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SURVIVAL ANALYSIS OF DURATION OF WAITING TIME TO CONCEPTION

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Abstract: *The length of waiting time to conception may be considered as the determinant of fertility. However, there is only limited empirical research investigating this subject in modern Indian societies. So, this study aims at analyzing the differentials and determinants of duration of waiting time to conception of women in Manipur, applying the survival analysis technique. In this study, a house-to-house survey of 1225 currently married women having at least one live birth is carried out through cluster sampling in Manipur, India. Among the eight explanatory variables of interest, only one variable– use of contraceptive devices has highly significant effect (P<0.01) on the duration of waiting time to conception and only four factors – age at marriage , parity, sex of child and infant mortality are found to be significant (P<0.05) on the duration variable.*

Keywords: *Censored case, relative risk, parity, infant mortality.*

1. Introduction

While the world has a population of six billion, India alone has a population of one billion in spite of the fact that India was the first country in the world to have a population policy. India's population as on March 2001 was 1,028, 737, 436 [18]. At the international level, India accounts for 2.4% of the world surface area and yet it supports and sustains 16.9 of the world population. In 1950, China with 22% of the population led the world followed by India with 14.2%. It is estimated that by 2050, India will overtake China to become the most populous country on the

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earth with about 17.2% population living here. India is still nowhere near a satisfactory solution of its population problem in spite of so much emphasis given on different family planning, family welfare and reproductive and child health programmes. At this crucial juncture, the study of fertility becomes paramount importance for population control. In fact, fertility specifically the natural fertility is defined as fertility that exists in the absence of deliberate birth control [10]. It depends on the duration of effective reproductive span and length of birth interval [4]. The birth interval, especially closed birth interval, is composed of three major components namely postpartum amenorrhoea (PPA), waiting time to conception and gestation [17]. In one sense, the gestation is treated to be a constant duration while PPA is in fact a physiological process which varies in a complex fashion [13, 15]. The second component – waiting time to conception, defined to be the time interval between the resumption of menses after a pregnancy until the beginning of the next pregnancy, is highly influenced by socio-economic and demographic factors [14, 11, 13]. A good number of researchers emphasizes that there is an inverse relationship between average duration of waiting time to conception and age at marriage of mother [15, 6, 2]. Al-Nehedh (1999) and Rao et al. (2006) observe that the proportion of women with short waiting time to conception is lower in higher parity [1, 19]. The average duration of waiting time to conception of women whose previous children are males is significantly longer than that of women whose children are female [5, 20]. The risk of conception is higher for the previous child death during infancy than for the child alive [12, 5, 20].

The rest of this paper is organized as follows. Section 2, which is further divided into two sections, 2.1 section contains details of the material used and section 2.2 reviews the empirical methodologies adopted in this paper. In section 3 the model is applied to the event history of waiting time to conception data and section 4 contains discussion.

2. Materials and methods

2.1 Materials

A cross sectional study was conducted in four valley districts of Manipur namely Bishnupur, Thoubal, Imphal West and Imphal East during the period from 1 January 2009 to 30 June 2009. Manipur is a tiny state of North East India inhabited mainly by the Mongoloid race. Under cluster sampling scheme, a house-to-house survey was carried out with pre-tested semi-structural interview schedule and ever-married women having at least one live birth were interviewed. The sample consists of 1225 eligible women. The eligible woman is defined if both spouses are alive and normally living together during her child bearing period. The clusters of randomly selected villages in rural area and wards in urban area are completely enumerated. Altogether 45 villages in rural areas and 35 wards in urban areas are randomly selected. 5 villages and 7 wards, 9 villages and 10 wards, 11 villages and 12 wards, and 20 villages and 6 wards are selected from Bishnupur, Thoubal, Imphal West, Imphal East districts respectively. Out of 1225 eligible women, 180, 316, 387 and 342 eligible women are picked up from Bishnupur, Thoubal, Imphal West, Imphal East districts respectively. A total of 1013 households are surveyed.

The response variable say duration of waiting time to conception is taken only for the last birth interval to control data recall error. The eligible women who conceive before survey date are considered to be uncensored cases. The length of the duration variable thereof is the time interval between end of PPA and the date of conception. The duration of the time interval observed from the women having at least one live birth who do not conceive till the date of survey is considered to be censored case. In that case the length of the duration variable is the time interval between the end of PPA and the survey date. While collecting the duration data, the following conditions are followed. That firstly, when survey date falls during PPA following the first birth, then such data are omitted from the study; secondly, for the women having more than two live births, the last duration data are taken; and lastly, if the survey date falls during the PPA just after second or whichever more birth, then the duration data are taken as that one just prior to the last birth. The explanatory variables or so termed as covariates are socio-economic and demographic factors. The socio-economic variables include place of residence, educational level and family income. The demographic variables are age at marriage, sex of previous child, parity, living status of previous child, and use of contraceptive devices.

2.2 Methodology

2.2.1 Basic Setting

Suppose that T is a continuous, non-negative valued random variable representing the waiting time to conception of an eligible woman. The distribution of T can be characterized by the following three equivalent functions:

Survival function (SF)

The survival function at time t denoted by $S(t)$ may be defined as:

$$S(t) = P[T \geq t] = \text{P [that a woman will not conceive at least time t]}$$
$$= 1 - P[T < t] = 1 - F(t) \qquad (1)$$

where $F(t) = P[T < t] = \int_0^t f(t) =$ P [that a woman conceives before time t] is called cumulative distribution of T. Here, $f(t)$ is called the p.d.f. of survival time T.

Probability Density Function (p.d.f.)

The probability density function of the survival time T denoted by $f(t)$ is defined as that probability of conceiving in a small interval per unit time. It can be expressed as:

$$f(t) = \underset{\Delta t \to 0}{Lt} \frac{\text{P[a woman conceives in the interval } (t, t+\Delta t)\text{]}}{\Delta t} = \underset{\Delta t \to 0}{Lt} \frac{\text{P}[t \leq T < t+\Delta t]}{\Delta t} \qquad (2)$$

Hazard Function (HF)

The hazard function of survival time T denoted by $\lambda(t)$ is defined as the probability that an eligible woman conceives in a very small time interval, $(t, t+\Delta t)$ given that the woman does not conceive to time t. It can be expressed as:

$$\lambda(t) = \underset{\Delta t \to 0}{Lt} \frac{\text{P[a woman conceives in the interval } (t, t+\Delta t)/ \text{ the woman does not conceive to time } t\,]}{\Delta t} = \underset{\Delta t \to 0}{Lt} \frac{\mathrm{P}[t \le T < t+\Delta t / T \ge t]}{\Delta t}$$

$$= \underset{\Delta t \to 0}{Lt} \frac{\mathrm{P}[t \le T < t+\Delta t] / \mathrm{P}[T \ge t]}{\Delta t} = \underset{\Delta t \to 0}{Lt} \frac{\mathrm{P}[t \le T < t+\Delta t\,] / \Delta t}{\mathrm{P}[T \ge t]}$$

$$= \frac{f(t)}{S(t)} \quad \text{[by (1) and (2)]} \qquad (3)$$

2.2.2 Non-parametric estimation of survival functions: The life-table analysis

The three elsewhere functions in survival analysis say survival function, probability density function and hazard function can be estimated by adopting life-table method. The life-table was introduced about a half century ago primarily with the application to clinical data. But this method has often been applied to many demographic data in the last two decades. Berkson and Gage (1950) and Cutler and Ederer (1958) give life-table for estimating the survival function [3, 8]. Gehan (1969) further provides methods for estimating all three functions of survival, density and hazard [9].

Suppose the duration of time to conception $(0, t)$ is under consideration. Let this interval be partitioned into a fixed sequence of intervals $[t_i,\ t_{i+1}),\ i = 1,2,......k$. These intervals are almost always, but not necessarily, of equal length. For a life table, let:

$n_i =$ the number of women who do not conceive at the beginning of the i^{th} interval

d_i = the number of women who conceive in the i^{th} interval. The survival time of these women is the time from end of PPA to conception.

$w_i =$ the number of women who are not conceiving in the i^{th} interval. The survival time of these women is the time from the end of PPA to the date of the survey.

P_i = P [not conceiving through i^{th} interval / not conceiving at the beginning of i^{th} interval].

Q_i = P [conceiving through i^{th} interval / not conceiving at the beginning of i^{th} interval] = 1- P_i

Life-table estimate of survival function, $S(t_k)$ is given by:

$$S(t_k) = P[T > t_k] = P[T > t_1] P[T > t_2 / T > t_1] .... P[T > t_k / T > t_{k-1}] = \prod_{i=1}^{k} P_i \qquad (4)$$

where $P_i = P[T > t_i / T > t_{i-1}]$

If $w_i = 0$ that is if all the women conceive at the date of survey,

then, $\hat{P}_i = 1 - \dfrac{d_i}{n_i}$

However, with w_i non-zero, we assume that on the average, those women who do not conceive during the i^{th} interval are at risk for half of the interval. Therefore the effective sample size is defined as: $n_i^{'} = n_i - \frac{1}{2} w_i$ and $\hat{Q}_i = q_i = \frac{d_i}{n_i^{'}}$, $\hat{P}_i = p_i = 1 - \hat{Q}_i$.

If the estimated value of survival function is known, the values of other functions can be estimated as follows.

2.2.3 Non-parametric methods for comparing survival distributions: Log rank test

In the case of censored data, Log rank test is the most commonly used nonparametric test for comparing two survival functions [16]. Suppose that there are two groups where the observations of waiting time to conception in group 1 are samples from a distribution with survival function $S_1(t)$ and the observations in group 2 are samples from the distribution with survival function $S_2(t)$.

Our null hypothesis is $H_0 : S_1(t) = S_2(t)$, against the alternative hypothesis, $H_1 : S_1(t) \neq S_2(t)$.

Let $t_1 < t_2 \ldots\ldots < t_g$ be distinct ordered waiting time to conception for combined sample of the two groups. Let d_j = the number of women experiencing the conception at t_j in both groups (for complete data d_j = 1 for every j). Let n_j = the number of women at risk at t_j.

We suppose:

- n_{1j} = the number of women at risk at t_j from group 1.
- n_{2j} = the number of women at risk at t_j from group 2.

The Log rank test compares the observed number of women experiencing conception and expected (under H_0) number of women experiencing conception in group1.

Let E = Expected (under H_0) number of women experiencing the conception in sample 1 = $\sum_{J=1}^{g} d_j \frac{n_{1j}}{n_j}$

The variance of E is given by:

$$V = \sum_{J=1}^{g} d_j \frac{n_{1j} n_{2j}}{n_j^2}$$

O = Observed number of women experiencing the conception in sample (group) 1

Under H_0 the test statistics is given by:

Z = $\frac{O-E}{\sqrt{V}}$ has asymptotically standard normal distribution.

i.e. $\frac{(O-E)^2}{V} \sim \chi^2$ (as square of standard normal variate is chi square variate) (5)

2.2.4 Cox's Proportional Hazard model

In this part Cox's proportional hazard model [7] has been used to determine the effects of various socio-economic and demographic factors on the duration of waiting time to conception. The simple form of the model is given by:

$$\lambda(t;\underline{x}) = \lambda_0(t)\,\varphi(\underline{x}) \qquad (6)$$

where $\lambda_0(t)$ is the baseline hazard function and is defined as the hazard function when all the x variables are ignored, that is, all x's equal zero. $\varphi(\underline{x})$ is a parametric link function bringing in the covariates. It satisfies $\varphi(0)=1$ and $\varphi(\underline{x}) \geq 0$ for all $\underline{x}$. The commonly used form of φ is $\varphi(\underline{x}) = \varphi(\underline{x},\underline{\beta}) = e^{\underline{\beta}/\underline{x}}$ so that the ratio, $\frac{\lambda(t;\underline{x})}{\lambda_0(t)} = e^{\underline{\beta}/\underline{x}}$ represents the 'relative risk' of failure or so termed as the risk of conception in the present study. The term proportional is used in the PH-model because given two observations with different values for the covariates, the ratio of the hazard function for those two observations do not depend on time i.e., $\frac{\lambda(t;\underline{x}_1)}{\lambda((t;\underline{x}_2)}$, the ratio of hazard function for two individuals with covariates $\underline{x}_1 = (x_{11}, x_{21} \cdots\cdots, x_{p1})$ and $\underline{x}_2 = (x_{12}, x_{22} \cdots\cdots, x_{p2})$ do not vary with time t. The Cox's proportional hazard model or so called Cox' regression model is also known as semi-parametric model as the base line hazard function, $\lambda_0(t)$ is a completely unknown and unspecified function. The regression coefficient ($\underline{\beta}$) is tested using Wald's test for its significant effect on the duration of waiting time and the test statistics is given by $\hat{\underline{\beta}}^{/} I^{-1} \hat{\underline{\beta}} \sim \chi^2_p$ where I= $E\left(-\frac{\partial^2 LogL(\underline{\beta})}{\partial \underline{\beta}^2}\right)$. The calculations in this paper have been carried out using the package SPSS.

3. Application

3.1 Life-table analysis

Table 1 provides information on life table estimates of median duration of waiting time to conception and the proportion of women who have not conceived before 6, 12, 18, 24, 30, 36 and 42 months by socio-economic and demographic characteristics. The overall median length of waiting to conception of the study area is 18 months. About 46%, 37%, 31%, 30% and 18% of the women who have married during the age group of below 15 years, 15-20 years, 20-25 years, 25-30 years, and 30 years and above respectively do not conceive before 24 months after PPA. It also highlights that the median duration of waiting time to conception decreases with the increase in the age at marriage of women. By the Log rank test, the association between age at marriage of women and duration of waiting time to conception is highly significant (χ^2= 25.37, P < 0.01). It could be examined that 58% of women having parity zero do not conceive within 24 months after the PPA in the study population.

Table1. Life table of duration of waiting time to conception

Variables	Proportion of not conceiving at months							Median (Month)	Log rank test
	6	12	18	24	30	36	42		
Demographic:									
Age at marriage of wife(Years)									
<15	.92	.77	.58	.46	.34	.25	.19	18.8	
15-20	.90	.74	.54	.37	.23	.16	.13	17.8	χ^2 = 25.37,
20-25	.87	.73	.52	.31	.19	.15	.12	14.7	d.f =4,P<0.01
25-30	.86	.67	.47	.30	.16	.13	.10	12.8	
≥30	.85	.45	.24	.18	.14	.12	.06	9.8	
Parity									
0	.93	.83	.73	.58	.46	.35	.31	27.0	
1	.92	.74	.54	.39	.21	.16	.13	18.8	χ^2 = 78.422,
2	.85	.70	.46	.30	.18	.13	.10	17.0	d.f=4, P<0.01
3	.87	.61	.43	.28	.17	.10	.06	15.9	
4+	.86	.66	.39	.19	.11	.06	.04	15.7	
Sex of the previous child									
Female	.90	.71	.49	.32	.20	.12	.07	17.7	χ^2 = 7.306,
Male	.88	.71	.52	.35	.21	.17	.14	18.7	d.f=1, P<0.05
Survival status of previous child									
Death	.63	.47	.20	.10	.07	.03	.01	8.8	χ^2 = 26.901,
Survival	.90	.72	.52	.34	.21	.15	.11	18.7	d.f = 1,P<0.01
Use of contraceptive devices									
No	.85	.63	.38	.20	.11	.06	.04	14.8	χ^2 = 149.66,
Yes	.94	.85	.71	.56	.38	.29	.24.	26.0	d.f =1,P<0.01
Socio-economic:									
Place of residence									
Urban	.88	.68	.49	.29	.18	.11	.07	17.8	χ^2=2.957,
Rural	.89	.72	.51	.35	.22	.16	.13	18.1	d.f = 1, P> 0.05
Educational level of wife									
No schooling	.70	.63	.39	.24	.14	.08	.06	15.7	
Primary school	.87	.70	.50	.39	.20	.14	.08	16.0	χ^2 = 38.542,
Sec. School	.88	.71	61	.43	.25	.18	.10	18.0	d.f = 4,P<0.01
Higher Sec. School	.90	.79	.62	.51	.28	.25	.16	22.0	
College & University	.91	.81	70	.59	.33	.29	.21	24.0	
Family income (in Rs.)									
<2000	.64	.60	.36	.19	.08	.05	.03	13.8	
2000-4000	.75	.64	.53	.33	.22	.15	.11	18.7	χ^2 =58.035,
4000-6000	.86	.67	.55	.41	.23	.18	.13	19.0	d.f = 5,P<0.01
6000-8000	.88	.73	.59	.43	.27	.22	.15	20.8	
8000-10000	.89	.76	.63	.46	.31	.28	.18	21.0	
≥10000	.91	.82	.66	.56	.39	.29	.27	26.0	
Overall								18.0	

On contrary, 39% of women having parity one, that of 30% of parity two, 28 % of parity three and 19% of parity four and above do not conceive within 24 months after their PPA. The median length of the time to conception decreases with the increase in parity and this variation is highly significant in the study population irrespective of other covariates (P < 0.01). About 32% of women with female as the previous child do not conceive within 24 months while 35% of women with male as the previous child do not conceive within 24 months. The median length of the time to conception for women with male as the previous child (18.7 months) is significantly longer than those with female (17.7 months) as previous child (P<0.05). While only 10% of women who have experienced the death of previous child during infancy do not conceive before 24 months after PPA, a higher proportion of women (34%) with the survival of previous child do not conceive during the same period of time. The survival status of the previous child shows a strong effect on the duration of waiting time to conception (χ^2=26.90, P<0.01). The longer duration of waiting time to conception is found with mothers who have alive child (18.7 months) than who experience dead child (8.8 months). It may be noted that about 20% of women who do not use any forms of contraceptive devices do not conceive within 24 months after PPA; and that 56% of women who use contraceptives of any forms do not conceive within the period of 24 months. The duration of waiting time to conception for the couple who use contraceptive devices is significantly longer than those who never use any form of contraceptive devices (P<0.01). Educational level of wife shows an upward linear trend with the duration of waiting time to conception (P<0.01). About 59% of college and university level women have not conceived within 24 months after PPA whereas 24% of women with no schooling and 39 % of women with primary school level, 43% of women with secondary school level and 51 % of women with higher secondary level have not conceived within the 24 months. Only 19% of women having income of below Rs. 2000 do not conceive within 24 months after PPA. But 33 % of the study subjects having family income of Rs. 2000-4000, 41% in the income of Rs. 4000-6000, 43% in Rs. 6000-8000, 46 % in Rs. 8000-10000 and 56 % in Rs. 10000 and above do not conceive within the same period. The variation in the median duration of waiting time to conception with respect to family income is highly significant even at 0.01 level of probability.

3.2 Cox's regression analysis

Table 2 presents the estimates from the Cox proportional hazard model for duration of waiting time to conception, that is, for the risk of conception. After adjustment of other covariates, the age at marriage of wife has significant and positive impact on the risk of conception which is explained by β=0.025, Wald's statistic=4.658, P<0.05. It is also shown that a one-year increase in age at marriage of wife leads to the increase in the risk of conception by 3% which is advocated by relative risk (RR), 1.025 with 95% CI: 1.002-1.048. After controlling other covariates, the parity is positively associated with the risk of conception (β=0.045, P<0.05). By increasing a parity, the adjusted RR of conception becomes 1.046 (95% CI: 1.000-1.095), indicating the risk is increased by around 5%. The Wald's test explains that the sex of the previous child has significant effect on the duration of time to conception which is found to significant at 0.05 probability level. The risk of conception of women with a preceding birth of male child is 0.83 times lower than those with a preceding birth of female child (RR=0.830). The survival status of the previous child has also significant impact on the risk of conception (β=-0.563 and P<0.05). For instance, women with the survival of previous child are subject to a hazard of 0.569 times lesser as compared with the women having the death of the previous child (RR=0.569). In case of contraceptive it is observed that the use of contraceptive devices also plays a significant role in the variation of waiting time to conception (β=-0.847) which is highly significant (P<0.01). The women who use contraceptive devices are found to be subject to a hazard of conception 0.429 lower than those who never use any kind of contraceptive devices.

Table 2. Adjusted Cox's regression analysis of waiting time to conception.

Explanatory variable	β	SE	Wald	P-value	e^{β}	95% CI for e^{β}	
						Lower	Upper
Demographic:							
Age at marriage of wife(Years)	0.025	0.011	4.658	0.031	1.025	1.002	1.048
Parity	0.045	0.023	3.876	0.049	1.046	1.000	1.095
Sex of the previous child	-0.186	0.076	5.958	0.015	0.830	0.715	0.964
Survival status of previous child	-0.563	0.228	6.133	0.013	0.569	0.364	0.889
Use of contraceptive devices	-0.847	0.100	71.720	0.000	0.429	0.352	0.521
Socio-economic:							
Place of residence	0.043	0.092	0.223	0.637	1.044	0.872	1.251
Educational level of wife	-0.001	0.009	0.006	0.940	0.999	0.680	1.018
Family income (in Rs.)	0.000	0.001	0.114	0.736	1.000	0.998	1.002

4. Discussion

This paper has applied a survival analysis to study the duration data of waiting time to conception of women which contain both the censored and uncensored observations. We use several methodologies including non-parametric survival analysis and Cox proportional hazard analysis to investigate the differentials and determinants of duration of waiting time to conception according to various socio-economic and demographic factors. The median length of waiting time to conception is 18 months in the present analysis. The similar figure estimated from Malaysian women was also observed two decades back [21]. Also the median birth interval in India is found to be 31 months according to National Family Health Survey (NFHS) - Report 2007. In one sense the average duration of post-partum amenorrhea calculated from the present data is about 6 months so that the median duration of waiting time is observed to be 16 months, considering the gestation period of 9.3 months. Thus the present finding shows the duration of waiting time is longer than that of all India figure. A green sign could be detected for population control in the state of Manipur owing to the advancement of two months in the waiting time to conception in comparison with the all India figure. The life table analysis of duration of waiting time to conception highlights that age at marriage, parity, sex of child, infant mortality, use of contraceptive, educational level and family income are found to be significantly associated with the duration of waiting time to conception. It may be noted that the place of residence differentiated by urban and rural characters has no effect on the median duration of waiting time. This is for statistical reason only as evidenced by P-value (>0.05). However, the median duration is visibly longer in rural areas than that of urban. It may be thought to be caused by many reasons associated with some unknown factors. The association cannot be explored in this analysis. But the results from the proportional hazards model show that only age at marriage, parity, sex of child, infant mortality, and use of contraceptive are associated with the duration of waiting time to conception. The significant and positive association of the age at marriage of wife with the risk of conception may be due to the fact that late married couple has psychological pressure to compensate their lost reproductive period by producing the desire number of children quickly. The results of this study are consistent with those reported in the literature [14, 15, 6]. The duration of waiting time to conception of the women whose previous child is male is significantly longer than that of those whose previous child is female. It may be due to the fact that in India, parents have put typically highly value on son since it is treated as an economic asset and old age assurance as well as the bearer of the family name, it is therefore less likely that they will accept contraception or other methods of fertility control until they have had the desire number of sons. This view is incorporated with the some previous findings [5, 19, 20]. Perhaps, the death of previous child during infancy limits the duration of time to conception through emotional feeling of the couples. An infant death may exert a psychological pressure on parent to make up the lost child as early as practicable by avoiding the use of contraceptives and other means of fertility control that they would otherwise have used. Biologically, the death of the infant and young child interrupts breastfeeding leading to an early return of ovulation. This finding is found to be in the same direction with the findings of different authors [12, 5, 20].

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