method that estimated probability of not having a subsequent child is higher for older mothers. In AFT model we found that estimated values of our coefficients for older aged mothers compare to lower aged mothers are positive and significant which indicates that, as age increases our duration of birth interval is accelerated that is duration of birth interval is increasing for older mothers and this factor has a significant role for duration of birth interval. Again for birth order we have found that estimated probability of not having a subsequent child is higher for higher birth order but have no significant difference as we have found from our AFT model.

As Bangladesh is an over populated country, the main concern issue goes to fertility which is directly related to duration of birth interval. In our analysis, we have observed in PL method that estimated probability of not having a subsequent child is higher for higher educated mother. In AFT model we found that estimated values of our coefficients for higher educated mothers compare to lower educated mothers are positive and significant which indicates that, as education of mothers goes higher our duration of birth interval is accelerated that is duration of birth interval is increasing for higher educated mothers and this factor has a significant role for duration of birth interval. Again for sex of index child we have found that the median birth interval is slightly shorter if the previous child was a girl than if it was a boy and estimated probability of not having a subsequent child is slightly higher if mothers have male child compare to female child. In AFT model we observed that this variable has no significant effect on birth interval. In part, this reflects the birth interval has significant difference for birth order of child. A child having lower birth order has a tendency to occur lower birth interval.

Birth intervals have a significant difference for residence of mothers. In AFT model we have found that the estimated coefficient value is negative which indicates our birth interval is decelerated for rural mothers compare to urban mothers that is the duration of birth interval is lower for rural mothers compare to urban mothers and has a significant difference. The longest birth intervals are found among women in Khulna Division and the shortest are among women in Sylhet Division.

This study provides some empirical evidence for association between some selected explanatory variables and subsequent birth intervals. The main strength of this study is that it is based on nationally representative data. Among the explanatory variables that are examined, place of residence and mothers' age seems to have a very strong effect on birth spacing. The next explanatory variable that seems to have a strong effect on birth spacing is the age of the mother at the birth of the child. Other explanatory variable, such as, sex of the index child and birth order do not seem to have much influence on birth spacing

----

1. Ahmed, N.R. (1981). "Family size and sex preferences among women in rural Bangladesh" Studies in Family Planning **12(3)**:100-109.
2. Anderson, J.E, S. Becker, A.H. Guinena and B.J. McCarthy (1986). "Breastfeeding effects on birth interval components: a prospective child health study in Gaza" Studies in Family Planning **17(3)**:153-160.
3. Bangladesh Bureau of Statistics (BBS) (1999), Statistical Year Book, 1999, Bangladesh Bureau of Statistics, Ministry of Finance and Planning.
4. Biswas, S.C, S.M. Sarwar (2002) "The Determination of Birth Interval in Bangladesh; A hazard model analysis" The Chittagong University Journal of Science, **26 (1&2)**.
5. Chen L.C., S. Ahmed, G. Melita and W.H. Mosley (1974). "A prospective study of birth interval dynamics in rural Bangladesh" Population Studies 28:277-297.
6. Guo, Guang. 1993. "Use of sibling data to estimate family mortality effects in Guatemala", *Demography* **30(1)**:15-32.
7. Khan, H.T.A, Roesside, R. (1998) "The determinants of first and subsequent births in urban and rural areas of Bangladesh" *Asia pacific Population Journal* **13(2)**:39
8. Koenig, M.A., J.F. Phillips, O.M. Campbell and S. D'Souza (1990). Birth intervals and childhood mortality in rural Bangladesh" *Demography* **27(2)***:*251-265.
9. Lawless, J.F. (2003),"Statistical Models and Methods for lifetime", Wiley-Interscience, A Jhon Wiley & Sons,incn., Publication.
10. Lee, E.T. (1992). Statistical Methods for Survival Data Analysis (second edition) (New York: John Wiley and Sons).
11. Markos Ezra, Eshetu Gurmu. "Breastfeeding, birth intervals and child survival: analysis of the 1997 community and family survey data in southern Ethiopia".
12. Miller, J.E., J. Trussell, A.R. Pebley and B. Vaughan (1992). "Birth spacing and child mortality in Bangladesh and the Philippines" *Demography* **29(2)**:305-318.
13. Mitra, S.N. et al. (1997): Bangladesh Demographic and Health Survey,1996-97, NIPORT, Dhaka, Bangladesh.
14. Nitai Chakraborty, Sayema Sharmin and M. Ataharul Islam. Differential Pattern of Birth Intervals in Bangladesh. *Asia-Pacific Population Journal,* **11(4)** (1996), pp. 73-86.
15. Rodriguez, G., J. Hobcraft, J. McDonald, J. Menken and J. Trussell (1984). "A comparative analysis of determinants of birth intervals" *WFS Comparative Studies No. 30.*
16. Shah, I.H. and J. Khanna (1990). Breast-feeding, infant health and child survival in the Asia-Pacific context" *Asia-Pacific Population Journal* **5(1)**: 25-44.
17. Zenger, Elizabeth (1993)."Siblings' neonatal mortality risks and birth spacing in Bangladesh", Demography **30(3)**:477-488.