Proximate Determinants of Fertility in Eastern Uttar Pradesh

BISHWANATH BHATTACHARYA,[1] KAUSHLENDRA KUMAR SINGH,[2]
AND UTTAM SINGH[3]

Abstract Our main objective here is to examine and discuss the effects of some sociocultural and economic factors on the proximate determinants of fertility in rural areas of eastern Uttar Pradesh (population more than 40 million persons). The region is known for its present demographic trends because the crude birth, death, and infant mortality rates are among the highest for India. The determinants considered are age at marriage of female, postpartum amenorrhea (PPA), fecundability and sterility, and menopause. The sociocultural and economic factors studied are caste, education, breast-feeding status, and social status of the currently married females in the reproductive age group. The study population is predominantly Hindu, among whom caste is a strong indicator of socioeconomic conditions. The average age of the female at return marriage (RM) is below 18 years in each religion or caste group but has been increasing over time. Median durations of breast feeding and PPA differ significantly among various socioeconomic and demographic subgroups. These are longest in scheduled castes and shortest in upper-caste Hindus. As the social status of the household increases, the median durations of breast feeding and PPA decrease. The estimates of fecundability consistently decrease with age, whereas those of sterility increase with age after 35 years. The smallest estimate of sterility is 4%, corresponding to the 25–30-year age group in each religion or caste group. Occurrence of menopause is rare before age 35, and it increases with the age of the female irrespective of religion or caste. However, the risk is minimum for females in upper castes and maximum for those in scheduled castes.

Knowledge of factors contributing to higher fertility levels assumes greater importance in view of the alarming population pressure being experienced in most developing countries, and it is essential for initiating family planning

[1] Population Studies Unit, Indian Statistical Institute, 203 Barrackpore Trunk Road, Calcutta 700 035, India.
[2] Department of Statistics, Banaras Hindu University, Varanasi 221 005, India.
[3] Department of Statistics, Harish Chandra Post Graduate College, Varanasi 221 002, India.

Human Biology, December 1995, v. 67, no. 6, pp. 867–886.

KEY WORDS: AGE AT MARRIAGE, POSTPARTUM AMENORRHEA, FECUNDABILITY, STERILITY, LIFE TABLE

efforts and regulating programs for fertility control. Economic, social, and cultural factors affect reproduction, and the average number of children born to a married female exposed to the risk of conception throughout the reproductive period varies considerably among different societies. To understand the causes of fertility variation, one must know the mechanisms through which socioeconomic and environmental variables influence fertility. In response to this need, demographers have turned to the study of proximate determinants of fertility, which are the biological and behavioral factors through which social, economic, and environmental variables affect fertility.

During the last three decades several suitable methodologies have been developed for systematic study of the determinants of fertility. Among them the analytical model of Davis and Blake (1956) gives a systematic listing of intermediate variables affecting fertility. It is argued that fertility is modified by one or more intermediate variables. Bongaarts (1983) pointed out that the influence of the factors affecting fertility can be explained in terms of seven proximate determinants. He has discussed extensively the methods to estimate the contributions of these factors and the possible use of the models in the study of fertility behavior.

The most interesting finding of comparative studies of natural fertility is the large variation in the natural marital fertility rates of different populations: The highest levels are more than twice as high as the lowest levels. Specifically, several studies have shown that the level of fecundability in Western societies is approximately 0.20, whereas in rural India it is below 0.10 (Henry 1961; James 1973; S.N. Singh 1969; Leridon 1977). The large gap between the two levels may be mainly due to the differences in various behavioral norms associated with fertility behavior.

Our objective here is to examine and discuss the level of the proximate determinants of fertility in rural areas of eastern Uttar Pradesh. For this purpose four determinants [age at marriage, postpartum amenorrhea (PPA), fecundability and sterility, and menopause] are considered. The inhibiting effect of existing sociocultural factors on them is examined.

The term *marriage* is used here to refer to the time when the partners enter conjugal relations. Age of the female at marriage identifies the onset of exposure to the risk of childbearing and, as such, is an important principal determinant of the number of births she will have.

Immediately after birth, females experience an anovulatory period in which the normal pattern of ovulation and menstruation is absent. This is known as postpartum amenorrhea.

Fecundity of a female is her capacity to conceive, which depends on the interplay of many factors, such as physiological status of both partners, frequency of intercourse, and use of contraceptives. Fecundability is a measure of fecundity and is defined as the probability that a nonpregnant fecund female will conceive in one unit of time of exposure to the risk. In general, the unit is 1 month, which is approximately the average length of one menstrual cycle.

The absence of fecundity is sterility, that is, if to a female conception is impossible physiologically, she is said to be sterile. If the fecundability is zero throughout the life of a female, she is said to be primarily sterile; if it becomes zero at any time during her reproductive period and onward, she is known as secondarily sterile, and if it becomes zero for a short time in the reproductive period, she is temporarily sterile.

A female can conceive only if both spouses are fecund. Menopause signals the definite end of the potential reproductive years of the female.

Data

The basic data used for this study were taken from a survey titled "Effect of Sociocultural Factors on Determinants of Fertility in Eastern Uttar Pradesh," carried out in 1987–1988 (reference date of the survey was October 1, 1987) by the Centre of Population Studies, Banaras Hindu University, under the financial support of the Indian Council of Medical Research (ICMR), New Delhi (S.N. Singh 1993).

The main objectives of the project were to obtain reliable data to study the socioeconomic and behavioral factors affecting fertility and to estimate biocultural parameters of human reproduction in a traditional society. In addition to other information, data relating to age at marriage and return marriage (RM) (a ceremony when the bride starts to live with her husband) and total number of children born and surviving (including details about duration variables such as lactation, PPA, and different types of birth interval for births occurring within the last seven years from the reference date) for each eligible female in the household were collected. Data on the length of breast feeding and PPA were collected retrospectively. The duration of breast feeding includes full and partial breast feeding.

A couple (or female) was eligible if both the partners were alive on the reference date and her age was less than 50 years. Information on the status of women (menstruating, pregnant, amenorrheic, menopausal) on the reference date was obtained. The survey is based on 4448 households in 3 districts, namely, Varanasi, Ghazipur, and Azamgarh in eastern Uttar Pradesh.

Caste has a socioreligious base. Therefore caste beliefs exert a strong and stable conditioning influence on human behavior, social habits, customs, and practices. Segregated caste-oriented living, as is commonly practiced in villages, reinforces caste beliefs and habits. Therefore, according to the proximity of social position, the households in the surveyed area fell into four religion or caste groups—upper castes, middle castes, scheduled castes, and Muslims—and the samples were taken from each subgroup. The figures for the study populations (total) were weighted according to the proportions of caste groups in the area. The proportions are 0.20, 0.48, 0.22, and 0.10 for the upper, middle, and scheduled castes and Muslims, respectively.

Several factors affect the social status of the household. The expenditure of rural households is determined not only by their income but also by their aspirations of either maintaining their status or achieving upward social mobility. In the study households were classified into three social status groups (low, medium, and high) using an aggregated score that takes into account total household income, household educational status, housing, landholding, and possession of luxuries [for details, see K. Singh (1990)]. The members of a household are assumed to have the social status of the household to which they belong.

Age of mother at birth of her child is known to be an important determinant of PPA. In countries such as India where preference for male children exists, it is believed that the breast-feeding pattern depends on the sex of the child. In the present study we examine the roles of woman's age and child's sex and education of the female on the duration of PPA.

Results

Age at Marriage. Early and universal marriages are the two most outstanding features of rural society in India. Often, girls are married at an age well before puberty. Together with economic causes, social considerations are important factors perpetuating the custom of early marriage. In almost all cases the marriage is arranged by the parents or guardians, and the prospective bride and groom are generally not consulted.

It is well known that low age at marriage of the female increases fertility and mortality by providing longer duration and higher incidence of maternal and infant mortality. Bose (1988) classified Indian states into four groups according to crude birth rate of rural areas for 1987, released by the Registrar General of India. Uttar Pradesh belongs to the fourth group, where the crude birth rate is more than 35 per 1000 and is the highest for that group. Specifically, crude birth, death, and infant mortality rates for rural Uttar Pradesh are 38.8, 13.7, and 126, respectively (Registrar General 1992). The rates are not uniform throughout the state. They are relatively higher in eastern Uttar Pradesh, which has 17 districts with a total population of more than 40 million. It is a thickly populated region with low per capita income. Most of the people in rural areas are poor and illiterate.

Indian marriage customs are extremely diverse. They vary by religion, caste, geographic location, education, etc. In rural areas of eastern Uttar Pradesh marriage does not signal the beginning of cohabitation or sexual relations. It is only after *Gauna* or *Rukhsat* [hereafter termed the return marriage (RM) ceremony] that the wife goes to live with her husband, and the partners enter conjugal relations. In general, the RM ceremony is performed at an age

Table 1. Average Age at Return Marriage of Eligible Females in Different Religion and Caste Groups According to Marriage Cohort

Marriage Cohort	*Upper Caste*	*Middle Caste*	*Scheduled Caste*	*Muslims*	*Total (Weighted)*
Earlier than 1960	15.13	14.75	14.89	14.70	14.85
1960–64	15.98	15.36	15.37	15.19	15.47
1965–69	16.22	15.50	15.26	15.69	15.61
1970–74	16.37	15.80	15.54	15.77	15.85
1975–79	16.94	15.79	15.67	16.02	16.02
1980–84	17.51	16.16	16.55	16.26	16.53
1985–87	17.96	17.18	16.45	16.95	17.15
Total	16.97	16.07	15.85	16.01	16.20

when a female is considered physically mature enough to have conjugal relations, although exceptions are not uncommon.

Table 1 presents the average age of females at RM in different marriage cohorts according to religion and caste groups. Eligible couples with wife's second or higher order of marriage on the reference date are not included in this study.

To examine the trend in age of female at RM, we classified couples according to seven marriage cohorts: earlier than 1960, 1960–1964, 1965–1969, 1970–1974, 1975–1979, 1980–1984, and 1985 and after. The figures reveal that the average age of the female at RM is below 18 years in each caste group, notwithstanding that the minimum age of the female at marriage was fixed at 18 years by the Indian government in 1978. The average age of the female at RM is consistently higher in upper castes in each marriage cohort. There is no appreciable difference for middle and scheduled castes, and the average age for Muslims lies between those for upper and middle castes. However, the trend over time in the average age of the female at RM in each religion and caste group is increasing, and it has reached 18, 17, 16, and 17 years in the upper, middle, and scheduled castes and Muslims, respectively, in recent years.

Postpartum Amenorrhea. The periods of PPA are demographically important in birth histories of females in historical societies with natural fertility. For example, when an infant survives, the birth interval is on average longer than that relating to an infant death or miscarriage. Henry (1964) concluded that the death of an infant either ends the anovulatory interval because breast feeding is terminated or causes the resumption of sexual relations in societies with a postpartum taboo against intercourse. Cleland et al. (1984) showed that PPA associated with breast feeding reduces total fecundity by 30–33% compared with a reduction by contraception of only 5–20%.

As a female begins to wean her child, the probability of her conceiving increases as the ovulation-inhibiting effects of lactation are attenuated. In most statistical studies of the contraceptive role of breast feeding, the duration of PPA is used as a proxy for the duration of postpartum anovulation. A female can easily observe menstruation, but she cannot directly tell the time of ovulation, which is therefore rarely recorded. Ovulation is, however, the phenomenon of real interest. Ovulation, not menstruation, makes a woman able to conceive.

Breast Feeding and Postpartum Amenorrhea. Breast feeding is believed to be a major determinant of prolonged PPA, the time between a birth and resumption of menses, in societies where it is nearly universal, prolonged, and of high intensity (Perez et al. 1972; Santow 1978; Howie and McNeilly 1982; Srinivasan et al. 1989; Nath et al. 1993; S.N. Singh and Singh 1989; S.N. Singh et al. 1990; K.K. Singh et al. 1993). Hence in countries with prolonged breast feeding birth intervals are usually longer because of the prolonged duration of PPA. Both empirical estimates and simulations of birth interval dynamics suggest that in such countries the contraceptive effect of breast feeding is substantial. However, conditions under which breast feeding can be used as a safe and effective method of family planning are not well established. In a 1988 Consensus Statement a group of international scientists agreed that the maximum birth spacing by way of breast feeding is achieved when a mother fully or nearly breast-feeds and remains amenorrheic.

Recent analyses of world fertility studies have indicated that each additional month in average duration of breast feeding increases the average birth interval from 0.25 to 0.50 month (Jain and Bongaarts 1981; Smith 1985).

Life table analysis (Kalbfleisch and Prentice 1980) is used in this study to assess the median durations of PPA and breast feeding and the proportion of females resuming menses before fixed time periods. This method makes it possible to include data for those women who have not yet resumed menses or those who have not weaned.

Table 2 gives the median duration of total (full or partial) breast-feeding duration calculated from life tables for several subgroups of the study population. The table shows that median duration of breast feeding for the overall population is more than 2 years and that each subpopulation exhibits a similar median.

There is some variation in the median duration of breast feeding among various socioeconomic and demographic subgroups (the Wilcoxon nonparametric test at the 5% level is used for group comparison; however, the values of the test statistics are not given here). There is about a 4-month difference in duration of breast feeding according to mother's age at the time of the infant's birth. Mothers aged 30 and above at the child's birth have longer durations of breast feeding than those under 20, and this difference is significant. The study population is predominantly Hindu, among whom caste is

Table 2. Life Table Estimates of Median Duration of Breast Feeding and Postpartum Amenorrhea (in Months) and Proportion of Women Returning to Menses by a Given Month

Characteristic	*Median Duration of Breast Feeding*	*Median Duration of Postpartum Amenorrhea*	*Proportion of Women Returning to Menses in*				*N*
			3 mos.	*6 mos.*	*12 mos.*	*18 mos.*	
Overall	27.33	6.78	48.33	50.86	77.10	86.96	3702
Age of female at birth of child							
<20 years	24.88	3.45	51.79	63.59	84.96	93.37	452
20–25 years	26.58	4.87	48.50	56.59	81.67	89.54	1102
25–30 years	27.87	8.24	41.27	48.59	75.38	86.34	974
⩾30 years	28.91	12.11	37.30	42.69	71.45	82.81	1174
Child's sex							
Male	29.43	6.65	43.63	51.34	78.29	88.25	1923
Female	26.03	6.89	43.00	50.33	75.80	85.58	1779
Wife's education							
Illiterate or nominal	27.43	8.39	41.26	48.73	74.99	85.32	3017
Literate	27.26	2.83	52.31	60.12	86.44	94.40	685
Religion or caste							
Scheduled	31.55	12.02	35.26	42.97	71.69	82.46	862
Middle	29.54	8.44	38.71	48.28	76.05	85.93	954
Muslim	24.58	8.38	41.28	48.77	73.31	85.06	978
Upper	24.77	1.99	55.80	63.09	87.05	93.94	908
Household social status							
Low	29.17	12.02	37.25	44.04	68.75	81.98	1475
Medium	28.65	8.79	40.32	48.31	75.39	85.92	1030
High	26.42	2.88	52.03	59.63	85.90	92.24	1197

often considered a strong indicator of socioeconomic conditions (Bhattacharya et al. 1976; Srinivasan et al. 1989). Scheduled castes, the poorest group, have the longest median duration of breast feeding, whereas Muslims have the same median duration as upper-caste Hindus. The difference in breast-feeding patterns among the religion and caste groups is highly significant.

Table 2 also contains the median length of PPA and the proportion of females returning to menses in 3, 6, 12, and 18 months, computed from life tables. Age of the female at birth of the child and resumption of menses are correlated. As the age of the mother at birth of the child increases, PPA also increases. Variation is also observed in average duration of PPA for females with no education and for those who are literate. The largest variation is observed in religion and caste groups; scheduled castes have the longest PPA period and upper-caste Hindus have the shortest. Differences in PPA among religion and caste groups are highly significant.

The median durations of PPA differ significantly among the household social status groups. PPA length for females with high social status is approximately one-fourth that for females with low social status. More than 50% and 85% of females with high social status return to menses within the first 3 and 12 months, respectively, whereas these percentages are 35% and 65%, respectively, for females with low social status.

Overall median duration of PPA is more than 6 months. This is similar to durations from other studies based on Indian data (Potter et al. 1965; Srinivasan et al. 1989). It has been argued that the living conditions of lower social classes in European countries in the nineteenth century were similar to the conditions in developing countries today. A Norwegian study (Liestol et al. 1988) based on nineteenth-century data support our findings.

Several studies (Lunn et al. 1980, 1981; Ramchandran 1987; Huffman et al. 1987) have suggested that maternal nutritional status has a role in the return to fertility. Females belonging to upper-caste Hindus and the high social status group usually get more nutritious food and better medical care than others. Return of menstruation during lactation may be delayed in undernourished females. This may be because poorly nourished mothers produce less milk and thus have hungrier babies who suckle more frequently and intensively, which lengthens the duration of PPA. This finding is supported by the median duration of PPA in different social status groups.

Fecundability and Sterility. Among fertility parameters fecundability and incidence of sterility are the two important factors that are not directly observable and hence are estimated with suitable models and appropriate data. A model may be complex or simple, according to whether or not it involves a large number of variables and takes into account the variation in these factors.

Fecundability and incidence of sterility have often been estimated with suitable models (distributions) for birth interval or number of births within a given period of time using appropriate data. Obviously, distributions are based on a number of simplifying assumptions about the reproduction process, which is purely biological. Several models have been proposed to describe variation in the number of births to an eligible female during a given time interval (S.N. Singh 1968; S.N. Singh et al. 1971; K.K. Singh 1983).

Recently, Bhattacharya et al. (1987) proposed a model for the number of births during the period (T', $T' + T$), where T' is some distant point from marriage and T is the duration of observation (see the appendix). The distribution involves seven parameters: π, h_1, h_2, c, θ, λ, and α. Here, h (with a subscript) denotes the duration of nonsusceptibility (gestation plus PPA) associated with a live birth. In most cases gestation is taken to be 9 months. Analysis of data revealed that the distribution of duration of PPA is bimodal and that the modes are about 3 months and 9 months. It was also seen that duration of PPA increases with age of female and is relatively smaller for females in upper castes. Because of this observation, in the specification of the model we assume that the women belong to two groups: group 1, consisting of women with a low value of duration of susceptibility h_1; and group 2, women with a high value h_2. π is the proportion of women in group 1. h_1 is taken to be 1.00 year for all females in group 1, and in group 2 h_2 is assumed to be 1.50 years for every female in the upper-caste group and for females aged less than 35 years in the middle castes, scheduled castes, and Muslims, whereas h_2 is 1.75 years for others in these castes.

An attempt was made to estimate the proportions (π, $1 - \pi$) of females in these two groups, and it was estimated that about 40% and 60% of females belong to these groups (S.N. Singh 1993). The average nonsusceptible period associated with fetal loss ($1/c$) is taken to be 0.5 year. The probability θ that a conception results in a live birth is assumed to be 0.85. Couples who did not adopt any terminal method of family planning to space and/or to limit births during the observed period of T years (where both husband and wife were normal residents of the village) constitute the sample studied in the present analysis.

The model with the assumed values of π, h_1, h_2, and θ is fitted to observed distributions of births to eligible females in age groups 20–25, 25–30, 30–35, 35–40, and 40–45 belonging to upper, middle, and scheduled castes among Hindus and to Muslims, where females have a 7-year ($T = 7$ years) exposure to risk of conception. Because the number of females in the 45–50-year age group is less than 50 in every caste group, the model is not applied to it. The maximum-likelihood estimates of λ (yearly risk of conception for a susceptible female) and α (incidence of sterility), obtained with the help of the model (see the appendix), for each religion or caste group according to the present age of the female are given in Table 3. The corresponding esti-

Table 3. Caste-wise Estimates of Fecundability (λ) and Sterility (α) According to Present Age Based on Number of Births within Last Seven Years

Age Group (Years)	*Upper Caste*	*Middle Caste*	*Scheduled Caste*	*Muslims*	*Total (Weighted)*
20–25					
λ	0.571	0.628	0.761	0.741	0.657
α	0.913	0.974	0.990	0.946	0.963
25–30					
λ	0.519	0.707	0.746	0.674	0.675
α	0.963	0.963	0.975	0.969	0.966
30–35					
λ	0.435	0.618	0.700	0.671	0.605
α	0.960	0.925	0.917	0.900	0.928
35–40					
λ	0.380	0.465	0.596	0.599	0.490
α	0.663	0.807	0.837	0.876	0.792
40–45					
λ	0.278	0.401	0.373	0.545	0.385
α	0.362	0.574	0.781	0.637	0.583
45–50					
λ	–	–	–	–	0.214
α	–	–	–	–	0.597

mates of fecundability (probability of conception in one month), denoted by p, can be obtained through the following relation:

$$p + pq + pq^2 + \ldots + pq^{11} = 1 - q^{12} = \lambda, \qquad (1)$$

where $p = 1 - q$ or $p = 1 - (1 - \lambda)^{1/12}$.

Estimates of Fecundability. The estimates of p (i.e., $\hat{p}$), representing fecundability, are obtained with values of λ in Table 3. These are 0.068, 0.059, 0.047, 0.039, and 0.027 for the age groups 20–25, 25–30, 30–35, 35–40, and 40–45, respectively, for females in the upper caste. The values of the estimates consistently decrease. The corresponding estimates of p are 0.079, 0.097, 0.077, 0.051, 0.042 for the middle castes, 0.112, 0.108, 0.096, 0.073, 0.038 for the scheduled castes, and 0.107, 0.089, 0.088, 0.073, 0.064 for Muslims.

In the middle caste the value of p increases from 0.079 to 0.097 and then decreases to 0.042 in the 40–45-year age group. The situation in scheduled castes is somewhat different. The estimates in the first two age groups are almost the same but then decrease slowly. The value corresponding to the 40–45-year age group is relatively small. The values of $\hat{p}$ for Muslims are nearly the same as those of scheduled castes for age groups 20–25, 25–30, 30–35, and 35–40. However, 0.064, the estimate of p in the 40–45-year age group for Muslims, is relatively high in comparison to those for other caste groups. Thus fecundability in Muslims is high even at older ages. The estimates of fecundability in the upper castes are relatively lower than those in other caste or religion groups for each age group. This indicates that perhaps use of nonterminal contraceptives is relatively higher in upper castes.

The estimates of p for the total study population are 0.085, 0.089, 0.075, 0.055, 0.040, and 0.020 for the age groups 20–25, 25–30, 30–35, 35–40, 40–45, and 45–50, respectively. From these figures it is evident that fecundability increases in the beginning, attains its maximum in the twenties, remains almost constant up to age 30, and gradually declines afterward. Similar trends have been reported by Agarwala (1966), S.N. Singh et al. (1971), James (1973), and Bhattacharya et al. (1987).

In the later part of the reproductive period, the estimate of p decreases with age. Obviously, the estimates are well below the observed maximum biological potential because of the following three biological, behavioral, and environmental factors. (1) An obvious factor is the decrease in coital frequency. This may be partly due to a decline in male sexual activity with age, health conditions of partners, etc. and partly due to behavioral factors (more responsibility of the household; presence of daughter-in-law, grown-up children, etc.) (Jain 1969; Nag 1972; Wyon and Gordon 1971). (2) The incidence of anovulatory cycles, found to be greater at extreme ages of childbearing, may depress fecundability. (3) It is observed that secondary sterility is prevalent among older females. In older age groups the transition from fecundity to sterility is more prevalent and may take place at any time. For example, about 20% of couples become sterile when the female partner reaches 35–40 years. These couples might have become sterile at any time during this interval, so they reduce the average number of births in this interval and hence the estimate of p. Besides these factors, practice of conventional or modern methods of nonterminal contraception to limit the number of births may be responsible for the low value of average fecundability for females over 30 years of age (S.N. Singh 1993).

Estimates of Sterility. It is difficult to identify the inability of a couple to procreate because sterility is suspected only if, in the absence of deliberate efforts to control fertility, a female is unable to have any recognizable conception during a sufficiently long period after marriage. The estimate of proportion of sterile couples $(1 - \alpha)$ is approximately the same for females whose present age is 25–30 in all caste groups. It is evident from Table 3 that sterility increases with age after 30. For females whose present age is 35–40 years or older the estimate of $(1 - \alpha)$ can be considered the sum of the proportion of couples who are primarily sterile and those attaining secondary sterility at any time from marriage to the beginning of the interval. Thus it is reasonable to consider the smallest value of $(1 - \alpha)$ as the estimate of primary sterility, assuming that the proportion of primarily sterile couples is the same for all birth cohorts or age intervals.

The smallest value of $(1 - \hat{\alpha})$ is 4% for the 25–30-year age group in all religion and caste groups. This estimate is in agreement with the findings of other studies conducted in India stating that the proportion of primarily sterile couples lies between 2.4% and 10.5% (Agarwala 1966; S.N. Singh et al. 1971; Bhattacharya and Singh 1983; Bhattacharya et al. 1988; K.K. Singh et al. 1992) and with studies based on data relating to Western countries (Vincent 1950; Lavis 1975; Pittenger 1973), where the smallest values of age-specific couple sterility are found to lie between 2% and 8%.

In this connection it is important to point out that the estimate of secondarily sterile couples or those using nonterminal methods of contraception effectively during the period of 7 years in any age interval after age 30 of the female is $1 - \alpha - 0.04$. For example, for couples in the upper castes in the age interval 35–40 years, the value is $1.000 - 0.663 - 0.040 = 0.297$. Thus about 30% of couples in the 35–40-year age group are secondarily sterile or use effective nonterminal methods of contraceptives.

Menopause. The reproductive period of a female begins with first menstruation and continues until menopause. When menstruation finally ceases, the female is said to have attained menopause, which terminates the reproductive period. Menopause varies considerably from female to female. So far, no precise minimum or maximum age is reported. Depending on a number of factors, menopause occurs at varying ages within a certain range, usually between 30 and 55 years and rarely beyond 55 years (Dandekar 1959; Post 1971; Amundsen and Diers 1973; Bhaduri 1975). In developed countries the mean age at menopause ranges from 47 to 50 years (McMahon and Worcester 1966; Gray 1979), whereas in developing countries the range is 44 to 50 years (Bhaduri 1975; Bongaarts 1980).

It is difficult to identify the precise age at which menopause occurs because it happens gradually and because postmenopausal females, generally rather old at the time of interview, do not remember the correct age. Amundsen and Diers (1973) stated that in modern times the age at menopause has increased, but others report that the evidence for such an increase is not conclusive and that the evidence to support Formmer's (1964) hypothesis that the age at menopause has changed noticeably in the last century is not firm (McKinley et al. 1972; Burch and Gunz 1967).

The present study consists of two types of observations. One is uncensored data for females who have experienced menopause before the survey date; the other is censored data for females who have not experienced menopause up to the survey date. The censored observation provide information that the time of menopause exceeds the date of the survey. Because both censored and uncensored observations are considered, life table analysis (Kalbfleisch and Prentice 1980) is used.

Table 4 presents the conditional probability that a female attains menopause in different age groups according to religion and caste groups. Because the data provide information for eligible females only, the conditional risk of

Table 4. Probability of Conditional Risk of Menopause in Different Religion and Caste Groups According to Age of Female

Age (Years)	*Upper Caste*	*Middle Caste*	*Scheduled Caste*	*Muslims*	*Total (Weighted)*
up to 30	0.000	0.000	0.003	0.000	0.001
30–35	0.017	0.021	0.022	0.010	0.019
35–40	0.082	0.082	0.084	0.053	0.080
40–45	0.226	0.220	0.318	0.189	0.240
45–50	0.271	0.347	0.429	0.316	0.347

menopause is calculated up to the female's age of 50 years. There is no information on age of menopause if the females are sterilized before the date of survey. These females are treated as censored, and the age of sterilization is treated as the age of withdrawal. Thus there may be a downward bias in the estimate of conditional probability of the risk of menopause.

It is observed from Table 4 that the incidence of menopause is rare before age 35. The conditional probability that a female attains menopause increases with her age in each caste and religion group; however, this probability is comparatively smaller for females in the upper castes and larger for females in the scheduled castes.

Conclusion and Suggestions

Early marriage of females has been prevalent in India for a long time. Considering its multifarious effects on health, education, fertility, etc., the government of India fixed 18 years as the minimum age at marriage for females irrespective of religion or caste and locality. But the overall mean age at RM (when the partners start living together) is still between 16 and 17 years in the study area. However, there is an increasing trend over time in each caste group. Mean age at RM is highest in upper castes and lowest in scheduled castes. Because in the calculation of mean age at marriage only currently married females were considered, there may be some downward bias, especially for marriages performed after 1980.

Together with economic causes, social considerations are important factors perpetuating the customs of early marriage. Parents consider the marriage of their children as one of their major responsibilities and hence play an important role in this ceremony, which is traditionally religious. While deciding about the marriage partners, it is customary to take into account the suitability of boys and girls and the status of households to which they belong. Thus it is difficult to raise the average age at marriage in the study area at least in the foreseeable future because of the existing economic and sociocultural factors.

The practice of breast feeding is almost universal in the study area. In general, breast feeding is prolonged and on average is extended up to two years. Children are normally fed on demand, and night feeding is common. Usually, complete weaning occurs only when the next pregnancy is in an advanced stage or when milk flow is almost negligible. There is no substantial difference in the duration of breast feeding among the population subgroups.

The overall median duration of PPA is about seven months. However, there is a considerable variation according to different characteristics. The median duration is less than 4 months if the age of the mother at the birth of her child is less than 20 years, whereas it is about 12 months if she is more than 30 years old. Duration of PPA varies according to caste, social status, and education of the female. In this connection it should be noted that the caste, social status, and female's education are associated in the sense that most of the upper-caste females have higher social status and a considerable proportion of them are literate. Females belonging to a higher social status group usually get more nutritious food and better medical care than others. This might play an important role in the early return of menses. Similar results have been reported by Lunn et al. (1980, 1981), Ramchandran (1987), and S.N. Singh (1993). It has been speculated that return of menstruation during lactation may be delayed in undernourished females. It may be that poorly nourished mothers produce less milk and thus might have hungrier babies who suckle more frequently and intensively, thus lengthening the duration of PPA (K. Singh 1990; S.N. Singh et al. 1990).

Estimates of p, representing fecundability, have been obtained with the help of the probability model given in the appendix and the observed distribution of the number of births to eligible females during a 7-year period. The estimates are highest in the 20–25-year age group in each religion or caste group (except in the middle-caste group) and decrease with increasing age. The values of $\hat{p}$ for upper castes are considerably lower than those for any other religion or caste group in each age group. This may be due to the use of nonterminal methods of contraception by upper-caste couples.

The weighted estimates of fecundability are lower in comparison to those in Western countries (Jain 1969; James 1973; Sullivan et al. 1974), but these values are consistent with studies conducted in eastern Uttar Pradesh (Srinivasan 1966; S.N. Singh et al. 1971; Bhattacharya and Singh 1984; Bhattacharya et al. 1987). Existing sociocultural factors prevalent in the region are likely to be responsible for the low estimates.

Prevalences of primary and secondary sterility have been obtained by applying the proposed model and the observed distribution of the number of births to eligible females during the period of the last seven years in different religion and caste groups. The values indicate that 4% of females are primarily sterile and that the incidence of secondary sterility increases with age of the female after 30 years of age.

It is difficult to identify the actual age at which menopause occurs because it happens gradually and because menopausal females generally do not remember the correct age. Here, estimates of the conditional risk of attaining menopause are obtained with the help of the life table technique. From the values of the estimates it is evident that the occurrence of menopause is rare before age 35 and increases with age of the female irrespective of religion or caste. However, this risk is minimum for females in upper castes and maximum for those in scheduled castes. This may be due to differences in health conditions.

From the present analysis it is evident that sociocultural and economic factors influence the fertility behavior of couples in the study area. Consequently, age at marriage and fecundability will remain low unless some alternative effective and culturally acceptable measures are adopted to change age at marriage and lactational and fertility behavior.

Appendix

Estimates of the conception rate and the proportion of sterile couples for the observed distribution can be obtained by using the theoretical distribution for number of births to a couple during a specified period of time, given by Bhattacharya et al. (1987), when the start is a considerable distance from marriage. The model is derived under the following five assumptions.

1. The population under consideration consists of two groups of females, namely, sterile and fecund with proportions $(1 - \alpha)$ and α, respectively, where $0 < \alpha \leqslant 1$. All fecund females have identical values of the biological parameters, described in the text and herein.

2. Given that the female is in sexual union throughout the interval (t_1, t_2), $0 < t_1 < t_2 < T$, the number of coitions of the couple during the interval is a random variable and follows a Poisson distribution with parameter $\lambda_1(t_2 - t_1)$, $\lambda_1 > 0$. For convenience the times t_1, t_2, and T are measured in years.

3. The coitions are mutually independent, and p', the probability that a coition results in a conception, is constant. Under assumptions 2 and 3 the number of conceptions during the time interval (t_1, t_2) follows a Poisson distribution with parameter $\lambda(t_2 - t_1)$, where $\lambda = \lambda_1 p'$.

4. A conception ends in either a live birth or a fetal loss. Let θ be the probability that a conception results in a live birth.

5. h is the length of the nonsusceptible period comprising the duration of pregnancy and PPA associated with conception leading to a live birth. The length of the nonsusceptible period associated with fetal loss is a random variable and follows an exponential distribution with mean $1/c$, $c > 0$.

Let t be the time measured from the start of observation. Suppose that the beginning of observation (i.e., $t = 0$) is a distant point since marriage and that for a fecund female the fertility parameters λ, the probability of a conception ending in a fetal loss $(1 - \theta)$, the nonsusceptible period associated with a live birth h, and the parameter of the distribution of nonsusceptible period associated with fetal loss c become stable before the start of observation so that equilibrium is attained at $t = 0$. Suppose that levels of these parameters remain the same throughout the period $(0, t)$.

It can be shown that the distribution of the time of the $(r + 1)$th conception in the interval $(0, T)$, say, $K_{r+1}(t)$, is

$$K_{r+1}(t) = F_{r+1}(t), \tag{A.1}$$

where

$$F_1(t) = \begin{cases} t/\mu & \text{for } 0 < t \leq h, \\ \dfrac{1}{\mu}\left[t - \sum_{i=1}^{2} A_1(i, 1)G(i, 1, t - h)\right] & \text{for } t > h, \end{cases} \tag{A.2}$$

$$F_{r+1}(t) = \frac{1}{\mu}\left\{\sum_{i=1}^{2}\sum_{j=1}^{r} A_r(i, j)G(i, j, t - rh) - \sum_{i=1}^{2}\sum_{j=1}^{r+1} A_{r+1}(i, j)G[i, j, t - (r + 1)h]\right\}, \tag{A.3a}$$

$$r = 1, 2, \ldots, \tag{A.3b}$$

$$\mu = \frac{1}{\lambda\theta}(1 + \lambda H), \tag{A.3c}$$

$$H = \theta h + \frac{(1 - \theta)}{c}, \tag{A.3d}$$

and for any $d > 0$

$$G(i, j, t - d) = \begin{cases} (t - d) - \dfrac{1}{v_i}\left\{j - \exp[-v_i(t - d)]\sum_{u=0}^{j-1}(j - u)\dfrac{[v_i(t - d)]^u}{u!}\right\} & \text{for } t > d, \\ 0 & \text{otherwise,} \end{cases} \tag{A.4}$$

$$A_{r+1}(1, j) = \frac{(v_1 v_2)^{r+1}}{c^{r+1} v_1^j}\sum_{k=0}^{r+1-j}(-1)^k\binom{r + k}{k}\binom{r + 1}{j + k} \times [(c - v_1)^{j+k}/(v_2 - v_1)^{r+k+1}]. \tag{A.5}$$

$A_{r+1}(2, j)$ is obtained by replacing v_1 and v_2 by v_2 and v_1, respectively:

$$v_1 = \frac{a+b}{2}, \quad v_2 = \frac{a-b}{2}, \tag{A.6}$$

where

$$a = m + c \quad \text{and} \quad b = (a^2 - 4mc\theta)^{1/2}. \tag{A.7}$$

The maximum number of births to a female in (0, T) is

$$n' = \begin{cases} T/h & \text{if } T \text{ is a multiple of } h, \\ (T/h) + 1 & \text{otherwise.} \end{cases} \tag{A.8}$$

The probability of exactly r births to a female in (0, T) is given by

$$P_r = \begin{cases} (1-\alpha) + \alpha[1 - K_1(T)] & \text{for } r = 0, \\ \alpha[K_r(T) - K_{r+1}(T)] & \text{for } r = 1, 2, \ldots, n' - 1, \\ \alpha K_r(T) & \text{for } r = n'. \end{cases} \tag{A.9}$$

If the population is heterogeneous with respect to h, it can be assumed to consist of q distinct homogeneous subpopulations; and if p_i is the proportion of fecund females in the ith group with $h = h_i$ $(0 < h_1 < h_2 < \ldots < h_q)$, then the probability of r or fewer births to a female during T years of marriage is

$$P_r = \begin{cases} 1 - \alpha \sum_{i=1}^{q} p_i K_1(T) & \text{for } r = 0, \\ \alpha \sum_{i=1}^{q} p_i [K_r(T) - K_{r+1}(T)] & \text{for } r = 1, 2, \ldots, n' - 1, \\ \alpha \sum_{i=1}^{q} p_i K_r(T) & \text{for } r = n', \end{cases} \tag{A.10}$$

where n' is obtained by replacing h with h_i in Eq. (A.8).

Acknowledgments We are thankful to S.N. Singh, the former director of the Centre of Population Studies, Banaras Hindu University, India, for giving us permission to use the data. We also thank the anonymous referees for their useful comments and suggestions.

Received 7 April 1994; revision received 23 September 1994.

Literature Cited

Agarwala, S.N. 1966. *Some Problems of India's Population.* Bombay, India: Vora.

Amundsen, D.W., and C.I. Diers. 1973. The age at menopause in medieval Europe. *Hum. Biol.* 45:605–612.

Bhaduri, T. 1975. A study of natural sterility and its effects on human fertility. Ph.D. thesis, Banaras Hindu University, Varanasi, India.

Bhattacharya, B.N., and K.K. Singh. 1983. On a modification of life table technique for analysis of birth interval data and its application. *Janasamkhya.* 1(2):99–116.

Bhattacharya, B.N., and K.K. Singh. 1984. A modification of a model for number of births and estimation of age specific fecundability and sterility. *Janasamkhya.* 2:1–18.

Bhattacharya, B.N., C.M. Pandey, and K.K. Singh. 1988. Model for first birth interval and some social factors. *Math. Biosci.* 92:17–28.

Bhattacharya, B.N., K.K. Singh, and C.M. Pandey. 1987. Some models for number of births and estimates of natural age specific fecundability and sterility for a rural part of northern India. *Math. Biosci.* 87:141–160.

Bhattacharya, B.N., R.C. Yadava, and G.D. Pandey. 1976. *Some Characteristics of Households in Rural Areas of Varanasi.* Varanasi, India: Centre of Population Studies, Banaras Hindu University.

Bongaarts, J. 1980. Does malnutrition affect fecundity? A summary of evidence. *Science* 208:564–569.

Bongaarts, J. 1983. The proximate determinants of natural marital fertility. In *Determinants of Fertility in Developing Countries,* R.A. Bulato and R.D. Lee, eds. New York: Academic Press, 103–138.

Bose, A. 1988. On search of a new strategy for family planning in India. Presidential Address, 13th Annual Conference, Indian Association for Study of Population, Waltair, India.

Burch, P.R., and F.N. Gunz. 1967. The distribution of the menopause age in New Zealand: An exploratory study. *New Zealand Med. J.* 66:6–10.

Cleland, J., J.B. Casterline, S. Singh et al. 1984. The effects of nuptiality, contraception, and breast-feeding on fertility in developing countries. *Int. Fam. Plann. Perspect.* 10(3):86–93.

Consensus Statement. 1988. Breast-feeding as a family planning method. *Lancet* 1204–1205.

Dandekar, K. 1959. *Demography of Six Rural Communities.* Bombay, India: Asia Publishing House.

Davis, K., and J. Blake. 1956. Social structure and fertility: An analytic framework. *Econ. Dev. Cult. Change* 4:211–235.

Formmer, D.J. 1964. Changing age of menopause. *Br. Med. J.* 2:349–351.

Gray, R. 1979. Biological and social interactions in the determination of late fertility. *J. Biosoc. Sci.* 6(suppl.):97–115.

Henry, L. 1961. Some data on natural fertility. *Eugen. Q.* 8:81–91.

Henry, L. 1964. Mesure du temps mort en fecondite naturelle. *Population* 19:485–514. Also appears in English in *On the Measurement of Human Fertility,* M. Sheps and E. Lapierre-Adamcyk, eds. (Amsterdam, Netherlands: Elsevier, 1972, pp. 115–154).

Howie, P.W., and A.S. McNeilly. 1982. Effect of breast-feeding patterns on human birth intervals. *J. Reprod. Fertil.* 65:545–547.

Huffman, S.L., K. Ford, H.A. Allen Jr. et al. 1987. Nutrition and fertility in Bangladesh: Breast-feeding and postpartum amenorrhoea. *Popul. Stud.* 47:447–462.

Jain, A.K. 1969. Fecundability and its relation to age in a sample of Taiwanese women. *Popul. Stud.* 23:69–85.

Jain, A.K., and J. Bongaarts. 1981. Breast-feeding: Patterns, correlates, and fertility effects. *Stud. Fam. Plann.* 12:79–108.

James, W.H. 1973. The fecundability of US women. *Popul. Stud.* 27:493–500.

Kalbfleisch, J.D., and R.L. Prentice 1980. *The Statistical Analysis of Failure Time Data.* New York: Wiley.

Lavis, D.R. 1975. *Oral Contraception in Melbourne 1961–1971.* Australian Family Formulation Project Monograph 3. Canberra, Australia: Department of Demography, Australian National University.

Leridon, H. 1977. *Human Fertility: The Basic Components.* Chicago, IL: University of Chicago Press.

Liestol, K., M. Rosenberg, and L. Walloe. 1988. Lactation and postpartum amenorrhoea: A study based on data from three Norwegian cities, 1860–1964. *J. Biosoc. Sci.* 20:423–434.

Lunn, P.G., A.M. Prentice, A. Austin et al. 1980. Influence of maternal diet on plasma prolactin levels during lactation. *Lancet* 1:623–625.

Lunn, P.G., M. Watkinson, A.M. Prentice et al. 1981. Maternal nutrition and lactational amenorrhoea. *Lancet* 1:1428–1429.

McKinley, S., M. Jeferys, and B. Thompson. 1972. An investigation of the age at menopause. *J. Biosoc. Sci.* 4:161–173.

McMahon, B., and J. Worcester. 1966. *Age at Menopause: United States, 1960–61.* US Vital and Health Statistics Monographs, ser. 11, no. 19. Washington, DC: US Government Printing Office.

Nag, M. 1972. Sex, culture, and human fertility: India and United States. *Curr. Anthropol.* 13:231–237.

Nath, D.C., K.K. Singh, K.C. Land et al. 1993. Breast-feeding and postpartum amenorrhoea in traditional society: A hazards model analysis. *Soc. Biol.* 40(1–2):74–86.

Perez, A., P. Vela, G.S. Masnick et al. 1972. First ovulation after childbirth: The effect of breast-feeding. *Am. J. Obstet. Gynecol.* 114:1041–1047.

Pittenger, D.B. 1973. An exponential model of female sterility. *Demography* 10:113–121.

Post, J.B. 1971. Ages at menarche and menopause: Some medieval authorities. *Popul. Stud.* 25:83–87.

Potter, R.G., M.L. New, J.W. Wyon et al. 1965. Lactation and its effects upon birth intervals in eleven Punjab villages. *Ind. J. Chron. Dis.* 18:1125–1140.

Ramchandran, P. 1987. Breast-feeding and fertility: Socio-cultural factors. *Int. J. Gynecol. Obstet.* 25(suppl.):191–206.

Registrar General. 1992. *Sample Registration System.* New Delhi, India. Vital Statistics Division, 95–159.

Santow, G. 1978. *A Simulation Approach to the Study of Human Fertility.* Publications of the Netherlands Interuniversity, Demographic Institute and the Population and Family Study Centre, v. 5. Boston, MA: Martinus Nijhoff Social Science Division.

Singh, K. 1990. An empirical study of the effect of breast-feeding on fertility. Ph.D. thesis, Banaras Hindu University, Varanasi, India.

Singh, K.K. 1983. Some analytical models for couple fertility and their applications. Ph.D. thesis, Banaras Hindu University, Varanasi, India.

Singh, K.K., C.M. Suchindran, and Kiran Singh. 1993. Breast-feeding and postpartum amenorrhoea: An Indian experience. Unpublished.

Singh, K.K., C.M. Suchindran, V. Singh et al. 1992. Age at return marriage and timing of first birth in India's Uttar Pradesh and Kerala states. *Soc. Biol.* 39:292–298.

Singh, S.N. 1968. A chance mechanism of variation in the number of births per couple. *J. Am. Stat. Assoc.* 63:209–213.

Singh, S.N. 1969. Low estimates of fecundability. Paper presented at the International Union for the Scientific Study of Population General Conference, London, SS1.11–1.19.

Singh, S.N. 1993. *Effects of Sociocultural Factors on Determinants of Fertility in Eastern Uttar Pradesh.* Project Report, Indian Council of Medical Research, New Delhi, India.

Singh, S.N., and K.K. Singh. 1989. Life table analysis of censored data on postpartum amenorrhoea. *Demogr. Ind.* 18:27–38.

Singh, S.N., B.N. Bhattacharya, and R.C. Yadava. 1971. On some distributions for couple fertility and their applications. In *Proceedings of All Indian Seminars on Demography and Statistics*, S.N. Singh, ed. Varanasi, India: Banaras Hindu University, 76–94.

Singh, S.N., K.K. Singh, K. Singh et al. 1990. Socioeconomic development and transition in the duration of postpartum amenorrhoea: Survival function analysis of data. *Janasamkhya* 8:41–54.

Smith, D.P. 1985. Breast-feeding, contraception, and birth intervals in developing countries. *Stud. Fam. Plann.* 16(3):154–163.

Srinivasan, K. 1966. An application of a probability model to the study of interlive birth intervals. *Sankhya*, ser. B, 28:175–182.

Srinivasan, K., K.B. Pathak, and A. Pandey. 1989. Determinants of breast-feeding and postpartum amenorrhoea in Orissa. *J. Biosoc. Sci.* 21:365–371.

Sullivan, J.M., K.H. Su, and T.H. Li. 1974. *The Fertility Effect of Induced Abortion in Taiwan*. Taiwan Population Studies Working Paper 29. Ann Arbor, MI: Population Studies Center, University of Michigan.

Vincent, P. 1950. La sterilite physiologique des populations. *Population* 5:45–64.

Wyon, J.B., and J.E. Gordon 1971. *The Khanna Study: Population Problems in Punjab*. Cambridge, MA: Harvard University Press.