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***Research Article***

# Open Birth Interval in Large Marital Duration

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**Abstract**

Sheps et al (1970) have given expression for finding the mean open birth interval in large marital duration. The results are based on the assumption that females are homogeneous with respect to their fecundability and period of non-susceptibility associated with each birth. We have tried to investigate that what will be the impact on mean open birth interval if females are heterogeneous with respect to fecundability and non- susceptibility period and we utilize the formula given by Srinivasan (1968) for heterogeneous group of females. In this context certain hypothetical distributions of fecundbility (conception rate) and non-susceptibility period have been taken and means of open birth interval have been found using the two approaches.

## Introduction

The study of human population is attracting increasing attention of demographers, economics and other social scientist because population constitutes an important factor in the socio-economic growth of a nation. In recent years, much attention has been paid towards the analysis of birth intervals to the study of human fertility. The data on birth intervals are taken as indicators of reproductive performance. Birth intervals which can be broadly classified into two categories viz. closed birth intervals and open birth intervals though in literature interior, forward and straddling intervals are also in use. It is important to mention that data on birth intervals can be obtained in quite different ways under different sampling frames and hence appropriate techniques are required for proper analysis of fertility. The closed birth interval has a major limitation. It relates to fertility performance of only those females who continue to reproduce. On the otherhand, open birth interval includes both type of females : who continue to reproduce as well as those who have stopped producing children due to any reason(s). It is in this reference that OBI is considered to be a better measure of fertility. However in the present study, we have considered the open birth interval (OBI). It has been defined as the interval between the survey date and the last birth. The data on open birth intervals has own strengths and weaknesses and require different methodologies to derive useful results.

Sheps and Menken (1972) have analysed that the distributions of birth intervals are very much affected by the choice of sampling frame and mentioned that inferences based on such data may in certain cases be incorrect and misleading. Srinivasan (1972) has given the distribution of OBI for different parities and had utilized them successfully to estimate instantaneous parity progression ratios. The average value for parity one to nine was 41.9, 40.4, 44.4, 47.6, 39.3, 47.7, 43.7, 46.9 and 53.3 months respectively. Bhattacharya (1984) has also estimated average values of open birth interval for different parities. These values ranged from 30.4 months for parity one to 50.1 months for parity eight and there was an increasing trend according to parity. Yadav (1998) has also reported the average value of OBI for Hindus and Muslims separately as 48.9 months and 29.7 months respectively. Sigh etal (1982) proposed a probability model for open birth interval of women for specified marital duration assuming fecundbality to be parity dependent. Shipra (2000) examined OBI for each parity and found that 12% and 16% of the females of parity 2 & 3 had OBI more than 10 years. These are the females who have probably opted sterilization just after 2nd and 3rd parities. This

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pattern of mean OBI is also an indicative of the fact that perhaps the sterilisatins are taking place more prominently at the lower parities rather than at the higher parities.

Srinivasan, in a number of papers, (Srinivasan 1966b,1967b,1968,) has advocated the use open birth interval as a sensitive measure of fertility of a population. In this context other researchers have also given their significant contributions ( Pathak 1971, Venkatacharya 1972, Singh and Yadava 1977, PathaK Sastry, (1984, Rajan 1998 and others). Pathak (1999) has provided an analytical review of models for number of birth, closed birth interval, open birth interval etc. to the woman of specific marital duration, family building strategies and stopping rules.

Pandey and Pathak (1989) has extended the above steady state model of open birth interval to estimate the tempo of secondary infertility along with the level of fecundability. Srinivasan (1968) derived a model for inter live birth interval (closed birth interval) assuming fecundability as well as post partum amenorrhoea (PPA) period following a birth to be variables among females. There he also considered open birth interval as the random segment of the closed birth interval and argued that mean of the open birth interval will be half of the mean of the closed birth interval. Just after the publication of this paper, Leridon (1969) pointed out about the fallacy in Srinivasan's result and showed that the mean of open birth interval will not be half of the mean of closed birth interval but it would be $\frac{E(T^2)}{2E(T)}$ where T is the random variable representing the closed birth interval. Leridon (1969) argued that this is occurring due to the phenomenon of length-biased sampling. It is pertinent to mention here that similar situation was already discussed in the form of 'Waiting Time Paradox' and solution to the paradox was already available.

Almost at the same time Sheps et al. (1970) wrote a large paper discussing the truncation effect on closed and open birth intervals in finite marital duration. There they have also derived the expression for $r^{th}$ moment of open birth interval for large marital duration. They have observed that the expression for mean open birth interval is coming as $\frac{E(T^2)}{2E(T)}$ which is the same as obtained for the case of open birth interval derived by Srinivasan (1968). It is important to mention here that the results derived in Sheps et al. (1970) implicitly assume that consecutive closed birth intervals are independent where as the consecutive closed birth interval considered in Srinivasan's set up would not be independent because of the heterogeneity in fecundability and PPA period among the females. The Srinivasan set up is mostly applicable to stationary population where $i^{th}$ order births are assumed to be uniformly distributed over time where as in Sheps et al, (1970) set up, births become uniformly distributed over time in large marital duration.

The objective of the present paper is to investigate the nature as well as the mean of the distribution of open birth interval for large marital duration assuming the heterogeneity in fecundability as well as PPA period among females so that now the consecutive closed birth intervals become dependent rather than independent as considered in Sheps et al. (1970). The results are shown by taking some hypothetical distributions of fecundability (conception rate) as well as PPA period. So it is just in the form of illustration to show the variations in the two set ups.

## Methodology

Here we try to investigate the differences (if any) in the mean open birth interval under two set-ups (Srinivasan's set up and Sheps et al set-up). For this, we demonstrate the differences in the results considering a hypothetical distribution of closed birth interval derived under some simplifying assumptions. Let us consider a population of married females who are characterized by their level of conception rate ($\lambda$) and non-susceptible period associated with a conception (h). In fact under this assumption the female is supposed to have probability $\lambda.\Delta t+ 0.\Delta t$ in the period (t, t+$\Delta$t) of length $\Delta$t (provided female is exposed to the risk of conception).

The non-susceptibility period, h, is defined as the period during which there is no possibility of any other conception after the occurrence of the conception. This period is nothing but the sum of the post partum amenorrhoea period and gestation period associated with a birth. Under these simplifying assumptions, the probability distribution function of closed birth interval X is given as:

$$f(x) = \lambda\, e^{-\lambda(x-h)} \qquad x>h \tag{1}$$

Obviously,

$$E(X) = \frac{1}{\lambda} + h \tag{2}$$

and $$E(X^2) = \frac{1}{\lambda^2} + \frac{2h}{\lambda} + h^2 \tag{3}$$

and $$V(X) = \frac{1}{\lambda^2} \tag{4}$$

If we assume that females are heterogeneous with respect to λ and h, (and λ and h are independent) then the expressions can be modified accordingly. For simplicity, if we assume that λ takes two values $\lambda_1$ and $\lambda_2$ and h also takes two values $h_1$ and $h_2$ and respective proportions for $(\lambda_1, h_1)$, $(\lambda_1, h_2)$, $(\lambda_2, h_1)$ and $(\lambda_2, h_2)$ are $\alpha_{11}$, $\alpha_{12}$, $\alpha_{21}$, and $\alpha_{22}$ then

$$E(X) = \alpha_{11}\left(\frac{1}{\lambda_1} + h_1\right) + \alpha_{12}\left(\frac{1}{\lambda_1} + h_2\right) + \alpha_{21}\left(\frac{1}{\lambda_2} + h_1\right) + \alpha_{22}\left(\frac{1}{\lambda_2} + h_2\right) \tag{5}$$

and

$$E(X^2) = \alpha_{11}\left(\frac{1}{\lambda_1^2} + h_1^2 + \frac{2h_1}{\lambda_1}\right) + \alpha_{12}\left(\frac{1}{\lambda_1^2} + h_2^2 + \frac{2h_2}{\lambda_1}\right) + \alpha_{21}\left(\frac{1}{\lambda_2^2} + h_1^2 + \frac{2h_1}{\lambda_2}\right) + \alpha_{22}\left(\frac{1}{\lambda_2^2} + h_2^2 + \frac{2h_2}{\lambda_2}\right) \tag{6}$$

Then under Srinivasan's set up

$$\text{Mean open birth Interval} = \frac{E(X^2)}{2E(X)} \tag{7}$$

Under Sheps et al (1970) set up (for large marital duration)

$$\text{Mean open birth Interval} = \begin{cases} \alpha_{11}\dfrac{\left(\dfrac{1}{\lambda_1^2} + h_1^2 + \dfrac{2h_1}{\lambda_1}\right)}{2\left(\dfrac{1}{\lambda_1} + h_1\right)} + \alpha_{12}\dfrac{\left(\dfrac{1}{\lambda_1^2} + h_2^2 + \dfrac{2h_2}{\lambda_2}\right)}{2\left(\dfrac{1}{\lambda_1} + h_2\right)} \\ + \alpha_{21}\dfrac{\left(\dfrac{1}{\lambda_2^2} + h_1^2 + \dfrac{2h_1}{\lambda_2}\right)}{2\left(\dfrac{1}{\lambda_2} + h_1\right)} + \alpha_{22}\dfrac{\left(\dfrac{1}{\lambda_2^2} + h_2^2 + \dfrac{2h_2}{\lambda_2}\right)}{2\left(\dfrac{1}{\lambda_2} + h_2\right)} \end{cases} \tag{8}$$

Obviously (7) and (8) may not be equal in all cases and we can say that observation made by Sheps et al. (1970) may not be true under the case of heterogeneous population. Of course the two results will be identical under the case of homogenous population because in that case consecutive closed birth intervals will be independent which is the underlying assumption in Sheps et al. (1970).

### Results and Discussion

We have obtained the mean open birth interval under two set ups taking certain hypothetical values of $\lambda_1$, $\lambda_2$, $h_1$, $h_2$, $\alpha_{11}$, $\alpha_{12}$, $\alpha_{21}$, and $\alpha_{22}$. The two means $OBI_1$ and $OBI_2$ (under Srinivasan set up and under Sheps et al., 1970, set up respectively) for different combinations of $\lambda_1$, $\lambda_2$ and $h_1$, $h_2$ are shown in the last two columns of table. From the table, it is seen that the two means are not identical although the differences are quite negligible. Thus we can conclude that although theoretically the two results are not identical but for practical purposes, the two means may be assumed to be same. However, it is to be noted that under the assumed situation, the two results are almost same but this does not necessarily imply that the two means will always be approximately equal under all forms of closed birth intervals. Thus more and more investigations are needed to reach to a more affirmative conclusion.

### Theoretical and Practical Implications

The analysis of open birth interval has important role in the study of human reproduction process. Sheps et al. (1970) derived expression for mean of open birth interval by assuming consecutive closed birth intervals are independent where as the consecutive closed birth interval considered in Srinivasan's set up would not be independent because of the heterogeneity in fecundability and PPA period among the females. Sheps set up is not true for heterogeneous population. The proposed study provides expression for mean open birth interval for large marital duration assuming the heterogeneity in fecundability as well as PPA period among females. In Indian context, it is very difficult to collect the data on parameters used in this study. The major limitation of this study is that model has been checked only on the hypothetical values of conception rate ($\lambda$) and non-susceptible period associated with a conception (h). In the last, it is believed that although the models are based on certain simplifying assumptions, the derived results are encouraging and have major policy implications. Thus, more and more analysis and research is needed to judge the adequacy of the models on variety of situations.

**Table1: Estimates of open birth interval for Srinivasan's set-up ($OBI_1$)and Sheps et al. set-up ($OBI_2$) under some hypothetical values of $\alpha_{11}$, $\alpha_{12}$, $\alpha_{21}$, $\alpha_{22}$, $\lambda_1$, $\lambda_2$, $h_1$ and $h_2$**

| (h) (in years) | | $\lambda$ (yearly conception rate) | | $\alpha$ (proportions) | | | | $OBI_1$ | $OBI_2$ |
|---|---|---|---|---|---|---|---|---|---|
| $h_1$ | $h_2$ | $\lambda_1$ | $\lambda_2$ | $\alpha_{11}$ | $\alpha_{12}$ | $\alpha_{21}$ | $\alpha_{22}$ | | |
| 1.00 | 1.25 | 0.5 | 1.00 | 0.20 | 0.20 | 0.30 | 0.30 | 1.313 | 1.263 |
| 1.00 | 1.50 | 0.5 | 1.00 | 0.20 | 0.20 | 0.30 | 0.30 | 1.382 | 1.325 |
| 1.00 | 1.75 | 0.5 | 1.00 | 0.20 | 0.20 | 0.30 | 0.30 | 1.456 | 1.387 |
| 1.00 | 2.00 | 0.5 | 1.00 | 0.20 | 0.20 | 0.30 | 0.30 | 1.534 | 1.450 |
| 1.25 | 1.25 | 0.5 | 1.00 | 0.20 | 0.20 | 0.30 | 0.30 | 1.370 | 1.325 |
| 1.25 | 1.50 | 0.5 | 1.00 | 0.20 | 0.20 | 0.30 | 0.30 | 1.434 | 1.388 |
| 1.25 | 1.75 | 0.5 | 1.00 | 0.20 | 0.20 | 0.30 | 0.30 | 1.502 | 1.450 |
| 1.25 | 2.00 | 0.5 | 1.00 | 0.20 | 0.20 | 0.30 | 0.30 | 1.575 | 1.513 |
| 1.00 | 1.25 | 1.00 | 0.5 | 0.20 | 0.20 | 0.30 | 0.30 | 1.409 | 1.363 |
| 1.00 | 1.50 | 1.00 | 0.5 | 0.20 | 0.20 | 0.30 | 0.30 | 1.478 | 1.425 |
| 1.00 | 1.75 | 1.00 | 0.5 | 0.20 | 0.20 | 0.30 | 0.30 | 1.551 | 1.488 |
| 1.00 | 2.00 | 1.00 | 0.5 | 0.20 | 0.20 | 0.30 | 0.30 | 1.629 | 1.550 |
| 1.25 | 1.25 | 1.00 | 0.5 | 0.20 | 0.20 | 0.30 | 0.30 | 1.467 | 1.425 |
| 1.25 | 1.50 | 1.00 | 0.5 | 0.20 | 0.20 | 0.30 | 0.30 | 1.530 | 1.488 |
| 1.25 | 1.75 | 1.00 | 0.5 | 0.20 | 0.20 | 0.30 | 0.30 | 1.599 | 1.550 |
| 1.25 | 2.00 | 1.00 | 0.5 | 0.20 | 0.20 | 0.30 | 0.30 | 1.672 | 1.612 |

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