Demography India
A Journal of Indian Association of Study of Population
Journal Homepage: https://demographyindia.iasp.ac.in/

Pattern of Childlessness and Probability of First Live Birth in Uttar Pradesh

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Abstract

The use of demographic models in describing demographic processes is important, particularly in developing societies where reliable and adequate data are unavailable. If a postulated model adequately describes the reality, the characteristics of a given population can be summarized by the parameters of the model, which in turn facilitates the study of variation between populations or within a population over time. These models are also useful to understand the changes in the parameters over time. Data from NFHS-I to V of Uttar Pradesh have been used to perform the study. Here, our aim is to estimate, the proportion of zero parity women (childlessness) and also describe some reproductive characteristics of women. The ultimate proportion remaining childless ranges from 1.3 percent in NFHS-I to 2.5 percent in NFHS-V. About 79 percent of women experienced first birth by age 20 in NFHS-I however only 59 percent in NFHS-V. The average age at first birth is also observed in increasing trend over the time.

Keywords

Childlessness, Modified exponential model, NFHS

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Introduction

Many attempts have been made to construct demographic models that have proceeded rapidly over the years with an aim to give brief descriptions of several characteristics of fertility, mortality, nuptiality, and other demographic phenomena from inadequate and substandard data. If a hypothesized model adequately describes the reality, the characteristics of a given population can be summarized by the parameters of the model, which in turn facilitates the study of variation between populations or within a population over time.

Human reproduction is a complex process and is influenced by various factors such as social, economic, physiological and psychological etc., but the importance and role of physiological factors in human reproduction can hardly be ignored. How and to what extent do the natural and induced variation in physiological factors affect human reproduction thus stands as an important area of investigation. A few physiological functions like reproductive period, probability of conception and its outcomes, non-susceptibility, have drawn the attention of many investigators and mathematical models have been developed to describe the levels of human natality from pertinent data (see, for instance, Gini, 1924; Potter, 1963; Potter and Parker, 1964; Henry, 1972; Sheps and Menken, 1973; Bongaarts, 1975; Leridon, 1975). A detailed description of the current status of demographic models may be found elsewhere (Menken, 1977).

Models on mortality developed by Ledermann and Breas (1959), Coale and Demeny (1966), Ledermann (1969), Brass (1971), and Carrier and Hobcraft (1971) are worth mentioning. The mathematical model is used first time by Ginni (1924) to estimate the average fecundability through the data of timing from marriage to first conception in months for a cohort of married women. For the study of natural fertility, there are several models have been proposed by Henry (1953) and Vincent (1961). They used the discrete form of waiting time to conception in their study however, Singh (1964) considered it as continuous and derived a relationship between fecundability and waiting time to conception. The pioneering works of Brass and Coale (1968), Coale (1971), and Coale and Trussell (1974) on the age pattern of fertility and nuptiality described by models have shown to be more useful for the estimation of demographic determinants. Bhattacharya and Singh (1986) developed a model for the time of first birth assuming that fecundability is increases as age increases and reaches a maximum in certain age groups after that decreases as age increases and lower in the starting phase of reproductive period. Bhattacharya et al. (1988) developed a model that is time dependent and suitable where lower age at marriage has existed.

In earlier times, there were several studies related to birth intervals, such as, Henry (1961), Henripin (1954) and Vincent (1961) analyzed the data of birth intervals in a more detailed way. Potter (1963) analyzed the data of inter-live birth intervals with component method to understand the structure and pattern of inter-live birth intervals. Geometric distribution of type I and compound geometric distribution is used for timing of first conception from marriage and beta distribution for describing the heterogeneity related to fecundability among married women by Singh (1961), Singh (1967), Potter and Parker (1964), Perrin and Sheps (1964), Sheps (1967) and Singh et al. (2012, 2017, 2018). In the present study, our aim is to use the zero birth (childlessness) data of Uttar Pradesh to describe some reproductive characteristics of women and also observe the pattern of zero birth among ever-married women.

Data Source

The data used in this study was taken from all five rounds of National Family Health Survey (NFHS) for Uttar Pradesh. In the present study, a woman is considered to be childless or having zero birth if she had not borne a live-born child until the time of survey. In the National Family Health Survey, the women have been given by their current age (also in age groups), the total number of children ever born and their current marital status like never-married, currently married, divorced, separated, and widow, the women who currently married, divorced, separated and widow are considered to be ever-married in this study. The percent of ever-married women under 'zero parity' represents, therefore, percent childless at different ages.

A discussion of the quality of data will be useful in assessing the reliability of the estimates derived from such data. Data on zero births (childless) are of variable quality in different communities and also may vary over time, but in general, the biases are small (Grabill and Glick, 1959). In this context, it may be argued that the great majority of those 'not-stated' cases may be carefully attributed to the category of zero birth (childless) (United Nations, 1967). However, if some of the non-stated cases represent a genuine lack of information, the attribution of such cases to 'zero' category will produce an over-estimate of proportion of women with zero birth and consequently an under-estimate of the mean number of children ever-born. El-Badry has called this error a 'zero error' and evolved a simple but effective method of detecting and correcting this error when data are tabulated by age and parity of women with non-stated categories in the censuses (El-Badry, 1961).

El-Badry's work reminded an awareness among the people dealing with such data. Children ever born (CEB) data are now becoming increasingly important in the analysis of fertility. Any error incorporated in the CEB data may seriously misrepresent the estimates. Even if such error occurs, there are a number of places which make it possible for the checking of occurrence of such possibilities (see: National Family Health Survey, individual core questionnaire, for ever-married women under the age of 50).

Age Pattern of Women with Zero Birth

The differences in age patterns of women with zero birth are produced by the differences in age of women at which they enter into sexual union. The factors responsible for women having no birth could be voluntary or involuntary or both. Even when voluntary methods of suppressing fertility are non-existent differences in involuntary factors such as impairment of fecundity, periods of widowhood, and divorce are accomplished to produce different age patterns of zero birth. The data on the proportion of ever-married women with zero parity is given in Table 1 for all five rounds of National Family Health Survey (NFHS).

To formulate the mathematical curve to describe the age pattern of zero birth among married women, these three factors seem to be relevant:

The origin reflects the extent of having no birth at the beginning.

Table 1 Observed proportion of women with zero birth among ever-married women by age in Uttar Pradesh

Age Group	NFHS-I	NFHS-II	NFHS-III	NFHS-IV	NFHS-V
15-19	0.573	0.548	0.640	0.784	0.982
20-24	0.197	0.192	0.186	0.320	0.608
25-29	0.044	0.047	0.059	0.086	0.175
30-34	0.024	0.024	0.021	0.032	0.049
35-39	0.028	0.018	0.016	0.022	0.024
40-44	0.013	0.019	0.014	0.015	0.019
45-49	0.017	0.018	0.014	0.015	0.018

The rate at which the proportion of ze ro birth drops per unit of time.

A constant, denoting the ultimate proportion remaining childless/zero (no) birth over the whole reproductive life-span.

To describe the observed age pattern of women with zero birth in percent among ever-married women, a three-parameter mathematical curve including the above features, has been postulated whose functional form is as follows:

$$f(y) = c + ab^{-y}, \qquad y = 0,1,2,...,6 \tag{1}$$

which is a modified negative exponential curve. As y increases $f(y)$ approaches c as a lower limit and when $y = 0,\ f(y) = c + a$. The curve has been found to be appropriate for the proportion of women having zero birth by age for Uttar Pradesh for all rounds of NFHS data considered here for analysis purposes. The relationship may also be put in the following convenient form:

$$f(y) = c + ae^{-my}, \qquad y = 0,1,2,...,6 \tag{2}$$

where $m = \log_e b$, a constant, denoting the rate at which proportion of zero birth decreases with increasing age or as age increases. $c =$ a constant denoting the ultimate proportion remaining childless (zero birth) during her whole reproductive period. and $a =$ a constant denoting the initial proportion of women with zero birth, who have no birth initially but get at least one birth in their reproductive period. Thus $c + a$ denotes the proportion of women with zero birth in the initial age group (15-19).

Estimation of Parameters in the Model

The estimation of parameters a, b and c can be accomplished by dividing the number of observations into three equal groups. If there are n observations, there will be k values in each group such that $3k = n$. Since in the present case we have 7 observations corresponding to the seven age groups, the last value has been discarded so that $n = 6$ and $k = 2$. If S_1, S_2 and S_3 represent the sums of k successive observed values of $f(y)$, Then $S_1 = \sum_{y=0}^{k-1}(c + ab^{-y})$, $S_2 = \sum_{y=k}^{2k-1}(c + ab^{-y})$, and

$$S_3 = \sum_{y=2k}^{3k-1}(c + ab^{-y}) \tag{3}$$

After summing the series, the estimates of the parameters in terms of S_1, S_2 and S_3 are obtained such as

$$a = \frac{(S_1 - S_2)(b-1)b^{2k-1}}{(b^k - 1)^2} \quad (4)$$

$$b = \sqrt[k]{\frac{(S_1 - S_2)}{(S_2 - S_3)}} \quad or \quad m = \frac{1}{k}\log_e \frac{(S_1 - S_2)}{(S_2 - S_3)} \quad (5)$$

and $$c = \frac{1}{k}\left[S_1 - \frac{a(b^k - 1)}{b^{k-1}(b-1)}\right] \quad (6)$$

The fitted curve is thus $f(y) = c + ae^{-my}$, where y's are the coded ages 0, 1, 2, ..., 6 which correspond respectively to the mid-points of the age groups 15-19, 20-24, 25-29, 45-49.

Table 2 Estimates of parameters for Uttar Pradesh

NFHS	a	m	c
I	61.04	1.63	2.00
II	57.52	1.49	1.76
III	63.52	1.35	1.47
IV	83.49	1.25	1.29
V	95.17	1.09	1.12

The value of m indicates that proportion of zero birth drops at different rates for different NFHS. The highest drop rate is observed in NFHS-I for Uttar Pradesh. The lowest drop rate is estimated in NFHS-V. A lower age at marriage contributes to a higher proportion of zero birth in the age group of 15-19 may be due to the presence of adolescent sterility. The proportion of zero birth, in the absence of contraception, is likely to drop fast by age group 20-24 and 25-29. In situations where there is contraception prevalent, on the other hand, the drop-in proportion of zero birth may not be so fast which may partly explain the phenomenon.

Table 3 Expected proportion of women with zero birth among ever-married women by age in Uttar Pradesh

Age Group	NFHS-I	NFHS-II	NFHS-III	NFHS-IV	NFHS-V
15-19	0.630	0.593	0.648	0.850	0.973
20-24	0.140	0.147	0.178	0.254	0.589
25-29	0.043	0.047	0.056	0.083	0.182
30-34	0.025	0.024	0.024	0.035	0.051
35-39	0.021	0.019	0.016	0.021	0.023
40-44	0.020	0.018	0.014	0.016	0.020
45-49	0.020	0.018	0.013	0.015	0.018

Estimation of First Birth Probabilities

Models for first birth and first conception have significant importance and require appropriate data for the estimation of conception and first birth probabilities. A group of women are followed from the time they are exposed to conception until they actually conceive. The distribution of conceptions by month thus developed are used for estimation of fecundability, waiting time for conception, etc. Such type of estimation is not free from difficulties. In this study, an indirect method is used for deriving the annual probability of first live birth by age. The estimation procedure makes use of the mathematical curve proposed earlier to describe the proportion of women having zero birth by age. If $f(x)$ and $f(x+k)$ respectively denote the proportion of zero birth at age x and $x+k$, then the expected proportion ${}_kp_x$ of those still having zero births at the beginning of the interval who become mothers during $(x, x+k)$ is

$$ {}_kp_x = \frac{f(x) - f(x+k)}{f(x)} = 1 - \frac{f(x+k)}{f(x)} = 1 - {}_kq_x \quad (7) $$

This is obviously the conditional probability of giving first birth during $(x, x+k)$ provided the woman survives to the end of age group $(x, x+k)$. ${}_kP_x$ may now be expressed in terms of the parameters a', m' and c of the mathematical curve $f(x) = c + a'e^{-m'x}$ as follows:

$$ {}_kp_x = \frac{1 - e^{-m'k}}{1 + \frac{c}{a'}\, e^{m'x}} \quad (8) $$

when $k = 1, \quad {}_1p_x = \frac{1 - e^{m'}}{1 + \frac{c}{a'}\, e^{m'x}}$ represents the annual probability of giving birth between ages x and $x+1$, we denote it by p_x, dropping the subscript 1. Since the numerator is a constant and the denominator increases with increasing age, this function is a monotonically decreasing function of x. The starting age for computation of these probabilities could be the minimal age of entry into sexual union. A recognizable age in this respect is the age at menarche. Since at such an age, the proportion of zero birth is expected to be 100 per cent, because child bearing usually starts several years after menarche, the proposed function is used to estimate the age α at which 100 percent women having zero/no birth by equating $f(\alpha)$ to 100 per cent. Thus,

$$ \alpha = -\frac{1}{m'} \log_e \frac{(100 - c)}{a'} \quad (9) $$

It is important to be noted here that the estimation of the parameters a, m and c, all are based on the percentage values instead of proportions. The estimated ages α where 100 percent of women having no birth, have been shown in Table 4. The question may now be raised as to the validity of the estimates of α in the different rounds of NFHS over time. The age at which all ever-married women are childless (no birth) is estimated to be 16.05, 15.70, 15.87, 16.84, and 17.21 years in NFHS-I, II, III, IV, and V for Uttar Pradesh. Therefore, this age should be taken as origin. But if the women are not at the risk of childbearing at this age, use of this age as a time of origin then it may yield a biased estimate. We can start computation of age-specific probabilities of live birth using α as the origin. But for convenience, we will round the estimated age to an integral value and this new origin is denoted by α' (where $\alpha - \alpha' \leq 1$) will be called translated age.

Mean Probability of First Birth

If P_i denotes the probability of first birth to a woman between ages $(i, i+1)$ and F_i the number of women with zero birth at age i, the mean annual probability of first live birth $\bar{P}$ averaged over the entire life span of women, can be estimated as

$$\bar{P} = \frac{\sum_{i=\alpha'}^{w} P_i F_i}{\sum_{i=\alpha'}^{w} F_i} \qquad (10)$$

When women leave state of zero birth by the occurrence of their first live birth, the number of women with zero birth at age i will be

$F_i = F_{\alpha'}(q_{\alpha'}, q_{\alpha'+1}, q_{\alpha'+2}, \ldots, q_{i-1})$, after substituting this value of F_i in the above formula we get

$$\bar{P} = \frac{\sum_{i=\alpha'}^{w} P_i \phi_i}{\sum_{i=\alpha'}^{w} \phi_i},$$

where

$$q_i = (1 - P_i), \qquad \phi_i = q_{i-1}\, q_{i-2} \ldots 1$$

and $q_\beta = 1 \quad for \quad \beta < \alpha'$ (11)

Mean Age at First Birth

The mean age at first birth has also a significant importance. Differences in the age pattern of child bearing of first order may be measured in terms of this mean age. If $\bar{X}$ denotes this age, we have

$$\bar{X} = \frac{\sum_{i=\alpha'}^{w} P_i \phi_i X_{i+0.5}}{\sum_{i=\alpha'}^{w} P_i \phi_i} \Rightarrow$$

$$\bar{X} = \frac{\sum_{i=\alpha'}^{w} P_i \phi_i X_i}{\sum_{i=\alpha'}^{w} P_i \phi_i} + 0.5 \qquad (12)$$

Application

The proposed mathematical function for the age pattern of women having zero birth has been applied to the data of Uttar Pradesh from different rounds of NFHS. The following parameters have been estimated:

(i) Age at which all women have zero birth (α),

(ii) Mean probability of first birth ($\bar{P}$),

(iii) Mean age of mother at first birth ($\bar{X}$)

For Uttar Pradesh, the estimated values of α, α', $\bar{P}$ and $\bar{X}$ are shown in Table 4 for NFHS-I, II, III, IV, and V.

Table 4 Estimated Ages (α, α'), Mean Probability of First Birth ($\bar{P}$)and Mean age of mother at first birth ($\bar{X}$)

NFHS	Uttar Pradesh			
	α	α'	$\bar{P}$	$\bar{X}$
I	16.05	16	0.2437	18.1
II	16.20	16	0.2278	18.4
III	16.37	16	0.2178	18.7
IV	16.84	16	0.2025	19.2
V	17.21	17	0.1982	19.8

Table 5 Cumulative Proportions of First Birth Women by Age Uttar Pradesh

Age	NFHS-I	NFHS-II	NFHS-III	NFHS-IV	NFHS-V
20	0.792	0.764	0.733	0.624	0.591
25	0.948	0.936	0.923	0.884	0.783
30	0.978	0.974	0.972	0.958	0.891
35	0.984	0.983	0.978	0.968	0.944
40	0.985	0.985	0.981	0.977	0.969
45	0.986	0.986	0.983	0.980	0.973
50	0.987	0.986	0.984	0.981	0.975
Ultimate Proportion remaining Childless					
All Ages	0.013	0.014	0.016	0.019	0.025

Results

Validity of the estimated ages (α) at which 100 per cent of the women are with zero birth has been discussed. From the present study we find that the age at which all women are with zero birth is 17 years in NFHS-V while in NFHS-I, II, III and IV it is 16 years for Uttar Pradesh. In this section discussion will be devoted to the estimated values of the remaining parameters. The probabilities P_i, have been shown for Uttar Pradesh respectively for NFHS-I, II, III, IV & V. It seems that the drop in the probabilities over time is slight. The short-end reproductive life span, seems to result from a quickening of permanent sterility (menopause). The mean annual probability of first birth $\bar{P}$ is in some ways similar to the general marital fertility rate (GMFR) which in the annual proportion of the married women giving birth. The estimated values of $\bar{P}$ is down from NFHS-I to NFHS-V for Uttar Pradesh, it decreases in a substantial amount from NFHS-I to NFHS-V. The measures $\bar{X}$ may be understood as describing the age pattern of childbearing of first order of a hypothetical group of women, all of whom are with zero birth at a specified age (α') gradually falling with increasing age through a predetermined schedule of birth probabilities.

It may be found that the estimated value of $\bar{X}$ varies only between 18.1 and 19.8 years for Uttar Pradesh from NFHS-I to V. It is usually supposed that the adolescent sterility operates about age 18 or so and usually only a few births take place before this age. Even if women practice contraception during this period following higher age at marriage such practice will have little effect on postponing the first live birth. Only contraception extending beyond the period of adolescent sterility will have an effect on the age at first birth. Contraception for much long periods in the case of nulliparous (zero birth) women is not likely to be prevalent to a great extent. The average time taken for first birth, ($\bar{X} - \alpha'$) is the least in NFHS-I (2.1 years) and most in NFHS-V (2.8 years) for Uttar Pradesh. The ultimate proportion remaining childless seems to reach an asymptotic value ranging from 1.3 to 2.5 per cent in Uttar Pradesh. It is increasing over the time and obvious that increasing knowledge of various dimensions of the married couples take a decision to have a smaller number of children or be remains childless. In some cases, marriages observed quite late and couples faces some infertility issues that also play an important role for childlessness.

Conclusion

The present study, an attempt to derive some reproductive parameters for Uttar Pradesh for all five rounds of National Family Health Survey. The estimation of parameters is based on a proposed mathematical curve fitted to the data on proportion of women with zero birth among the ever-married women at different ages. The curve is found to be suitable to describe the age pattern of women with zero birth adequately for the data of Uttar Pradesh. The same mathematical curve is also used to estimate the age at which 100 percent women are with zero birth, the age specific probability of first birth, mean probability of first birth, the mean age of women at her first birth. The various parameters estimated from the data of proportion of zero birth at different ages which enable us to state the fertility level Uttar Pradesh in different rounds of National Family Health Survey. From the analysis we found that Uttar Pradesh experiencing high level of fertility in NFHS-I in comparison to NFHS-V. These results may be used for the comparison of fertility pattern and level over time.

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