International Journal of Scientific Research and Management (IJSRM)
||Volume||09||Issue||1||Pages||M-2021-296-314||2021||
Website: www.ijsrm.in ISSN (e): 2321-3418
DOI: 10.18535/ijsrm/v9i01.m01

An Indirect Method to Estimate Total Fertility Rate on the Basis of the Moments of Age Distribution of Women in Reproductive age

Brijesh P. Singh[1], Sandeep Singh[1] & Aalok Ranjan Chaurasia[2]

[1]Department of Statistics, Institute of Science, Banaras Hindu University, Varanasi
[2]MLC Foundation, Bhopal

Abstract
Total fertility rate (TFR) is the universally used indicator to measure and monitor fertility transition and population stabilization. Calculation of TFR requires data on births by age of woman. In the absence of these data, several indirect methods have been proposed to estimate TFR but their application is limited to specific period and place. This paper deduces a simple regression method for estimating TFR based on the current age distribution of women in reproductive age. The method can be used to estimate TFR at local level and for different sub-groups of the population.

Keywords: Total fertility rate; regression; moments; coefficient of variation; stability of model.

Introduction

Fertility is the primary engine of global population change (Gerland et al. 2014). Reduction in fertility is argued to be essential for sustainable development including woman education, child and maternal mortality, gender equality, and reproductive health (Abel et al. 2016). Total fertility rate (TFR) is a completed measure of fertility that is commonly used in demographic and development research. Direct estimation of TFR requires full birth history data (FBH) of women in reproductive age (15-49 years). These data are generally not available at the local level. To overcome this problem, different indirect methods of estimating TFR have been suggested. These include Brass P/F Ratio method (Brass 1975), Own Children method (Cho et al. 1986), and several regression methods (Bogue and Palmore 1964; Palmore 1978; Gunasekaran and Palmore 1984; and Rele 1967 and 1987; Pacheco and Engracia 1985; Rao 1987; Hanenberg 1983). Coale and Demeny (1967) developed a formula (TFR= P_3^2/P_2) to estimate TFR, where P_2 and P_3 are mean number of births to women aged 20-24 and 25-29 years. This method has been modified by Gupta et al. (2014). Mauldin and Ross (1991) and Jain (1997) have used CPR to predict TFR. Singh et al. (2012) modified this method by taking the combination of CPR and sterility as predictor variables. Yadava and Kumar (2002) used proportion of women having open birth interval more than five years for prediction of TFR but this predictor has an error due to recall lapse and digit preference, therefore keeping this error into mind Singh et al. (2020) used the proportion of women having birth in the last five years prior to the date of survey as the predictor variable, as in count variable the chance of such type of error is lesser than the time variable (open birth interval more than five years) as taken by Yadava and Kumar (2002). Tiwari et al. (2020) used counterparts of the predictor variable taken by Singh et al. (2020) to estimate TFR. Singh et al. (2017) have suggested that IMR does not Granger Cause TFR whereas TFR Granger Cause IMR which means TFR can be predicted on the basis of IMR but IMR cannot be predicted on the basis of TFR. However, nearly all these methods are based on variables (mean age at marriage, percent of woman ever married, etc.) that are usually not available from census or survey data so that they are typically limited to areas, time periods, and populations with sufficiently detailed data. In addition, the relationship between fertility and social indices can differ over time and over populations, making indirect methods error prone when applied outside the context from which the regression coefficients are derived (Tuchfeld et al. 1974, Hauer et al. 2013, Schmertmann and Hauer 2019).

Palmore (1978) has suggested a method which is a modification of a technique introduced by Bogue and Palmore in 1964. Like Rele's method (1967), this method also postulates a linear relationship between the child woman ratio, a measure of mortality and TFR. However, unlike Rele's method, Palmore (1978) method is derived empirically using census and vital registration data from different countries. This method requires more data than Rele's method, but the data required are usually available from census or surveys. Moreover, instead of using the expectation of life at birth, Palmore (1978) uses IMR as the measure of mortality. It has been observed that Rele's method tends to under-estimate fertility whereas Palmore (1978) method tends to over-estimate TFR particularly when IMR decreases rapidly. Gunasekaran and Palmore (1984) developed a regression method to estimate gross reproduction rate (GRR) and then TFR by multiplying GRR by 2.05. They used moments of the entire woman age distribution instead of the child woman ratio. Also Smith (1992) and Zhang (2006) observed TFR and the general fertility rate are directly proportional to the crude birth rate, however, Preston and Coale (1982) developed a method for calculating the TFR based on net population reproductivity.

In this paper, we develop a regression method similar to Gunasekaran and Palmore (1984). The advantage of the method being proposed here is that the data pertaining to the age distribution of currently married reproductive age women can be culled out from the records maintained by the grassroots level health and family welfare services providers. As such, the method can be used for estimating TFR even at the grassroots level which, then, can become the basis for planning for the delivery of family welfare services and monitoring fertility transition at the grassroots level. This is important as reliable demographic data for small domains are essential for meaningful local level population planning. Estimation of demographic indicators at the grassroots level is based on the civil registration data. Although, registration of births in India is compulsory under the Birth and Death Registration Act of 1969, yet registration under the civil registration system in India grossly incomplete to calculate fertility indicators including TFR. Annual estimates of TFR in India are available through the Sample Registration System (SRS) but the system provides estimates up to state level only and that too for major states. The only source of data to estimate TFR at the district level is the summary birth history (SBH) data available through decennial population census. Using these data, estimates of TFR have been calculated at the district level (Bhat, 1996; Drěze and Murthi, 2001; Satyanarayana and Kumar, 2012; Guilmoto and Rajan, 2013; Ponnapalli and Soren, 2018). These estimates, however, are available at an interval of 10 years only (Natarajan and Singh 1988; Natarajan and Puri 1988; RGI, 1997, 2011).

Development of the Model

The model proposed for estimating TFR is based on establishing an empirical relationship between TFR and the age distribution of currently married women in the reproductive age group. The age distribution of currently married reproductive age women can be characterised in terms of the first four moments of the age distribution. In the present paper, we have attempted to establish empirical relationship between TFR and coefficient of variation (*CV*), involving first and second moments; skewness (*Sk*), involving third and second moments; and kurtosis (*Ku*), involving fourth and second moments. Using these three indicators the following seven models depicting the relationship between TFR and the age distribution of currently married reproductive age women can be conceptualized:

Model 1 $\Rightarrow TFR = f(CV, Sk, Ku)$

Model 2 $\Rightarrow TFR = f(CV, Sk)$ **Model 3** $\Rightarrow TFR = f(CV, Ku)$

Model 4 $\Rightarrow TFR = f(Sk, Ku)$ **Model 5** $\Rightarrow TFR = f(CV)$

Model 6 $\Rightarrow TFR = f(Sk)$ **Model 7** $\Rightarrow TFR = f(Ku)$

In order to test the cross-validity predictive power of these models, we have used the method proposed by Herzberg (1969). The cross-validity prediction power of the model is calculated as

$$\rho_v^2 = 1 - \frac{(n^2-1)(n-2)(1-c^2)}{n(n-p-1)(n-p-2)}$$

Where n is the number of observations, p is the number of explanatory or independent variables in the model and c is the correlation coefficient between predicted and observed value of the dependent variable or TFR. Moreover, standard adjustment has been made in the coefficient of determination to compensate for the subjective effects of further sampling. We have also estimated shrinkage which is the reduction in the effects of sampling variation. It is well known in the regression analysis that a fitted relationship performs less well on a new data set than on the data set that is used for fitting (Everitt, 2002) so that the value of the coefficient of determination, particularly, 'shrinks'. Shrinkage is separate from the standard adjustment made in the coefficient of determination. The shrinkage of the model is estimated by the following formula:

Shrinkage= $|\rho_v^2 - r^2|$

where r^2 is the coefficient of determination. Finally, we have also calculated the stability of the model which is equal to (1-Shrinkage) which implies that the lower the shrinkage the more stable the model.

Source of Data

In order to examine the empirical relationship between TFR and the age distribution of currently married reproductive age women, we have used data available from the fourth round of the National Family Health Survey (NFHS) which was conducted during 2015-16. The National Family Health Survey Programme was launched by the Government of India, Ministry of Health and Family Welfare in the 1990s to generate population-based data to monitor and evaluate the family planning and reproductive and child health programmes at national and state levels.

Table 1. Statistical Moments of Age Distribution of Women in India and Major States NFHS-4

State	Mean (μ_1')	μ_2	μ_3	μ_4	N
Andhra Pradesh	31.29	94.09	118.65	16643.50	10428
Bihar	28.69	94.67	350.04	18194.80	45812
Chhattisgarh	29.60	97.81	319.23	18751.73	25172
Gujarat	30.42	95.06	157.57	16898.96	22932
Haryana	29.76	90.82	285.62	16496.87	21654
Jharkhand	29.14	92.74	312.57	17286.27	29046
Karnataka	30.63	92.16	150.41	16222.52	26291
Kerala	32.16	99.20	-19.76	17910.54	11033

Madhya Pradesh	29.61	97.22	297.16	18241.69	62803
Maharashtra	30.34	97.22	182.13	17769.10	29460
Odisha	30.30	97.02	210.25	17791.26	33721
Punjab	30.88	91.39	139.80	16037.36	19484
Rajasthan	29.10	93.51	325.52	17312.95	41965
Tamil Nadu	31.40	95.84	75.07	17177.99	28820
Telangana	30.55	91.58	219.12	16188.44	7567
Uttarakhand	29.55	96.04	282.36	17893.94	17300
Uttar Pradesh	28.60	96.63	389.44	18580.92	97661
West Bengal	30.55	91.58	219.12	16188.44	17668
INDIA	**29.83**	**95.26**	**251.02**	**17512.84**	**699686**

The NFHS has been expanded to generate district level data in the fourth round. The first four moments of the age distribution of currently married reproductive age women in India and in its different states are presented in table 1. It is evident from the table that the age distribution of currently married reproductive age women varies widely across states. Notably, there is only one state, Kerala, where the third moment of the age distribution of reproductive age women is negative in rest of the states, it is positive. On the other hand, the age curve is platykurtic in all states as well as in the country. Table 1 reveals that the statistical moments of the age distribution of women in reproductive age in India and some major states for NFHS-4 data. In southern states the mean age is higher than the northern and other states.

Table 2. Regression Models, r^2 (Coefficient of Determination), Adjusted r^2 and Standard Error

Model	Mathematical form	r^2	Adjusted r^2	Standard error
1	TFR =44.708(CV^{***})-3.699(Sk^{*})+7.724(Ku^{**}) -3.149	0.900	0.870	0.181
2	TFR =31.885(CV^{**})+0.759(Sk) -8.352	0.797	0.760	0.246
3	TFR =28.937(CV^{**})+2.768(Ku) -4.247	0.854	0.817	0.215
4	TFR =2.191(Sk)+2.402(Ku)+4.181	0.653	0.590	0.322
5	TFR=38.717(CV^{***})-10.381	0.787	0.769	0.241
6	TFR =3.624(Sk^{***})+1.350	0.640	0.610	0.313
7	TFR =6.559(Ku^{***})+9.157	0.609	0.576	0.327

*=p<0.05, **=p<0.01, ***=p<0.001

Coefficient of variation (CV)= $\frac{\mu_1'}{\mu_2}$, Skewness (Sk)= $\frac{\mu_3}{\mu_2^{3/2}}$ and Kurtosis (Ku)= $\frac{\mu_4}{\mu_2^2}-3$

Table 3. Correlation between Observed and Predicted Value of TFR (c^2)
RMSE, ρ_v^2 and Stability of r^2

Model	c^2	RMSE	ρ_v^2	Shrinkage of r^2	Stability of r^2
1	0.928	0.170	0.788	0.112	0.888
2	0.868	0.222	0.708	0.089	0.911
3	0.900	0.197	0.775	0.079	0.921
4	0.796	0.268	0.566	0.087	0.913
5	0.881	0.228	0.733	0.057	0.943
6	0.783	0.306	0.541	0.099	0.901
7	0.770	0.277	0.518	0.092	0.908

Results and Discussion

Table 2 shows the relationship between TFR and different indicators characterizing the age distribution of currently married reproductive age women. In all models, the regression coefficients are statistically significant but the coefficient of determination is the highest in Model 1. The standard error of r^2 is also the lowest in Model 1. On the other hand, Table 3 presents the correlation between observed and predicted values of TFR (c^2), root mean square error (RMSE), Cross-validity prediction power ρ_v^2 and stability of r^2 for different

Table 4. Observed and Predicted TFR through Various Regression Models for Some Major States of India NFHS-4

States	Observed TFR	Estimated TFR by													
		Model 1		Model 2		Model 3		Model 4		Model 5		Model 6		Model 7	
		estimate	% Diff.	estimate	% Diff.	estimate	% Diff.	estimate	% Diff.	estimate	% Diff.	estimate	% Diff.	estimate	% Diff.
Andhra Pradesh	1.83	1.58	13.72	1.63	10.87	1.62	11.29	1.78	2.97	1.62	11.40	1.82	0.49	1.81	1.04
Bihar	3.41	3.12	8.64	2.75	19.36	2.88	15.49	2.68	21.30	2.75	19.37	2.73	20.03	2.79	18.04
Chhattisgarh	2.23	2.54	-13.69	2.55	-14.44	2.54	-14.02	2.41	-7.89	2.56	-14.58	2.55	-14.17	2.34	-4.74
Gujarat	2.03	1.82	10.17	2.00	1.65	1.90	6.41	1.84	9.40	2.03	0.08	1.97	3.15	1.75	14.02
Haryana	2.05	2.22	-8.44	2.11	-2.88	2.25	-9.83	2.50	-22.05	2.02	1.60	2.55	-24.19	2.60	-26.73
Jharkhand	2.55	2.68	-5.27	2.45	3.89	2.58	-1.00	2.57	-0.78	2.41	5.34	2.62	-2.68	2.66	-4.45
Karnataka	1.80	1.82	-0.85	1.77	1.65	1.81	-0.29	1.94	-7.52	1.75	2.58	1.97	-9.23	2.01	-11.54
Kerala	1.56	1.66	-6.20	1.51	3.36	1.45	7.14	1.30	16.49	1.61	-3.19	1.28	18.11	1.42	9.14
Madhya Pradesh	2.32	2.33	-0.31	2.50	-7.80	2.43	-4.62	2.29	1.29	2.51	-8.26	2.47	-6.61	2.14	7.81
Maharashtra	1.87	2.03	-8.38	2.15	-15.20	2.06	-9.99	1.91	-1.98	2.20	-17.72	2.04	-9.01	1.81	3.16
Odisha	2.05	2.00	2.57	2.18	-6.35	2.09	-1.83	2.00	2.60	2.21	-7.57	2.15	-4.75	1.88	8.46
Punjab	1.62	1.76	-8.53	1.64	-1.27	1.72	-6.30	1.94	-19.59	1.61	0.91	1.93	-19.13	2.07	-27.98
Rajasthan	2.40	2.50	-4.06	2.52	-4.86	2.55	-6.06	2.52	-4.99	2.48	-3.53	2.65	-10.61	2.47	-2.78
Tamil Nadu	1.70	1.77	-3.89	1.65	2.95	1.65	3.10	1.64	3.41	1.69	0.57	1.64	3.53	1.75	-2.67
Telangana	1.78	1.67	6.37	1.83	-2.58	1.86	-4.27	2.16	-21.27	1.75	1.83	2.26	-26.74	2.14	-20.16
Uttarakhand	2.07	2.38	-15.02	2.45	-18.36	2.42	-16.70	2.29	-10.73	2.46	-18.80	2.44	-17.74	2.20	-6.50
Uttar Pradesh	2.74	2.90	-5.82	2.92	-6.51	2.90	-5.95	2.65	3.16	2.93	-6.80	2.84	-3.50	2.53	7.58
West Bengal	1.77	1.67	5.84	1.83	-3.16	1.86	-4.86	2.16	-21.96	1.75	1.28	2.26	-27.46	2.14	-20.84
INDIA	**2.18**	**2.22**	**-1.63**	**2.29**	**-4.83**	**2.26**	**-3.63**	**2.20**	**-1.03**	**2.29**	**-4.90**	**2.33**	**-6.81**	**2.14**	**1.89**

Model 1 and also the root mean square error (RMSE) is the lowest for model 1. Cross validity prediction power ρ_v^2 also suggests that Model 1 is the most powerful among the seven models. However, the shrinkage is the lowest in Model 5 whereas its stability is high in all the seven models. Model 1 shows highest r^2 and ρ_v^2 but the lowest RMSE and shrinkage of the model is high so that its stability is quite low. Ranking all the seven models in terms of five parameters r^2, RMSE, ρ_v^2, shrinkage of r^2 and stability of r^2 the mean rank score has been found to be the lowest in case of Model 5 which means that Model 5 best estimates TFR among the seven models. A comparison of the observed and estimated values of TFR based on different models is given in Table 4. The predicted value of TFR is close to the observed values in case of all models. The percent difference between observed and estimated TFR is also shown in the table. For model 1, 2, 3, 4, 6 and 7, more than half of the states show over estimation in TFR and for Model 5, only 8 states show over estimation. An interesting result from the Table 4 is that all models provide under-estimated TFR for Bihar and over-estimated TFR for Uttarakhand. The possible reason may be the variability in the age distribution of currently married reproductive age women in the two states.

Validation of Model 5

We have used Model 5 to estimate TFR at district level on the basis of the data available from NFHS-4. Moreover, we have also compared TFR estimates for the districts of Uttar Pradesh obtained from Model 5 with the estimates obtained by Jayachandran and Ram (2019) using the *tfr2* SATA module (Schoumaker, 2013) using the data from NFHS-4 and shown in Table 5. It is interesting that there is a good agreement in the results that in 27 districts the difference is less than 10 percent in TFRs. 19 districts have differences in TFRs between 10-20 percent and 12 districts between 20-30 percent. Rest in 11 districts, the TFR differs more than 30 percent. Maximum differences observed in Lucknow, Kanpur Nagar, Rai Bareli, Pratapgarh, Bahraich, Shrawasti and Mahoba. In the appendix estimate of TFR and its standard error (SE) for all districts of India is provided. These estimates may be helpful for programme makers for future planning of intervention programme.

Conclusion

The simple method proposed in this paper, involving first and second moments of the age distribution of currently married reproductive age women, provides fairly reliable estimate of TFR. Data pertaining to the age of currently married reproductive age women is regular collected and maintained at the grassroots level by the health care services providers. This means that the paper proposed can be used to estimate TFR at the grass roots level. This will help measuring and monitoring fertility transition at the local level, the interface with the people.

Table 5. Comparison of TFR in Uttar Pradesh

Districts	Estimated TFR		Absolute Percent difference
	Jaychandran & Ram (2019)	Model 5	
Kanpur Dehat	2.54	2.53	0.29
Chitrakoot	3.36	3.38	0.61
Bulandshahar	2.92	2.94	0.71
Etah	3.02	2.99	0.94
Saharanpur	2.72	2.69	1.13
Aligarh	2.85	2.90	1.83
Kaushambi	3.27	3.37	3.21
Basti	3.01	3.12	3.59
Kannauj	3.06	2.94	3.96
Lalitpur	2.31	2.40	4.08
Agra	2.80	2.92	4.34
Sant Ravidas	3.00	2.87	4.38

Nagar			
Chandauli	2.75	2.89	5.11
Barabanki	2.60	2.76	6.17
Sant Kabir Nagar	3.05	3.24	6.33
Mirzapur	2.91	2.72	6.69
Hardoi	3.03	2.81	7.39
Pilibhit	2.73	2.95	8.15
Auraiya	2.60	2.38	8.28
Banda	2.67	2.89	8.39
Moradabad	2.95	3.20	8.47
Rampur	2.94	3.19	8.55
Juanpur	2.72	2.95	8.61
Ghaziabad	2.42	2.64	8.97
Siddhartha Nagar	3.41	3.08	9.59
Sonbhadra	2.83	2.55	9.88
JP Nagar	2.95	3.24	9.96
Farrukhabad	3.24	2.90	10.64
Gonda	3.31	2.96	10.71
Muzaffarnagar	3.10	2.74	11.56
Mathura	2.88	3.22	11.66
Kushinagar	3.00	3.37	12.36
Allahabad	2.46	2.78	12.85
Bijnor	2.74	3.09	12.92
Ballia	2.84	3.23	13.62
Shahjahanpur	3.48	2.99	14.02
Etawah	2.51	2.87	14.46
Unnao	2.74	3.14	14.77
Ghazipur	2.80	3.22	14.96
Budaun	3.73	3.12	16.32
Mahrajganj	2.82	3.29	16.61
Firozabad	2.78	3.26	17.10
Varanasi	2.22	2.60	17.29
Meerut	2.27	2.72	19.86
Mainpuri	2.69	3.23	19.92
Balrampur	3.38	2.71	19.94
Sitapur	3.32	2.62	21.02
Gautam Buddha Nagar	2.61	2.06	21.21
Kheri	3.38	2.62	22.44
Faizabad	2.63	3.25	23.74
Mau	2.66	3.30	24.20
Deoria	2.43	3.02	24.34
Fatehpur	2.32	2.90	24.95
Sultanpur	2.74	3.42	24.97
Gorakhpur	2.38	2.98	25.04
Hamirpur	2.34	2.93	25.25
Jalaun	2.00	2.56	27.80
Ambedkar Nagar	2.36	3.07	29.99
Azamgarh	2.45	3.19	30.04
Jhansi	2.05	2.67	30.39
Baghpat	2.24	2.92	30.41
Bareilly	2.52	3.34	32.68
Pratapgarh	2.30	3.15	37.10
Rae Bareli	2.48	3.43	38.19
Kanpur Nagar	1.64	2.32	41.73
Mahoba	2.43	3.51	44.27
Bahraich	4.22	2.22	47.51
Lucknow	1.58	2.33	47.69

Shrawasti	4.40	2.27	48.32
Uttar Pradesh	**3.30**	**2.93**	**11.21**

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Appendix

Table 6. Estimated TFR for all districts of India and Standard Error (SE) using Model 5

States	Districts	Estimated TFR	SE
India	**Total**	**2.29**	**0.071**
Andaman and Nicobar Islands	Nicobars	1.44	0.116
	North & Middle Andaman	1.77	0.079
	South Andaman	1.30	0.134
	Total	**1.51**	**0.107**
Andhra Pradesh	Srikakulam	1.69	0.088
	Vizianagaram	1.64	0.093
	Visakhapatnam	1.65	0.091
	East Godavari	1.58	0.099
	West Godavari	1.65	0.091
	Krishna	1.70	0.086
	Guntur	1.43	0.117
	Prakasam	1.96	0.067
	Sri Potti Sriramulu Nellore	1.94	0.068
	Y.S.R.	1.54	0.103
	Kurnool	1.54	0.104
	Anantapur	1.10	0.161
	Chittoor	1.53	0.105
	Total	**1.62**	**0.095**
Arunachal Pradesh	Tawang	1.78	0.079
	West Kameng	1.71	0.085
	East Kameng	2.16	0.065
	Papumpare	1.87	0.072
	Upper Subansiri	1.89	0.071
	West Siang	1.64	0.092
	East Siang	1.35	0.127
	Upper Siang	1.74	0.083
	Changlang	1.76	0.081
	Tirap	1.95	0.068
	Lower Subansiri	1.80	0.077
	Kurung Kumey	1.97	0.067
	Dibang Valley	1.70	0.087
	Lower Dibang Valley	1.76	0.081
	Lohit	2.28	0.071
	Anjaw	1.53	0.105
	Total	**1.87**	**0.072**
Assam	Kokrajhar	2.04	0.065
	Dhubri	2.10	0.064
	Goalpara	2.17	0.066
	Barpeta	2.53	0.093
	Morigaon	2.53	0.093
	Nagaon	2.43	0.083
	Sonitpur	1.93	0.068
	Lakhimpur	1.92	0.069
	Dhemaji	2.08	0.064
	Tinsukia	2.10	0.064
	Dibrugarh	1.82	0.075
	Sivasagar	1.55	0.103
	Jorhat	2.12	0.065
	Golaghat	1.91	0.070
	Karbi Anglong	1.61	0.095
	Dima Hasao	1.65	0.091
	Cachar	2.21	0.067
	Karimganj	2.32	0.073
	Hailakandi	2.65	0.107
	Bongaigaon	2.00	0.066
	Chirang	1.72	0.084
	Kamrup	1.65	0.092
	Kamrup Metropolitan	1.31	0.133
	Nalbari	2.04	0.065
	Baksa	1.49	0.110
	Darrang	2.89	0.137
	Udalguri	2.01	0.065

	Total	**2.04**	**0.065**
Bihar	Pashchim Champaran	2.05	0.065
	Purba Champaran	2.53	0.093
	Sheohar	3.03	0.156
	Sitamarhi	3.03	0.156
	Madhubani	2.12	0.065
	Supaul	2.54	0.094
	Araria	2.57	0.098
	Kishanganj	2.93	0.142
	Purnia	2.63	0.104
	Katihar	2.22	0.068
	Madhepura	2.19	0.066
	Saharsa	2.91	0.139
	Darbhanga	2.59	0.100
	Muzaffarpur	3.07	0.162
	Gopalganj	2.69	0.112
	Siwan	2.58	0.099
	Saran	2.71	0.114
	Vaishali	2.41	0.081
	Samastipur	2.70	0.114
	Begusarai	3.09	0.164
	Khagaria	2.46	0.086
	Bhagalpur	2.66	0.108
	Banka	2.56	0.096
	Munger	2.89	0.137
	Lakhisarai	2.76	0.120
	Sheikhpura	2.82	0.128
	Nalanda	2.66	0.109
	Patna	2.58	0.098
	Bhojpur	3.27	0.190
	Buxar	2.66	0.108
	Kaimur (Bhabua)	2.67	0.109
	Rohtas	2.96	0.147
	Aurangabad	3.00	0.153
	Gaya	3.17	0.176
	Nawada	3.22	0.182
	Jamui	2.78	0.123
	Jehanabad	2.96	0.146
	Arwal	3.06	0.160
	Total	**2.74**	**0.118**
Chandigarh	Chandigarh	1.80	0.077
	Total	**1.80**	**0.077**
Chhattisgarh	Korea (Koriya)	2.26	0.070
	Surguja	2.29	0.071
	Jashpur	1.89	0.071
	Raigarh	2.42	0.082
	Korba	2.58	0.098
	Janjgir - Champa	3.29	0.193
	Bilaspur	2.79	0.124
	Kabirdham	3.19	0.178
	Rajnandgaon	2.70	0.113
	Durg	2.48	0.088
	Raipur	2.51	0.090
	Mahasamund	2.84	0.131
	Dhamtari	2.78	0.123
	Uttar Bastar Kanker	2.55	0.095
	Bastar	2.05	0.065
	Narayanpur	2.49	0.089
	Dakshin Bastar Dantewada	2.06	0.064
	Bijapur	2.63	0.105
	Total	**2.56**	**0.096**
Dadra and Nagar Haveli	Dadra & Nagar Haveli	1.83	0.075
	Total	**1.83**	**0.075**
Daman and Diu	Diu	2.28	0.071
	Daman	1.08	0.164
	Total	**1.78**	**0.079**
Goa	North Goa	1.36	0.126
	South Goa	1.72	0.084
	Total	**1.53**	**0.105**
Gujarat	Kachchh	2.21	0.067

	Banaskantha	2.77	0.121
	Patan	1.94	0.068
	Mahesana	2.10	0.064
	Sabarkantha	2.46	0.086
	Gandhinagar	1.60	0.097
	Ahmadabad	1.68	0.088
	Surendranagar	2.11	0.065
	Rajkot	1.49	0.110
	Jamnagar	1.61	0.096
	Porbandar	1.83	0.075
	Junagadh	1.98	0.066
	Amreli	2.04	0.065
	Bhavnagar	2.16	0.065
	Anand	1.96	0.067
	Kheda	2.21	0.067
	Panchmahal	2.06	0.065
	Dohad	2.46	0.086
	Vadodara	2.04	0.065
	Narmada	2.26	0.070
	Bharuch	1.93	0.068
	The Dangs	2.29	0.072
	Navsari	1.55	0.102
	Valsad	1.72	0.084
	Surat	1.46	0.113
	Tapi	2.03	0.065
	Total	**2.02**	**0.065**
Haryana	Panchkula	1.44	0.116
	Ambala	1.88	0.071
	Yamunanagar	1.87	0.072
	Kurukshetra	1.74	0.083
	Kaithal	1.94	0.068
	Karnal	1.71	0.085
	Panipat	1.40	0.121
	Sonipat	1.92	0.069
	Jind	2.00	0.066
	Fatehabad	1.94	0.068
	Sirsa	1.81	0.077
	Hisar	2.44	0.084
	Bhiwani	2.47	0.087
	Rohtak	2.08	0.064
	Jhajjar	1.55	0.103
	Mahendragarh	2.58	0.099
	Rewari	1.88	0.071
	Gurgaon	1.17	0.152
	Mewat	3.03	0.156
	Faridabad	2.37	0.077
	Palwal	2.43	0.083
	Total	**2.02**	**0.065**
Himachal Pradesh	Chamba	2.06	0.065
	Kangra	0.99	0.176
	Lahul and Spiti	0.65	0.225
	Kullu	1.66	0.090
	Mandi	1.14	0.155
	Hamirpur	1.57	0.100
	Una	1.62	0.095
	Bilaspur	1.16	0.153
	Solan	1.26	0.140
	Sirmaur	1.90	0.070
	Shimla	1.21	0.146
	Kinnaur	1.52	0.106
	Total	**1.46**	**0.114**
Jammu and Kashmir	Kupwara	2.10	0.064
	Badgam	1.99	0.066
	Leh	0.67	0.222
	Kargil	1.91	0.069
	Punch	2.97	0.149
	Rajouri	2.38	0.078
	Kathua	2.17	0.066
	Baramula	1.96	0.067
	Bandipore	2.19	0.066
	Srinagar	1.08	0.164

	Ganderbal	1.78	0.079
	Pulwama	1.24	0.142
	Shupiyan	1.96	0.067
	Anantnag	1.70	0.086
	Kulgam	2.47	0.087
	Doda	2.45	0.085
	Ramban	2.29	0.071
	Kishtwar	2.16	0.065
	Udhampur	2.21	0.067
	Reasi	2.38	0.078
	Jammu	1.53	0.105
	Samba	1.31	0.132
	Total	**2.03**	**0.065**
Jharkhand	Garhwa	2.88	0.136
	Chatra	2.20	0.067
	Kodarma	2.47	0.087
	Giridih	2.57	0.098
	Deoghar	1.74	0.083
	Godda	2.06	0.065
	Sahibganj	2.26	0.070
	Pakur	2.80	0.126
	Dhanbad	2.38	0.079
	Bokaro	2.68	0.110
	Lohardaga	2.91	0.140
	Purbi Singhbhum	1.69	0.087
	Palamu	2.55	0.096
	Latehar	2.53	0.093
	Hazaribagh	2.69	0.112
	Ramgarh	2.52	0.092
	Dumka	1.91	0.069
	Jamtara	2.41	0.081
	Ranchi	2.46	0.086
	Khunti	2.40	0.080
	Gumla	2.88	0.136
	Simdega	1.94	0.068
	Pashchimi Singhbhum	2.30	0.072
	Saraikela Kharsawan	2.42	0.082
	Total	**2.42**	**0.082**
Karnataka	Belgaum	1.71	0.086
	Bagalkot	2.30	0.072
	Bijapur	1.39	0.122
	Bidar	2.58	0.098
	Raichur	1.76	0.081
	Koppal	1.89	0.071
	Gadag	2.18	0.066
	Dharwad	1.67	0.089
	Uttara Kannada	1.75	0.081
	Haveri	1.68	0.088
	Bellary	1.74	0.083
	Chitradurga	1.92	0.069
	Davanagere	1.87	0.072
	Shimoga	1.44	0.115
	Udupi	1.47	0.113
	Chikmagalur	1.69	0.087
	Tumkur	1.15	0.154
	Bangalore	0.91	0.187
	Mandya	1.58	0.099
	Hassan	1.15	0.154
	Dakshina Kannada	1.49	0.109
	Kodagu	1.56	0.101
	Mysore	1.48	0.112
	Chamarajanagar	1.63	0.094
	Gulbarga	1.87	0.072
	Yadgir	2.27	0.071
	Kolar	1.90	0.070
	Chikkaballapura	1.65	0.092
	Bangalore Rural	1.75	0.082
	Ramanagara	1.50	0.108
	Total	**1.76**	**0.081**
Kerala	Kasaragod	1.34	0.129
	Kannur	1.43	0.118

	Wayanad	1.78	0.078
	Kozhikode	2.03	0.065
	Malappuram	2.02	0.065
	Palakkad	1.75	0.081
	Thrissur	1.72	0.084
	Ernakulam	1.79	0.078
	Idukki	1.66	0.091
	Kottayam	1.58	0.099
	Alappuzha	1.39	0.122
	Pathanamthitta	1.02	0.173
	Kollam	0.93	0.184
	Thiruvananthapuram	1.54	0.103
	Total	**1.61**	**0.096**
Lakshadweep	Lakshadweep	1.08	0.164
	Total	**1.08**	**0.164**
Madhya Pradesh	Sheopur	2.71	0.114
	Morena	2.44	0.084
	Bhind	2.28	0.071
	Gwalior	2.55	0.096
	Datia	2.31	0.073
	Shivpuri	2.67	0.109
	Tikamgarh	2.28	0.071
	Chhatarpur	2.80	0.126
	Panna	3.01	0.153
	Sagar	2.43	0.083
	Damoh	2.63	0.104
	Satna	2.85	0.131
	Rewa	3.10	0.165
	Umaria	2.68	0.110
	Neemuch	2.02	0.065
	Mandsaur	1.84	0.074
	Ratlam	1.98	0.066
	Ujjain	2.14	0.065
	Shajapur	2.16	0.065
	Dewas	2.23	0.068
	Dhar	2.16	0.065
	Indore	1.86	0.072
	Khargone (West Nimar)	3.31	0.196
	Barwani	2.92	0.142
	Rajgarh	2.61	0.102
	Vidisha	2.36	0.077
	Bhopal	2.34	0.075
	Sehore	2.59	0.100
	Raisen	2.60	0.101
	Betul	2.65	0.107
	Harda	2.58	0.099
	Hoshangabad	2.60	0.101
	Katni	2.82	0.128
	Jabalpur	2.22	0.068
	Narsimhapur	2.00	0.066
	Dindori	2.40	0.080
	Mandla	2.03	0.065
	Chhindwara	2.54	0.095
	Seoni	2.69	0.111
	Balaghat	2.31	0.073
	Guna	2.75	0.119
	Ashoknagar	2.60	0.101
	Shahdol	2.41	0.081
	Anuppur	2.73	0.117
	Sidhi	2.88	0.136
	Singrauli	3.03	0.157
	Jhabua	2.29	0.072
	Alirajpur	3.05	0.159
	Khandwa (East Nimar)	2.91	0.139
	Burhanpur	2.65	0.106
	Total	**2.51**	**0.091**
Maharashtra	Nandurbar	2.16	0.065
	Dhule	2.30	0.072
	Jalgaon	1.96	0.067
	Buldana	1.99	0.066
	Akola	2.62	0.103

	Washim	1.97	0.066
	Amravati	1.95	0.067
	Wardha	1.73	0.083
	Nagpur	1.77	0.080
	Bhandara	1.99	0.066
	Gondiya	1.58	0.099
	Gadchiroli	2.20	0.067
	Chandrapur	1.61	0.095
	Yavatmal	1.88	0.071
	Nanded	1.82	0.076
	Hingoli	2.09	0.064
	Parbhani	1.93	0.068
	Jalna	2.13	0.065
	Aurangabad	1.79	0.078
	Nashik	2.11	0.065
	Thane	2.08	0.064
	Mumbai Suburban	2.02	0.065
	Mumbai	2.11	0.065
	Raigarh	1.73	0.084
	Pune	1.53	0.105
	Ahmadnagar	1.44	0.116
	Bid	1.93	0.068
	Latur	2.44	0.084
	Osmanabad	2.08	0.064
	Solapur	1.99	0.066
	Satara	1.96	0.067
	Ratnagiri	1.73	0.083
	Sindhudurg	1.70	0.086
	Kolhapur	1.52	0.106
	Sangli	1.55	0.103
	Total	**1.97**	**0.067**
Manipur	Senapati	2.15	0.065
	Tamenglong	1.62	0.095
	Churachandpur	1.99	0.066
	Bishnupur	1.76	0.080
	Thoubal	2.11	0.065
	Imphal West	1.32	0.132
	Imphal East	1.43	0.117
	Ukhrul	1.99	0.066
	Chandel	1.69	0.087
	Total	**1.75**	**0.081**
Meghalaya	West Garo Hills	2.41	0.081
	East Garo Hills	2.65	0.107
	South Garo Hills	3.18	0.177
	West Khasi Hills	2.63	0.105
	Ribhoi	2.69	0.112
	East Khasi Hills	2.14	0.065
	Jaintia Hills	2.57	0.097
	Total	**2.58**	**0.098**
Mizoram	Mamit	1.68	0.089
	Kolasib	1.43	0.117
	Aizawl	1.89	0.071
	Champhai	1.78	0.078
	Serchhip	1.23	0.144
	Lunglei	1.58	0.099
	Lawngtlai	1.94	0.068
	Saiha	2.07	0.064
	Total	**1.70**	**0.087**
Nagaland	Mon	2.15	0.065
	Mokokchung	1.10	0.161
	Zunheboto	2.50	0.090
	Wokha	1.49	0.110
	Dimapur	1.81	0.076
	Phek	1.99	0.066
	Tuensang	1.47	0.113
	Longleng	1.59	0.098
	Kiphire	2.09	0.064
	Kohima	1.70	0.087
	Peren	1.87	0.072
	Total	**1.87**	**0.072**
Delhi	North West	1.79	0.078

	North	2.00	0.066
	North East	2.12	0.065
	East	1.54	0.104
	New Delhi	2.47	0.087
	Central	1.92	0.069
	West	1.67	0.089
	South West	1.73	0.083
	South	2.11	0.065
	Total	**1.93**	**0.068**
Odisha	Bargarh	1.98	0.066
	Jharsuguda	2.14	0.065
	Sambalpur	1.80	0.077
	Debagarh	1.52	0.107
	Sundargarh	2.40	0.080
	Kendujhar	2.10	0.064
	Mayurbhanj	2.08	0.064
	Baleshwar	2.02	0.065
	Bhadrak	1.88	0.072
	Kendrapara	1.90	0.070
	Jagatsinghapur	2.15	0.065
	Cuttack	1.40	0.121
	Jajapur	2.07	0.064
	Dhenkanal	1.79	0.078
	Anugul	2.02	0.065
	Nayagarh	1.91	0.069
	Khordha	1.88	0.071
	Puri	2.00	0.066
	Ganjam	2.32	0.073
	Gajapati	2.23	0.068
	Kandhamal	2.98	0.150
	Baudh	2.78	0.123
	Subarnapur	2.02	0.065
	Balangir	2.56	0.096
	Nuapada	2.80	0.126
	Kalahandi	2.31	0.073
	Rayagada	2.79	0.124
	Nabarangapur	2.82	0.128
	Koraput	2.65	0.107
	Malkangiri	2.17	0.066
	Total	**2.21**	**0.067**
Puducherry	Yanam	1.77	0.080
	Puducherry	1.80	0.077
	Mahe	1.15	0.153
	Karaikal	1.85	0.073
	Total	**1.71**	**0.086**
Punjab	Gurdaspur	1.45	0.115
	Kapurthala	2.22	0.068
	Jalandhar	1.51	0.108
	Hoshiarpur	1.65	0.091
	Sangrur	1.41	0.120
	Fatehgarh Sahib	1.49	0.109
	Ludhiana	1.46	0.113
	Moga	1.89	0.070
	Firozpur	1.76	0.080
	Muktsar	1.06	0.167
	Faridkot	1.53	0.105
	Bathinda	1.73	0.083
	Mansa	1.77	0.080
	Patiala	1.33	0.129
	Amritsar	1.91	0.069
	Tarn Taran	1.56	0.102
	Rupnagar	1.39	0.123
	SAS Nagar	1.05	0.168
	SBS Nagar	1.75	0.081
	Barnala	1.79	0.078
	Total	**1.60**	**0.097**
Rajasthan	Ganganagar	2.33	0.074
	Hanumangarh	1.87	0.072
	Bikaner	2.53	0.094
	Churu	2.52	0.092
	Jhunjhunun	2.70	0.113

	Alwar	2.19	0.066
	Bharatpur	2.67	0.109
	Dhaulpur	2.93	0.142
	Karauli	3.45	0.216
	Sawai Madhopur	2.78	0.123
	Dausa	2.96	0.147
	Jaipur	2.18	0.066
	Sikar	2.51	0.090
	Nagaur	2.95	0.146
	Jodhpur	2.38	0.078
	Jaisalmer	1.82	0.075
	Barmer	2.30	0.072
	Jalor	2.55	0.095
	Sirohi	2.29	0.071
	Pali	2.99	0.150
	Ajmer	2.35	0.076
	Tonk	2.79	0.124
	Bundi	2.61	0.102
	Bhilwara	2.49	0.089
	Rajsamand	2.46	0.086
	Dungarpur	2.66	0.108
	Banswara	2.33	0.074
	Chittaurgarh	1.69	0.087
	Kota	2.04	0.065
	Baran	2.77	0.122
	Jhalawar	2.24	0.069
	Udaipur	2.47	0.087
	Pratapgarh	2.37	0.078
	Total	**2.48**	**0.088**
Sikkim	North District	1.89	0.071
	West District	2.03	0.065
	South District	1.98	0.066
	East District	1.13	0.156
	Total	**1.65**	**0.091**
Tamil Nadu	Thiruvallur	2.19	0.066
	Chennai	1.19	0.148
	Kancheepuram	1.46	0.113
	Vellore	1.59	0.099
	Tiruvannamalai	1.71	0.085
	Viluppuram	1.66	0.090
	Salem	2.50	0.090
	Namakkal	1.65	0.092
	Erode	2.46	0.086
	The Nilgiris	1.89	0.071
	Dindigul	1.68	0.088
	Karur	1.56	0.101
	Tiruchirappalli	1.45	0.115
	Perambalur	2.07	0.064
	Ariyalur	1.15	0.154
	Cuddalore	1.63	0.094
	Nagapattinam	1.76	0.080
	Thiruvarur	0.95	0.181
	Thanjavur	1.90	0.070
	Pudukkottai	1.17	0.152
	Sivaganga	1.45	0.115
	Madurai	0.99	0.176
	Theni	1.57	0.100
	Virudhunagar	1.51	0.108
	Ramanathapuram	1.61	0.096
	Thoothukkudi	1.38	0.123
	Tirunelveli	1.55	0.102
	Kanniyakumari	1.11	0.160
	Dharmapuri	2.30	0.072
	Krishnagiri	2.23	0.068
	Coimbatore	2.02	0.065
	Tiruppur	1.79	0.078
	Total	**1.69**	**0.088**
Tripura	West Tripura	1.61	0.096
	South Tripura	1.95	0.067
	Dhalai	1.95	0.067
	North Tripura	2.18	0.066

	Total	**1.86**	**0.072**
Uttar Pradesh	Saharanpur	2.69	0.112
	Muzaffarnagar	2.74	0.118
	Bijnor	3.09	0.165
	Moradabad	3.20	0.180
	Rampur	3.19	0.179
	Jyotiba Phule Nagar	3.24	0.186
	Meerut	2.72	0.115
	Baghpat	2.92	0.141
	Ghaziabad	2.64	0.105
	Gautam Buddha Nagar	2.06	0.065
	Bulandshahr	2.94	0.144
	Aligarh	2.90	0.139
	Mahamaya Nagar	2.84	0.131
	Mathura	3.22	0.182
	Agra	2.92	0.141
	Firozabad	3.26	0.188
	Mainpuri	3.23	0.183
	Budaun	3.12	0.169
	Bareilly	3.34	0.200
	Pilibhit	2.95	0.146
	Shahjahanpur	2.99	0.151
	Kheri	2.62	0.103
	Sitapur	2.62	0.104
	Hardoi	2.81	0.126
	Unnao	3.14	0.172
	Lucknow	2.33	0.075
	Rae Bareli	3.43	0.212
	Farrukhabad	2.90	0.138
	Kannauj	2.94	0.144
	Etawah	2.87	0.135
	Auraiya	2.38	0.079
	Kanpur Dehat	2.53	0.093
	Kanpur Nagar	2.32	0.074
	Jalaun	2.56	0.096
	Jhansi	2.67	0.110
	Lalitpur	2.40	0.081
	Hamirpur	2.93	0.143
	Mahoba	3.29	0.192
	Banda	2.89	0.138
	Chitrakoot	3.38	0.205
	Fatehpur	2.90	0.138
	Pratapgarh	3.15	0.173
	Kaushambi	3.37	0.204
	Allahabad	2.78	0.122
	Bara Banki	2.76	0.120
	Faizabad	3.25	0.187
	Ambedkar Nagar	3.07	0.161
	Sultanpur	3.42	0.211
	Bahraich	2.22	0.067
	Shrawasti	2.27	0.071
	Balrampur	2.71	0.114
	Gonda	2.96	0.146
	Siddharth Nagar	3.08	0.163
	Basti	3.12	0.168
	Sant Kabir Nagar	3.24	0.186
	Mahrajganj	3.51	0.223
	Gorakhpur	2.98	0.149
	Kushinagar	3.37	0.204
	Deoria	3.02	0.155
	Azamgarh	3.19	0.178
	Mau	3.30	0.194
	Ballia	3.23	0.183
	Jaunpur	2.95	0.146
	Ghazipur	3.22	0.182
	Chandauli	2.89	0.137
	Varanasi	2.60	0.101
	Bhadohi (SRN)	2.87	0.134
	Mirzapur	2.72	0.115
	Sonbhadra	2.55	0.095
	Etah	2.99	0.151

	Kanshiram Nagar	3.19	0.178
	Total	**2.93**	**0.142**
Uttarakhand	Uttarkashi	2.33	0.075
	Chamoli	2.02	0.065
	Rudraprayag	2.41	0.081
	Tehri Garhwal	2.28	0.071
	Dehradun	2.09	0.064
	Garhwal	2.82	0.128
	Pithoragarh	1.87	0.072
	Bageshwar	2.48	0.088
	Almora	2.69	0.111
	Champawat	2.65	0.107
	Nainital	2.29	0.072
	Udham Singh Nagar	2.42	0.082
	Hardwar	2.96	0.147
	Total	**2.46**	**0.085**
West Bengal	Darjiling	2.14	0.065
	Jalpaiguri	2.46	0.086
	Koch Bihar	2.24	0.069
	Uttar Dinajpur	3.19	0.179
	Dakshin Dinajpur	2.74	0.118
	Maldah	2.21	0.067
	Murshidabad	2.21	0.067
	Birbhum	2.34	0.075
	Barddhaman	2.03	0.065
	Nadia	2.02	0.065
	North 24 Parganas	1.67	0.090
	Hugli	1.78	0.079
	Bankura	2.22	0.068
	Puruliya	2.08	0.064
	Haora	2.13	0.065
	Kolkata	1.62	0.094
	South 24 Parganas	2.71	0.114
	Paschim Medinipur	2.65	0.107
	Purba Medinipur	1.99	0.066
	Total	**2.27**	**0.070**
Telangana	Adilabad	1.96	0.067
	Nizamabad	1.67	0.089
	Karimnagar	1.58	0.099
	Medak	1.75	0.081
	Hyderabad	1.67	0.090
	Rangareddy	1.46	0.113
	Mahbubnagar	1.53	0.105
	Nalgonda	2.16	0.065
	Warangal	1.64	0.093
	Khammam	2.00	0.066
	Total	**1.75**	**0.082**