ESTIMATION OF CONCEPTION WAITS AND FECUNDABILITY: LEVELS AND TRAINDS IN BANGLADESH

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Abstract: *The concept of fecundability derives its importance for the study of human fertility from the fact that it is one of the principal determinants of fertility and is a major standard by which the impact of fertility regulation can be assessed; very few attempts have been made in Bangladesh for estimating fecundability. The concept of fecundability—the monthly probability of conception in women—is one of the principle determinants of fertility and one of the most important parameters for studying fertility patterns in different societies. Significance variables of the study are age at first marriage, respondent current age, husband's age, marital duration, use of contraceptive, spousal age difference, age at first birth, respondent education level, husband's education level, respondent work status, husband's occupation, body mass index and religion out of seventeen variables.*

Key words: *Fecundability, Estimation, Conception, Levels, Trends and Bangladesh*

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INTRODUCTION

The human reproduction starts from the onset of marriage and the timing of first conception signifies couples fertility at early stage of married life. The time, a woman takes to conceive for the first time after her marriage is called the first conception wait or conception delay. A conception delay is defined as the exposure months preceding, but not including, the month of conception, whereas the conception wait or the time required to conceive includes that month as well (Potter and Parker, 1964).

A woman may take several months to conceive after entering the susceptible period. She may enter the susceptible period by marriage or after resumption of menses after a birth while living with her partner. The time a woman takes to conceive from the time of marriage is called marriage to first birth interval, which is also called waiting time to conception. The women who are more fecund conceive more quickly than those who are less fecund. Fecundability is inversely related to the marriage to first birth interval; the higher the fecundability, the shorter the marriage to first birth interval, and vice versa. In fact, it can be shown that there is an exact inverse relationship between the marriage to first birth interval (W) and fecundability (f) [(W = I/f)] in a homogeneous population of women [2-4]. However, in reality, fecundability is not the same for all women because they have different frequencies of intercourse and different biological characteristics. In such a heterogeneous population the average marriage to first birth interval is longer than that in homogeneous case, as with heterogeneity women with the highest fecundability conceive quicker, leaving slower conceivers with decreasing levels of fecundability in successive months (Potter and Parker, 1964).

In the past, at least five different methods for the estimation of the mean value of fecundability in a population have been explored-

1. Calculating fecundability from coital frequency and the duration of the viability of sperm and ovum (Glass and Grebenik, 1954; Lachenbruch, 1967; Westoff et al., 1961; Tietze, 1960).
2. Observing the proportion of women conceiving during a one-month period (cycle) of exposure to the risk of conception (Barrett, 1969, 1971; Gini, 1924; Henry, 1953; Potter, 1961; Sheps, 1965; Tietze et al., 1950; Whelpton and Kiser, 1950).

3. Fitting models to the distribution of waiting times to conception (Henry, 1964a; Jain, 1969; Majumdar and Sheps, 1970; Potter and Parker, 1964; Sheps, 1964; Sheps and Menken, 1972, 1973). This method can also yield estimates of the variance of fecundability (Henry, 1964a; Jain, 1969; Majumdar and Sheps, 1970; Sheps and Menken, 1973).
4. Fitting models to birth interval distributions (D'Souza, 1973; Srinivasan, 1966, 1967).
5. Fitting models to the distribution of parities attained within a certain period of time by a group of women (Brass, 1958; James, 1963; Singh, 1963, 1969).

MODEL OF HOMOGENEOUS FECUNDABILITY (GEOMETRIC DISTRIBUTION)

The process of human reproduction starts from the onset of effective marriage and the timing of first conception following it depends on the biological characteristics of women. According to Gini (1924), conception is a random event even though all the possible biological and sociological factor influencing conception are controlled. This randomness of conception gave a clue for the application of probability theory. Treating fecundability to be constant for a long span till she conceives and time as a discrete random variable, Gini (1924) derived the geometric distribution for the time of first conception. Further applications are found in the works of Henry (1953), Henripon (1954) and Vincent (1961). Gini's results obtained the mean fecundability of the population and the co-efficient of variation from the data on the proportion of women conceiving during the first and second months of exposure to risk. The simplest case to consider is that in which fecundablity is not only constant among women but also from month to month.

Let for a woman p, $0<p>1$, be the probability of conception in any month and assume that the month represent independent trials. If the month in which conception occur is denatured by the random variable T, then prob (T=1) =p which is the probability that the conception occurs in the first month. If T=t such that t>1, then the preceding (t-1) months conception has not occurred with probability $(1-p)^{t-1}$ and first conception occurs in the t-th month with probability p. Therefore, we can write

$h(t)=prob\ [T=t]=p\ (1-P)^{t-1}, t=1,2,3,...........$ is the desired formula for the probability density function of T. This probability function is, of course, that of the well-known geometric distribution.

The probability function is a monotonic decreasing function of t with a mode, the most probable value, at t=l. The survival function at time t, s(t) defined by s(t)=prob[T>t] is given by $s(t) = (l- p)^t = q^t$. The distribution function of the random variable T is given by

$H(t) = P[T \leq t] = 1 - (1 - P)^t$.

The mean time of conception is E(T) = m = $\frac{1}{P}$, represent the mean number of ovulations before conception. The mean time to conception is between m and m-1, depending on the interval that separated marriage from the first ovulation thus follows.

The variance of distribution is.

$V(T) = \frac{1-P}{P^2}$ In the homogeneous case, the mean waiting time for the first conception is

$$E(T) = \frac{1}{\text{Arithmatic mean of p}}$$

Since $\frac{1}{H.M.} > \frac{1}{A.M.}$, we underestimate fecundability if we use homogeneous model.

The moment estimator of p is $\frac{1}{T}$. For the geometric distribution, the maximum likelihood estimator coincides with the moment estimator.

MODEL OF HETEROGENEOUS FECUNDABILITY:

In the last centuries, demographers have employed a variety of techniques to study the mean value of fecundability and its distribution discussed in this study. Among these techniques, the most commonly and widely applicable technique, is the fitting of a theoretical distribution to the observed distribution of waiting time to conception. In such case the waiting time to conception or the conception interval is measured by subtracting the date of first marriage from the date of first conception. The theoretical fitting of the type I geometric distribution has the limitation that it can be used only after the beginning of the marital life of the women as the conception interval for the pre-marital pregnant women are not possible to calculate.

However, the model has the great advantages that it makes minimum assumption and is equivalent with the Gini's definition of fecundability because the range of the Pearsonian type I geometric distribution lies between 0 and 1. Pearson's type I distribution has been recommended and used by the Henry (1964) for the first time to study the mean value of fecundability. Following his work, Potter and Parker (1964), Majumdar and Sheps (1970) and Anrudh Kumar Jain (1969) fitted the type I beta geometric distribution for predicting the time required to conceive and for estimating the mean fecundabilities for women in the United States, Princeton fertility survey data and Taiwanese women respectively.

The Model

For analyzing the data on the conception interval the type I geometric distribution is considered as a useful model. The model relies on the following assumptions:

(i) The fecundability of each couple remains constant from month to month until pregnancy,

(ii) Among couples, fecundability is distributed as a Pearson Type I curve, i.e., Beta distribution with parameters a and b.

(iii) Conception is a random event conditional on fecundability.

(iv) The number of couples is large.

In a population, not all women may be having same fecundability to bear children. There is simple evidence that couples vary in their fecundability. A significant proportion of sexually active couples get pregnancy in their first non-contraception cycle, a smaller proportion of the remaining couples conceive in the conception rate continues to decline as the risk dampens. Therefore, the first assumption may be violated if spouse are temporarily separated, if the couple intentionally changes the timing and frequency of intercourse, and or if a miscarriage of six or eight weeks is not reported. Even among healthy, regularly menstruating women, the proportion of anovulalory cycles is put at 5 percent or thereabouts (Potter, 1961). During the period of separation occurs for a short period and does not coincide with the fertile period during the month, then it will no effect on the monthly probability of conception. The pronounced decrease in the probability of conception over time is not purely due to time effect but as a sorting effect in a heterogeneous population (Leridon 1977; Weinberg and Gladen, 1986). As such, the fecundability, p of a particular woman, which is assumed to be constant earlier from month to month may be though as a realization of the random variable P, hence the distribution of T is the conditional distribution of T for given P, that.

$\text{Prob}[T=t/P] = P(1-P)^{1-1}$, t = 1,2,3..................

the unconditional probability that a conception occurs at t for a randomly selected couple is given by h(t) = Prob[T=t] = $\int_0^1 \Pr ob[T = t|P] f(P) dp$ = $\int_0^1 f(P) f(t|P) dp$

t= 1.2,3......... is the probability density function of the random variable T. it is easy to see that *f(t/P)* is a proper probability density function for each P, then so is h(t).The given probability density function are frequently referred to as mixture distributions.

It can also be shown that the variance of the waiting time of first conception in case of heterogeneity is always greater than the variance of the same in the homogeneous estimation. For the application of the above mathematical model, we need to have a specific form of f(P). A Judicious choice of f(P), when *f(t/P)* is the probability density function of the geometric distribution is the well-known two-parameter Beta distribution whose probability density function is.

$$f(P) = \frac{1}{B(a,b)} P^{a-1}(1-P)^{b-1}$$ Where, 0<p<1,a>0 and b>0

The distribution is also known as a Type I Geometric, so named because of a classification system introduced by the British statistician, Karl Pearson. Pearson Type I distribution has been recommended first by Henry (1961) to study the fecundability. Following his work Potter and Parker (1964) constructed the Type I geometric model for predicting the time required to conceive and for estimating the mean fecundability for women in United States. Pearson type I distribution is convenient and gives a good approximation to unimodal distributions that are encountered in reality, for a variable that, like fecundability, ranges between 0 and 1. The normalizing constant B(a,b) is the famous beta type I function defined by.

B(a,b)= $\int_0^1 P^{a-1}(1-P)^{b-1} dp$; which may also be written

f(p) = $AP^{a-1}(1-P)^{b-1}$ with A = $\frac{\Gamma a \Gamma b}{\Gamma(a+b)}$

The mean, mode and variance of fecundability are

$\overline{P} = \frac{a}{a+b}, P^1 = \frac{(a-1)}{(a+b-2)}$ and *V*(P) = $\frac{ab}{(a+b)^2(a+b+1)}$

For a>l and b>l, the mode of the Beta geometric distribution M (p) is given by M(p) = $\frac{a-1}{a+b-1}$

It is moreover, simple to calculate the value of the coefficient of variation of fecundability in case of a beta distribution. Starting from

$\overline{P} = \frac{a}{a+b}$ and $c^2 = \frac{v}{\overline{p}^2} = \frac{ab}{a(a+b+1)}$; where c is the coefficient of variation and v is the variance of fecundabilitry. The proportion of conceiving during the first month of exposure is given by

$$P(1) = \int_0^1 f(P)Pdp = \int_0^1 \frac{P^a(1-P)^{b-1}}{(a,b)}dp = \frac{B(a+b)}{B(a,b)}$$

More generally, the number of conceiving during the month of exposure is equal to

$$P(j) = \int_0^1 f(P)(1-P)^{j-1}Pdp = \frac{B(a+1,b+j-1}{B(a,b)}$$

$= \frac{ab(b+1).......(b+j-1)}{(a+1)(a+b+1)......(a+b+j)}$, for j=2,3,............. and P(0) $= \frac{a}{a+b} = \overline{P}$.

The number of women conceiving during the j-th month is N(j) = N.P(j)

Where, N is the total number of women in the sample.

The rate of conceiving in month j is given by $q_j = \frac{a}{a+b+j}$

Under the assumption of Type I geometric model, the theoretical average and variance of time required to conceive are given by the following expression:

E(T) $= m = \int_0^1 E\left(\frac{1}{P}\right)f(P)dp = \frac{\Gamma(a+b)}{\Gamma a \Gamma b}\int_0^1 P^{a-1}(1-P)^{b-1}dp = \frac{a+b-1}{a-1}$ and this is true when a>l.

Simply, the variance of time of first conception can be obtained as

$$V(T) = S^2 = \frac{ab(a+b-1)}{(a-1)^2(a-2)}, \text{if } a > 2$$

Table-1 Estimates of conception delay and fecundability for women by marital duration, Bangladesh (2011) BDHS.

Marital duration (in year)	Mean conception wait(in month)	Variance	Number of women	Fecundability
0-4	7.06	77.197	997	0.1416
5-9	13.84	292.871	2097	0.0723
10-14	15.02	395.016	2258	0.0666
15-19	18.73	600.993	1827	0.0534
20-24	22.91	752.688	1513	0.0436
25-29	24.83	1.043E3	1415	0.0403
30 and above	26.94	953.180	3503	0.0371
Total	19.40	668.238	13610	0.0515

Fecundabilities are estimated on the basis of Geometric distribution as the individual marriage cohorts are homogeneous.

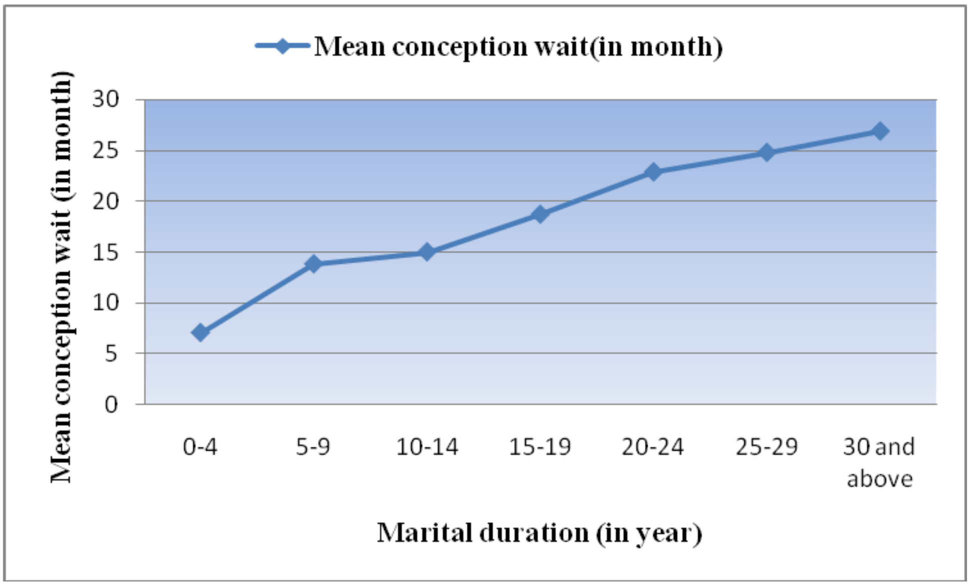

Figure-1 Mean conception wait by marital duration

The trend line regarding marital duration and mean conception wait indicates that up to 9 years mean conception wait is increasing sharply, after that it is increasing slowly.

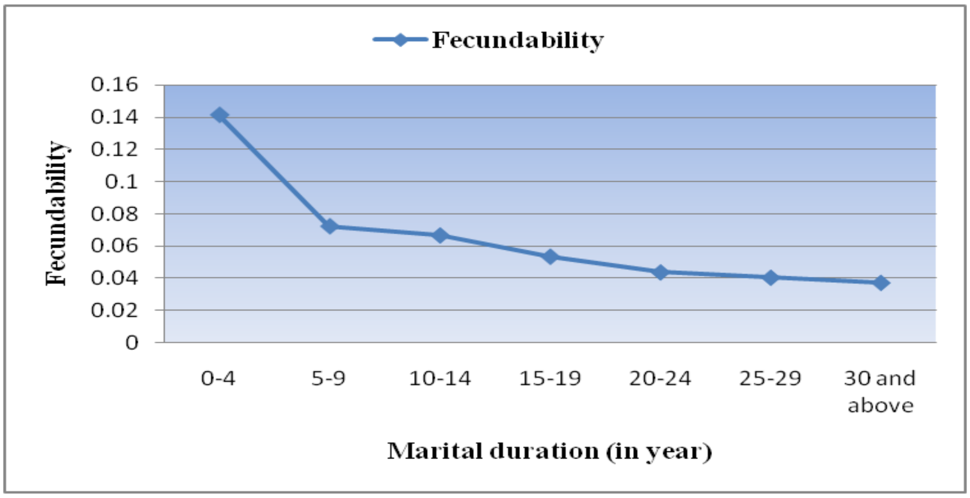

Figure-2 Mean fecundability by marital duration

The trend line regarding marital duration and mean fecundability indicates that up to 9 years fecundability is decreasing sharply, after that it is slowly decreasing.

Table 2: Mean conception wait and Fecundability in Bangladesh, 1993-2011(BDHS)

Source	Year	Mean Conception waits (estimated)	Standard deviation	Fecundability
BDHS	1993-94	29.35	27.05	0.03407
BDHS	1996-97	28.75	28.01	0.03478
BDHS	1999-2000	28.73	28.03	0.03474
BDHS	2004	24.42	26.00	0.04095
BDHS	2007	23.88	25.87	0.04187
BDHS	2011	19.40	25.850	0.0515

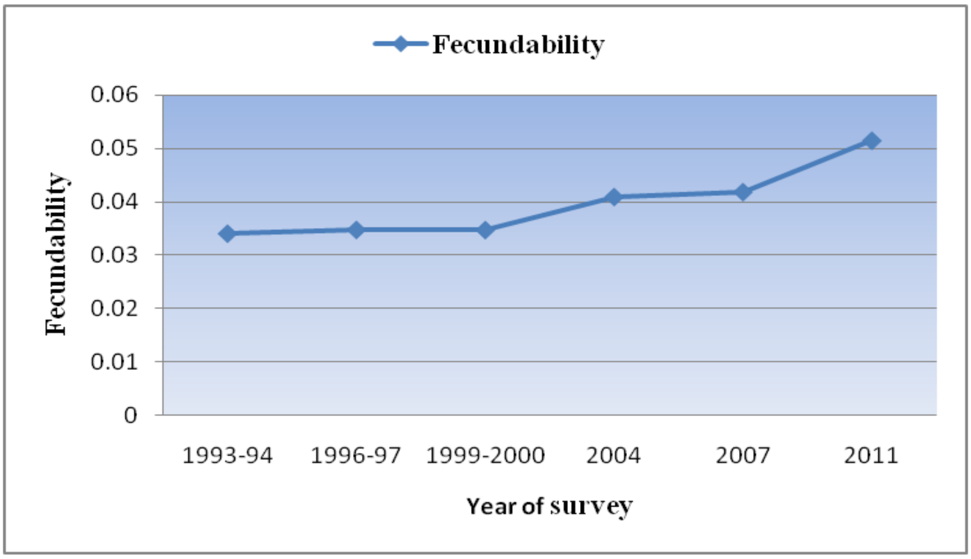

Figure-3 Fecundability trends in Bangladesh, 1993-2011(BDHS)

This shows that fecundability trends in Bangladesh are gradually increasing in nature except a little decrease in 1999-2000.

TRENDS IN MEAN CONCEPTION DELAY

It is seen from Table 3 that the mean conception delay decreases as the respondent's (wife's) age at first marriage increases for any of the four cases of marital duration. On the other hand mean conception delay increases as the marital duration increases for any of the three cases of respondent's age at first marriage.

Table-3. Mean conception delay for women by marital duration and respondent's age at first marriage

Duration of Marriage (years)	Mean conception wait Wife's age at marriage (in completed years)			Total
	≤ 15	16-18	19 or more	
≤9	13.71(1181)	11.07(1012)	10.25(1309)	11.72(3502)
10-19	17.45(2310)	16.19(954)	14.57(1257)	16.69(4521)
20-29	28.56(3455)	23.07(928)	22.65(1204)	24.96(3215)
≥30	31.31(1567)	23.46(324)	21.29(481)	28.35(2372)
Total	22.34(6946)	16.85(2894)	15.65(3770)	

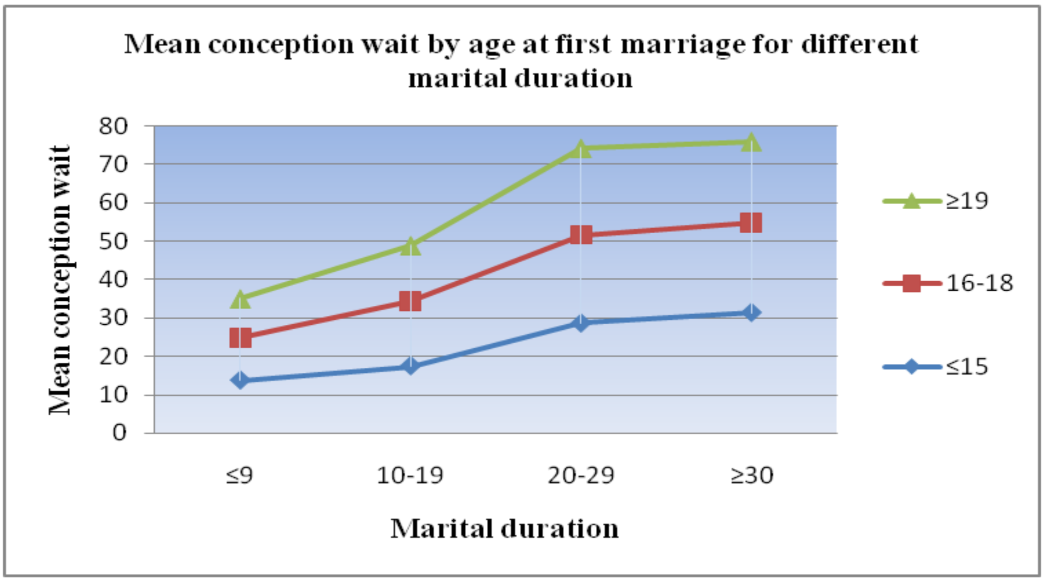

Figure 4: Mean conception wait by age at first marriage for different marital duration

The trend line regarding marital duration, age at first marriage and mean conception wait indicates that mean conception wait is slowly increasing when marital duration is increasing for all the three groups of age at first marriage.

TRENDS IN MEAN FECUNDABILITY

It is observed from Table 4 that the mean fecundability increases as the respondent's (wife's) age at first marriage increases for any of the four cases of marital duration. On the other hand mean fecundability decreases as the marital duration increases for any of the three cases of respondent's age at first marriage.

Table-4. Mean fecundabilities for women by marital duration and respondent's age at first marriage

Duration of Marriage (years)	Fecundability			Total
	Wife's age at marriage (in completed years)			
	≤ 15	16-18	19 or more	
≤9	0.0729(1181)	0.0903(1309)	0.0976(1012)	0.0853(3502)
10-19	0.0573(2310)	0.0592(1257)	0.0686(954)	0.0599(4521)
20-29	0.0350(3455)	0.0433(1204)	0.0461(928)	0.0400(3215)
≥30	0.0319(1567)	0.0426(481)	0.0470(324)	0.0353(2372)
Total	0.0448(6946)	0.0593(3770)	0.0639(2894)	

From the figure 5 the trend line regarding marital duration, age at first marriage and mean fecundability indicates that mean fecundability is slowly decreasing as the marital duration is increasing for all the three groups of age at first marriage.

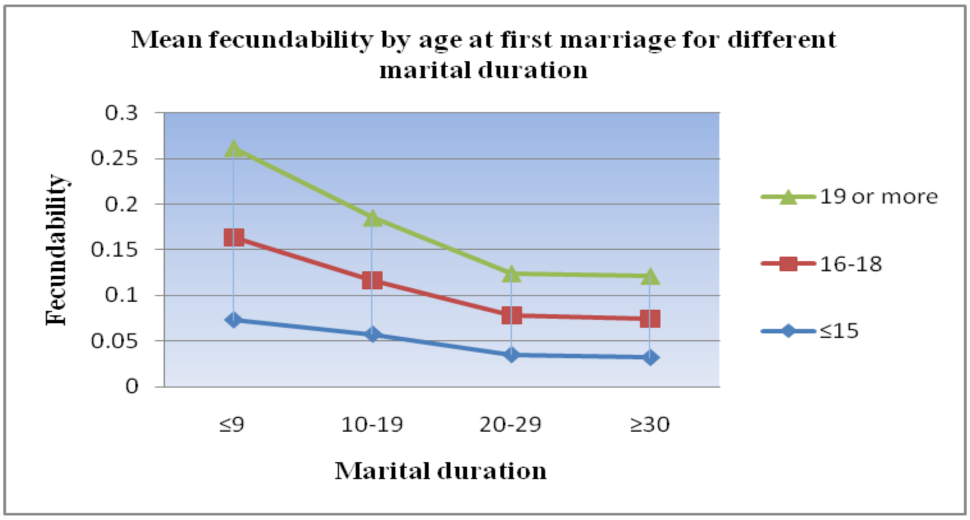

Figure 5: Mean fecundability by age at first marriage for different marital duration

Table-5. Mean fecundabilities for women by marital duration in Bangladesh since 2011

Marital duration	1975 BFS	1989 BFS	1993-1994 BDHS	1996-1997 BDHS	1999-2000 BDHS	2004 BDHS	2007 BDHS	2011 BDHS
0-4			0.050	0.055	0.058	0.055	0.067	0.142
5-9	0.061	0.053	0.037	0.038	0.043	0.047	0.050	0.072
10-14	0.067	0.051	0.033	0.035	0.040	0.041	0.043	0.063
15-19	0.058	0.049	0.030	0.032	0.034	0.037	0.038	0.053
20-24	0.047	0.043	0.027	0.027	0.031	0.035	0.037	0.044
All	0.062	0.051	0.033	0.034	0.038	0.041	0.041	0.039

Abbreviations: BFS, Bangladesh Fertility Survey. Source: BFS 1975, BFS 1989.

From the table-5 we have the fecundability transition by marital duration. Estimates are derived from Bangladesh fertility survey (BFS) data of 1975 and 1989 and Bangladesh demographic and health survey (BDHS) data from 1993- 1994 to 2007. The overall fecundability in 1975, 1989 and 1993- 1994 were 0.06, 0.05 and 0.033 per month suggesting a declining trend in fecundability in Bangladesh over time. This decline may be mainly due to the increased use of contraceptives. But from 1996-1997 a slightly increasing trend can be noticed in the fecundability.

CONCLUSION

For studying the differentials of marriage to first conception wait and fecundability among women the data are extracted from the 2011 Bangladesh Demographic and Health Survey (BDHS), according to the objectives of the study 13610 ever-married women have been considered out of 15427 respondents, who have at least one birth preceding the last five years of the survey, in order to overcome memory lapse of the respondents. Marriage to first conception wait plays an important role in population dynamics and has significant impact on fertility. It also involves biological characteristics, which are related to the social, economic and in many cases religious aspects. In this study, however, different techniques are employed to intensively investigate the patterns and socio-economic and demographic differentials of marriage to first conception wait and fecundability. In order to understand the significance of factors for marriage to first conception wait logistic regression analysis is employed. Geometric and type I geometric are fitted and the parameters are estimated by the method of moments.

From the study age at first marriage is an important factor for conception wait and fecundability. The Government should pay attention to ensure the existing marriage act (where the age at first marriage for women is 18 years) to prevent the early marriage in Bangladesh. This is because the women who got marriage at early age has higher conception wait as a result they have low fecundability.

Since education is one of the most important factor that's affect fecundability. Education delays marriage and maturity that comes with age may result in use more effective contraception. Higher educated persons have less conception wait and higher fecundability. Thus government needs to take necessary steps to educate people.

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