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Application of Life Table Technique to Estimate the Fecundability through First Birth Interval Data

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Abstract: The term fecundability is an important biological determinant of fertility, which regulate the actual number of children produced by the female. Since fecundability is the monthly chance of conception thus it can be defined as inverse of the waiting time required for a conception, but this time cannot be measured directly and due to this reason birth interval can be used. The paper deals with the estimation of fecundability from the data of waiting time to first conception, i.e., 9 months smaller (on average) than the first birth interval through life table technique. The relevant data is extracted from the National Family Health Survey-III. The result reveals that fecundability increase as the age at marriage of a female increases. It is observed from the data that urban and Muslim females are more fecundable than their counterparts i.e. rural and Hindu females.

Keywords: fertility, fecundability, life table, life expectancy, waiting time to first conception, age at marriage.

1 Introduction

Fertility analysis has the central importance in demographic analysis as births are a vital component of responsible for population growth in the developing countries as well as in the underdeveloped countries. The study of fertility also provides important information about female's reproductive behaviour. Many studies have been carried out to look at the fertility variations across states and the factors which are influencing fertility level over time ([7], [2], [12], [9]). It is worthwhile to mention here that socio-economic and cultural factors affect fertility mainly through biological factors. To determine these factors as well as tempo and quantum of the fertility in the society, different type of birth intervals such as first birth interval, last closed birth interval, most recent closed birth interval, straddling birth interval, interior birth interval and forward birth interval offer an interesting and fruitful area for scientific research.

Among these, first birth interval plays an important role in determination of fertility level of the society because the length of first birth interval can be considered as start of parenthood, i.e., the couple start their reproductive process. This interval has been important for the analysis of fertility pattern because it is free from post-partum amenorrhea (PPA) period. In the traditional society the females usually do not use any type of contraception before giving first birth. Therefore, the timing of first birth can be considered an actual measure of fcundability if the female is adequately mature at the time of marriage.

There is a need to study how different factors influence the duration of the first birth interval in different Indian social contexts during the present days. A female's age at marriage is considered to be one of the most important variable accounting for variation in fertility levels among different societies of the world. A negative relationship between age at marriage and fertility also has been noted in several studies conducted in developing countries ([3], [4], [6], [13], [1]). Several socio demographic variables have been found to influence significantly the length of the first birth interval ([12], [10] & [11]).

Life table analysis, one of the oldest statistical techniques extensively by medical statisticians and by actuaries to analyse survival data, is now being increasingly applied to data for the analysis of first birth interval, because it includes

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open ended incomplete intervals and compensates to a degree for the truncation effect. In this respect [2] have analysed the data of time of first birth interval based on life table technique from for married females in reproductive ages enumerated in a retrospective survey. The waiting time to first conception, which is generally taken as nine months smaller than the interval between marriage and first birth is considered in this paper and the waiting time to first conception has been analyzed to know the current situations of fertility pattern using life table technique. The main objective of this paper is to estimate the level of fecundability for some demographic characteristics using the data of National Family Health Survey (NFHS)-III for the state of Uttar Pradesh.

2 Data and Methodology

In this study data has been taken from NFHS-III for currently married females aged 15-49 years of the most populous state Uttar Pradesh of India. To avoid recall bias, only those females have been considered who delivered their first birth in last 10 year, i.e., 10 year prior to the reference date of the survey. Also, the data restrict the waiting time to first conception up to 60 months because beyond this the number of females are very less. Data on first birth interval collected under retrospective surveys are considered to be useful for determining the tempo as well as quantum of fertility.

The observations on first birth interval under retrospective survey are, however, met with complete as well as incomplete because some females may be childless at the time of survey date. In such a situation, life table technique, which considers both the complete (having at least one birth at the time of survey date) as well as censored observations (childless females at the time of survey date), are considered to be an appropriate technique for analyzing the data. The total sample size is obtained as 3274 females and out of which 642 females are censored. Place of residence, religion and age at first marriage have been considered as covariates for the fecundability in the present study.

2.1 A brief description of Life Table

The life table technique is essentially based on the concept of exposure to the risk of the event under consideration, happening in specified age groups. Among others, two main assumptions are involved are in the computation of different columns of life table:

–The population is homogeneous with respect to the characteristics under study and
–There is no connection between censoring and occurrence of the event.

A population is said to be homogeneous if and only if all of its members are subjected to the same conditional probability of experiencing the event at duration, say T, given that they are at risk (of experiencing the event) as at given T. The independence of failure and censoring mechanism implies, for example, that individuals are not selectively censored because of a relatively poor or relatively good prognosis [8].

Consider a survey where information on the waiting time to first conception on the reference date has been collected for a female population. Let the reference period of inquiry be divided into n subgroups, x_1, x_2,... x_n defined below.
x_i(i=1,2,... ,n): The i^{th} interval of length half year.
l_x: The number of females who have not conceived on or before the reference date in interval x_i.
d_x: The number of females who have conceived on or before the reference date in the interval x_i.
q_x: Estimated conditional probability of the females in each age interval who have not conceived at the beginning of the interval, and conceived before reaching the end of the interval x_i.
L_x: Total number of person-years survived by the females without any conception in the interval x_i.
T_x: The number of years survived by the females without any conception in the interval x_i and in all subsequent years.
$e_x{}^0$: An estimate of average future time of first conception of a female after attainment of age x_i.

2.1.1 Estimation of Fecundability

The two columns q_x and e_x^0 are of the main interest in any life table analysis. According to usual life table e_x^0 gives an estimate of the average required time for conception after attainment of age x. The q_x value gives the conditional probability of conception during the interval $(x,x+1)$ for the females who have not conceived up to x. If $\lambda(x)$ represents the constant conception rate in the interval $(x,x+1)$, then the chance of conception in $(x,x+1)$ unit of time is obtained as

$$q_x = 1 - \exp^{-\lambda(x)}$$

This equation can serve to estimate the value of $\lambda(x)$ for the interval $(x,x+1)$. After estimating fecundability can be obtained by dividing $\lambda(x)$ by 6, since the width of interval is 6 months here.

3 Results

Life table values corresponding to waiting time to first conception for all the females of the state Uttar Pradesh as well as for different subgroups such as place of residence, age at marriage group and religion are given in Tables 1-8. From the Tables it can be clearly seen that last column, i.e., e_x^0 (average additional waiting time to conception) is decreasing continuously as the time is increasing. From Table 1 it is observed that if we consider all the females of Uttar Pradesh it was observed that in the first unit of time interval, i.e., 0-6 months the waiting time to first conception is observed as 2.77 month, whereas, for the last interval, i.e., 54-60 months it is found as 0.37. Since the width of each interval in table is 6 months so that the female of the first interval will take on an average 6 times of 2.77, i.e., 16.62 additional months for conception and the female in the last interval will take on an average 2.22 months to conceive. The estimated value q_x, i.e., probability of conception for the first unit of time interval, i.e., 0-6 months is found as 0.216, whereas, for the last interval 54-60 months it is observed as 0.732 which is very high as compared to first time interval, which indicates chance of conception is increasing continuously as the time after marriage is increasing.

Similar pattern is observed for the females living in urban as well as rural areas which are represented in Table 2 and Table 3 respectively. From these tables it is observed that average waiting time for the first conception at the beginning after marriage is 2.21 months among urban females, whereas, this duration is observed as 3.13 months among rural females per unit time. Further, from Table 4, 5 and 6 it can be clearly observed that as the age at first marriage of females is increasing average waiting time to the first conception is decreasing with respect to time after marriage and the probability of conception is also increasing. When we compare the average waiting time to conception religion wise (Table 7 and 8) it is found that just after marriage Hindu females on an average take 3 months to get first conception, whereas, Muslim females take only 2 months per unit of time.

In this study, the main emphasis is to calculate q_x (Probability of conception) with the help of life table technique. Considering the value of q_x, which is used for calculation of the estimate of λ with the formula discussed above. Obviously λ gives the conception rate per unit of time which is 6 months. Thus, an estimate of fecundability is calculated as $\lambda/6$. From the Tables it is clear that the overall estimated fecundability is 0.048 and the yearly conception rate is 0.576. According to estimated results urban female's fecundability is 0.059, whereas, it is less for rural females, i.e., 0.044. With respect to age at marriage, fecundability increases as the age at marriage group increases. Fecundability were observed as 0.041, 0.046 and 0.054 for the females whose age at marriage is below 16 years, between 16-18 years, and above 18 years respectively. Thus, it can be said that fecundability of females increases as the female's age at marriage increases. If we compare according to religion then it is observed that fecundability among Hindu and Muslim females are 0.042 and 0.059 respectively.

4 Discussion and Conclusion

Study of interval between marriage to first conception is significant because this is an indicator that the female enter into the state of motherhood. Results presented here show that, in the absence of contraception the females of Uttar Pradesh, India experience usually longer waiting time to first conception. This may be due to abstinence from coitus which is a cultural practice scrupulously observed for various reasons by most couple in the study population and other traditional societies in India. Age at marriage is the most important factor explaining fecundability of the study population. A negative relationship is observed between the age at marriage of the females and the average waiting time to first conception which were also observed in the studies ([3], [4], [6] and [13]). Due to the adolescent sterility and visit after marriage to the parental home the fecundability is low in the younger female in the study sample, as age of female is increasing the fecundability is also increasing [2]. [9] have shown that fecundability is high among urban females as compared to rural females and Muslim females are more fecund that Hindus. Recently [5] observed same result for the females of Bangladesh. Thus, in nut cell it is concluded that there is no change in fertility differentials over the time.

Table 1: Life table values corresponding to waiting time to first conception for all the females of Uttar Pradesh.

Waiting to Conception (in months)	x	l_x	d_x	q_x	L_x	T_x	$e_x{}^0$
0-6	0	3274	706	0.216	2828.0	9077.0	2.77
6-12	1	2475	563	0.227	2011.5	6249.0	2.52
12-18	2	1730	388	0.224	1466.0	4237.5	2.45
18-24	3	1272	340	0.267	989.0	2771.5	2.18
24-30	4	819	185	0.226	706.5	1782.5	2.18
30-36	5	614	173	0.282	456.5	1076.0	1.75
36-42	6	370	86	0.232	315.0	619.5	1.67
42-48	7	272	87	0.320	181.5	304.5	1.12
48-54	8	138	52	0.377	97.0	123.0	0.89
54-60	9	71	52	0.732	26.0	26.0	0.37
Estimate of Fecundability (monthly chance of conception)=0.048							

Table 2: Life table values corresponding to waiting time to first conception for Urban females of Uttar Pradesh.

Waiting to Conception (in months)	x	l_x	d_x	q_x	L_x	T_x	$e_x{}^0$
0-6	0	1285	412	0.321	1043.0	2841.5	2.21
6-12	1	837	237	0.283	660.5	1798.5	2.15
12-18	2	542	154	0.284	437.0	1138.0	2.10
18-24	3	360	119	0.331	273.5	701.0	1.95
24-30	4	214	52	0.243	175.0	427.5	2.00
30-36	5	149	43	0.289	111.5	252.5	1.69
36-42	6	90	24	0.267	71.0	141.0	1.57
42-48	7	59	19	0.322	44.5	70.0	1.19
48-54	8	35	12	0.343	20.0	25.5	0.73
54-60	9	14	11	0.786	5.5	5.5	0.39
Estimate of Fecundability (monthly chance of conception)=0.059							

Table 3: Life table values corresponding to waiting time to first conception for Rural females of Uttar Pradesh.

Waiting to Conception (in months)	x	l_x	d_x	q_x	L_x	T_x	$e_x{}^0$
0-6	0	1989	294	0.148	1785.0	6235.5	3.13
6-12	1	1638	326	0.199	1351.0	4450.5	2.72
12-18	2	1188	234	0.197	1029.0	3099.5	2.61
18-24	3	912	221	0.242	715.5	2070.5	2.27
24-30	4	605	133	0.220	531.5	1355.0	2.24
30-36	5	465	130	0.282	345.0	823.5	1.77
36-42	6	280	62	0.221	244.0	478.5	1.71
42-48	7	213	68	0.319	137.0	234.5	1.10
48-54	8	103	40	0.388	77.0	97.5	0.95
54-60	9	57	41	0.719	20.5	20.5	0.36
Estimate of Fecundability (monthly chance of conception)=0.044							

Table 4: Life table values corresponding to waiting time to first conception for females whose age at marriage is below 16 years.

Waiting to Conception (in months)	x	l_x	d_x	q_x	L_x	T_x	$e_x{}^0$
0-6	0	700	94	0.134	645.0	2518.5	3.60
6-12	1	598	112	0.187	516.0	1873.5	3.13
12-18	2	460	82	0.178	412.0	1357.5	2.95
18-24	3	371	92	0.248	315.0	945.5	2.55
24-30	4	269	61	0.227	235.5	630.5	2.34
30-36	5	205	51	0.249	155.5	395.0	1.93
36-42	6	130	28	0.215	116.0	239.5	1.84
42-48	7	102	34	0.333	72.0	123.5	1.21
48-54	8	55	23	0.418	41.5	51.5	0.94
54-60	9	30	20	0.667	10.0	10.0	0.33
Estimate of Fecundability (monthly chance of conception)=0.041							

Table 5: Life table values corresponding to waiting time to first conception for females whose age at marriage is between 16-18 years.

Waiting to Conception (in months)	x	l_x	d_x	q_x	L_x	T_x	$e_x{}^0$
0-6	0	988	178	0.180	871.0	2835.5	2.87
6-12	1	782	164	0.210	639.0	1964.5	2.51
12-18	2	557	125	0.224	476.5	1325.5	2.38
18-24	3	414	119	0.287	313.5	849.0	2.05
24-30	4	254	56	0.220	223.0	535.5	2.11
30-36	5	195	65	0.333	137.5	312.5	1.60
36-42	6	105	26	0.248	89.0	175.0	1.67
42-48	7	76	28	0.368	50.0	86.0	1.13
48-54	8	36	13	0.361	27.5	36.0	1.00
54-60	9	21	17	0.810	8.5	8.5	0.40
Estimate of Fecundability (monthly chance of conception)=0.046							

Table 6: Life table values corresponding to waiting time to first conception for females whose age at marriage is above 18 years.

Waiting to Conception (in months)	x	l_x	d_x	q_x	L_x	T_x	$e_x{}^0$
0-6	0	1586	434	0.274	1312.0	3723.0	2.35
6-12	1	1095	287	0.262	856.5	2411.0	2.20
12-18	2	713	181	0.254	577.5	1554.5	2.18
18-24	3	487	129	0.265	360.5	977.0	2.01
24-30	4	296	68	0.230	248.0	616.5	2.08
30-36	5	214	57	0.266	163.5	368.5	1.72
36-42	6	135	32	0.237	110.0	205.0	1.52
42-48	7	94	25	0.266	59.5	95.0	1.01
48-54	8	47	16	0.340	28.0	35.5	0.76
54-60	9	20	15	0.750	7.5	7.5	0.38
Estimate of Fecundability (monthly chance of conception)=0.054							

Table 7: Life table values corresponding to waiting time to first conception for Hindu females of Uttar Pradesh.

Waiting to Conception (in months)	x	l_x	d_x	q_x	L_x	T_x	e_x^0
0-6	0	2619	541	0.207	2284.5	7489.5	2.86
6-12	1	2014	438	0.217	1651.0	5205.0	2.58
12-18	2	1432	295	0.206	1226.5	3554.0	2.48
18-24	3	1079	286	0.265	836.0	2327.5	2.16
24-30	4	693	159	0.229	596.5	1491.5	2.15
30-36	5	517	146	0.282	382.0	895.0	1.73
36-42	6	309	77	0.249	262.5	513.0	1.66
42-48	7	224	73	0.326	148.5	250.5	1.12
48-54	8	112	41	0.366	80.5	102.0	0.91
54-60	9	60	43	0.717	21.5	21.5	0.36
Estimate of Fecundability (monthly chance of conception)=0.042							

Table 8: Life table values corresponding to waiting time to first conception for Muslim females of Uttar Pradesh.

Waiting to Conception (in months)	x	l_x	d_x	q_x	L_x	T_x	e_x^0
0-6	0	655	165	0.252	543.5	1587.5	2.42
6-12	1	461	125	0.271	360.5	1044.0	2.26
12-18	2	298	93	0.312	239.5	683.5	2.29
18-24	3	193	54	0.280	153.0	444.0	2.30
24-30	4	126	26	0.206	110.0	291.0	2.31
30-36	5	97	27	0.278	74.5	181.0	1.87
36-42	6	61	9	0.148	52.5	106.5	1.75
42-48	7	48	14	0.292	33.0	54.0	1.13
48-54	8	26	11	0.423	16.5	21.0	0.81
54-60	9	11	9	0.818	4.5	4.5	0.41
Estimate of Fecundability (monthly chance of conception)=0.059							

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