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Estimation of Fecundability: Levels and Trends in Bangladesh

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Introduction

The concept of fecundability - the monthly probability of conception in women - is one of the principal determinants of fertility and one of the most important parameters for studying fertility patterns in different societies. Fecundability affects fertility through its relationship with the average time required for a conception to occur, and can also be thought of as the transition probability for the passage from the susceptible state to pregnancy [1].

In practice, fecundability is measured in women who are ovulating regularly, that is, pregnant, sterile or post-partum, anovulatory women are excluded. The term natural fecundability is used non-contracepting populations; 'total (or physiological)' fecundability considers all conceptions regardless of outcome, including non-implanted fertilized ova and conceptions aborted spontaneously before the end of the cycle [2], [3], while 'recognizable' fecundability relates to conceptions recognizable at the end of the conception cycle by the non-occurrence of menstruation [2], and 'effective' fecundability includes only pregnancies ending in live births [4]. In this study, the term 'fecundability' mainly refers to effective fecundability.

Although the theoretical importance of fecundability is beyond question, there are several difficulties in estimating it from direct observation. Fecundability is frequently [2], [5] [6], [7], [8], [9] estimated from the distribution of waiting time to conception.

However, observations on waiting times are typically censored at higher values, introducing systematic bias into the estimates [10]. In a recent study Goldman and her colleagues [11] examined waiting times from marriage to first recognized conception using World Fertility Survey data from a number of countries and observed that in addition to several methodological problems there were other sources of bias.

Other techniques for estimating fecundability involve: (1) calculations based on coital frequency and the viability of the ovum and sperm [12], [13]; (2) observations on proportion of women conceiving during a one-month period of exposure to the risk of conception [14], [15], [16], [17] [18]; and (3) models fitted to the distribution of birth intervals or parities attained within a certain period of time by a group of women [19] [20] [21] [22].

The objective of this paper is to estimate fecundability by the model fitting technique to data on the distribution of the number of births to women with a fixed marital duration and to study its levels and trends in Bangladesh.

Data and Methodology

The study is based on data available from two national level fertility surveys, the Bangladesh Fertility Surveys (BFS) of 1975 and 1989. The 1975 BFS was conducted within the framework of the World Fertility Survey (WFS) program, which was also followed by the 1989 survey [23]. The patterns and trends of fecundability in Bangladesh were investigated by fitting the model developed by Singh [21] with a slight modification. Bhaduri [24] and Singh et al [25] have also utilized this model to study the fecundability of women in Varanasi, India.

The Model

Under some simplified assumptions, Singh [26] has derived a model which gives the probability distribution of the number of conceptions to a couple during a given time interval (0, T) of length T, and is given by

$P[X = 0] = 1 - a\ (l - e^{-l\ T})$......... (1)

$P[X = r] = a\ [_{s=0}{}^{r}S\ e^{-l\ (T-rh)}\ \{l\ (T - rh)\}^{s}/S! \text{ -- } _{s=0}{}^{r}S\ e^{-l\ (T-(r-1)\ h)}\ \{l\ (T - (r-1)\ h)\}^{s}/S!]$

For r = l, 2,......., n -1 and P[X = n] = 1 -P [X(n - l)]

where X = the number of conceptions during time (0, T),

h = the non-susceptible period defined as the sum of the gestation and postpartum amenorrhoea periods (PPA),

1 - a = the proportion of sterile females, and

1 = conception rate

The total number of conceptions during the time interval (O,T) cannot be more than 'n', where 'n' = [T/h]+l and [T/h] stands for the greatest integer not exceeding T/h.

Since there is a one-to-one correspondence between the number of conceptions and the number of births, the above model, can be applied to data on the number of births also. In fact, the number of conceptions within the period (O,T) is the same as the number of births in (O,T+g) where 'g' is the gestation period which is taken as nine months.

The above model assumes that women exposed to the risk of conception during the time interval (O,T) have the same conception rate, '1', and also assumes that all women have the same non-susceptible period 'h', though, in practice, it may vary from woman to woman within a certain period of time. Therefore, considering variations in the non-susceptible period as well as in the conception rate but assuming them to be constant for a woman throughout the period of observation, we have modified Singh's model as discussed in the following paragraphs.

The non-susceptible period 'h' and conception rate '1' of the women varies among women depending upon the pattern of breast-feeding and contraceptive use respectively, as also due to other socioeconomic, cultural, behavioral and physiological factors. Therefore, with respect to their non-susceptible period and conception rate, a heterogeneous population of married women can be considered as an aggregate of homogeneous subgroups of women.

Let there be 'k' homogeneous sub-groups of women having non-susceptible periods, h_1, h_1, ..., h_k with corresponding proportions q_1, q_2,..., q_k such that

$$_{i=0}{}^{K} S\, q_1 = 1$$

Also let the population be divided i = l into 'u' homogeneous sub-groups with respect to conception rates of 1_1, 1_2, ..., 1_u with corresponding proportions p_1, p_2,..., p_u such that

$$_{j=1}{}^{U} S\, P_1 = 1$$

It is also assumed that 'h' and 'l ' are independent. Thus, considering the variability in both 'h' and 'l', the distribution of the number of conceptions during the time interval (0,T) will be given by

$$P'[X = 0] = {}_{i=1}{}^{k}S\; {}_{j=1}{}^{u}S\; q_1 P_j P[X = 0h = h_1, l = l_j] \text{......................}[4]$$

$$P'[X = r] = {}_{i=1}{}^{k}S\; {}_{j=1}{}^{u}S q_1 P_j P[X = rh = h_1, l = l_j] \text{.......................}[5]$$

For r =1, 2, ..., n-1

P [X = n] 1 - P' [X < n-1] ....[6]

Parameter estimation and model fitting

The above model contains a large number of parameters, which are extremely difficult to estimate by any method of statistical estimation unless some simplified assumptions are made. Here, the values of the parameters 'a' and 'h' were estimated from observed data and then, considering these as known, '1' was estimated by the method of moments.

The parameter 'a' was taken as the complement of the ratio of women who had no births among all women with 15 and more years of marital duration, assuming that women who had no births during their first 15 years of marital duration were primarily sterile. The estimated values of 'a' worked out to 0.980 and 0.978 respectively for 1975 and 1989.

It is very difficult to make any definite assumptions about the possible pattern of variation in fecundability (1) and the non-susceptible period (h). However, the analysis of the BFS data indicates that the observed distribution of the non-susceptible period was bimodal in nature [27] [28], the first and second peaks occurring at 2-3 months and 15-16 months respectively in 1975, and 2-3 months and 12-13 months respectively in 1989. A similar pattern of distribution of post partum amenorrhoea was observed by Singh and Bhaduri [29], [30], [31] among others.

As an approximation, we assumed the population to consist of two sub-groups having shorter (corresponding to the first peak of the bio-modal distribution of the average non-susceptible periods). If 'h_i' and 'h_2', are the average non-susceptible periods of these two groups of women with corresponding proportions q_1 and q_2 estimates of q_1=0.3 and q_2=0.7 respectively were obtained from observed data for both 1975 and 1989; their corresponding estimated 'h_i' and 'h_2' were 1.10 and 2.16 years in 1975 and 1.00 and 1.85 years in 1989.

We further assumed that the population of married women consists of two categories - one group having a low conception rate (i.e. low fecundability), say 'l_i', and the other group having a high conception rate, say 'l_2', with corresponding proportions in the population p_i and p_2 (=1-p_i). Then, using the known values of 'l ' and 'h', the values of 'l 'were estimated by applying the method of moments.

Following Brass [S], an approximate expression was obtained for the mean of the above distribution under the simplified assumptions, with respect to the non-susceptible period and conception rate for the two homogeneous sub-groups of women:

` $x = {}_{i=1}{}^{2}S\ {}_{j=1}{}^{2}S\ al_i\ T\ /1+l_jh_i\ (1-h/2T)\ P_iq_j$ ....(7)

where` x is the mean number of conceptions for a given marital duration 'T'.

The estimated values of the parameters '1_i', '1_2' and 'P_i' for different marital duration's are presented at the bottom of Tables 1 and 2. Using the estimated values of these parameters, the model was fitted and Chisquare values were obtained.

Results and Discussion

The Chi-square values presented in Table 1 and Table 2 are observed to be insignificant at a 5 per cent level of significance for almost all marital duration's except for 5-9 years in 1975 (though the value is insignificant at one per cent level of significance) and 20-24 years in both 1975 and 1989. This indicates that the model gives a satisfactory fitting for the number of births up to marital duration's of 15-19 years, but beyond that it fails to describe the distribution of births well. This may be attributed to the violation of the strong assumption that the fertility parameters for a woman remain constant throughout the period of observation in the case of women, who have been married for 20-24 years.

Table 1: Observed and expected distributions of couples married for 5-9 years and 10-14 years by number of births

Number of births	**1975**		**1989**	
	Observed no. of couples	**Expected no. of couples**	**Observed no. of couples**	**Expected no. of couples**
	$h_1 = 1.10$	$h_2 = 2.16$	$h_1 = 1.00$	$h_2 = 1.85$
	$f_1 = 0.30$	$f_2 = 0.70$	$f_1 = 0.30$	$f_2 = 0.70$
	a = 0.98		**a = 0.978**	
A. Marital duration: 5-9 years				
0	96	90	169	166
1	236	236	551	551
2	339	341	953	967
3	200	205	585	607
4	94	80	201	176
5 +	41	54	60	52
Total	**1006**	**1006**	**2519**	**2519**
	$1_1 = 0.30$; $1_2 = 1.15$ $P_1 = 0.49$; $P_2 = 0.51$ 1 = 0.73		$1_1 = 0.37$; $1_2 = 0.85$ $P_1 = 0.44$; $P_2 = 0.56$ 1 = 0.64	

	0.64 Chi-square : 6.11; d.f. = 2		Chi-square : 5.84; d.f. = 2	
A. Marital duration : 10-14 years				
0	39	32	75	73
1	70	69	156	157
2	150	160	360	363
3	227	218	515	514
4	252	268	500	515
5	184	170	315	286
6	76	80	129	124
7 +	58	59	51	69
Total	**1056**	**1056**	**2101**	**2101**
	$1_1 = 0.33$; $1_2 = 1.16$ $P_1 = 0.43$; $P_2 = 0.57$ 1 = 0.73 0.64 Chi-square : 4.87; d.f. = 4		$1_1 = 0.31$; $1_2 = 0.87$ $P_1 = 0.46$; $P_2 = 0.54$ 1 = 0.64 Chi-square : 8.36; d.f. = 4	

The unit of time in this study has been taken as one year. The estimates of 'l_1' and 'l_2', therefore represent the annual conception rates. Dividing these values by twelve gives the monthly conception rate, which may be taken as the estimate of fecundability.

Table 2: Observed and expected distributions of couples married for 15-19 years and 20-24 years by number of births

Number of births	**1975**		**1989**	
	Observed no. of couples	**Expected no. of couples**	**Observed no. of couples**	**Expected no. of couples**
	$h_1 = 1.10$	$h_2 = 2.16$	$h_1 = 1.00$	$h_2 = 1.85$
	$f_1 = 0.30$	$f_2 = 0.70$	$f_1 = 0.30$	$f_2 = 0.70$
	a = 0.98		**a = 0.978**	
A. Marital duration: 15-19 years				
0	16	17	47	47
1	15	13	58	46
2	49	52	134	149
3	84	102	256	263
4	135	130	375	345
5	145	162	372	393
6	159	145	301	321
7	89	74	190	172
8	46	44	88	82
9 +	38	37	35	40
10 +			29	27

Total	**776**	**776**	**1885**	**1885**
	$1_1 = 0.34$; $1_2 = 0.98$ $P_1 = 0.44$; $P_2 = 0.56$ $1 = 0.70$ Chi-square : 10.20; d.f. = 6		$1_1 = 0.30$; $1_2 = 0.81$ $P_1 = 0.43$; $P_2 = 0.57$ $1 = 0.59$ Chi-square : 12.89; d.f. = 6	
B. Marital duration : 20-24 years				
0	12	13	23	31
1	11	4	31	9
2	18	18	49	41
3	42	52	100	105
4	62	90	154	177
5	88	108	187	233
6	109	118	287	266
7	105	110	220	226
8	102	62	148	127
9	58	36	83	65
10	30	24	59	58
11 +	18	20	25	28
Total	**655**	**655**	**1366**	**1366**
	$1_1 = 0.33$; $1_2 = 0.82$ $P_1 = 0.50$; $P_2 = 0.50$ $1 = 0.57$ Chi-square : 58.32; d.f. = 7		$1_1 = 0.30$; $1_2 = 0.67$ $P_1 = 0.42$; $P_2 = 0.58$ $1 = 0.52$ Chi-square : 29.38; d.f. = 7	

It is evident from Table 3 that the proportion of women having low fecundability is around 45 per cent in both 1975 and in 1989, and, around 55 per cent of the women have high levels of fecundability. In 1975, fecundability ($l_1/12$) varied from 0.025 to 0.028 for different marital duration's among the first group of women with low fecundability, while in 1989 it varied from 0.025 to 0.031. The fecundability ($l_1/12$) ranged from 0.069 to 0.097 in 1975 and 0.056 to 0.072 in 1989 for the second, high fecundability group of women.

The average conception rates which were obtained as the weighted averages of '1_1', and 'l_2' for a given duration of marriage were estimated as 0.73, 0.80, 0.70 and 0.57 for marital duration's of 5-9, 10-14, 15-19 and 20-24 years respectively in 1975, while the average conception rates for corresponding marital duration's in 1989 were 0.64, 0.61, 0.59 and 0.52. Both in 1975 and in 1989, there was little difference between the average conception rates for marital duration's of 5-9, 10-14, and 15-19 years, though the rates were comparatively lower in the case of 20-24 years of marriage both in 1975 and 1989 than for other marital duration groups. This implies that the fecundability of the women remained almost constant up to 15-20 years of marriage and after that it began to decline substantially thereafter. Similar findings have been reported in the context of Indian data [32] [33] [34].

Low fecundability after 15-20 years of marital duration may be attributed to various factors such as the incidence of secondary sterility, a reduction in coital frequency due to several social customs and taboos, the presence of increased anovulatory cycles, and so on. One important social factor is the practice of permanent sexual abstinence arising from the attainment of the grandmother status. Since the age at first marriage is very low in Bangladesh, a large number of women become grandmothers by the time they reach their 35th year, that is, after 15 to 20 years of marriage. Mothers attaining their grandmother status usually feel embarrassed to 'compete' with their daughters (or daughters-in-law) and usually practice permanent sexual abstinence although they are still physiologically capable of reproduction. The grandmother status thus marks a cultural as opposed to a biological end of the reproductive period of the woman's life.

Although there is a small difference in fecundability between women married for 5-9 years, 10-14 years and 15-19 years, in 1989, fecundability was observed to decline with an increase in marital duration. However, in 1975 there was a reverse trend in that fecundability peaked at 10-14 years of marital duration and declined thereafter. The low average value of fecundability in the 5-9 year marital duration group in 1975 as compared to that of the 10-14 year group may be interpreted as the effect of adolescent sterility resulting from the lower age at marriage in 1975. In fact, in 1975 the age at marriage was lower (SMAM=1,630 years) than in 1989 (SMAM=18.00 years).

It is evident that the average fecundability for different marital periods in 1989 is consistently lower than that of 1975. The overall conception rate, which was estimated as the weighted average of all marital duration groups in a (excluding 20-24 years of marital duration) was observed to be 0.75 in 1975 which declined to 0.65 in 1989. Thus the overall fecundability in 1975 and 1989 was 0.06 and 0.05 respectively suggesting a declining trend in fecundability in Bangladesh over time. This decline may be mainly due to the increased use of contraceptives in 1989. In fact, the contraceptive prevalence rate was reported to be 7.7 per cent in the 1975 survey while it increased to 31 per cent during the 1989 survey.

Table 3: Estimates values of the average fecundability for different marital duration's

Marital duration (in years)	Fecundability	
	1975	1989
5 - 9	0.061	0.053
10 - 14	0.067	0.051
15 - 19	0.058	0.049

20 - 24	0.047	0.043
All	0.062	0.051

As compared to western countries where fecundability levels have been reported to range from 0.15 to 0.31, [2], [7], [35], [36] our estimates are much lower. Several Indian studies [21], [32] have also reported very low levels of fecundability including those in the range of 0.04 to 0.05 for North Indian women. The low fecundability of Bangladeshi women as compared to that of women in western countries may be due to a number of social, biological and cultural factors, as also the many sexual taboos. One of the factors is low age at marriage of girls (below 15 years) especially in rural areas. Utilizing the 1975 survey data, Rahman [37] reported mean female age at first marriage to be 12.3 years. The fecundability during the first few years of marriage could be lower due to adolescent sterility. This is also reflected in our analysis which shows that in 1975, the average fecundability during the first years of marriage (5-9 years) was lower than that between 10-14 years of marriage.

Many social customs and cultural practices also affect the exposure period of conception and may also contribute to the low average levels of fecundability. For example, according to one custom there is a cultural practice, young brides visit their parental home frequently during the early years of married life and stay there for quite long periods. Another custom requires a woman to go to her parental home for her first delivery and she often remains there for many months after the birth of her baby and thereby remains out of sexual contact with her husband. Moreover, marriages, which take place at very early ages are usually consummated at a future date. Another factor which may affect the fecundability of the rural women is sterility due to various diseases as also complications of repeated childbirth under unsanitary conditions.

The exposure period of conception is also affected by temporary spousal separation due to migration. Bangladesh is overwhelmingly a rural country and more than 85 per cent of the total population live in rural areas. It is one of the most densely populated countries in the world with a density of about 750 people per sq.km. As a result, almost half of the rural population comprises landless or marginal farmer households, [38] a large number of whom migrate to urban and other economically productive areas to earn their livelihood; leaving their families in the village home, only visiting them from time to time. Seasonal labor migration is also prevalent in rural areas; for example, during the rice harvesting season, agricultural laborers migrate from one area to another while fishermen live away from their wives for a long time to fish in major rivers during the fishing seasons. Ruzica and Bhatia [39] have reported that in rural Bangladesh (Matlab), around 25 per cent of the husbands frequently stay away from home and almost half of them for periods exceeding three months. A large number of married men also go to the oil-rich middle east countries leaving their families behind. All the above factors affect women's exposure to the risk of conception and are responsible for lowering fecundability.

Bangladesh is a poor country, and malnutrition and ill-health are largely prevalent particularly among women, and may also contribute to low fecundability though the fertility rate is rather high due to the low contraceptive use rate and/or lack of effective use of contraception, as also due to the higher desired family size.

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