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Duration of Post-partum Amenorrhoea: A Model-based Approach

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Abstract

This paper develops a model to examine the distribution of the duration of post-partum amenorrhoea based on extreme value distributions. The applicability of the model is examined using data from India's National Family Health Survey 2005-06.

Introduction

Every woman, following the childbirth, goes through a temporary period of infecundability which is referred to as the period of post-partum amenorrhoea (PPA). During this period, the woman does not ovulate and, therefore, is not susceptible to conception. The duration of PPA period is a significant determinant of birth interval in societies in the absence of the practice of contraception and, therefore, influences the level of fertility. There are many factors that determine the duration of PPA. The main determinant is breastfeeding. The duration and the nature of breastfeeding is directly related to the duration of PPA (Perez et al, 1971; 1972; Srinivasan et al, 1989; Nath et al, 1993; Singh et al, 1994). The duration of PPA is also influenced by weaning and the death of child which results in either reduction in the frequency or stopping of breastfeeding. The nutritional and health status of the woman also influences the duration of PPA. Under nutrition affects woman's reproductive health and causes a delay in resuming the menstrual cycles. An undernourished woman produces reduced quantity of breast milk and, therefore, the child suckles more intensely and frequently to get adequate milk which results in increasing the inhibition of ovulatory hormones (Jones, 1989; Jones, 1990). Because of these and many other factors, the duration of PPA varies widely across women. There are studies to suggest that the distribution of the duration of PPA is bimodal with the first mode at around 3-4 months and the second mode at around 12-14 months in a developing country like India depending upon the duration of breastfeeding. When the breastfeeding is not initiated or when breastfeeding is stopped because of the death of the child, the duration of PPA is short. However, prolonged breastfeeding results in extended duration of PPA. Cleland et al (1984) have shown that, in the developing countries, the duration of PPA has a strong

impact on the level of fertility. The length of PPA is, therefore, one of the proximate determinants of fertility (Bongaarts, 1978).

In India, breastfeeding is nearly universal. Therefore, the duration of PPA is quite long (Ramchandran, 1987; Srinivasan et al, 1989; Nath et al, 1993; Singh et al, 1994). In rural areas, it is one of the important factors in deciding the birth interval. The relationship between the duration of PPA and the duration of breastfeeding has been extensively studied (Habicht et al, 1984; Singh and Singh, 1989; Singh et al, 1990; Nath et al, 1994; Singh et al, 1994; Mukharjee et al, 1994; Singh et al, 1999).These studies suggest that the relationship between the duration of breastfeeding and the duration of PPA is not direct because the duration of PPA is also influenced by many other factors (Frisch, 1978; Huffman et al, 1987).

The information related to the duration of PPA is usually collected through household surveys like National Family Health Survey (NFHS) in India or Demographic and Health Survey (DHS) in other countries of the world. There are studies to suggest that data regarding the duration of PPA available through these surveys are generally of poor quality as women do not remember the exact time of the return of menstruation after their last birth. Moreover, information about the duration of PPA is recorded in completed months so that it is found that these data suffer from age heaping usually at months 3,6,9 and 12 (Singh et al, 1994). The duration of PPA, however, is a continuous variable. At the same time, substantial variation in the duration of PPA has been observed among populations despite nearly universal breastfeeding pattern (Singh et al, 1999).

In view of the limitations of household survey-based approach of establishing the distribution of the duration of PPA in contemporary populations, model-based approaches have been evolved to estimate the duration of PPA in the context of fertility-related research. Efforts, in this direction, have been made by Barrette (1969), Lesthaeghe and Page (1980) and Potter and Kobrin's (1981). Barrette has used modified Pascal distribution; Lesthaeghe and Page have used logit model while Potter and Kobrin have used mixed geometric negative binomial model to characterise the distribution of the duration or length of PPA. Ford and Kim (1987) have used a mixture of two extreme value distributions to model the distribution of the duration of PPA in the presence of censored cases. The applicability of these models has generally been examined through data obtained from prospective studies. In all these studies, the duration of PPA is treated as a discrete variable.

In the present paper, we model the distribution of the duration of PPA under the assumption that the duration of PPA is a continuous variable. Moreover, we test the applicability of the model based on the retrospective data available from a large-scale household survey. The paper is organized as follows. The next section of the paper describes the model that characterises the bimodal nature of the distribution of the duration of PPA. Section three of the paper describes the source of data that has been used to apply the model. We have used the data available from India's National Family Health Survey 2005-06. Results of fitting the model to the real time data are

presented in the fourth section of the paper. The last section of the paper discusses the nature of the distribution of the duration of PPA in India and its policy and programme implications.

The Model

We have used type I extreme value distribution or Gumbel distribution (Jhonson and Kotz, 1970) to model the duration of PPA in the present study. The Gumbel distribution, named after the pioneer German mathematician Emil J. Gumbel (1891-1966), has been extensively used in various fields including hydrology for modelling extreme events. Nath and Talukdar (1992) have used type I extreme value model to describe the pattern of woman age at marriage in a traditional society in India in which women marry at an early age and where all births occur within the institution of marriage. Singh and Dixit (2017) have used this distribution for modelling age at first birth. The distribution and density function of the extreme value distribution can be given as follows

$$F(x) = \exp\left(-\exp\left(-\frac{(x-M)}{\theta}\right)\right) \tag{1}$$

$$f(x) = \frac{1}{\theta}\exp\left(-\frac{x-M}{\theta} - \exp\left(-\frac{(x-M)}{\theta}\right)\right) \tag{2}$$

In the above model M is the mode and is termed as the location parameter while θ is the scale parameter. The model used here incorporates both unimodal and bimodal behaviour of the distribution of the duration of PPA by using a mixing parameter α, which ranges between 0 and 1. The mixture distribution can be written as

$$f(x) = \alpha f_1(x) + (1-\alpha) f_2(x) \tag{3}$$

where $f_1(x)$ is the first extreme value distribution and $f_2(x)$ is the second extreme value distribution. The desired density function is now given by

$$f(x)_m = \frac{\alpha}{\theta_1}\exp\left(-\frac{(x-M_1)}{\theta_1} - \exp\left(-\frac{(x-M_1)}{\theta_1}\right)\right) + \frac{\big((1-\alpha)\big)}{\theta_2}\exp\left(-\frac{(x-M_2)}{\theta_2} - \exp\left(-\frac{(x-M_2)}{\theta_2}\right)\right) \tag{4}$$

and the mixture distribution can be expressed as:

$$F(x)_m = \alpha\exp\left(-\exp\left(-\frac{x-M_1}{\theta_1}\right)\right) + (1-\alpha)\exp\left(-\exp\left(-\frac{x-M_2}{\theta_2}\right)\right) \tag{5}$$

The mixing parameter α of the model reflects the proportion of those women with short duration PPA so that 1-α reflects the proportion of women with prolonged

duration of PPA. The mean and variance of women having short duration PPA and mean and variance of women having long duration PPA can be described by the set of parameters (M_1, θ_1) and (M_2, θ_2).The relationship between mode (M) and mean (μ) of type I extreme value distribution can be described as:

$$\mu = M + \theta\gamma$$

Where γ, approximately equal to 0.5772, is known as the Euler-Mascheroni constant (Singh and Dixit, 2017). Since M and θ are positive, mean (μ) of the distribution is always more than the mode (M) which means that the distribution of the duration of PPA is always positively skewed.

The model has five parameters which need to be estimated. We have used non-linear minimisation procedure to estimate the parameters of the model. This procedure minimises the following quantity:

$$SS_F = \sum_x \left(S_x - \left(1 - F(x)\right)\right)^2 \qquad (6)$$

where S_x is the life table survival function, while $F(x)$ is the distribution function of the mixture model. The proposed model can also incorporate censored data (Ford and Kim, 1987), but we consider here complete observations only.

Application

We apply the above model to the data available from India's National Family Health Survey-3 (NFHS-3) 2005-06for five states – Kerala, Andhra Pradesh, Maharashtra, Uttar Pradesh, and West Bengal (Government of India, 2007). The data pertain to the duration of PPA reported by ever-married women aged 15-49 years at their last but one birth. Any missing or conflicting data have been excluded from the analysis. An exploratory data analysis was carried out to identify and exclude outliers and extreme values in the data before fitting the model.

Table 1: Summary statistics of the distribution of the duration of PPA in five states.

State	Percentage of women with duration of PPA (months) less than				Mean	Median	SD
	3	6	9	12			
Kerala	53.0	76.2	89.3	95.8	4.88	3.00	3.86
Andhra Pradesh	43.5	73.8	87.2	97.2	5.17	4.00	3.66
Maharashtra	40.3	62.1	74.0	94.4	5.14	5.00	4.50
Uttar Pradesh	50.6	65.7	73.4	93.8	5.28	3.00	5.04
West Bengal	53.4	73.3	81.2	94.2	5.16	3.00	4.56

Source: Authors' calculation

Table 1 gives the distribution of the ever-married women by the duration of PPA in five states. The mean duration of PPA is higher than the median duration of PPA

in all the five states which indicates that the distribution of the duration of PPA in all states is positively skewed. Among different states, the mean duration of PPA is estimated to be the longest in Uttar Pradesh, but the shortest in Kerala. However, the median duration of PPA is estimated to be the longest in Maharashtra. Table 1 also suggests that in all states, less than 5 per cent ever-married women had a PPA of at least 12 months. In all state, majority of the ever-married women had at the most 3 months of PPA. This proportion was around 53 per cent in West Bengal and Kerala but only about 40 per cent in Maharashtra. Kerala is the only state where the distribution of the duration of PPA is found to be unimodal. In rest of the states, the distribution of the duration of PPA is found to be bimodal.

Table 2 gives estimates of the parameters of the model for the five states. In states where the distribution of the duration of PPA is bimodal, the second mode, as revealed by parametersM_2, is around 8-10 months. The mean duration of PPA, estimated based on the model, is found to be the close approximation of the mean duration of PPA obtained directly from the data. This suggests that the model fits the observed distribution of the duration of PPA very well. In fact, the difference between the observed mean duration of PPA and the mean duration of PPA estimated from the model is found to be statistically insignificant in all the five states.

Table 2**:** Estimates of the parameters of the model

PPA Pattern	States	Parameters					Duration of PPA	
		M_1	θ_1	M_2	θ_2	α	Mean	SD
Unimodal	Kerala	2.65	4.04	-	-	-	4.98	5.18
Bimodal	Andhra Pradesh	2.15	1.80	7.82	3.88	0.71	5.18	3.08
	Maharashtra	1.39	1.29	7.66	4.03	0.65	4.88	2.88
	Uttar Pradesh	0.35	1.79	10.34	2.69	0.66	4.96	2.69
	West Bengal	0.58	2.60	8.92	5.45	0.66	5.48	4.58

Source: Authors' calculation

It may also be seen from table 2 that the first mode of the distribution of the duration of PPA is the lowest in Uttar Pradesh and very low in West Bengal. This implies that the duration of PPA in a substantial proportion of women in these states is too short to have a regulating effect on fertility.

Empirical and fitted distribution of the duration of PPA five states are given in figures 1 through 5. In Kerala, the distribution has single mode at around 3 months and a mean duration of around 5 months. The distribution is positively skewed. In Andhra Pradesh, on the other hand, the distribution is bimodal with estimated modes at around 2 and 8 months but the distribution remains positively skewed (Figure 2).

Figure 3 shows the distribution of the duration of PPA in Maharashtra. There are also two modes in the distribution at around 1and 8 months respectively. The estimated mean duration of PPA is more than 5 months. In Uttar Pradesh, the first mode of the distribution of the duration of PPA is at 0.35 months only so that the mean

duration PPA is very low despite the second mode at more than 10 months. The median duration of PPA in the state is 3 months.

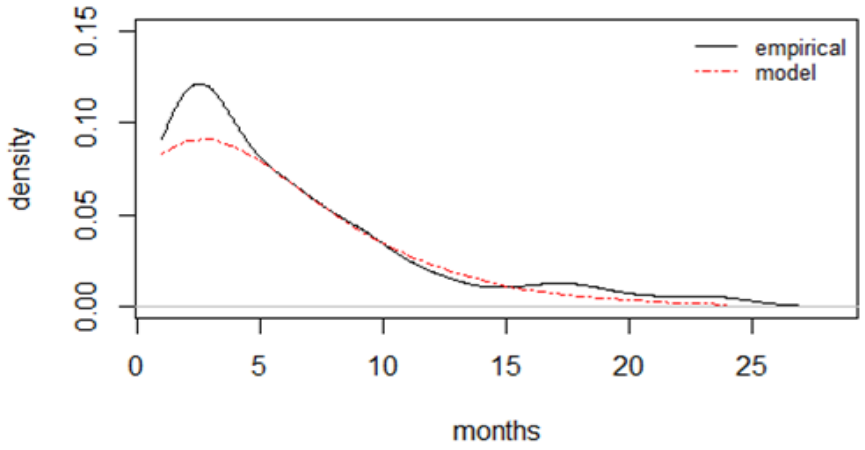

Figure 3: Empirical density and model estimates for Kerala
Source: Authors

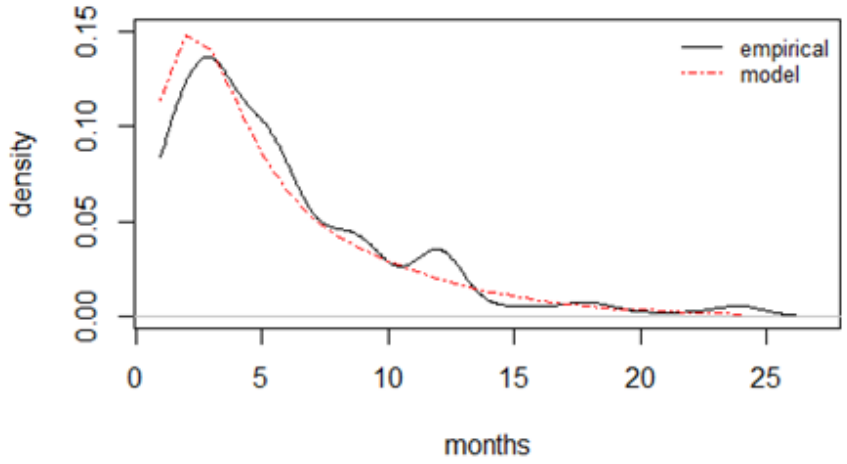

Figure 2: Empirical density and model estimates for Andhra Pradesh
Source: Authors

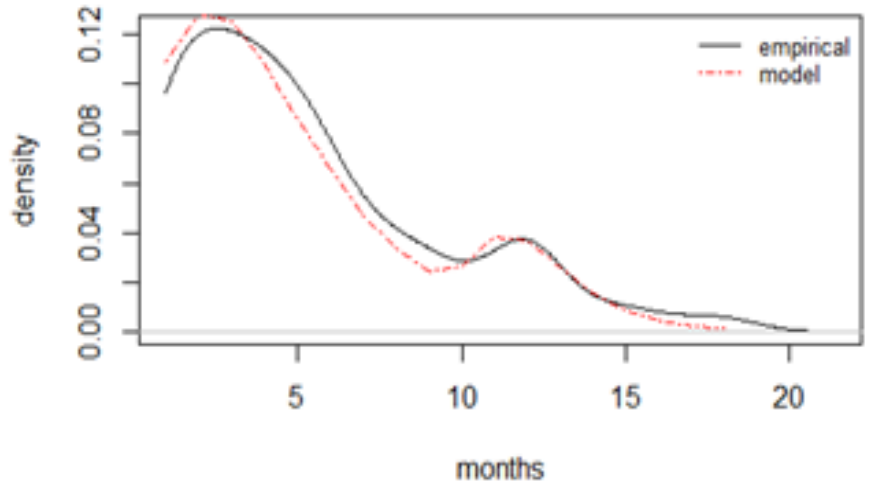

Figure 3: Empirical density and model estimates for Maharashtra
Source: Authors

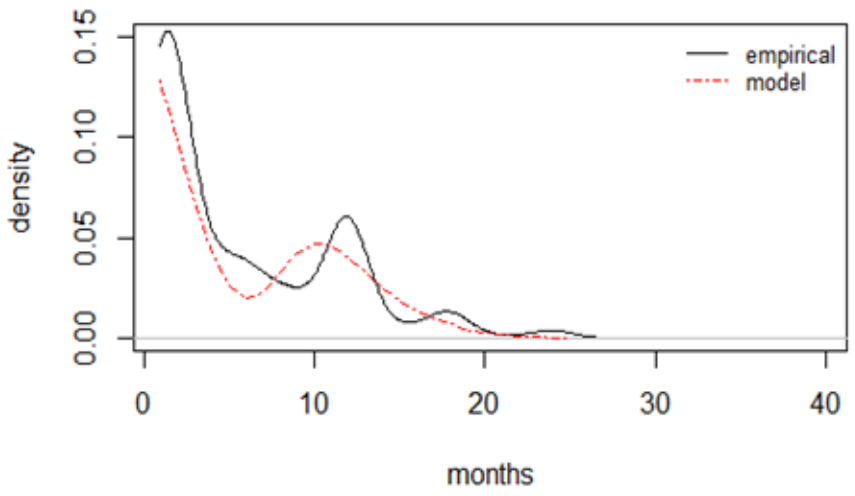

Figure 4: Empirical density and model estimates for Uttar Pradesh
Source: Authors

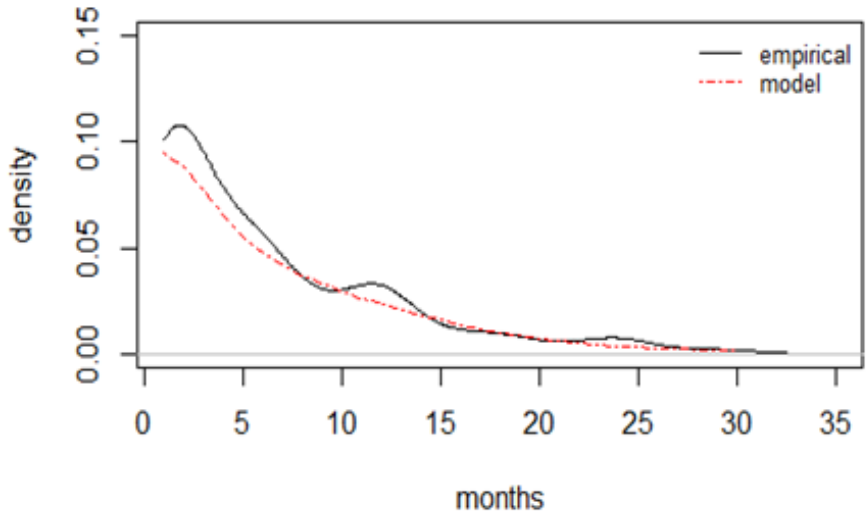

Figure 5: Empirical density and model estimates for West Bengal
Source: Authors

The fitting of the model reveals interesting differences in the distribution of the duration of PPA across five states. First, the distribution is unimodal in Kerala but bimodal in the remaining four states. Second, the first model value is the highest in Kerala but the lowest in Uttar Pradesh. Third, the second modal value of the distribution is the highest in Uttar Pradesh among the four states but the lowest in Maharashtra. These variations in the parameters of the model across the five states suggest that factors influencing the duration of PPA are essentially different in different states. For example, women in four states other than Kerala can be divided into two groups, one having short duration PPA and the other having long duration PPA. It would be interesting to explore the distinguishing characteristics of the two groups of women. Similarly, it would be illustrating to examine the fertility impact of the duration of PPA in women belonging to two groups.

Conclusion

This study has attempted to fit a mixture of two extreme value distributions to model the distribution of the duration of PPA in selected states of India as the available evidence suggests that the distribution of the duration of PPA may be unimodal as well as bimodal. Our modelling exercise confirms that the distribution of the duration of PPA in most of the states of India is bimodal with the only exception of Kerala where this distribution is unimodal. The paper also reveals that in majority of women, the duration of PPA is short which means that the impact of PPA on fertility is not substantial, although there are women in all states having long duration PPA. The paper

suggests the need of analysing the distinguishing characteristics of women having short duration PPA and women having long duration PPA in different states of the country.

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