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ARTICLE

Proximate determinant of fertility in India and estimation of total fertility rate[1]

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Abstract

Fertility is one of the crucial components in the study of population changes. In India, Total Fertility Rate (TFR) has declined steadily as observed by National Family Health Survey (NFHS) from 1991-92 (2.7) to 2019-21 (2.0) child per women. There is large variation in fertility due to fact that variations in geographic, environmental, behavioural and social factors. To measure the fertility, Bongaart's (1982) proposed a model to estimate TFR using four specific factors (Marriage, Contraception, Induced abortion and Lactational infecundability). In this article, we have estimated the indices of the proximate determinants of fertility for India and using these indices, we have estimated the total fertility rate for 2019-21 of India and its major states. There were large differences found in the observed and estimated values of TFR for India as well as its states. So, we try to investigate whether this model with some modification may provide reasonable estimates of TFR? For estimation of Lactational infecundability Index, we have calculated postpartum amenorrhea (PPA) using Prevalence/ Incidence method. The studies indicate that contraception (66.7%) had the most significant impact on reducing fertility rates in India followed by marriage (36.4%), lactational infecundability (20.6%) and induced abortion (1%).

Keywords: Fertility; Proximate Determinants; Postpartum Infecundability; Abortion; Total Fecundity; Total Fertility Rate.

1. Introduction

India is the most populous country in the world. According to UN, it is a country of about 1.4 billion people living within an area of 32, 87,263 km^2. The density of India is 438.58 per km^2 (UN DESA, 2022). India's population is increasing day by day. The large population in this country exerts significant strain on its agricultural areas, forests, and other natural resources. Consequently, the country struggle to adequately meet the fundamental needs of its entire population, including food, shelter, education, and healthcare. Hence, it is important to regulate the rate of population growth in this country and implement a strategy that can effectively utilized its current population. To successfully control population size, it is crucial to evaluate both the current population and the rate at which it is growing in the country. The total fertility rate (TFR) is an indicator used to predict the future population size of a country. It represents the average number of children a woman would give birth during her reproductive years, assuming that the current age-specific birth rates remain constant throughout her childbearing years. Fertility significantly influences the socioeconomic status of a country. By understanding the magnitude, structure, and characteristics of fertility, policymakers can implement appropriate measures to develop a customized policy for a country.

However, in most developing nations, vital registration systems are lacking in both coverage and quality. Therefore, it is necessary to explore some indirect methods for computing it that do not rely on extensive data and can be constructed to have certain desirable qualities, such as minimal data requirements, computational efficiency and accurate findings. Several indirect techniques have previously been suggested for determining TFR. Brass (1968) proposed a method based on the P/F ratio to estimate TFR and this method was further refined by Hobcraft *et al.*(1982). Mauldin and Ross (1991) and Jain (1997) have utilized the contraceptive prevalence rate (CPR) as a predictive measure for the TFR of a given community. Yadava *et al.*(2009) estimate TFR through birth order statistics. These methods are highly beneficial in situations where we lack direct data on the number of births, as they provide indirect estimates of the TFR.

The total fertility rate is influenced by many factors, known as intermediate fertility variables, determined by Davis & Black (1956). They suggested 11 intermediary fertility variables through which socio-economic and cultural factors to influence fertility. By analyzing data of 41 developed and developing countries, Bongaart's (1978, 1982) and Bongaart's & Potter (1983) suggested eight intermediate variable and finally Bongaart's (1983) found that 96% of the variation in total fertility rates could be accounted by four specific factors (marriage, contraception, induced abortion and lactational infecundability). As a result, it seemed appropriate to exclude these 'redundant' intermediate variables from further analysis. Bongaart's developed a methodology to estimate the TFR using four proximate determinants that can be measured by four indices. Later on, many modifications have been done in Bongaart's model (Stover 1998, Gupta *et al.*, 2014, Bongaart's, 2015).

Studies conducted in multiple countries by demographers have found diverse disparities in fertility rate. Islam *et al.*(2015) conducted a study in Bangladesh and found that the utilization of contraceptives has a substantial role in changing fertility patterns. According to study conducted in Zambia, marriage and postpartum infecundability account for the largest inhibiting effect on natural fertility from its biological maximum of 19.10 (Chola & Michelo, 2016). Factors like age at marriage, women's employment, place of residence, educational attainment, and ethnic group may influence fertility. The usage of contraceptives and the wealth index were significant factors in the fertility disparities in Philippines (Lai & Tey, 2014). According to Ghanaian research (Rutaremwa *et al.*, 2015), a woman's use of contraception, marital status, and postpartum infertility are significant indicators of her chances of having children. Lower fertility rates were consistently linked to higher levels of education and urban residency. Johnson *et al.* (2011) conducted study in Sub-Saharan Africa found that the use of contraceptives, postpartum amenorrhea, and single status are all significant proximal predictors of fertility that reduce fertility. The study also determined the background characteristics that influence fertility, including the number of children desired, the national family planning effort, the under-five mortality rate, education level, female workforce participation, and place of residence. Majumder N, Ram F (2015) found that induced abortion and marital patterns were major factors in lower female fertility in Asian nations.

In this article, we have estimated the indices of the proximate determinants of fertility for India and using these indices, we have estimated the total fertility rate for 2019-21 of India and its major states. There were large differences found in the observed and estimated values of TFR for India as well as its states. This clearly shows that the use of Bongaart's Model for estimating the TFR does not work in India in current scenario. So, we try to investigate whether this model with some modification may provide reasonable estimates of TFR?

2. Materials and Methods

2.1 Data Sources

This study is based on the fifth round of the India National Family Health Survey (NFHS) carried out between 2019 to 2021. The survey gathers data on standard Demographic and Health indicators, including the attributes of households and respondents, maternal and child health, marriage, fertility, and contraception usage at the national, state, and district levels. The NFHS is a survey conducted across the country level, using a sampling strategy that involves two stages and is stratified based on probability proportional to size. The initial phase was the selection of primary sampling units (PSUs), which consisted of villages in rural regions and Census Enumeration Blocks (CEBs) in urban areas. For the second phase, a total of 22 homes were chosen through systematic sampling from each PSU. A total of 724,115 women aged 15–49 living in 636,699 households enrolled in 2019-21 surveys made up the sample for this study.

2.2 Bongaart's Proximate Determinants Model

Bongaart's model contains four proximate determinants: marriage, contraception, abortion and postpartum infecundability. The model for estimating the TFR is

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

where C_m, C_c, C_a *and* C_i are the index of marriage, index of contraception, index of induced abortion and index of lactational infecundability respectively. TF is the total fecundity (TF).

2.3 Estimation of Index of Marriage

The index of marriage (C_m) measures the reduction in fertility that is caused by the marriage. The estimation of index of marriage is based on the proportion currently married by five-year age groups among women of reproductive age, which representative the sexual activity and likelihood of pregnancy. The value of index lies between 0 and 1. The value is 0 if no one is married and the value is 1 if all women of reproductive age are married. The index of marriage is calculated by the formula given as

$$\boldsymbol{C_m = \frac{\sum m(a)g(a)}{\sum g(a)}} \quad (2)$$

where $m(a)$ is the proportion of married women among reproductive age group, $g(a)$ is the age specific marital fertility rate of reproductive age group.

2.4 Estimation of Index of Contraception

The index of contraception (C_c) measure the reduction in the fertility that is caused by the contraception. The index equals 1 when no contraception is used in the population and 0 when all the women of reproductive age use methods that are 100% effective. The estimated value of index of contraception is calculated as

$$\boldsymbol{C_C = 1 - 1.08 \times u \times e} \quad (3)$$

where, u is the proportion of currently married women using any type of contraceptive, e is the average effectiveness of contraception and the adjustment factor, 1.08, which remove the infecund women from the equation.

The average effectiveness of contraceptive use (e) is obtain by using the formula

$$\boldsymbol{e = \frac{\sum u(m)e(m)}{u}} \quad (4)$$

where $e(m)$ is the effectiveness of various type of contraceptive given by WHO and $u(m)$ is the proportion of women using specific type of contraceptive.

2.5 Estimation of Index of Induced Abortion

The index of induced abortion (C_a) measure the reduction in the fertility that is caused by the induced abortion. If the value of index is 1 then there is no induced abortion in pregnant women of reproductive age group and value of index zero then all the pregnancy are aborted. The formula below can be used to estimate this index

$$\boldsymbol{C_a = \frac{TFR_{Observed}}{TFR_{Observed} + 0.4(1+u) \times TA}} \tag{5}$$

where, u is the proportion of currently married women using any type of contraceptive and TA is the total abortion rate.

2.6 Estimation of Index of Lactational Infecundability

The index of postpartum infecundability (C_i) measure the reduction in the fertility that is caused by the postpartum amenorrhea. This refers to the ratio of birth intervals due to absence of breastfeeding and the presence of breastfeeding. The average birth interval in the absence of breastfeeding is approximately 20 months, which is the sum of 1.5 months postpartum infertility from not breastfeeding, 7.5 months of waiting for conception, 2 months from spontaneous intrauterine death, and 9 months for a full-term pregnancy. In the presence of breastfeeding the average birth interval roughly 18.5 (7.5+2+9) months, plus average duration of postpartum infertility. The value of index equal 1 if no women are postpartum amenorrhoeic and 0 if all the women of reproductive age group are postpartum amenorrhoeic. The estimate of postpartum in fecundability is obtain by formula

$$\boldsymbol{C_i = \frac{20}{18.5 + i}} \tag{6}$$

where i is the average duration of postpartum infecundability. Bongaarts and Potter (1983), developed the estimate of i if a direct estimate is not accessible which is given below

$$\boldsymbol{i = 1.753\, e^{(0.1396\, L - 0.00187\, L^2)}} \tag{7}$$

where L is the average duration of breastfeeding.

2.7 Estimation of Postpartum Infecundability

For the estimation of postpartum infecundability Bongaart's and Potter proposed above equation (7) and they obtain mathematical equation on the basis of a set of observed average duration of breastfeeding and amenorrhoea. Yadava and Islam (1994) check the suitability of this equation on the data of eight different country including India and they indicated that the equation (7) given by Bongaart's and Potter does not suit well for estimating the amenorrhea period for a given duration of breastfeeding especially when the duration of breastfeeding is prolonged or very short. In any population where long breastfeeding is cultural practice there is a possibility of overestimating the amenorrhoea period by this formula.

In order to address this issue, we estimated the value of the average duration of postpartum amenorrhea (PPA) by using the prevalence/incidence mean (Maurya *et al.,* 2025a). Since the raw data on PPA of last birth is available in NFHS-5.

It is a widely recognized result that if X is a random variable that takes non-negative values, then

$$\boldsymbol{Mean(\mu) = \int_0^\infty [1 - F_X(x)]dx} \tag{8}$$

where $F_X(x)$ is the distribution function of X, i.e. $F_X(x) = P[X \leq x]$. If X is discrete the integral change in summation. The duration variable (X) takes non-negative values. If we make the assumption that the number of births is evenly distributed across time in a population. In other words, if the number of births in each month is the same, then the Prevalence/Incidence for a specific month (x) can be defined as $[1 - F_X(x)]$ for given X. The Prevalence/Incidence mean of postpartum amenorrhea is calculated by dividing the number of mothers who are amenorrhoeic at the survey date by the average number of births per month during a 36-month period. i.e.:

$$Prevalence/incidence\ mean(i^{*}) = \sum_{0}^{35} \frac{Number\ of\ mother\ who\ are\ amenorrheic\ at\ the\ survey\ date}{Average\ number\ of\ births\ per\ month}$$

The value of index of lactational infecundability is given by

$$\boldsymbol{C_i^{*}} = \frac{\mathbf{20}}{\mathbf{18.5}+\boldsymbol{i^{*}}} \qquad (9)$$

2.8 Estimation of Total Fertility Rate

To estimate the TFR, we have applied the formula $TFR = C_m \times C_c \times C_a \times C_i^{*} \times 15.3$ on the data of NFHS-5 and calculated the TFR for all major states as well as India which are presented in table (6). There are large differences in the observed and estimated value of the all states as well as in the country. This clearly shows that the use of above formula for estimating the TFR does not well in India. This may be mainly due to value of Total Fecundity (TF).

Bongaart's has determined that the value of TF is 15.3, primarily based on data from Western countries. Societies marked by poverty, frequent spousal separation, societal conventions, and sexual taboos tend to have a low average value of TF. India is a country that exhibits all characteristic of a below-average value of TF. Therefore, it is probable that the TF in India is below 15.3. Arora and Kumar (1987) calculated that the value of TF for India is 12. Singh *et al.*(1998) proposed that the TF value for India should be adjusted to around 11.67, instead of the value of 15.3 recommended by Bongaart's. Jayachandran and Stover (2018) estimate total fecundity of 10.9 per woman in India. Recently Singh *et al.*(2022) estimate TFR for India using Bongaart's proximate determinant model with TF 10.9 suggested by Jayachandran and Stover (2018). In this article, we have estimated TFR using four different values of TF (15.3, 12, 11.67 and 10.9) proposed by researchers for India.

3. Results

The estimated values of all indices of the proximate determinants of fertility and estimated value of TFR for different values of TF are given in table 1 to 6.

Table 1 provides an estimate of the marriage index based on proportion of currently married females. The estimated value of index of marriage for India is 0.635 and highest for Bihar (0.7808) followed by Rajasthan (0.6912). Punjab with (0.5570) gives the lowest estimate of marriage index. This shows that delayed/non marriage inhibited fertility by 36.4% at national level.

Table 2 displays details about the various contraceptives and their efficacy given by ("Birth Control Methods", U.S. Department of Health and Human Services, Office on Women's Health, Nov. 2011) WHO. The table suggests that the IUD is the most effective form of contraception (e(m)=0.99), which is equivalent to the effectiveness of sterilization, and that the traditional approach (i.e., Rhythm/Withdrawal) is the least effective method with a greater failure rate and lesser efficacy.

Table 3 contains state-wise CPR and index of Contraception. For India, CPR is 66.71 percent. Among the major states of India, Andra Pradesh, Gujrat, Haryana, West Bengal, Madhya Pradesh, and Odisha have CPR more than the India and among them, Gujrat topped the table with CPR of 76.50 percent followed by Odisha (74.56). Bihar is the only state with a CPR of less than 60 percent. For India the value of index of Contraception is 0.33286, this show that contraceptive use has reduced fertility by 66.7%. Gujrat has the highest reduction in fertility (76.4%) due to uses of contraception. Bihar has the lowest reduction in fertility (56.9%) due to lesser uses of contraception.

Table 4 contains total abortion rate, and index of induced abortion C_a. The total abortion rate for India is 0.029 with Odisha having the highest total abortion rate of 0.047. Odisha shows the lowest C_a (0.9823) and Bihar has the highest C_a (0.9964) followed by Rajasthan. The index of abortion for India is 0.9904 this show that reduction in fertility (TFR) due to induced abortion is only 1 percent at national level.

Table 5 provides an estimate of postpartum infecundability and index of lactational infecundability for India and its major states. The average duration of postpartum infecundability for India is 6.66 months. Chhattisgarh, Bihar, Odisha, MP, Telangana, and Karnataka have average postpartum infecundability greater than 7 months. The lowest average postpartum infecundability is 4 months for Punjab. The index of lactational infecundability is 0.794 for India and state-wise if the Index of lactational infecundability from high to low is Punjab (C_{i*}=0.8889), Haryana (C_{i*}=0.8547), West Bengal (C_{i*}=.8414), Gujrat (C_{i*}=.8330) and so on. The index of lactational infecundability is 0.794 for India, this show that reduction in fertility (TFR) due to Lactational infecundability is 20.6%.

Table 6 shows the index of four proximate determinants: marriage, contraception, abortion, and lactational infecundability, observed TFR and estimated TFR at different values of TF. Sixth column of the table provides the estimate of TFR for the TF 15.3. It shows that percent difference between estimated and observed TFR is more than 30% for many states. This TF value provide better estimate of TFR for only Madhya Pradesh. The estimated TFR at TF=12 and TF=11.67 is close to the observed TFR. Values in the parenthesis indicate the percentage difference between observed TFR and estimated TFR. For India and eight major states, the percentage difference is less than ten percent (India=2.3, Chhattisgarh=8.7, Bihar=0.1, Rajasthan=8.7, West Bengal=6.6, Haryana=3.5, Maharashtra= 5.4, Telangana=3.5, Karnataka=4.7) when TFR is estimated at TF=11.67. Similarly for India and seven states, the percentage difference is less than ten percent (India=0.4, Chhattisgarh=6.1, Bihar=3.0, Rajasthan=6.1, Haryana=0.8, Maharashtra= 2.7, Telangana=0.8, Karnataka=2.0) when TFR is estimated at TF=12 and also for India and six states, the percentage difference is less than ten percent (India=7.5, Uttar Pradesh=5.4, Bihar=6.4, Jharkhand=3.5, West Bengal=0.4, Haryana=9.8, Telangana=9.9) when TFR is estimated at TF=10.9.

Table 1. Index of Marriage for India and its Major States (NFHS-5)

	States	C(m)
1	Uttar Pradesh	0.6711
2	Madhya Pradesh	0.6634
3	Chhattisgarh	0.5968
4	Bihar	0.7808
5	Rajasthan	0.6912
6	Jharkhand	0.6648
7	Odisha	0.6229
8	West Bengal	0.6614
9	Punjab	0.557
1o	Haryana	0.6454
11	Gujrat	0.6503
12	Maharashtra	0.6085
13	Telangana	0.6383
14	Kerala	0.6385
15	Karnataka	0.6186
16	Tamil Nadu	0.571
17	Andhra Pradesh	0.6034
18	India	0.6356

Table 2. Contraceptives with their Effectiveness

	Method of Contraception	Effectiveness e(m)
1	Pills	0.92
2	IUD	0.99
3	Injection	0.97
4	Diaphragm	0.84
5	Condom	0.85
6	Female sterilization	0.99
7	Male sterilization	0.99
8	Implants	0.99
9	Female condom	0.97
10	Foam/Jelly	0.71
11	Standard days	0.88
12	Rhythm/periodic abstinence	0.75
13	Withdrawal	0.73
14	Lactational amenorrhea	0.98

Source: World Health Organization (2011)

Table 3. Index of Contraception for India and Its Major States (NFHS-5)

	States	Contraceptive Prevalence Rate	Index of Contraception C(c)
1	Uttar Pradesh	62.43	0.41273
2	Madhya Pradesh	71.54	0.26314
3	Chhattisgarh	65.26	0.32649
4	Bihar	57.5	0.43092
5	Rajasthan	72.35	0.27683
6	Jharkhand	60.9	0.39115
7	Odisha	74.56	0.288
8	West Bengal	73.88	0.27343
9	Punjab	67.12	0.35818
10	Haryana	72.39	0.28902
11	Gujrat	76.5	0.23528
12	Maharashtra	68.49	0.28893
13	Telangana	66.81	0.29086
14	Kerala	61.58	0.36799
15	Karnataka	68.1	0.28092
16	Tamil Nadu	68.68	0.27747
17	Andhra Pradesh	71.12	0.24104
18	India	66.71	0.33286

Table 4. Index of Induced Abortion for India and its Major States (NFHS-5)

	States	Total Fertility Rate (Observed)	Total Abortion Rate	C(a)
1	Uttar Pradesh	2.35	0.031	0.9915
2	Madhya Pradesh	1.99	0.013	0.9955
3	Chhattisgarh	1.82	0.017	0.9939
4	Bihar	2.98	0.017	0.9964
5	Rajasthan	2.01	0.015	0.9949
6	Jharkhand	2.26	0.024	0.9932
7	Odisha	1.82	0.047	0.9823
8	West Bengal	1.64	0.036	0.985
9	Punjab	1.63	0.031	0.9874
10	Haryana	1.91	0.027	0.9903
11	Gujrat	1.86	0.02	0.993
12	Maharashtra	1.71	0.04	0.9845
13	Telangana	1.75	0.041	0.9846
14	Kerala	1.79	0.032	0.9886
15	Karnataka	1.67	0.024	0.9904
16	Tamil Nadu	1.76	0.044	0.9834
17	Andhra Pradesh	1.68	0.041	0.9836
18	India	1.99	0.029	0.9904

Table 5. Postpartum Infecundability by Using Prevalence/Incidence and Index of Lactational Infecundability for India and its Major States (NFHS-5)

	States	Average Duration of Postpartum Infecundability (i*)	Index of Lactational Infecundability C(i*)
1	Uttar Pradesh	5.65	0.8282
2	Madhya Pradesh	7.92	0.757
3	Chhattisgarh	8.71	0.735
4	Bihar	7.7	0.7634
5	Rajasthan	5.71	0.8261
6	Jharkhand	5.55	0.8316
7	Odisha	7.84	0.7593
8	West Bengal	5.27	0.8414
9	Punjab	4	0.8889
10	Haryana	4.9	0.8547
11	Gujrat	5.51	0.833
12	Maharashtra	6.48	0.8006
13	Telangana	6.78	0.7911
14	Kerala	5.35	0.8386
15	Karnataka	6.74	0.7924
16	Tamil Nadu	5.79	0.8234
17	Andhra Pradesh	6.54	0.7987
18	India	6.66	0.7949

Table 6. Comparison of Observed TFR with Estimated TFR Under Different Values of Total Fecundity (TF)

	States	Estimated value of different Indexes				Estimated TFR for different value of TF				Obs. TFR
		C(m)	C(c)	C(a)	C(i)*	TF=15.3	TF=12	TF=11.67	TF=10.9	
1	Uttar Pradesh	0.6711	0.4127	0.9915	0.8282	3.48(48.0%)	2.73(16.1%)	2.65(12.9%)	2.48(5.4%)	2.35
2	Madhya Pradesh	0.6634	0.263	0.9955	0.757	2.01(1.0%)	1.58(-20.7%)	1.53(-22.9%)	1.43(-27.9%)	1.99
3	Chhattisgarh	0.5968	0.3264	0.9939	0.735	2.18(19.6%)	1.71(-6.1%)	1.66(-8.7%)	1.55(-14.7%)	1.82
4	Bihar	0.7808	0.4308	0.9964	0.7634	3.91(31.3%)	3.07(3.0%)	2.99(0.1%)	2.79(-6.4%)	2.98
5	Rajasthan	0.6912	0.2767	0.9949	0.8261	2.41(19.6%)	1.89(-6.1%)	1.83(-8.7%)	1.71(-14.7%)	2.01
6	Jharkhand	0.6648	0.3911	0.9932	0.8316	3.29(45.3%)	2.58(14.0%)	2.51(10.8%)	2.34(3.5%)	2.26
7	Odisha	0.6229	0.288	0.9823	0.7593	2.05(12.4%)	1.61(-11.8%)	1.56(-14.2%)	1.46(-19.8%)	1.82
8	West Bengal	0.6614	0.2733	0.985	0.8414	2.29(39.7%)	1.80(11.1%)	1.75(6.6%)	1.63(-0.4%)	1.64
9	Punjab	0.557	0.3581	0.9874	0.8889	2.68(64.3%)	2.10(28.9%)	2.04(25.3%)	1.91(17.0%)	1.63
10	Haryana	0.6454	0.289	0.9903	0.8547	2.42(26.4%)	1.89(-0.8%)	1.84(-3.5%)	1.72(-9.8%)	1.91
11	Gujrat	0.6503	0.3503	0.993	0.833	2.88(54.9%)	2.26(21.5%)	2.20(18.2%)	2.05(10.4%)	1.86
12	Maharashtra	0.6085	0.2888	0.9845	0.8006	2.12(23.9%)	1.66(-2.7%)	1.62(-5.4%)	1.51(-11.6%)	1.71
13	Telangana	0.6383	0.2908	0.9846	0.7911	2.21(26.4%)	1.74(-0.8%)	1.69(-3.5%)	1.58(-9.9%)	1.75
14	Kerala	0.6385	0.3679	0.9886	0.8386	2.98(66.4%)	2.34(30.5%)	2.27(29.9%)	2.12(18.5%)	1.79
15	Karnataka	0.6186	0.2808	0.9904	0.7924	2.09(24.9%)	1.64(-2.0%)	1.59(-4.7%)	1.49(-11.0%)	1.67
16	Tamil Nadu	0.571	0.2773	0.9834	0.8234	1.96(11.4%)	1.54(-12.5%)	1.50(-14.9%)	1.40(-20.6%)	1.76
17	Andhra Pradesh	0.6034	0.241	0.9836	0.7987	1.75(4%)	1.37(18.4%)	1.33(20.6%)	1.25(25.8%)	1.68
18	India	0.6356	0.3329	0.9904	0.7949	2.55(28%)	2.00(0.43%)	1.94(-2.3%)	1.82(-7.5%)	1.99
	Average % Difference					30.47%	2.33%	-0.48%	-7.00%	

4. Discussion

The present study examines how four key determinants (marriage, contraceptives, lactational infecundability and induced abortion) affect TFR in India and its state. The current study focuses on the NFHS-5 data (conducted in 2019–21) and incorporates abortion as a proximate determinant while some previous studies (Singh *et al.*, 1998) assume that the index of abortion as constant due to unavailability of data. The study of the proximate determinant of fertility and their impact on the total fertility rate (TFR) in India and its main states yields major findings.

Delayed or non-marriage reduces fertility by 36.4% at the national level. This reduction is more pronounced in states like Punjab, where marriage is less prevalent or delayed, compared to Bihar, where early and widespread marriage contributes to higher fertility. Punjab has the highest reduction in fertility followed by Tamilnadan, Chhattisgarh, Andhra Pradesh and Maharashtra due to delayed/non marriage. Bihar has the lowest reduction in fertility followed by Rajasthan, Uttar Pradesh, Jharkhand, Madhya Pradesh and West Bengal due to early marriage. According to some earlier research (Maurya *et al.*, 2025b; Singh *et al.*, 2023; Subramanian, 2008), the age at first marriage is actually lower in northern Indian states than in southern ones, as this study shows.

Table 2 highlights that modern contraceptive methods such as IUDs and sterilization are the most effective whereas traditional methods like rhythm and withdrawal have higher failure rates.

The contraceptive prevalence rate (CPR) for India stands at 66.71% (Singh *et al.*,2023). Among states, Gujarat and Odisha show the highest CPR, while Bihar lags with less than 60%. The index of contraception for India indicates that contraceptive use has reduced fertility by 66.7%. Gujarat achieves the highest fertility reduction whereas Bihar has the lowest primarily due to lesser contraceptive usage.

Total abortion rate for India is low, with Odisha recording the highest (0.047). The index of induced abortion (C_a) for India is approximately 1, indicating minimal impact on TFR. Odisha has the lowest, suggesting a slightly higher reduction in fertility compared to other states, such as.

This study estimates the postpartum infecundability by using the concept of prevalence/incidence method which improve the estimate of index of lactational infecundability. Average duration of postpartum infecundability for India is 6.66 months which is close to NFHS reported value. States like Chhattisgarh, Bihar, Odisha, Madhya Pradesh, Telangana, and Karnataka report durations exceeding 7 months, while Punjab has the shortest duration (4 months). The index for India is 0.794, indicating a fertility reduction of 20.6%. Punjab has the highest index, followed by Haryana, showing lesser fertility inhibition due to shorter postpartum infecundability periods compared to states with longer durations.

The proximate determinants of fertility i.e. marriage, contraception, abortion, and postpartum infecundability play distinct roles in shaping the fertility landscape in India. Contraceptive use emerges as the most significant factor in fertility reduction, followed by marriage patterns and lactational infecundability. The impact of induced abortion remains minimal. Estimating TFR using TF = 11.67 offers the more consistent and accurate results for India and its major states, with minimal deviation from observed TFR values as compare to TF=15.3, 12 and 10.9. These findings underscore the need for targeted interventions in states like Bihar, where lower contraceptive prevalence and higher marriage indices contribute to elevated fertility levels.

5. Conclusions

The findings of this study indicate that contraception had the most significant impact on reducing fertility rates in India followed by marriage, lactational infecundability, and induced abortion. The overestimates (around 30%) of TFR were found when TF value was considered 15.3 (suggested by Bongaart's). The estimated TFR value obtain by using TF=11.67 and TF=12 closely aligns with the national average and is consistent across most of the states under consideration (except Tamil Nadu, Andhra Pradesh and MP). This study indicates that the value of TF=11.67 is more appropriate in estimating the TFR for India and its states. The poverty, social and cultural conventions, frequent spousal separation etc. tend to have a low average value of TF. Result of the study indicate that better estimates of TFR can be obtained for below-average value of TF.

Future Scope

The current study offers important new information about the relationship between TFR and determinant of fertility in India and its states. Future research can be done on the association between TFR and its determinants across population subgroups based on important women's characteristics, such as age, place of residence, household wealth index, year of educational attainment, and caste, is also made possible by this study.

Limitation of the Study

The current study utilised secondary data from the NFHS 5. The sample size for this study is large, however the data is self-reported and may be subject to recall bias.

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Conflicts of Interest

The authors declare no conflict of interest.

Author Contributions

Conceptualization: TIWARY, A.K.; SINGH, P. K. Data curation: SINGH, P. K. Formal analysis: SINGH, P. K. Funding acquisition:- Investigation: TIWARY, A.K. Methodology: TIWARY, A.K.; SINGH, P. K. Project administration:- Software:- Resources: MAURYA, R.K.; SINGH, P. K. Supervision: TIWARY, A.K. Validation: TIWARY, A.K.; MAURYA, R.K.; SINGH, P. K. Visualization: TIWARY, A.K.; SINGH, P.K. Writing - original draft: SINGH, P. K. Writing - review and editing: TIWARY, A.K.; MAURYA, R.K.; SINGH, P. K.

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