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Fertility Situation in Bangladesh: Application of Revised Bongaarts Model

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Abstract In this paper we used Revised Bongaarts Model (RBM) for estimating approximately correct value of total fertility rate (TFR) for data obtained from 1975-2011, nationwide demographic surveys. The contribution of each of the proximate variables has been obtained through the decomposition of TFR for the period 1975-2011 at four points of time. Our analyses clearly indicate that contraceptive practice is playing the key role in fertility change in Bangladesh. The findings of the study provide a basis for drawing out some policy adoption and prescribe some recommendations for further decrease in TFR of Bangladesh.

Keywords Original Bongaarts Model (OBM), Revised Bongaarts Model (RBM), Fertility Situation, Miscarriage & Stillbirth, Contraception, Fetal Wastage

1. Introduction

Bangladesh is the most densely and is the 8th most populated country in the world. According to the results of the 2011 Population and Housing Census (PHC), the population of the country stood at about 14, 98, 00, 000 with a population density of 1,015 persons per square kilometer, which is the highest population density in the world (BBS, 2011). During the past century, the population of Bangladesh has increased exponentially. Between 2001 and 2011 censuses, about 19.8 million people were added to the population, which represents a 15% increase and a 1.37% annual growth rate.

Bangladesh has undergone a remarkable demographic change over the last 45 years. In 1971-1975, women in Bangladesh were having on average 6.3 children. The total fertility rate (TFR) declined to 5.1 children fifteen years later and to 4.2 children in 1989-1991. The TFR, plateau at around 3.3 per woman for most of the 1990s when the three earlier Bangladesh Demographic and Health Survey (BDHS) took place (BDHS, 1993/94, 1996/97, 1999/2000). The fertility rate has declined slightly to 3 children per woman (BDHS, 2004). Comparison of the TFR, with other Asian countries that have implemented a Demographic and Health Survey (DHS), indicates that, with a TFR of 3, Bangladesh is in the mid-range among the countries-below Nepal 4.1 in 2001, Cambodia 3.8 in 2000, and the Philippines 3.5 in 2003, but higher than India 2.8 in 1998-1999, Indonesia 2.6 in 2002-2003, and Vietnam 1.9 in 2002 (BDHS, 2007; Alene & Worku, 2008; Gurmu & Mace, 2008; Mekonnen & Worku, 2011).

The level of fertility in a society is directly influenced by a set of variables called intermediate variables or proximate determinants. The primary character of an intermediate fertility variable is its direct influence on fertility. Davis and Blake (1956) produced the first systematic classification of the proximate determinants of fertility through which economic, social and other factors must operate to control fertility.

Bongaarts (Bongaarts, 1978 and Mosley, 1978) revised the original classification and provide a simple analytical method accounting framework, which permits a quantitative assessment of the contribution of different proximate determinants to give fertility levels (Cain & Weininger, 1973; Heer & David, 1966; Defranzo, 1976; Bongaarts & Potter, 1983; Ijaiya et al., 2009). Bongaarts (1982) demonstrated that most of the variation in fertility was due to four intermediate variables which were marriage, contraception, induced abortion and lactational infecundability. If a proximate determinant such as contraceptive use changes, then fertility necessarily changes assuming the other proximate determinants remains constant (Kohli, 1977; Saleem & Pasha, 2008). As a result, fertility differences among population and changes in fertility over time can always be traced to variations in one or more of the proximate determinants (Saleem and Pasha, 2008; Jayaraman et al., 2008).

In Bangladesh, Islam et al. (1996) and some other researchers (Kabir & Rob, 1990; Islam & Islam, 1993; Abedin & Islam, 1994) showed contraception was the most important fertility inhibiting factor from 1971 to 2007,

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followed by lactational infecundability, marriage and induced abortion. To improve our clear understanding of the fertility change (Islam, 1996; Jayaraman et al., 2008; Mekonnen and Worku, 2011), we critically examine the effect of major proximate determinants: marriage, contraception, lactational infecundability on fertility and their changing effects. The fertility inhibiting effects of these proximate determinants have significant implications on reproductive health and future population growth (Spoorenberg, 2009).

This study attempts to identify the four intermediate variables namely proportion married among females, contraceptive use effectiveness, fetal wastage (including, induced abortion) and duration of lactational infecundability and investigates their impacts on change in the level of fertility. During this period decomposing Original Bongaarts Model (OBM) (Bongaarts, 1983) and RBM (Islam et al., 2014) assesses the individual contribution made by each of the four intermediate variables to change the fertility level. The study also examines how well these determinants predict fertility level in Bangladesh. This has been done by comparing observed total fertility rate as estimated by the model.

2. Sources of Data

Data have been derived from Bangladesh Fertility Surveys 1975, 1989 and Bangladesh Demographic and Health Surveys 1993-94, 1996-97, 1999-2000, 2004, 2007 and 2011. All these surveys are nationally representative and the data have provided by these surveys are of good quality.

3. Methodology

3.1. The Original Bongaarts Model

Bongaarts model of estimating the effect of four proximate determinants assumes that the natural reproductive capacity that is total fecundity rates (TF) is nearly the same for all women, but their actual reproductive performance is modified by four major proximate determinants. In his model, Bongaarts (1978) expressed TFR is the product of four indices measuring the fertility inhibiting effect of these four indices and the TF is the average number of live births expected among women who during their entire reproductive period, remain married, do not use contraception, do not have any induced abortion and do not breastfeed their children (Bongaarts, 1982). According to Bongaarts model, the TFR can be written as

$$TFR = C_m \times C_c \times C_a \times C_i \times TF \quad (1)$$

Where, C_m is the index of proportion married, C_c is the index of non-contraception, C_a is the index of induced abortion, C_i is the index of lactational infecundability and TF is the total fecundity.

3.2. Revised Bongaarts Model (RBM)

In original Bongaarts model, it is replaced only the index "all fetal wastage" (combination of miscarriage, abortion and stillbirth) instead of the index "induced abortion" which was one of the proximate determinants of fertility. Other indices have remained same as proposed by Bongaarts original model. Revised Bongaarts model (Islam et al., 2014) is

$$TFR = C_m \times C_c \times C_{fw} \times C_i \times TF \quad (2)$$

Where, the index of fetal wastage (C_{fw}) is defined as the ratio of the observed TFR to the estimated TFR with all fetal wastage which is (TFR+AFW), that is

$$C_{fw} = \frac{TFR}{(TFR + AFW)} \quad (3)$$

Where AFW equals the average number of birth averted per woman by the end of the reproductive years for all fetal wastage and which is estimated by

$$AFW = 0.4 \times (1 + u) \times TFW \quad (4)$$

Where, TFW is the total fetal wastage rate and AFW is the average number of all fetal wastage per woman at the end of the reproductive years.

3.3. Total Fertility Inhibiting Effect Accounted for Proximate Determinants

The difference between the TF, taken as 15.3 in 2011 BDHS and the estimated TFR is attributed the result of the inhibitory effect of each variable. The total inhibiting effect is prorated by the proportion of the logarithm of each index to the sum of logarithm of all indices (Wang, 1987).

Effect of marriage =

$$\frac{[TF - TFR(estimated)] \times \log_e C_m}{\log_e C_m + \log_e C_c + \log_e C_i + \log_e C_{fw}}$$

Effect of Contraception =

$$\frac{[TF - TFR(estimated)] \times \log_e C_c}{\log_e C_m + \log_e C_c + \log_e C_i + \log_e C_{fw}}$$

Effect of Postpartum Infecundability =

$$\frac{[TF - TFR(estimated)] \times \log_e C_i}{\log_e C_m + \log_e C_c + \log_e C_i + \log_e C_{fw}}$$

Effect of fetal wastage =

$$\frac{[TF - TFR(estimated)] \times \log_e C_{fw}}{\log_e C_m + \log_e C_c + \log_e C_i + \log_e C_{fw}}$$

Here, TFR (estimated) = $C_m \times C_c \times C_i \times C_{fw} \times 15.30$ (5)

3.4. Decomposition of the Changes in Fertility

Revised Bongaarts model (RBM) given by the equation (2) of 3.2 can easily be turned to a decomposition equation that allows the quantification of the contribution made by each of

the four intermediate fertility variables to an observed change in fertility between two time points t_1 and t_2 the basic equation is as follows

$$\frac{TFR(t_2)}{TFR(t_1)} = \frac{C_m(t_2)}{C_m(t_1)} \times \frac{C_c(t_2)}{C_c(t_1)} \times \frac{C_{fw}(t_2)}{C_{fw}(t_1)} \times \frac{C_i(t_2)}{C_i(t_1)} \times \frac{TF(t_2)}{TF(t_1)} \quad (6)$$

If the two points of times are 1975 and 2011, using equation (6) for two times 1975 and 2011, we can show that:

$$\frac{TFR(2011)}{TFR(1975)} = \frac{C_m(2011)}{C_m(1975)} \times \frac{C_c(2011)}{C_c(1975)} \times \frac{C_{fw}(2011)}{C_{fw}(1975)} \times \frac{C_i(2011)}{C_i(1975)} \times \frac{TF(2011)}{TF(1975)} \quad (7)$$

Again,

$P_f = \frac{TFR(2011)}{TFR(1975)} - 1$ = Proportional change in TFR between 1975 and 2011.

$P_m = \frac{C_m(2011)}{C_m(1975)} - 1$= Proportional change in TFR due to a change in the index of marriage.

$P_c = \frac{C_c(2011)}{C_c(1975)} - 1$= Proportional change in TFR due to a change in the index of contraception.

$P_{fw} = \frac{C_{fw}(2011)}{C_{fw}(1975)} - 1$= Proportional change in TFR due to a change in the index of fetal wastage.

$P_i = \frac{C_i(2011)}{C_i(1975)} - 1$= Proportional change in TFR due to a change in the lactational infecundability.

$P_r = \frac{TF(2011)}{TF(1975)} - 1$= Proportional change in TFR due to a change in the remaining proximate determinants: natural fecundability, spontaneous intrauterine mortality and permanent sterility.

Equation (1) can be rearranged as

$$P_f = P_m + P_c + P_{fw} + P_i + P_r + I \quad (8)$$

Where, 'I' represent an interaction factor. This equation simply states that a given proportional change in the TFR between 1975 and 2011 equal to the sum of the proportional fertility changes due to the different intermediate fertility variables plus an interaction term. It is simply estimated by substituting the sum of P_m, P_c, P_{fw}, P_i and P_r from P_f. Equation (8) can now easily be turned into a decomposition equation for the absolute decline in TFR (2011) viz. TFR (2011) - TFR (1975) multiplying TFR (1975).

4. Results and Discussion

On the basis of OBM given in equation (1) and RBM in equation (2), the estimated values of the measures and indices for different time points are presented in Table 1. The complement of the indices represents the proportionate reduction in fertility attributed to the fertility determinant. The lower the estimated value of the indices, the larger the fertility reduction effect. Thus, we have found the value of C_m in 1975 was 0.859, indicating that the proportion of married women reduces fertility by 14.1%, while the value of C_m in 1989 was 0.785, in 1996-1997 was 0.781, in 19999-2000 was 0.776, in 2004 was 0.731, in 2007 was 0.7474 and in 2011 was 0.8142 indicating that the proportion of women married were reduces fertility by 21.5%, 21.9%, 22.34%, 26.9%, 25.26% and 18.58% respectively. The value of C_c in 1975 was 0.932 indicating that the index of contraception reduces fertility by 6.8%, while the value of C_c in 1989 was 0.718, in 1996-1997 was 0.548, in 1999-2000 was 0.5294, in 2004 was 0.4537, in 2007 was 0.4757 and in 2011 was 0.425 indicating that the index of contraception reduces fertility were by 28.20%, 45.2%, 47.06%, 54.61%, 52.43% and 57.5% respectively.

Table 1. Estimates of different indices of fertility, Bangladesh 1975-2011

Year and sources / Measures and indices	1975 BFS	1989 BFS	1993-'94 BDHS	1996-'97 BDHS	1999/2000 BDHS	2004 BDHS	2007 BDHS	2011 BDHS
TFR(obs.)	6.329	4.895	3.440	3.265	3.310	3.0	2.705	2.30
TF (assumed)	15.087	15.30	15.30	15.30	15.30	15.30	15.30	15.30
C_m	0.859	0.785	0.756	0.781	0.7766	0.732	0.7474	0.814
C_c	0.932	0.718	0.573	0.548	0.5294	0.4539	0.4757	0.4250
C_i	0.524	0.66	0.66	0.571	0.593	0.735	0.616	0.6689
C_a	1.000	0.983	0.976	0.967	0.950	0.925	0.910	0.881
C_{fw}	NA	0.850	0.844	0.840	0.857	0.834	0.835	0.842
TFR (OBM); (esti.)	6.594	5.595	4.269	3.615	3.544	3.456	3.05	3.12
TFR (RBM); (esti.)	NA	4.837	3.692	3.141	3.197	3.116	2.797	2.981

Note- (NA: Not available); TFR (obs.): Total fertility rate (observed), C_m: Index of proportion married, C_c: Index of non-contraception, C_a: Index of induced abortion, C_{fw}: Index of fetal wastage, C_i: Index of lactational infecundability

Sources: BFS 1975, 1989; BDHS 1993-1994, 1996-1997, 1999-2000, 2004, 2007, 2011. Other than observed and assumed values indicate author's calculation based on the above sources.

The impact of contraception on reducing fertility varies from one time point to other, because of increase in use effectiveness of methods. In recent years, the use of contraception increased and as a result the average fertility reducing impact on contraception also increased. It is clear from Table 1 that there are downward trend in C_m and C_c, and C_i which indicate the reduction of fertility.

Again, the index lactational amenorrhea C_i in 2011 was 0.6689. It indicates that the average estimated effect was stronger for the reduction in fertility 33.11%, compared with the value of the index C_i in 2004 was 0.7432 which indicates that the average estimated effect is strong for the reduction in fertility 25.68%. And the value of C_i in 2007 was 0.6161 indicates that the average estimated effect is stronger for the reduction in fertility 38.39% during the last decade. The results presented in Table 1 recommend that fetal wastage is also playing a positive role in fertility reduction from 1989 to 2011. In the last twenty three years, it reduces about 16% fertility, which confirms the increase of fetal death in Bangladesh.

Table 2 exhibits the trend for each proximate variable of fertility for the period 1975-2011. The results indicate that a total of 8.493 births in 1975 being inhibited: 1.487 births were due to effect of marriage variable; 0.685 was due to contraception and 6.321 were due to postpartum infecundability. A total of 12.319 births in 2011 being inhibited; 1.55 births were due to effect of marriage variable; 6.445 births were due to contraception; 3.029 births were due to postpartum infecundability and 1.295 birth was due to fetal death.

Table 2 depicts that the contribution of marriage in reducing fertility were increased to 2.389 births per woman in 2004 to decreased 0.839 birth per woman in 2011, from a level of 1.487 births per woman in 1975. Also, the effect of contraceptive use increased to 6.048 births per woman in 2004 and increased to 6.445 births per woman in 2011, from a level of 0.685 births per woman in 1975. Oppositely, the effect of postpartum infecundability decreased during three and a half decades but perfectly we could not draw any clear conclusion about lactational infecundability during these periods. Same directional results we had found between two period 2007 and 2011, except the effect of fetal death.

Table 3 suggests that, a total 100% births had constrained in the period 1975 due to four major proximate determinants. Marriage pattern inhibited 17.509% births, contraception 8.065%, and lactational infecundability 74.426% births. Similarly, in 2011, a total of 100% births: marriage pattern, contraception, lactational infecundability and fetal wastage inhibited 12.582%, 52.318%, 24.588% and 10.512% births respectively.

The analyses suggest that lactational infecundability had played a significant role in reducing fertility before the period 2004. From 1991, family planning methods occupied its sovereignty and had emerged as a key factor of fertility change in Bangladesh. The results also indicate that, due to successive reduction of postpartum amenorrhea, the fertility reducing effect of lactational infecundability were constantly decreasing, it is hopeful that the value of lactational infecundability increased in 2007, and after 2007 it was decreased 4% in 2011. The effect of marriage pattern was almost constant meanwhile fetal wastage showing better performance (it should be discourage culturally, because it might break down family formation and is harmful for women's ovultory function) in reducing fertility.

Table 2. Trends in total fertility inhibiting effect for proximate variables, 1975-2011

Proximate Variables	Fertility Inhibiting Effect & Births per woman							
	BFS 1975	BFS 1989	BDHS 1993/'94	BDHS 1996-'97	BDHS 1999-2000	BDHS 2004	BDHS 2007	BDHS 2011
Marriage	1.487	1.877	2.284	1.798	1.931	2.389	2.143	1.550
Contraception	0.685	2.597	4.547	4.375	4.859	6.048	5.467	6.445
Postpartum Infecundability	6.321	3.257	3.393	5.013	5.295	2.357	3.566	3.029
Fetal wastage	0.0	1.274	1.385	1.268	1.179	1.390	1.327	1.295
[TF-TFR(esti.)]	8.493	9.005	11.608	12.454	13.264	12.184	12.503	12.319

Source: calculation based on Table 1

Table 3. Percentage in total fertility inhibiting effect for proximate variables, 1975-2011

Proximate Variables	Percentage distribution of Fertility Inhibiting Effect							
	BFS 1975	BFS 1989	BDHS 1993/'94	BDHS 1996-1997	BDHS 1999-2000	BDHS 2004	BDHS 2007	BDHS 2011
Marriage	17.509	20.844	19.676	14.437	14.558	19.608	17.140	12.582
Contraception	8.065	28.840	39.171	35.129	36.633	49.639	43.726	52.318
Postpartum Infecundability	74.426	36.169	29.230	40.252	39.920	19.345	28.521	24.588
Fetal wastage	0.0	14.148	11.931	10.181	8.889	11.408	10.613	10.512
[TF-TFR (esti.)]	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0

Source: calculation based on Table 2

Table 4. Decomposition of changes in TFR in Bangladesh: 1975 to 2011

Changing Indices	Percentage change in TFR				Distribution of percentage change in TFR				Absolute change in TFR			
	1975 to 1989	1989 to 2000	2000 to 2011	1975 to 2011	1975 to 1989	1989 to 2000	2000 to 2011	1975 to 2011	1975 to 1989	1989 to 2000	2000 to 2011	1975 to 2011
P_m	-8.60	-1.10	4.90	-5.22	-38.05	-3.40	16.07	-8.18	-0.544	-0.054	0.162	-0.33
P_c	-23.0	-26.90	-19.70	-54.40	-101.77	-83.03	-64.59	-85.23	-1.455	-1.312	-0.652	-3.44
P_i	26.0	-23.4	33.80	27.65	115.04	-74.70	110.82	43.32	1.645	-1.18	1.119	1.75
P_{fw}	NA	-0.80	-1.80	-11.90	NA	2.5	-5.902	-18.64	NA	0.04	-0.06	-0.75
P_r	-12.50	22.0	-5.0	1.41	-55.31	67.901	-16.40	2.21	-0.791	1.073	-0.166	0.09
I	-4.50	-3.0	-42.7	-21.37	-19.91	-9.26	-140.0	-33.50	-0.285	-0.146	-1.414	-1.35
P_f	-22.60	-32.40	-30.5	-63.83	-100	-100	-100	-100	-1.43	-1.58	-1.01	-4.03

Source: calculation based on Table 1 and using equation (8).

Table 4 represents the decomposition of change of all indices in TFR among 1975 - 1989; 1989 - 2000 and 2000-2011. It indicates that TFR had declined about 22.6% or absolutely 1.43 births from 6.329 births in 1975 to 4.895 births in 1989; 32.4% or absolutely 1.58 births from 4.895 births in 1989 to 3.31 births in 2000 and 30.5% or absolutely 1.01 births from 3.31 births in 2000 to 2.3 births in 2011.

It also indicates that the decomposition of this decline in TFR between 1975 to 1989 had nearly 8.6% decline due to increase in the proportion of women married, about 23% decline due to an increase in contraceptive use and effectiveness but a dramatically change about approximately 26% increase due to decrease the duration of lactational infecundability. The remaining proximate determinants together contribute about 12.5% increases and by interaction factor decrease 4.5% in TFR. Again, the decomposition of this decline in TFR between 1989-2000 had 1.1% decline due to increase in the proportion of women married, about 27% decline due to an increase in contraceptive use and effectiveness, a change about 23.4% decline due to increase of the duration of lactational infecundability, about 1% decline due to increase use of fetal wastage . The remaining proximate determinants together contribute about 22% increases and by interaction factors decreases 3% in TFR.

Furthermore, Table 4 indicates that during 1975 to 1989, it had declined by 1.43 births per woman of which 0.54 birth declined by proportion married, 1.45 births declined due to contraceptive use, 1.6 births increased due to decreased of lactational infecundability, remaining proximate determinants together decline 0.8 birth and the interaction factor had decreased 0.3 birth per woman. During 2000 to 2011, it had declined by 1.01 births per woman of which 0.16 birth had increased by proportion married, 0.65 birth had declined due to contraceptive use, 1.12 births increased due to lactational infecundability which indicate that a negative change due to lactation within 11 years period, i.e., women reduce to lactate their children recently, it negatively affect to reduce fertility; 0.06 birth decreased by increase use of fetal wastage, 0. 2 birth decreased by other proximate determinants is negligible and 1.41 births declined by the interaction factor. During 1975 to 2011, it had declined by 4.03 births per woman of which 0.33 birth had declined by proportion married, 3.44 births declined due to contraceptive use, 1.75 births increased due to lactational infecundability which indicate that a negative change due to lactation within 37 years period; that is women reduce to lactate their children recently, it negatively affect to reduce fertility; 0.75 birth decreased by increase use of fetal wastage, 0.09 births increased by other proximate determinants, which is negligible; and 1.35 births declined by the interaction factor.

5. Conclusions

Revised Bongaarts model (RBM) indicates that between 1989 and 1999-2000, the amount of decrement of TFR was about 34% and it was about 36% between 1989 and 2004, the amount of decrement of TFR was only 3% between 2000 and 2004; the amount of decrement of TFR was 42% between 1989 and 2007, the amount of decrement of TFR was 10% between 2004 and 2007; the amount of decrement of TFR was 4.3% between 2004 and 2011; but the amount of increment of TFR was 6.6% between 2007 and 2011; the amount of decrement of TFR was 38.4% between 1989 and 2011. These were primarily caused by an increase in the use and effectiveness of the contraceptive methods.

Thus to achieve the replacement level of fertility in Bangladesh the policy implications can be drawn as follows:

- Awareness should be made-up to increase the use of modern contraceptive methods, which have better use-effectiveness.
- Make certain available information regarding bad effect of teenage pregnancy through different electronic and print media.
- Provide information among couples, low costing and greater benefit for the mother and the child for a long term exclusive breastfeeding.

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