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# Estimation of Total Fertility Rate by using Stopping Behavior of Females

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***Abstract:*** **The peculiarity of parity-specific fertility decisions plays an important role in determining the family size. Couples control their family size by keeping the desirable number of children in mind. When women quit having children at younger ages, overall fertility begins to decline. As a result, information on stopping behavior of females is regarded critical in the assessment of fertility. In the present study, authors have analyzed stopping behavior of females for 1991 & 2014 and proposed two predictors based on stopping behavior of females for the estimation of total fertility rate. For the analysis, the datasets of National Family Health Survey i.e. NFHS-I and NFHS-IV have been used. Both the proposed predictors provide reasonably good estimates of total fertility rate.**

***Index Terms:*** **Parity, PPR, TFR, stopping behavior, indirect estimation.**

## I. INTRODUCTION

Population increase is the greatest threat to any nation's growth, and population stabilization is a must for fostering sustainable growth with more redistribution of resources. Many studies have acknowledged various determining and regulatory factors of fertility (Davis and Blake, 1956; Bongaarts, 1978; 1982; Bongaarts and Potter, 1983) however the most significant aspect of fertility is that it is far more a matter of personal preference. It is well established that Total Fertility Rate (TFR) is the widely used measure of fertility for evaluating the impact of policy interventions. However, it does not expose the proportion of females in the population who will ever proceed to the next birth after having a specified number of children. The understanding of these proportions is significant to a population's total fertility performance, particularly in emerging countries like India.

Fertility is basically based on the choice of family size determined individually by females or couples. The more they would like to extend their family size, the more fertility rate will increase. As a result, when fertility begins to decline, it is likely that the main changes are due to parity-specific shifts, which happened as a consequence of a decline in higher-order births. This information is utilized as determining instruments for the level of family controlling behavior in the population. Hence, it obviously becomes necessary in the fertility analysis to estimate the proportions of females according to their family size. Its knowledge can also be used to distinguish communities based on their fertility levels. The parity-wise analysis is significant in understanding trends and disparities in fertility with implication of population growth. Therefore, it can be said that the proportions of females who stopped childbearing after attaining a specific family size or parity would be used as fruitful predictors in the estimation of total fertility rate. In this paper, authors have tried to analyze the parity specific stopping behavior among females of India in 1991 & 2014. However, most of the developing nations' vital registration systems are not good in coverage and quality. Moreover, any survey data from these countries, however, carefully planned and executed, are subject to huge errors of exclusion of event, errors in the identification of the appropriate time period in which the events have occurred, and serious errors in the reporting of the age of the mothers like recall lapse, heaping etc. So it is required to develop, if possible, some indirect techniques for its computation wherein such detailed data may not be required and may also be so designed to possess certain desirable qualities like easy data requirements, computational case and accuracy of results.

There exist a large number of indirect techniques for the estimation of Total Fertility Rate using exploratory variables. For the indirect estimation of TFR, Brass (1968) suggested a P/F ratio method for estimating fertility and its advancement has been studied Hobcraft et al. (1982). After that Cho et al. (1986) have suggested own-child method which contains reverse survival technique (15 years) for estimating age specific fertility rate (ASFR) from cross-sectional survey. Furthermore Rele (1967) has used stable population method for estimating TFRs.

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**Table I. Percentage Distribution of Females according to their Parity Specific Birth Stopping Behavior in 1991**

| State | Achieved Parity before Stopping Childbearing* | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | 0 | 1 | 2 | 3 | 4 | 5 | 6 | 7 |
| India | 0.4 | 6.6 | 23.1 | 25.0 | 17.3 | 11.4 | 7.3 | 8.4 |
| Andhra Pradesh | 0.0 | 6.2 | 22.0 | 29.6 | 19.0 | 5.9 | 4.8 | 2.3 |
| Bihar | 0.3 | 6.4 | 12.3 | 20.5 | 13.9 | 15.8 | 15.8 | 12.7 |
| Gujarat | 0.8 | 5.2 | 26.5 | 33.1 | 15.1 | 10.3 | 5.9 | 3.1 |
| Haryana | 1.3 | 2.3 | 21.8 | 24.6 | 22.1 | 13.6 | 9.6 | 4.7 |
| Karnataka | 0.0 | 6.0 | 26.4 | 34.8 | 12.3 | 7.9 | 4.9 | 4.4 |
| Kerala | 0.8 | 7.2 | 50.5 | 32.8 | 4.5 | 2.4 | 0.9 | 1.0 |
| Maharashtra | 0.2 | 5.7 | 25.8 | 26.1 | 21.8 | 11.5 | 3.2 | 2.2 |
| Madhya Pradesh | 0.0 | 3.6 | 11.8 | 20.0 | 14.5 | 13.6 | 7.7 | 18.4 |
| Odisha | 0.7 | 10.7 | 24.2 | 22.4 | 22.2 | 10.5 | 6.0 | 3.3 |
| Punjab | 2.5 | 4.4 | 28.6 | 27.4 | 21.1 | 9.1 | 3.6 | 3.3 |
| Rajasthan | 2.1 | 8.2 | 21.9 | 19.4 | 16.8 | 12.8 | 9.0 | 8.0 |
| Tamil Nadu | 0.1 | 10.7 | 34.5 | 29.4 | 14.6 | 8.3 | 1.9 | 0.5 |
| Uttar Pradesh | 0.0 | 2.0 | 10.3 | 14.5 | 14.9 | 14.6 | 13.0 | 27.7 |
| West Bengal | 0.0 | 8.7 | 22.7 | 23.4 | 9.1 | 11.4 | 6.4 | 6.4 |

*The estimated values 0.0 are not actually zero. These values are nearer to zero.

With the use of Sample Registration System some modification has been done by Swamy et al. (1992). To overcome the difficulties present in the above mentioned methods some regression technique has been used indirect estimation of TFR. Coale and Demeny (1967) have developed a formula i.e. $TFR=P_3^2/P_2$ to estimate TFR, where $P_2$ and $P_3$ represent mean births to females of age group (20-24) and (25-29) and further it was modified by Yadava and Tiwari (2007) by taking $P_3^2/P_2$ and percentage of current contraceptive users jointly as predictors. Another modification has been done by Gupta et al. (2014) considering situation of current time point and estimated TFR has been obtained by $P_4^2/P_3$ as a predictor variable, where $P_3$ and $P_4$ are mean births to females of age groups (25-29) and (30-34), respectively. Yadava and Kumar (2002) have estimated TFR using percentage of currently married women having open birth interval greater than equal to 60 months. Further, Yadava et al. (2009) proposed another predictor which is the weighted average of proportions of different birth orders and estimated the TFR. Jain (1997) has used Contraceptive Prevalence Rate (CPR) to estimate total fertility rate of any population. Mauldin and Ross (1991) and Jain (1997) have used CPR and sterility as a predictor variable to predict TFR of any population. Using information on the child stopping behavior of females, authors have also proposed predictors for estimation of Total Fertility Rate.

## II. Data and Methodology

In the present study, true and synthetic parity cohort approaches are being used for the estimation of Period Parity Progression Ratios (PPPRs) i.e. $P_B$, $P_M$, $P_1$, $P_2$ and so on as described in (Bhrolchain, 1987; Feeney and Yu, 1987; Hinde, 1998; Sweeney, 2013). However, the methodology requires a large number of dataset which provides information on birth history of women. Hence, the authors have used National Family Health Survey (NFHS-I & NFHS-IV) datasets for analysis.

### *A. Estimation of Stopping Behavior of Females*

The stopping behavior of the females (Tiwari and Mishra, 2021) can be studied by the estimated set of PPPRs as:

**$(1 - P_B)$** → Proportion of females who never marry (females with age at marriage > 35 years are considered as never married)

**$P_B * (1 - P_M)$** → Proportion of females who marry but never had children,

**$P_B * P_M * (1 - P_1)$** → Proportion of females who marry and stop at one child,

**$P_B * P_M * P_1 * (1 - P_2)$** → Proportion of females who have one child and stop at second child,

**$P_B * P_M * P_1 * P_2 * (1 - P_3)$** → Proportion of females who have two children and stop at third child,

**$P_B * P_M * P_1 * P_2 * P_3 * (1 - P_4)$** → Proportion of females who have three children and stop at fourth child, and so on.

**Table II. Percentage Distribution of Females according to their Parity Specific Birth Stopping Behavior in 2014**

| State | Achieved Parity before Stopping Childbearing* | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | 0 | 1 | 2 | 3 | 4 | 5 | 6 | 7 |
| India | 4.5 | 12.4 | 36.7 | 27.1 | 6.8 | 3.0 | 1.3 | 1.0 |
| Andhra Pradesh | 3.0 | 9.8 | 57.5 | 21.2 | 0.9 | 0.4 | 0.0 | 0.0 |
| Bihar | 2.0 | 3.9 | 18.6 | 25.1 | 24.3 | 13.2 | 5.8 | 6.0 |
| Gujarat | 9.5 | 13.5 | 38.8 | 20.1 | 4.1 | 1.2 | 0.7 | 0.2 |
| Haryana | 1.7 | 17.9 | 44.8 | 28.4 | 3.2 | 1.6 | 0.8 | 0.7 |
| Karnataka | 5.3 | 11.0 | 43.5 | 23.8 | 2.2 | 0.6 | 0.3 | 0.0 |
| Kerala | 6.2 | 28.9 | 49.0 | 11.5 | 0.4 | 0.1 | 0.0 | 0.0 |
| Maharashtra | 5.9 | 10.8 | 48.3 | 26.4 | 2.5 | 1.4 | 0.3 | 0.0 |
| Madhya Pradesh | 3.7 | 6.3 | 40.8 | 21.0 | 12.1 | 5.4 | 2.5 | 1.4 |
| Odisha | 3.5 | 16.1 | 38.5 | 24.8 | 5.0 | 2.2 | 0.6 | 0.2 |
| Punjab | 2.1 | 26.7 | 47.0 | 17.9 | 2.5 | 0.4 | 0.2 | 0.0 |
| Rajasthan | 3.8 | 7.2 | 39.1 | 30.8 | 7.0 | 3.6 | 1.3 | 1.5 |
| Tamil Nadu | 5.8 | 15.0 | 65.4 | 9.1 | 0.2 | 0.0 | 0.0 | 0.0 |
| Uttar Pradesh | 3.9 | 8.4 | 25.3 | 28.2 | 14.5 | 8.1 | 4.6 | 3.7 |
| West Bengal | 3.1 | 24.6 | 46.0 | 19.9 | 1.9 | 0.7 | 0.2 | 0.0 |
| Telangana | 3.0 | 8.4 | 49.9 | 24.0 | 1.5 | 0.3 | 0.0 | 0.0 |
| Uttarakhand | 3.8 | 6.4 | 44.8 | 30.1 | 5.4 | 2.1 | 1.5 | 0.7 |
| Chhattisgarh | 9.4 | 11.0 | 36.8 | 26.6 | 7.7 | 1.5 | 0.6 | 0.4 |
| Jharkhand | 4.6 | 10.6 | 26.3 | 28.6 | 14.4 | 5.2 | 1.6 | 1.3 |

*The estimated values 0.0 are not actually zero. These values are nearer to zero.

*B. Proposed Predictors*

Based on the child stopping behavior data of females, two predictors are proposed for the estimation of total fertility rate, which are:

**First Predictor ($PR_1$)** → Cumulative proportion of females who have stopped childbearing after achieving parity up to three, i.e. proportion of females who have restricted their family size up to three children.

**Second Predictor ($PR_2$)** → Weighted mean of proportions of females who stopped childbearing after achieving specific parity by using current parity as weights.

The second predictor weighted mean $M_t$ for a given year $t$ is calculated by the given formula:

$$M_t = \frac{\left[\sum_{i=0}^{j} iF_i + kF_k\right]}{100} \qquad (1)$$

where, $i(i = 0, \dots, j)$ denotes the specified parity after which the females stopped childbearing, $k$ denotes the open-ended parity group (for 7+ births, assumed as $k$ = 8), $F_i$ and $F_k$ are the proportions of females who are presently at parity $i$ and $k$ respectively and are exposed to proceed for next parity.

**Table III. Changes in Birth Stopping Behavior of Females from 1991 to 2014**

| State | Achieved Parity before Stopping Childbearing | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | 0 | 1 | 2 | 3 | 4 | 5 | 6 | 7 |
| India | 4.2 | 5.8 | 13.7 | 2.1 | -10.5 | -8.4 | -5.9 | -7.3 |
| Andhra Pradesh | 3.0 | 3.6 | 35.6 | -8.5 | -18.1 | -5.4 | -4.8 | -2.3 |
| Bihar | 1.7 | -2.5 | 6.3 | 4.6 | 10.4 | -2.6 | -10.1 | -6.7 |
| Gujarat | 8.7 | 8.3 | 12.3 | -13.0 | -11.0 | -9.1 | -5.2 | -2.9 |
| Haryana | 0.4 | 15.5 | 23.0 | 3.8 | -18.9 | -12.0 | -8.8 | -4.0 |
| Karnataka | 5.3 | 5.0 | 17.1 | -11.0 | -10.1 | -7.3 | -4.6 | -4.4 |
| Kerala | 5.4 | 21.7 | -1.4 | -21.3 | -4.1 | -2.3 | -0.9 | -1.0 |
| Maharashtra | 5.7 | 5.1 | 22.5 | 0.3 | -19.3 | -10.0 | -2.9 | -2.2 |
| Madhya Pradesh | 3.7 | 2.6 | 29.0 | 1.0 | -2.4 | -8.2 | -5.2 | -16.9 |
| Odisha | 2.8 | 5.4 | 14.3 | 2.4 | -17.2 | -8.3 | -5.4 | -3.1 |
| Punjab | -0.4 | 22.2 | 18.4 | -9.5 | -18.5 | -8.7 | -3.5 | -3.3 |
| Rajasthan | 1.7 | -0.9 | 17.3 | 11.5 | -9.9 | -9.2 | -7.7 | -6.5 |
| Tamil Nadu | 5.6 | 4.3 | 30.8 | -20.2 | -14.4 | -8.2 | -1.9 | -0.5 |
| Uttar Pradesh | 3.8 | 6.4 | 15.0 | 13.7 | -0.5 | -6.5 | -8.4 | -24.0 |
| West Bengal | 3.1 | 15.9 | 23.3 | -3.6 | -7.1 | -10.6 | -6.2 | -6.4 |

*C. Estimation of Total Fertility Rate*

The estimation of TFR is based on the regression line technique. By using this technique, a relationship has been established between the observed TFR (taken as dependent variable Y) and proposed predictor variable $X$. The observed values of TFR ($Y$) for India and its major states have been taken from NFHS-I India report (1992-93) and NFHS-IV India report (2015-16) for the year 1991 and 2014 respectively.

**By using Predictor PR1**

For the year 1991, the obtained regression equation is:

$Y = 6.0528 - 0.0475*X$ (2) or,

TFR = 6.0528 – 0.0475*(cum. prop. of females having at most 3 children) with $R^2 = 0.93$

For the year 2014, the obtained regression equation is:

$Y = 5.2061 - 0.0348*X$ (3) or,

TFR = 5.2061 – 0.0348*(cum. prop. of females having at most 3 children) with $R^2 = 0.94$

**By using Predictor $PR_2$**

For the year 1991, the obtained regression equation is:

$Y = 1.0859 - 0.2317*X$ (4) or,

TFR = 1.0859 – 0.2317*(parity-wise weighted mean of prop. of females) with $R^2 = 0.93$

For the year 2014, the obtained regression equation is:

$Y = 1.0195 - 0.2498*X$ (5) or,

TFR = 1.0195 – 0.2498*(parity-wise weighted mean of prop. of females) with $R^2 = 0.95$.

**Table IV. Estimated Total Fertility Rate using the Proposed Predictors for Major States (1991)**

| State | Obs. TFR | Estimated TFR from | | % difference from Observed TFR | |
|---|---|---|---|---|---|
| | | Birth Control (3)* | Weighted Mean# | Birth Control (3)* | Weighted Mean# |
| India | 3.39 | 3.41 | 3.38 | 0.51 | -0.23 |
| Andhra Pradesh | 2.59 | 2.82 | 2.72 | 8.18 | 4.63 |
| Bihar | 4.00 | 4.07 | 4.09 | 1.69 | 2.16 |
| Gujarat | 2.99 | 2.94 | 2.97 | -1.74 | -0.74 |
| Haryana | 3.99 | 3.67 | 3.38 | -8.60 | -17.95 |
| Karnataka | 2.85 | 2.71 | 2.88 | -5.23 | 1.16 |
| Kerala | 2.00 | 1.72 | 2.22 | -16.06 | 9.79 |
| Maharashtra | 2.86 | 3.14 | 2.86 | 8.91 | -0.10 |
| Madhya Pradesh | 3.90 | 3.88 | 4.04 | -0.64 | 3.47 |
| Odisha | 2.92 | 3.30 | 3.00 | 11.47 | 2.62 |
| Punjab | 2.92 | 3.07 | 2.87 | 4.76 | -1.68 |
| Rajasthan | 3.63 | 3.51 | 3.38 | -3.28 | -7.36 |
| Tamil Nadu | 2.48 | 2.50 | 2.51 | 0.92 | 1.15 |
| Uttar Pradesh | 4.82 | 4.64 | 4.97 | -3.92 | 3.11 |
| West Bengal | 2.92 | 2.88 | 2.99 | -1.29 | 2.34 |

* denotes predictor $PR_1$ as cumulative proportion of females who have stopped childbearing after achieving parity up to three.

\# denotes the predictor $PR_2$ as weighted mean of proportions of females who stopped childbearing after achieving specific parity

## III. Results and Discussion

If the proportions of females at each parity are known, the parity specific stopping behavior among females can be easily calculated. The state-wise percentage distribution of the females who stopped childbearing after achieving a specific number of parity is given in Table I for the year 1991 and in Table 2 for the year 2014. At India level, around 85 percent females are stopping their childbearing after attaining fifth parity in 1991 while more than 85 percent females have stopped childbearing after third birth in 2014. From Table I, it is observed that a large proportion of females proceed up to fifth parity before stopping childbearing in most of the states except Southern states and Punjab. Most of the females of populated states like Uttar Pradesh and Bihar proceed up to six parity before birth stopping. Table II shows that around 12 percent females of Bihar proceed further after parity five, which is the highest among all the states. Telangana, Tamil Nadu, Kerala, and Andhra Pradesh perform better in shifting the birth stopping behavior to lower parities. A significant amount of females have started limiting the childbearing after two births in almost all states in 2014. There is a trend common among all the states that most of the family size varies between 2 to 5 children in 1991, while in 2014 the family size reduced and varies between 1 to 3 children mostly.

Table III shows the differences in parity specific birth stopping behavior of females between 1991 and 2014. The most interesting finding of this table is that the proportion of never married females has been increased in most of the states except Andhra Pradesh, Bihar, Madhya Pradesh, and West Bengal. Also, an observation strikes in the mind that there is an increase in the proportion of females who have stopped childbearing after achieving parity zero, one, two, and three from 1991 to 2014; while the proportion of females, who have stopped childbearing after achieving higher parities four, five, six, seven, and more, has decreased during the same period.

Table IV and Table V present the estimated total fertility rates for the year 1991 and 2014 respectively by using two proposed predictors i.e. proportion of females who have controlled their birth up to three parity and weighted mean of proportions of females with parity specific birth control behavior. Both the predictors provide the values of India's TFR nearer to the observed ones for 1991 as well as 2014. In 1991, the difference between observed TFR and estimated TFR is less than 10 percent in all the states except Kerala and Odisha for first predictor and Haryana for second predictor. Similarly in 2014, only Kerala and Punjab for first predictor and Gujarat for second predictor have difference of more than 10 percent. For rest of the states, estimates are closer to the observed TFRs.

## Conclusion

Parity-specific nature of fertility decisions is an integral part of family building process. Couples may have an anticipated family size. The parity specific intention arises only after attaining a marginally acceptable number of children. When the females start child stopping at earlier parities, the overall fertility starts to decline. Hence, the information about the stopping behavior of females is considered crucial in the fertility estimation. The stopping behavior reveals the family formulation of society. It provides the proportions of females who stopped childbearing after attaining a specified parity. The regression equations (2) and (3) indicate that the first predictor, which is cumulative proportion of females having family size up to three children; is negatively associated with TFR. The negative association has been obtained because the overall fertility will obviously decline if the proportion of females having a small family size increases. The regression equations (4) and (5) indicate that the second predictor is positively associated with TFR. Second Predictor is the weighted mean of proportions of females who stopped childbearing after achieving specific parity. Hence, it is quite simple to conclude that the increment in the average lifetime parity of females will increase the overall fertility (TFR). Hence, it is observed that the proposed indirect technique seems to provide reasonably good estimates of total fertility rate.

**Table V. Estimated Total Fertility Rate using the Proposed Predictors for Major States (2014)**

| State | Obs. TFR | Estimated TFR from | | % difference from Observed TFR | |
|---|---|---|---|---|---|
| | | Birth Control (3)* | Weighted Mean# | Birth Control (3)* | Weighted Mean# |
| India | 2.18 | 2.15 | 2.16 | -1.57 | -0.73 |
| Andhra Pradesh | 1.83 | 1.77 | 1.83 | -3.35 | 0.08 |
| Bihar | 3.41 | 3.44 | 3.42 | 0.82 | 0.18 |
| Gujarat | 2.03 | 1.94 | 1.84 | -4.61 | -10.12 |
| Haryana | 2.05 | 1.94 | 2.06 | -5.68 | 0.51 |
| Karnataka | 1.80 | 1.84 | 1.83 | 1.92 | 1.47 |
| Kerala | 1.56 | 1.74 | 1.65 | 10.44 | 5.23 |
| Maharashtra | 1.87 | 1.87 | 1.93 | -0.05 | 3.31 |
| Madhya Pradesh | 2.32 | 2.47 | 2.40 | 6.10 | 3.47 |
| Odisha | 2.05 | 2.00 | 1.97 | -2.47 | -3.90 |
| Punjab | 1.62 | 1.83 | 1.80 | 11.60 | 9.80 |
| Rajasthan | 2.40 | 2.19 | 2.28 | -9.79 | -5.31 |
| Tamil Nadu | 1.70 | 1.73 | 1.69 | 1.91 | -0.52 |
| Uttar Pradesh | 2.74 | 2.80 | 2.85 | 2.17 | 4.01 |
| West Bengal | 1.77 | 1.82 | 1.81 | 2.93 | 2.29 |
| Telangana | 1.78 | 1.78 | 1.82 | 0.26 | 2.27 |
| Uttarakhand | 2.07 | 2.06 | 2.17 | -0.42 | 4.53 |
| Chhattisgarh | 2.23 | 2.08 | 2.03 | -7.36 | -9.78 |
| Jharkhand | 2.55 | 2.51 | 2.41 | -1.66 | -5.90 |

* denotes predictor $PR_1$ as cumulative proportion of females who have stopped childbearing after achieving parity up to three.

# denotes the predictor $PR_2$ as weighted mean of proportions of females who stopped childbearing after achieving specific parity

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