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Understanding Fertility Trends in India through Relational Gompertz Model

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Abstract

Population growth is the increase in the number of people in a population mainly due to births. Fertility analysis studies about the births of child is one of the most significant parts of the population growth. The study of fertility plays an important role to know the current scenario of marital fertility and population growth. In this paper, an indirect technique, Relational Gompertz method have been used to estimate the fertility pattern through age-specific marital fertility rate (ASMFR) and total marital fertility rate (TMFR) by using the data of mean number of children ever born or average parities for India and its most populous state Uttar Pradesh. It is observed that the ASMFR is found to be lower for India with respect to Uttar Pradesh from NFHS-I to IV which is also detected in the investigation according to residence and religion. It is noticed that the peak of marital fertility is shifted from 20-24 & 25-29 age-group to 25-29 & 30-34 age-group respectively, in India as well as in Uttar Pradesh, which also confirms through graphical investigation. The age at first birth is also increasing over time (NFHS-I to IV) and the distribution of marital fertility is narrowing over time as well.

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Introduction

The National Family Health Survey (NFHS) and the Sample Registration System (SRS) have provided data showing that fertility

is dropping in India, but at a slower rate than that had been expected. The crude birth rate (CBR) is declining to 19 and 22.6 births per 1000 people in NFHS-IV (2015-16) from 28.7 and 36 births in NFHS-I (1992-1993) for India and Uttar Pradesh respectively. The total fertility rate (TFR) in India and Uttar Pradesh decreased from 3.39 and 4.82 births per woman in her reproductive age in NFHS-I to 2.18 and 2.74 births per woman in her reproductive age in NFHS-IV respectively. CBR and TFR, both falling from NFHS-I to II and NFHS-III to IV. The TFR is also found to be dropping in rural areas as compared to urban areas from NFHS-I to IV and it is also dropping in Hindus in comparison to Muslims. This shows that the pattern and level of fertility is changes over time. In fact, in India, children out of marriage are not allowed so the fertility is much affected by the institution of marriage and age at marriage as well as age at first birth which are increases as level of education is increases. In this paper, we have examined the age pattern of marital fertility using an indirect technique Relational Gompertz method through mean number of children ever born as an input, for India and Uttar Pradesh from NFHS-I to IV.

It is logical to assume that changes in age patterns of fertility and age patterns of marital fertility have contributed to the decline in fertility and marital fertility in India since NFHS-I. However, hardly any attempt has been made to examine how the fertility reduction scheme influenced the age distribution of fertility or marital fertility. The rate of reproduction within marriage was lower in India between 1951 and 1960 rather than it was in Sweden and Finland in the late nineteenth century as a result of the high level of abstinence brought by social taboos and customs, the longer breast-feeding duration, along with other factors (Kumar, 1977). However, there hasn't been an attempt made recently to determine how India's age patterns of marital fertility have shifted and what it implies.

Several variables, such as (1) patterns of marriage (2) patterns of widowhood (3) patterns of divorce and separation (4) the distribution of females in the reproductive ages and (5) the total children ever born, influences the age-related variation in fertility of currently married women. However, the age-related variation in reproduction inside the institution of marriage, which is mainly influenced by the direction of fertility control initiatives, affects the total marital fertility rate (TMFR). The majority of births is concentrated in the early stages of reproductive life of a woman where the usual approach is to restrict the number of births rather than properly spacing between births. When a couple reaches the desired family size, there is an intentional attempt to stop conceiving, allowing marital fertility to fall significantly as women mature and reach their last stage of reproductive years.

There are many studies has been done to examine the pattern of fertility obtaining the total fertility rate (TFR) and age-specific fertility rate (ASFR) using mathematical models in current time and also over the period of time in India. James and Nair (2005) observed the trend of fertility among Hindus and Muslims since 1980s in India. Chaurasia (2010) examines the age pattern of marital fertility through the relational Gompertz model using the data on ASFR from sample registration systems in between 1970 to 2007. Islam (2009) studies Bangladesh fertility using third-degree polynomial model however, Singh et al. (2015) have this model and the fertility pattern for high fertility state Uttar Pradesh using third-degree inverted polynomial model, where they modelled fertility is the function of reciprocal of age instead of age of the women in reproductive age group (15-49 years). Mishra et al. (2017) have obtained the pattern of ASFR through skew-logistic distribution function. Pandey and Kaur (2019) study the variation in fertility pattern in India by fitting the fifth-degree polynomial on the line of Singh et al. (2015). Visalakshi and Geetha (2018) observed the

existing pattern of ASFR and change in fertile age-group by appropriate non-linear models to the ASFR data obtained from sample registration system of India.

Henry (1961) found that the age pattern of fertility within marriage is approximately uniform in the societies where there is relatively little voluntarily or conscious control of conceiving exist. According to Henry, voluntary or intentional regulation of fertility refers to any actions that change as parity increases. He described reproduction which happens naturally, without attentive or voluntary determination, as "natural fertility" and observed that, whereas natural fertility varying between societies, its age pattern remains constant. The scenario in which couples voluntarily want to space between births but have no issue with the final number of children born was excluded in Henry's research. Leridon (1975) developed the concept of "natural fertility" to cover the conditions in which couples are not intentionally try to control or space between their number of births. In order to ensure the health of women and their child as well as the children's survival, couples in Indonesia and Nigeria have been noticed to voluntarily space their pregnancies (Caldwell and Caldwell, 1977). The official family planning programmes in India was founded on enhancing the health of women and their children, rather than reduction in fertility.

Coale and Trussell (1974), based on Henry's research, developed a model that, simplifying the patterns of natural fertility, may explain the fertility experience in the societies where fertility control was experienced voluntarily. The underlying assumption of the model is that marital fertility either follows natural fertility (assuming no aggressive fertility control is employed) or deviates from natural fertility in a predictable manner (United Nations, 1983). This model had been used by Coale and Trussell (1974) to produce a model for the study of fertility schedules that displayed

variations in the age distribution of childbearing in human beings across different levels of fertility. Coale et al. (1975) discuss the use of this model in estimating the fertility measures from the data on children ever born. Many studies have been employed the Coale and Trussell (1974) fertility model's parameter 'm' as a measure of the extent of fertility control (Knodel, 1977; Lavely, 1986). This indicator measures how quickly fertility declines after ages 20 to 24 or how much the age-specific marital fertility curve is concave (Anderson and Silver, 1992).

Brass (1978) proposed a relationship between a "standard" fertility schedule and any alternative fertility schedule to simulate the pattern of fertility. Brass Basically, Brass' method utilizing a Gompertz transformation to linearize the age-specific fertility curve. Brass also developed an adequate standard fertility schedule based on the Coale and Trussell (1974) model fertility schedules to serve as the basis for the execution of his suggested plan. Another "standard" fertility schedule was created by Booth (1984) with keeping high fertility populations in mind. In this study, we estimate the change in the age pattern of marital fertility in India and its most populus state Uttar Pradesh between NFHS-I to IV by using the relational Gompertz method (Brass, 1980). This technique is used by several researchers to estimates the levels and differentials of fertility (Osiemo, 1986; Kabir and Howladar, 1981 and Chaurasia, 2010).

Here, we want to examine how the age pattern of marital fertility has evolved from the pattern that was existing in NFHS-I during 1992-93. The analysis is based on 5-yearly estimates of average parities, in other word the mean number of children ever born to the women of the 5-years age-group such as 15-19, 20-24, …, 45-49 from the NFHS-I, II, III & IV. The consequences of the changes observed in the age distribution of marital fertility in India

and UP are also discussed in the study with regard to declining fertility and stability of the population.

Methodology

An indirect technique namely Relational Gompertz Method has been used to estimate the fertility pattern through age-specific marital fertility rate (ASMFR) and total marital fertility rate (TMFR) using the data of mean number of children ever born or average parities for India and Uttar Pradesh.

Relational Gompertz Model

The application of Gompertz function has been done in 1970s to describe the fertility rates. Brass (1964) used the Gompertz model as a model of fertility to estimate the fertility rates to represent the age-specific fertility rate. Murphy and Nagnur (1972) also describe the cumulative fertility through the Gompertz function. Brass (1980) developed the relational Gompertz method, which is generated from the Brass P/F ratio method by using some modifications. In Brass P/F ratio method, fertility is assumed to be constant but the data obtained from the census or survey cannot fulfilled such assumption, while there is no need of such assumption for relational Gompertz method. So, the relational Gompertz method is used for the analysis of data obtained from survey or census. This method gives an outline for estimating the fertility rates and also used to find the ASFR's and TFR's by regulating the type of fertility obtained by direct methods and measuring the level of fertility using the mean parity (Moultrie, 2013). It overcomes the errors in the fertility data occurred due to under or over-reporting of births. Misreporting of births and ages by elderly women because of memory lapses may be result in errors in fertility data that may be adjusted through the indirect method of fertility (Avery et al., 2013). It also eliminates the errors and exclusions from the parities reported by the lower age-group women (Famule, 2005).

The shape of cumulated Gompertz distribution is sigmoid in nature, on that property the relational Gompertz method is based. Gompertz distribution explained relation between the fertility and average parities very well. A double negative log transformation is used to linearize the distribution due to its property of sigmoid. Here, the Relational Gompertz model used data that is observed on average parities (mean number of children ever born), and this model is a three -parameter model which describe the age pattern of marital fertility very well. The model is expressed as

$$Y(x) = -\ln\left(-\ln\ \frac{F(x)}{F}\right) = \alpha + \beta x \qquad (1)$$

where α is a location, β is a measure of the spread and width of the age-specific marital fertility distribution and F is the cumulative marital fertility rate through the end of childbearing age. $F(x)$ is the cumulated age-specific marital fertility rate to the particular age x. A standard fertility pattern $Y^s(x)$ is generated by Heather Booth (1984) and substituted in equation (1), we get

$$Y(x) = \alpha + \beta\ Y^s(x) \qquad (2)$$

this is the Gompertz method, which keeps the key elements of simplicity and providing a modification over the initial model. Zaba (1981) modify the standard fertility schedule given by Booth which is founding not much appropriate to explain the pattern of childbearing in younger age-group of women. The parameters α and β of the model interpreted as, α is the location of age of fertility schedule and β determines the spread or degree of concentration of fertility schedule (United Nations, 1983). If $\alpha = 0$ and $\beta = 1$ then the age patterns of $Y(x)$ and $Y^s(x)$ are being same.

Using mean parities (P_1) by age of women and total marital fertility F, age-specific marital fertility rate (ASMFR) for 5-year age groups is estimated. If P_i for (45-49) age group is used, it would give F directly. On the other hand, F, α and β have to be estimated by selection of three P_i values based on the knowledge of the age pattern of fertility and accuracy in reporting of children ever born (CEB). Using equation (1) and (2), Z is defined as

$$Z = \frac{\ln P_3 - \ln P_2}{\ln P_2 - \ln P_1} = \frac{e^{-\beta Y^s(2)} - e^{-\beta Y^s(3)}}{e^{-\beta Y^s(1)} - e^{-\beta Y^s(2)}} \tag{3}$$

After identifying the three values of P_i, the middle term of equation (3) can be solved, and the reasonable value of β, is then determined and α is obtained by solving the following equation (4)

$$e^{-\alpha} = \frac{\ln P_3 - \ln P_2}{e^{-\beta Y^s(2)} - e^{-\beta Y^s(3)}} \tag{4}$$

Then F is obtained as

$$F = \exp\left(\ln P_3 + e^{-\alpha} e^{-\beta Y^s(3)}\right) \tag{5}$$

After substituting the estimates of α and β, $Y(x)$ can be derived as

$$\hat{Y}(x) = \alpha + \beta\, Y^s(x) \tag{6}$$

$\hat{Y}(x)$ value thus obtained can be converted into $\frac{F(x)}{F}$ as

$$\frac{F(x)}{F} = \exp\left(-e^{-\hat{Y}(x)}\right) \tag{7}$$

And hence age-specific fertility rate can be derived from $\frac{F(x+n)-F(x)}{n}$, where n is the length of age interval taken as usually in 5 years. The three values of P_i, that seems to reasonable corresponding to the age group 15-19, 30-34 and 40-44 are used for the further analysis.

Source of Data

In this paper, we have used the data of various round from NFHS conducted during the 1992-93, 1998-99, 2005-06, 2015-16. These surveys are conducted by Ministry of Health and Family Welfare (MoHFW), Government of India. MoHFW nominated the International Institute for Population Sciences (IIPS), Mumbai, as the nodal agency for the Survey and funded by the Government of India. The data on the birth histories of a woman and their current age is recoded in Women's file named as Individual file. Individual file also contains the data regarding various variable present in the Women's questionnaire for de-facto women with some other variables from the household questionnaire. Here we used the data on children ever born to a woman for the further analysis to estimate the marital fertility through relational Gompertz model for India and its most populous state Uttar Pradesh.

Results and Discussion

The estimates of mean number of children ever-born and age-specific marital fertility rate obtained using the relational Gompertz method for India and Uttar Pradesh for four rounds of NFHS. The estimates of parameters α, β and F (total marital fertility) is also given in table 2 and 3. In Table 1, the observed mean number of children ever born (average parities) is given for India and Uttar Pradesh for four rounds of NFHS. Further we also obtained the age-specific marital fertility rate and the estimates of

parameters for urban and rural areas as well as for Hindus and Muslims for both India and Uttar Pradesh in Table 4, 5, 6 & 7. The explanation of parameters α, β and F is also discussed on the basis of their estimates. The negative value of α indicates that the maximum number of births occur in older ages and positive value indicates that the most of the births occur in younger ages. The value of parameter beta measures the scattered ness of fertility pattern and the value of F specifies the total marital fertility.

From Table 1, for India, we have observed that the mean number of children ever born per woman (average parity) approximately remain same for 15-19, 20-24, 25-29 and 30-34 age group in NFHS-I & II and decreasing with a little amount in NFHS-II from NFHS-I in other age group 35-39, 40-44 and 45-49. But there is sharp decline for 15-19 & 20-24 age group from NFHS-II to NFHS-III and also same behavior is shown in NFHS-IV from NFHS-III and for other age group also a considerable amount of decrement is observed in NFHS-III & IV from NFHS-II & III respectively, which is also observed from Fig. 1. In case of Uttar Pradesh, there is a slight increment in 15-19, 20-24 and 25-29 age group and after that a little decrement is observed in NFHS-II from NFHS-I. From NFHS-II to NFHS-III, mean number of children ever born is declining very sharply for 15-19 and 20-24 age group and the same behavior is also observed in NFHS-IV from NFHS-III, for other age group, a significant decrement is observed, which is also observed from the Fig. 2.

Table 1: Observed Mean Number of Children Ever Born per Women for India and Uttar Pradesh

Age Group	India			
	NFHS I	NFHS II	NFHS III	NFHS IV
15-19	0.60	0.60	0.11	0.05
20-24	1.58	1.59	0.93	0.74
25-29	2.69	2.61	2.05	1.76
30-34	3.54	3.36	2.81	2.50
35-39	4.11	3.83	3.34	2.93
40-44	4.60	4.25	3.65	3.27
45-49	4.96	4.59	3.92	3.52
Uttar Pradesh				
15-19	0.53	0.61	0.12	0.02
20-24	1.57	1.77	1.31	0.67
25-29	3.09	3.20	2.78	2.05
30-34	4.38	4.42	4.06	3.14
35-39	5.10	4.98	4.68	3.80
40-44	5.84	5.61	5.13	4.39
45-49	6.16	5.71	5.35	4.80

Fig. 1: Observed Mean No. of Children Ever Born in India

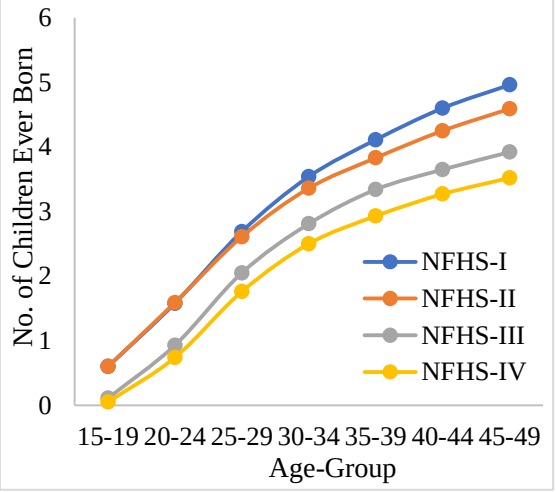
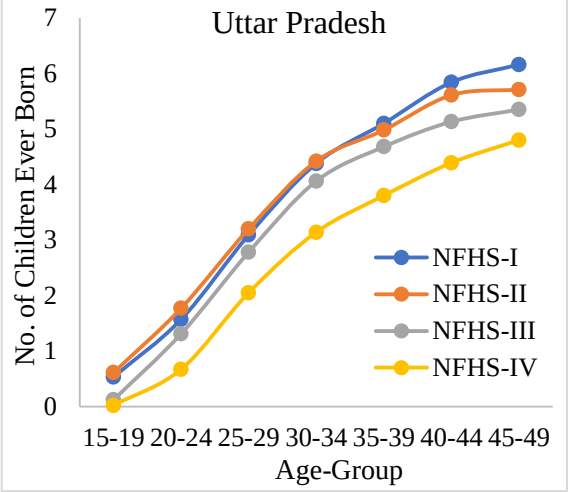


Fig. 2: Observed Mean No. of Children Ever Born in Uttar Pradesh



In Table 2, the ASMFR and marital fertility is obtained from relational Gompertz method using the mean number of children ever born per woman data for India. It is observed that the ASMFR is almost same in NFHS-I & II for 15-19 and 20-24 age group and it is decreasing from NFHS-I to NFHS-II, for other age group. Whereas ASMFR is declining in early age group 15-19 & 20-24 and increasing for 25-29, 30-34 & 35-39 age group in NFHS-III from NFHS-II and it is also declining for 15-19, 20-24 & 25-29 age group from NFHS-III to NFHS-IV and approximately same for the 30-34, 35-39, 40-44 and 45-49 age group in NFHS-III & IV. From Fig. 3, it is observed that the ASMFR is abruptly falls for 15-19 and 20-24 age group in NFHS-III & IV from NFHS-I & II. For age group 25-29 and 30-34 there is a slight increment in NFHS-III & IV from NFHS-I & II and after that age group ASMFR is decreases as age increases. We also observed that the marital fertility is decreasing gradually from NFHS-I to NFHS-IV. The peak of marital fertility is observed for 20-24 age group in NFHS-I & II whereas it is observed for 25-29 age group in NFHS-III & IV. The values of parameter α are found to be negative for all surveys which indicates

that the most of the birth occurring in higher age group or at older ages. The value of parameter β is less than one for NFHS-I & II and more than one for NFHS-III & IV which indicates that the distribution of marital fertility is narrower in NFHS-III & IV than in NFHS-I & II and it is also confirmed from Fig. 4.

Table 2: Age Specific Marital Fertility Rate by Relational Gompertz Model for India

Age Group	NFHS I						
	P_i	$Y_s(x)$	Ln (P_i)	Y(x)	$F(x)/F$	$F(x)$	ASMFR
15-19	0.60	-0.691	-0.511	-0.717	0.129	0.611	0.122
20-24	1.58	0.026	0.457	-0.053	0.348	1.650	0.208
25-29	2.69	0.700	0.990	0.572	0.569	2.692	0.208
30-34	3.54	1.479	1.264	1.293	0.760	3.598	0.181
35-39	4.11	2.626	1.413	2.355	0.909	4.306	0.142
40-44	4.60	4.810	1.526	4.377	0.988	4.675	0.074
45-49	4.96		1.601		1.000	4.734	0.012
	α = -0.0764			β = 0.926		F = 4.734	
	NFHS II						
15-19	0.60	-0.691	-0.511	-0.677	0.140	0.617	0.123
20-24	1.59	0.026	0.464	0.012	0.372	1.641	0.205
25-29	2.61	0.700	0.959	0.659	0.596	2.629	0.198
30-34	3.36	1.479	1.212	1.407	0.783	3.452	0.165
35-39	3.83	2.626	1.343	2.508	0.922	4.066	0.123
40-44	4.25	4.810	1.447	4.604	0.990	4.367	0.060
45-49	4.59		1.524		1.000	4.411	0.009
	α = -0.0130			β = 0.961		F = 4.411	

	NFHS III						
15-19	0.11	-0.691	-2.207	-1.254	0.030	0.121	0.024
20-24	0.93	0.026	-0.073	-0.403	0.224	0.900	0.156
25-29	2.05	0.700	0.718	0.397	0.511	2.053	0.231
30-34	2.81	1.479	1.033	1.322	0.766	3.079	0.205
35-39	3.34	2.626	1.206	2.684	0.934	3.754	0.135
40-44	3.65	4.810	1.295	5.276	0.995	3.999	0.049
45-49	3.92		1.366		1.000	4.020	0.004
	$\alpha =$ -0.4334			$\beta =$ 1.187		$F =$ 4.020	
	NFHS IV						
15-19	0.05	-0.691	-2.996	-1.430	0.015	0.056	0.011
20-24	0.74	0.026	-0.301	-0.528	0.183	0.669	0.123
25-29	1.76	0.700	0.565	0.320	0.484	1.764	0.219
30-34	2.50	1.479	0.916	1.300	0.761	2.776	0.202
35-39	2.93	2.626	1.075	2.743	0.938	3.418	0.129
40-44	3.27	4.810	1.185	5.490	0.996	3.630	0.042
45-49	3.52		1.258		1.000	3.645	0.003
	$\alpha =$ -0.5606			$\beta =$ 1.258		$F =$ 3.645	

Fig. 3: Mean No. of Children Ever-Born for India by Relational Gompertz Method

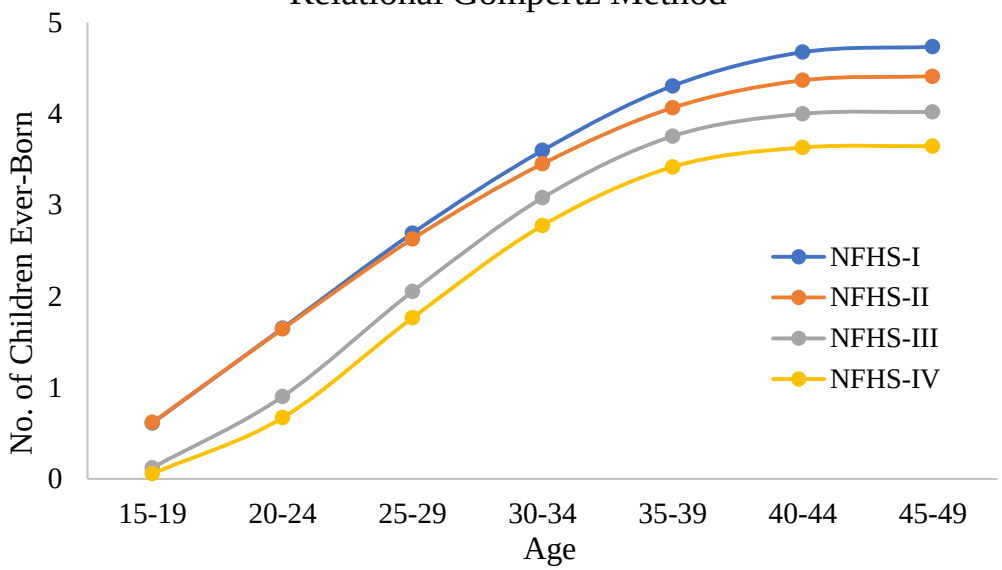
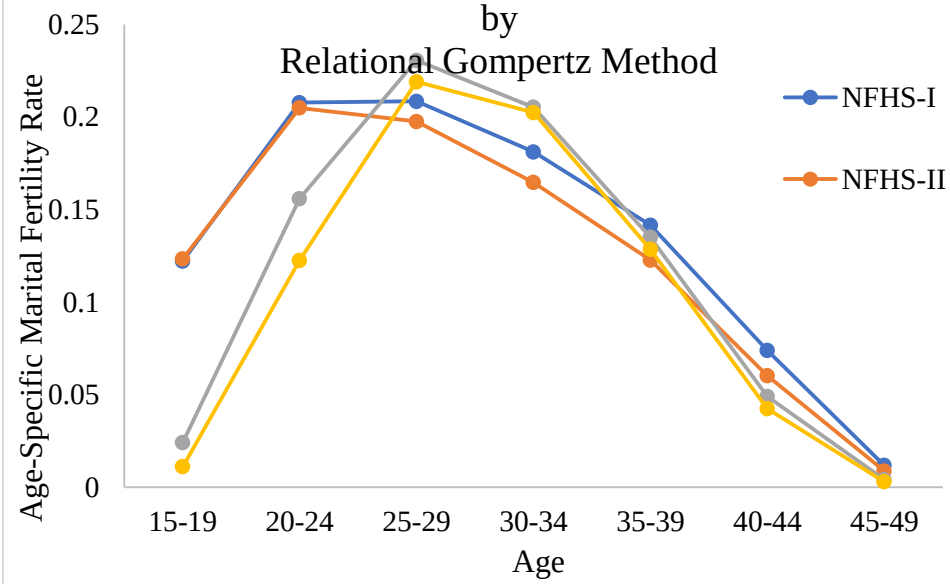


Fig. 4: Age Specific Marital Fertility Rate for India by Relational Gompertz Method



From Table 3, the same result is obtained for Uttar Pradesh, we observed that the ASMFR is increases for 15-19 & 20-24 age group and decreases in NFHS-II from NFHS-I for other age groups. Whereas ASMFR is falling abruptly for 15-19 age group in NFHS-III from NFHS-II and it is increases for 25-29, 30-34 & 35-39 age group from NFHS-II to NFHS-III. In NFHS-IV, it is also declining abruptly for 15-19 & 20-24 age group from NFHS-III and it is decreases for 25-29 and increasing for 30-34, 35-39 & 40-44 age group from NFHS-III. Marital fertility is decreases from NFHS-I to NFHS-IV. The peak of marital fertility is observed for 25-29 age group in NFHS-I, II & III while it is observed for 30-34 age group in NFHS-IV. Fig. 5 confirms the above results. The value of parameter α is negative for all surveys and it indicates that the age at first birth is increases with time. The value of β is less than one for NFHS-I and it is greater than one for other surveys which indicates that the distribution of marital fertility is narrower for NFHS-II, III & IV than NFHS-I and the same result is observed from Fig. 6 also.

Table 3: Age Specific Marital Fertility Rate by Relational Gompertz Model for Uttar Pradesh

Age Group	NFHS I						
	P_i	$Y_s(x)$	Ln (P_i)	Y(x)	$F(x)/F$	$F(x)$	ASMFR
15-19	0.53	-0.691	-0.635	-0.881	0.090	0.523	0.105
20-24	1.57	0.026	0.451	-0.192	0.298	1.739	0.243
25-29	3.09	0.700	1.128	0.456	0.531	3.100	0.272
30-34	4.38	1.479	1.477	1.204	0.741	4.328	0.246
35-39	5.10	2.626	1.629	2.307	0.905	5.288	0.192
40-44	5.84	4.810	1.765	4.405	0.988	5.771	0.097
45-49	6.16		1.818		1.000	5.842	0.014
	$\alpha =$ -0.2167			$\beta =$ 0.961		$F =$ 5.842	

	NFHS II						
15-19	0.61	-0.691	-0.494	-0.801	0.108	0.593	0.119
20-24	1.77	0.026	0.571	-0.074	0.341	1.877	0.257
25-29	3.20	0.700	1.163	0.609	0.581	3.200	0.265
30-34	4.42	1.479	1.486	1.399	0.781	4.306	0.221
35-39	4.98	2.626	1.605	2.562	0.926	5.102	0.159
40-44	5.61	4.810	1.725	4.777	0.992	5.465	0.073
45-49	5.71		1.742		1.000	5.511	0.009
	$\alpha =$ -0.1004			$\beta =$ 1.014		$F =$ 5.511	
	NFHS III						
15-19	0.12	-0.691	-2.120	-1.324	0.023	0.123	0.025
20-24	1.31	0.026	0.270	-0.412	0.221	1.165	0.208
25-29	2.78	0.700	1.022	0.447	0.528	2.779	0.323
30-34	4.06	1.479	1.401	1.438	0.789	4.155	0.275
35-39	4.68	2.626	1.543	2.899	0.946	4.985	0.166
40-44	5.13	4.810	1.635	5.679	0.997	5.250	0.053
45-49	5.35		1.677		1.000	5.268	0.004
	$\alpha =$ -0.4441			$\beta =$ 1.273		$F =$ 5.268	
	NFHS IV						
15-19	0.02	-0.691	-3.912	-1.688	0.004	0.023	0.005
20-24	0.67	0.026	-0.400	-0.772	0.115	0.589	0.113
25-29	2.05	0.700	0.718	0.090	0.401	2.055	0.293
30-34	3.14	1.479	1.144	1.085	0.713	3.657	0.320
35-39	3.80	2.626	1.335	2.551	0.925	4.743	0.217
40-44	4.39	4.810	1.479	5.342	0.995	5.104	0.072
45-49	4.80		1.569		1.000	5.128	0.005
	$\alpha =$ -0.8050			$\beta =$ 1.274		$F =$ 5.128	

Fig. 5: Mean No. of Children Ever-Born for Uttar Pradesh by Relational Gompertz Method

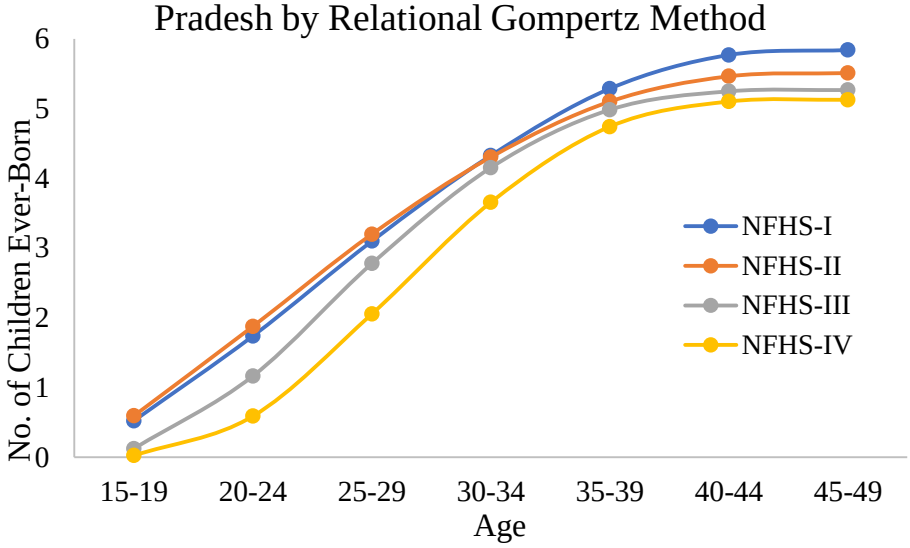
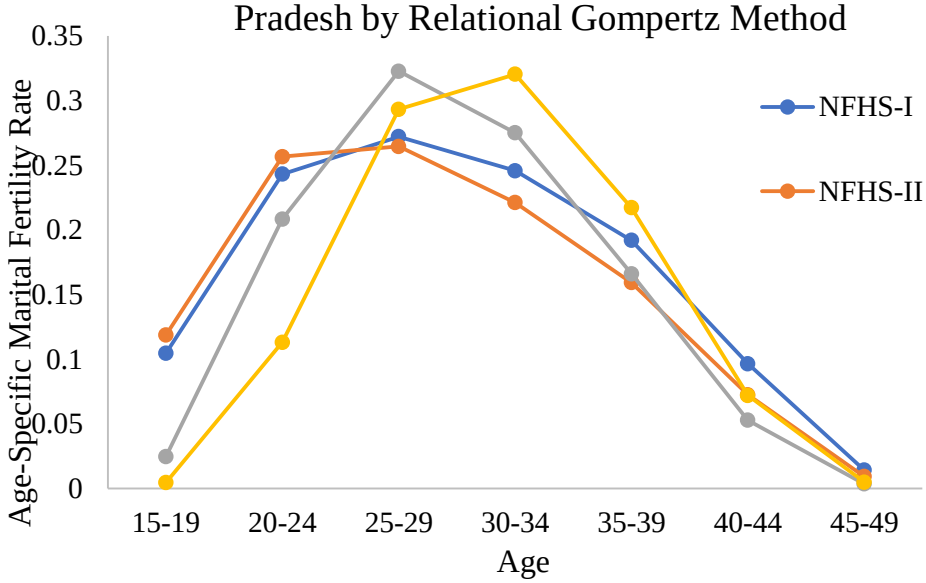


Fig. 6: Age Specific Marital Fertility Rate for Uttar Pradesh by Relational Gompertz Method

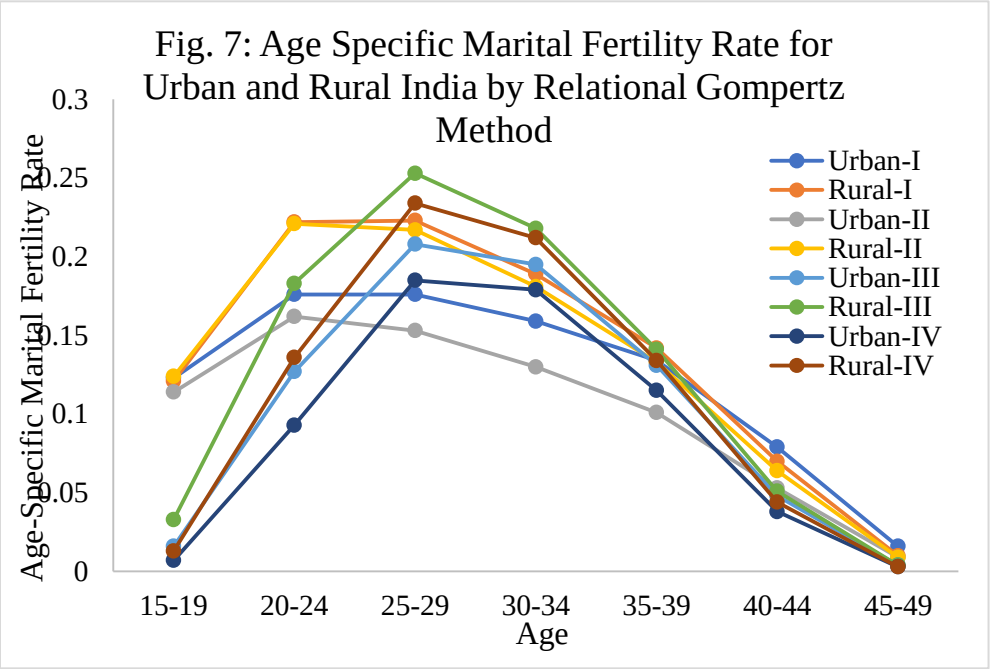


From Table 4, we observed that the age-specific marital fertility rate for 15-19 and 20-24 age group is decreasing for both urban and rural areas in India from NFHS-I to IV and a sharp decline is also observed from NFHS-II to III and NFHS-III to IV. The peak of marital fertility is observed for 20-24 age group in NFHS-I & II and in NFHS-III & IV, it is observed for 24-29 age group and after that started to decline. The values of parameter α is found to be negative for both urban and rural areas for all four surveys except urban areas in NFHS-II. The values of α for urban areas are greater than the rural areas, from which we noticed that the age at first birth is increases from NFHS-I to IV, but in NFHS-II for urban areas, the value of α is positive that means most of the child bearing is in younger ages. The value of parameter α is increasing from NFHS-I to NFHS-IV, if we skip the fluctuations occurred in NFHS-II for urban areas. The value of parameter β is less than one in NFHS-I & II and more than one in NFHS-III & IV for both urban and rural areas. The value of parameter β is increases over time which indicates that the distribution of marital fertility is also narrowing over time (NFHS-I to IV). The cumulative marital fertility (F) is also decreasing for both urban and rural areas over time.

Table 4: Estimates of Age Specific Marital Fertility Rate According to Residence for India in NFHS-I, II, III & IV.

Age Group	NFHS I		NFHS II		NFHS III		NFHS IV	
	Urban	Rural	Urban	Rural	Urban	Rural	Urban	Rural
15-19	0.123	0.121	0.114	0.124	0.016	0.033	0.007	0.013
20-24	0.176	0.222	0.162	0.221	0.127	0.183	0.093	0.136
25-29	0.176	0.223	0.153	0.217	0.208	0.253	0.185	0.234
30-34	0.159	0.189	0.130	0.181	0.195	0.218	0.179	0.212
35-39	0.134	0.142	0.101	0.133	0.131	0.141	0.115	0.134

40-44	0.079	0.070	0.053	0.064	0.048	0.051	0.038	0.044
45-49	0.016	0.010	0.009	0.009	0.004	0.004	0.003	0.003
TMFR	4.32	4.89	3.61	4.75	3.65	4.41	3.10	3.88
α	0.0790	0.0703	-0.0172	0.0360	0.5198	0.3722	0.6370	0.5335
β	0.849	0.964	0.912	0.975	1.191	1.188	1.269	1.256
F	4.3160	4.8873	3.6106	4.7467	3.6460	4.4088	3.1011	3.8818



In Table 5, we observed the most of the results are similar for urban and rural areas of Uttar Pradesh as found in Table 4 for urban and rural areas of India. The peak of the marital fertility is quite different from Indian scenario which is found for 25-29 age group in NFHS-I & III and for 20-24 age group for NFHS-II, in NFHS-IV it is found for 30-34 age group. From Table 6, we observed that the ASFR is decreases for 15-19 & 20-24 age group

for both Hindu and Muslim category in India. The peak of marital fertility is observed for 25-29 age group for Hindus in NFHS-I, III & IV while for 20-24 age group in NFHS-II and it is found for 25-29 age group for Muslims in NFHS-I, II & III whereas for 30-34 age group in NFHS-IV and after that it is declining. The values of α are found to be negative for both Hindus and Muslims for all four rounds of surveys, which indicates that the child bearing is higher in older ages. The values of parameter α are decreases from NFHS-I to II for Hindus as well as Muslims and then increases from NFHS-II to IV. The value of parameter β is less than one for Hindus in NFHS-I & II and for Muslims in NFHS-II which means the distribution of marital fertility is not as much of narrow as observed for both Hindus and Muslims in other surveys. The total marital fertility is decreasing from NFHS-I to IV for Hindus but it increases from NFHS-I to II and then decreases from NFHS-II to IV for Muslims.

Table 5: Estimates of Age Specific Marital Fertility Rate According to Residence for Uttar Pradesh in NFHS-I, II, III & IV.

Age Group	NFHS I		NFHS II		NFHS III		NFHS IV	
	Urban	Rural	Urban	Rural	Urban	Rural	Urban	Rural
15-19	0.095	0.103	0.153	0.096	0.012	0.034	0.003	0.007
20-24	0.205	0.254	0.156	0.220	0.158	0.242	0.083	0.133
25-29	0.231	0.285	0.136	0.215	0.286	0.359	0.260	0.308
30-34	0.215	0.254	0.115	0.164	0.252	0.308	0.327	0.320
35-39	0.176	0.193	0.092	0.106	0.149	0.192	0.247	0.213
40-44	0.095	0.093	0.053	0.041	0.045	0.064	0.091	0.071
45-49	0.016	0.013	0.010	0.004	0.003	0.005	0.007	0.005
TMFR	5.17	5.98	3.57	4.23	4.52	6.02	5.09	5.28

α	0.2368	0.2135	-0.1522	0.0132	0.5468	0.4194	0.9388	0.7368
β	0.919	0.986	0.847	1.109	1.321	1.238	1.232	1.271
F	5.1699	5.9774	3.5722	4.2309	4.5220	6.0190	5.0908	5.2826

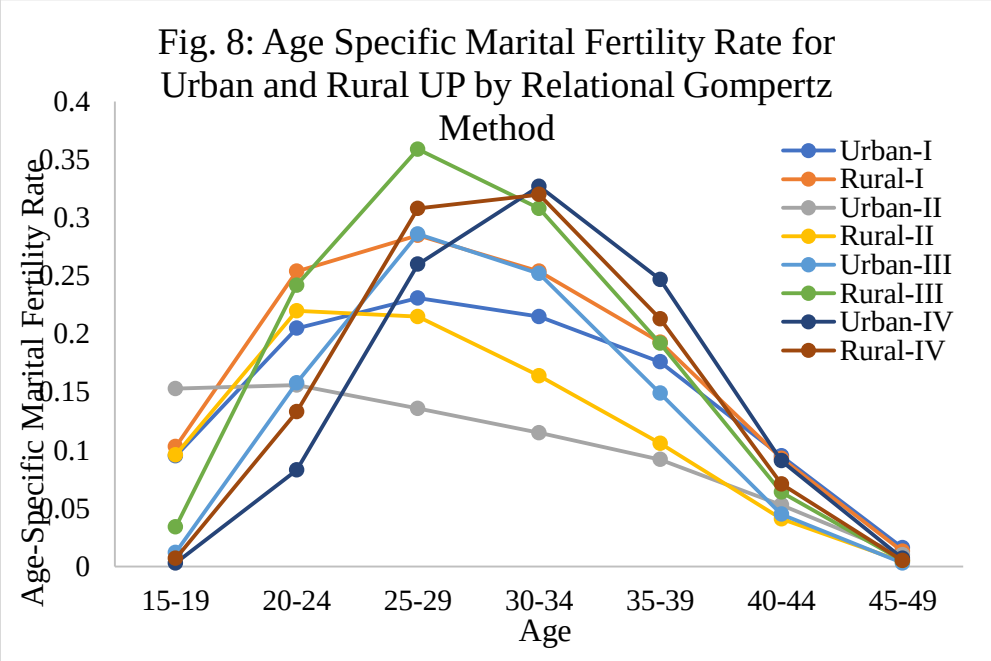
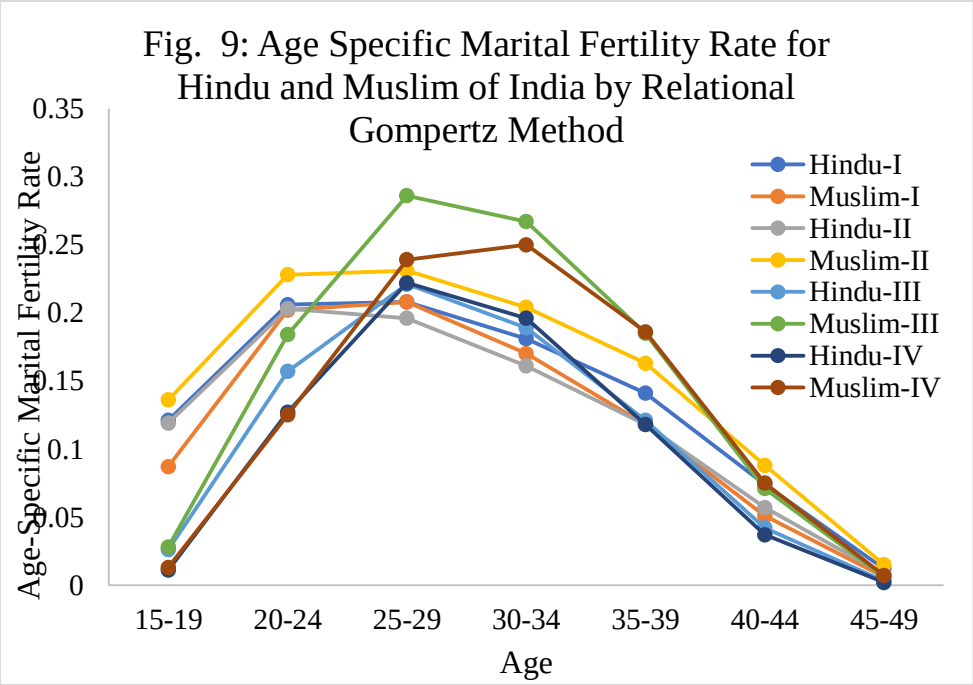


Table 6: Estimates of Age Specific Marital Fertility Rate According to Religion for India in NFHS-I, II, III & IV.

Age Group	NFHS I		NFHS II		NFHS III		NFHS IV	
	Hindu	Muslim	Hindu	Muslim	Hindu	Muslim	Hindu	Muslim
15-19	0.121	0.087	0.119	0.136	0.026	0.028	0.011	0.013
20-24	0.206	0.202	0.203	0.228	0.157	0.184	0.127	0.125
25-29	0.208	0.208	0.196	0.231	0.221	0.286	0.222	0.239
30-34	0.181	0.170	0.161	0.204	0.189	0.267	0.196	0.250
35-39	0.141	0.118	0.118	0.163	0.121	0.185	0.118	0.186
40-44	0.074	0.051	0.057	0.088	0.042	0.071	0.037	0.075

45-49	0.012	0.006	0.008	0.015	0.003	0.006	0.002	0.007
TMFR	4.71	4.21	4.31	5.33	3.80	5.14	3.57	4.47
α	0.0794	0.0962	0.0081	0.0958	0.3828	0.4846	0.5267	0.6536
β	0.927	1.049	0.975	0.908	1.204	1.154	1.297	1.142
F	4.7071	4.2139	4.3124	5.3264	3.7977	5.1352	3.5689	4.4729

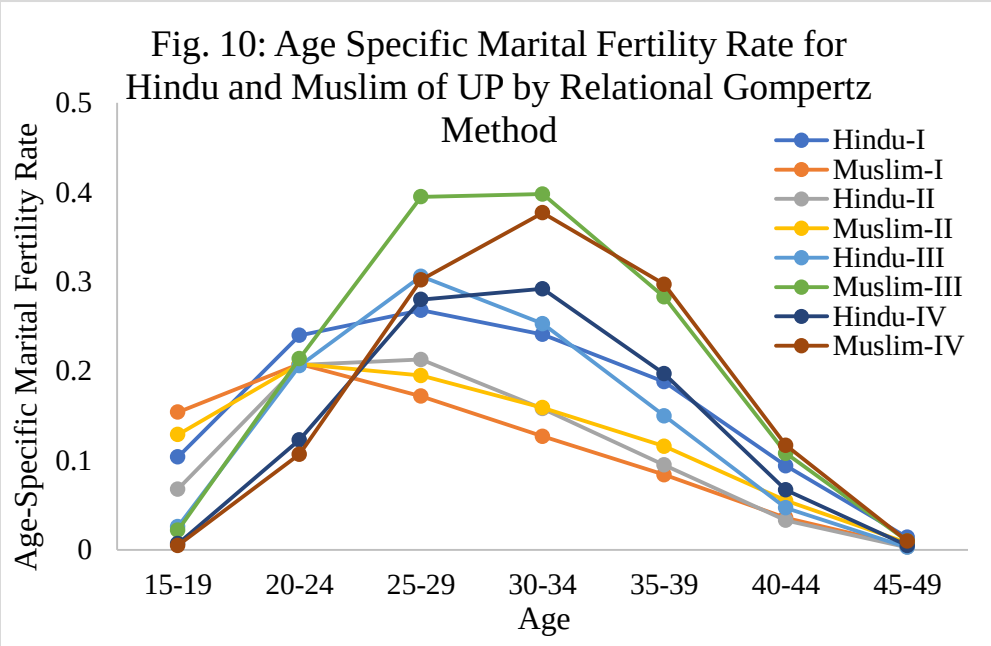


In Table 7, we observed the results for Hindus and Muslims of Uttar Pradesh, ASMFR for Hindus is found to be higher than Muslims in NFHS-I while in other surveys it reversed and observed that it is almost same for NFHS-II and for NFHS-III & IV, there is not much difference in 15-24 age group while after that age group there is a considerable difference between Muslims and Hindus ASMFR. The peak of marital fertility of Hindus is observed for 25-29 age group in NFHS-I, II & III while for 30-34 age in NFHS-IV and it is observed for 20-24 age in NFHS-I & II whereas for 30-34

age group in NFHS-III & IV for Muslims. The values of parameter α for Hindus are negative for all surveys while for Muslims, it is found to be positive for NFHS-I & II and negative for NFHS-III & IV. Muslim women bearing most of the child in their younger age in NFHS-I & II. The value of parameter β is found to be less than one for Hindus and Muslims in NFHS-I and NFHS-II respectively. Marital fertility for Hindus is decreases from NFHS-I to II and slight increment in NFHS-III from NFHS-II and then decreases in NFHS-IV, for Muslims, there is a minor increment is observed in NFHS-II from NFHS-I and then a big increment is observed in NFHS-III from NFHS-II and after that decreases in NFHS-IV.

Table 7: Estimates of Age Specific Marital Fertility Rate According to Religion for Uttar Pradesh in NFHS-I, II, III & IV.

Age Group	NFHS I		NFHS II		NFHS III		NFHS IV	
	Hindu	Muslim	Hindu	Muslim	Hindu	Muslim	Hindu	Muslim
15-19	0.104	0.154	0.068	0.129	0.026	0.022	0.007	0.005
20-24	0.240	0.208	0.207	0.208	0.206	0.214	0.123	0.107
25-29	0.268	0.172	0.213	0.195	0.306	0.395	0.280	0.302
30-34	0.241	0.127	0.158	0.159	0.253	0.398	0.292	0.377
35-39	0.188	0.084	0.095	0.116	0.150	0.283	0.197	0.297
40-44	0.094	0.036	0.033	0.055	0.047	0.108	0.067	0.117
45-49	0.014	0.004	0.003	0.008	0.003	0.010	0.005	0.010
TMFR	5.74	3.92	3.88	4.35	4.95	7.16	4.86	6.07
α	0.2100	-0.2312	0.0655	-0.0284	0.4044	0.6172	0.7302	0.9018
β	0.962	1.038	1.191	0.973	1.283	1.169	1.256	1.182
F	5.7419	3.9232	3.8812	4.3487	4.9505	7.1571	4.8579	6.0743



Conclusion

The fertility is declining after 1990 in India. To assess the actual pattern of declining fertility in India and its most populus state Uttar Pradesh, here we have used an indirect technique namely relational Gompertz method. It is observed that the marital fertility is declining for India as well as Uttar Pradesh considered for the analysis. Marital fertility is falling approximately by one child from NFHS-I (1992-93) to NFHS-IV (2015-16) for India which is displayed in further investigation through urban and rural areas estimates of marital fertility whereas in Uttar Pradesh, it is decreases by about 0.7 child in NFHS-IV from NFHS-I and urban women having almost same fertility behavior in NFHS-IV as having in NFHS-I with some increasing fertility in older ages. It decreases in Hindus women for both India and Uttar Pradesh while there is some increment is observed for Muslims women of India and Uttar Pradesh. We say that the marital fertility level is higher in Uttar Pradesh women as compared to Indian women in all four surveys

used for analysis purpose. ASMFR is also found to be lower in Indian women in respect of Uttar Pradesh women from NFHS-I to IV which is also observed in the analysis according to residence and religion. The peak of marital fertility in India as well as in Uttar Pradesh shifted from 20-24 & 25-29 age-group to 25-29 & 30-34 age-group respectively which also confirms from the Fig. 3 & 4. The same result is also observed in further analysis according to residence and religion. The age at first birth is also increasing over time (NFHS-I to IV) and the distribution of marital fertility is narrowing over time as well.

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