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ARTICLE

A Probabilistic Study of Duration of Post-partum Amenorrhoea in rural Uttar Pradesh[1]

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Abstract

The present study introduces a model designed to assess the distribution of post-partum amenorrhea durations through a mixture of two Weibull distribution. The suitability of the model is evaluated by analysing data extracted from a research project funded by the Indian Council for Medical Research (ICMR). The analysis shows that breastfeeding plays a significant role in how long PPA lasts, with longer breastfeeding linked to longer periods without menstruation. Additionally, women with lower socio-economic status and poorer nutrition tend to have longer PPA durations. Using the two Weibull distributions helps capture the different patterns of PPA, providing a detailed understanding of this important health issue.

Keywords: Post-partum amenorrhea, Body-mass index, Religion, Rural, Uttar-Pradesh

1. Introduction

Postpartum amenorrhea (PPA) is the absence of menstruation periods after giving birth. During pregnancy, hormonal changes prevent ovulation and menstruation. After childbirth, it can take some time to resume its normal function of reproduction system. The length of time it takes for menstruation to return varies from woman to woman, but it typically takes between six weeks and six months to resume cycle to after giving birth. It is also influenced by various factors such as breastfeeding, age, and parity. Also, death of a child affect the duration of PPA by reducing or stopping breastfeeding frequency. Nutrition and health status of the woman also influences the duration of PPA. Since undernourished woman produces less breast milk, which results in the child sucking more intensely and frequently in order to get adequate milk, thereby were decreasing the production of ovulatory hormones (Jones, 1989, 1990). Because of these and many other factors, the duration of PPA prolongs and varies widely across women.

In a developing country, studies show that PPA duration tends to be bimodal with the first mode around 3-4 months and the second mode around 12-14 months depending on breastfeeding duration and maturation states. The duration of PPA is short when breastfeeding is not initiated or stopped because of the death of the child. In India, the median duration of PPA varies from 4 months in Delhi, Punjab and Goa, to 10 months in Assam, Bihar and West Bengal (NFHS-1 report). While median duration of rural and urban females of UP were found to be 9.2 and 6.3 respectively. Yadav (1988) has reported mean duration of PPA for rural eastern UP as 7.2 months excluding the censored cases and 7.7 months when censored cases were allocated. Postpartum contraception adoption and adherence are impeded by a range of socio-economic factors specific to low-income countries (Pal *et al.* 2020; Joshi *et al.* 2020).

Cleland *et al.* (1984) have found that the duration of PPA has a significant effect on fertility levels. As a result, PPA is one of the proximate determinants of fertility (Bongaarts, 1978). In India, the prevalence of breastfeeding is almost 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, this is an important factor in determining 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.* 1991; Singh *et al.* 1999; Singh *et al.* 2021).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). Several probability distributions have been used to model postpartum amenorrhea, including the Weibull, Gamma, and Lognormal distributions (Kapoor, 2016; Rahman *et al.* 2019). In 2009, Yadava et.al had fitted the distribution of PPA for 371 females who came to the hospital/clinics to deliver their current birth in Lucknow district. He had considered three distributions namely truncated Poisson distribution, displaced Poisson distribution and displaced negative binomial distribution, concluded that truncated Poisson distribution and displaced negative binomial distribution can be considered as choice for theoretical distribution for PPA.

As it well known, that Uttar Pradesh is the most populous state of our country. Economically as well as demographically it is one of the poorest performing states. Its total fertility rate was maximum in 2005. Eastern Uttar Pradesh is a thickly populated region having relatively lower per capita income and has its peculiar problems in terms of socio-economic and demographic developments due to deep rooted cultural norms especially rural areas. PPA is one of the important measures that affect fertility in any region. In this context, the aim of this study is to fit distributions of the data on last first postpartum amenorrhea in rural eastern Uttar Pradesh, and to identify the distribution that best fits the data. This information can be used to estimate the median and mean duration of postpartum amenorrhea, and to provide insights into the factors that influence the duration of postpartum amenorrhea in this population. The findings of this study can inform family planning policies and programs in Rural Eastern Uttar Pradesh and contribute to improving maternal and child health outcomes in the country.

2. Materials and Methods

2.1 The Model

In this study, we use the Weibull distribution to model the duration of PPA. It is a continuous

probability distribution that can take on a wide range of shapes depending on the values of its parameters. Aryal (2007, 2011) have used Weibull distribution model to the duration of post-partum amenorrhea for Nepal data. Hossain *et al.* 2007 have used, Weibull hazard model the impact of childhood morality on fertility in six rural thanas of Bangladesh.

The Weibull distribution's distribution and density function (as $\boldsymbol{x} > \mathbf{0}$, ($\boldsymbol{\lambda}$, $\boldsymbol{k} > \mathbf{0}$)) are as follows:

$$F(x) = \begin{cases} 1 - e^{-(x/\lambda)^k} & , \quad 0 < \lambda < \infty, \\ 0 & , \quad 0 < k < \infty. \end{cases} \tag{1}$$

$$f(x) = \begin{cases} \frac{k}{\lambda}(\frac{x}{\lambda})^{k-1} e^{-(x/\lambda)^k} & , \quad 0 < \lambda < \infty, \\ 0 & , \quad 0 < k < \infty. \end{cases} \tag{2}$$

We assume total population can be considered in two groups on basis of their nutritional status. The female whose nutritional status is good have lower PPA duration and female who have poor nutritional status have larger PPA. It is observed that the pattern of PPA bimodal. The first mode is 3 months and second mode is 9 months. Therefore in the proposed model, we have used mixture of two Weibull distributions for the modelling PPA data. The parameters and represents the shape of the distribution, while the parameters and represents the scale of the distribution. The mixing parameter ranges between 0 and 1. The mixture distribution can be written as

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

The first Weibull distribution is denoted by $f_1(x)$, and the second by $f_2(x)$. We can now write down the desired density function as

$$f(x)_m = p\frac{k_1}{\lambda_1}\left(\frac{x}{\lambda_1}\right)^{k_1-1} e^{-(x/\lambda_1)^{k_1}} + (1-p)\frac{k_2}{\lambda_2}\left(\frac{x}{\lambda_2}\right)^{k_2-1} e^{-(x/\lambda_2)^{k_2}} \tag{4}$$

And the CDF mixture distribution can be expressed as:

$$F(x)_m = p\left(1 - e^{-(x/\lambda_1)^{k_1}}\right) + (1-p)\left(1 - e^{-(x/\lambda_2)^{k_2}}\right) \tag{5}$$

A mixing parameter that represents the proportion of women with short duration postpartum amenorrhea (PPA), and this represents the proportion of women with longer duration of PPA. The mean values of women with short and long duration PPA are represented by two sets of parameters. This model could be used to study the relationship between PPA duration and other variables of interest.

Proposed model contain five parameters, which needs to be estimated. We have estimated the model parameter using a non-linear minimization approach. This procedure minimises the following quantity:

$$SS_F = \sum_X (S_X - (1 - F(x)))^2 \tag{6}$$

In this equation, S_X represents the survival function of the life table, and $F(x)$ represents the distribution function of the mixture model.

2.2 Data

We use the above model to analyse data taken from a research project funded by the Indian Council for Medical Research (ICMR). The data collected from rural Eastern Uttar Pradesh on fertility, nutrition's etc. The findings are about the length of PPA reported by ever-married women between

the ages of 15 and 49 who had only one child. Before fitting the model, an exploratory data analysis was done to find outliers and extreme numbers in the data and exclude from the data.

Ethical Consideration

Our research relies on survey data that has undergone anonymization, ensuring the removal of any identifiable information associated with individuals. Prior to participating in the survey, all participants provided informed consent, and data collection was conducted in a confidential manner.

3. Results and Discussion

Figure 1, 2 and 3 compares the empirical density of postpartum amenorrhea (PPA) durations with the estimates generated by the model for Hindu, Muslim and overall women in rural Uttar Pradesh. The closeness of the fit between the empirical density and the model estimates indicates how well the model explains the data. A good fit suggests that the model is effective in capturing the key characteristics of the PPA duration distribution in rural Uttar Pradesh.

Table 1 shows that religion-wise percentage of BMI for underweight, normal and overweight. Among Hindu women, approximately 49 percent are underweight, with a mean (PPA) duration of 7.42 months. About 47 percent of Muslim women are underweight, and the overall percentage of underweight women is 49 percent. Around 45 percent of Hindu, Muslim, and overall women exhibit a normal BMI, with a mean PPA duration of 6.46 months. Among Hindu women, about 6 percent fall into the overweight category, while approximately 9 percent of Muslim women are overweight. Overall, about 7 percent of women are overweight, with a mean PPA duration of 4.09 months for this group.

In Table-2, parameter estimates are presented, where PPA duration of corresponds to short and corresponds to longer PPA. The mixing proportion for the short PPA duration among Hindus is 70 percent and the estimated mean PPA is 6.58 months. Similarly, the mixing proportion for the short PPA duration among Muslims is 53 percent and the estimated mean PPA is 7.22 months. Lastly, the mixing proportion for the short PPA duration across the entire population is 64 percent with an estimated mean PPA of 6.68 months.

3.1 Figures and tables

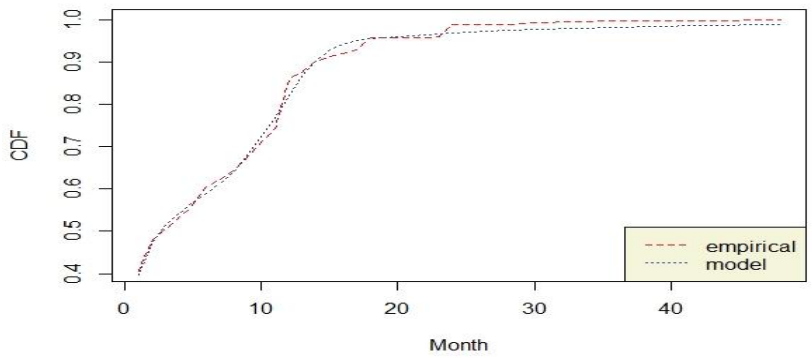

Figure 1: Empirical density and model estimates for Hindu.

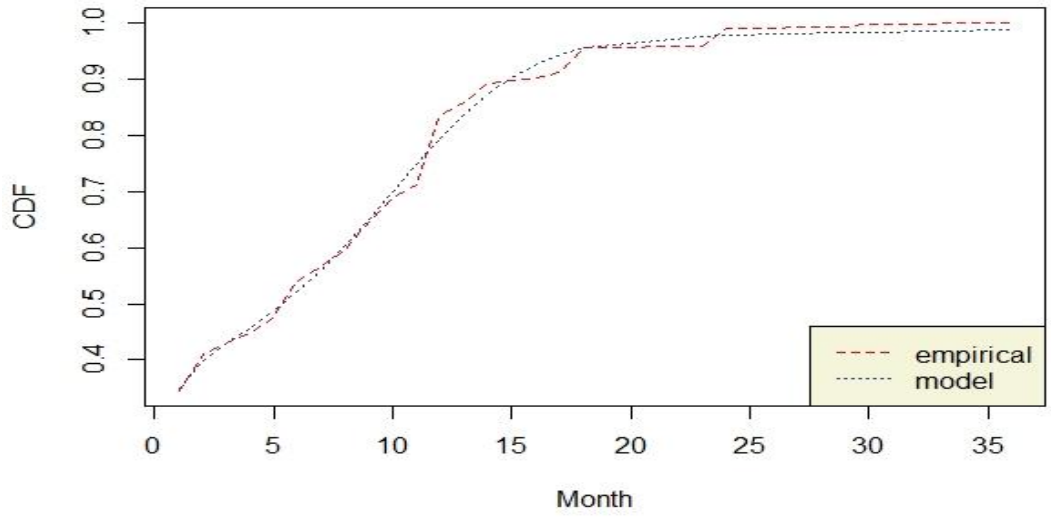

Figure 2: Empirical density and model estimates for Muslim.

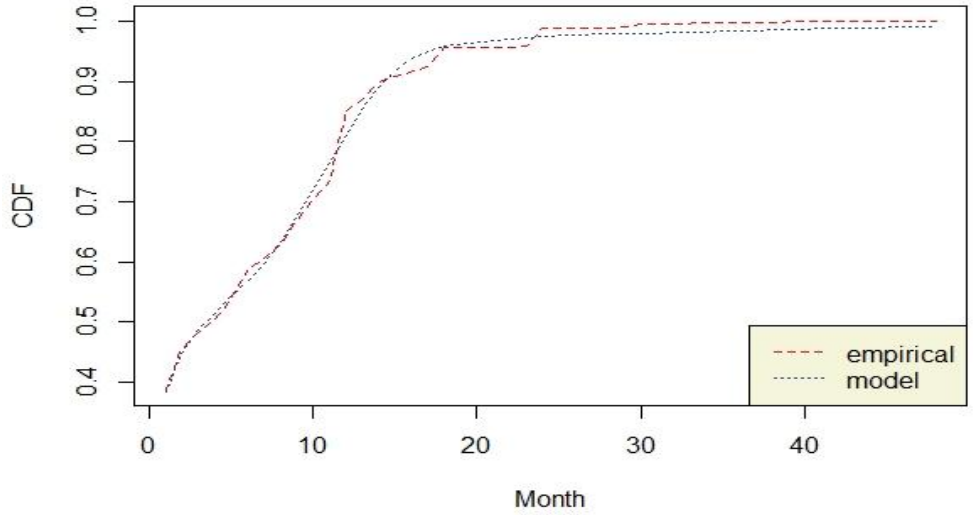

Figure 3: Empirical density and model estimates for Over-all.

Table 1. Percentage of body mass index according to religion in rural Uttar-Pradesh

BMI	Hindu	Muslim	Over-all	Mean of PPA
Underweight	48.80	46.70	48.30	7.42
Normal	45.00	44.50	44.70	6.46
Overweight	6.20	8.80	7.00	4.09

Table-2 Estimate of the parameter of the model

Religion	Estimate of Parameters					Mean duration of PPA
	k_1	λ_1	k_2	λ_2	p	
Hindu	1.5342	0.4125	12.0415	4.7298	0.7004	6.5897
Muslim	0.8666	0.3493	11.7806	2.9005	0.5360	7.2265
Overall	1.2843	0.3967	12.0297	3.6936	0.6432	6.6806

4. Conclusions

This study concludes that mixture of two Weibull distributions fitted the postpartum amenorrhea (PPA) duration of women in rural Uttar Pradesh. By supporting breastfeeding, enhancing maternal nutrition, and addressing socio-economic disparities, targeted health interventions can be developed to improve maternal and child health outcomes in rural areas. The findings of the study indicate that a significant proportion of women in this region experience a short duration of PPA implying that the nutrition level in village women is good. The considered mixture Weibull distribution fits better and supports the theoretical results. In the rural area it is in practice that women during PPA duration eat reach foods and take complete rest perhaps this may be one reason. The success of this probabilistic model paves the way for its application in future research, contributing to a deeper understanding of postpartum health dynamics.

Limitation of the study

The data used in this study is sourced from a specific research project funded by the Indian Council for Medical Research (ICMR). The sample may not be fully representative of all rural areas in Uttar Pradesh, leading to potential biases.

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Author Contributions

Conceptualization: TIWARI, A.K.; SINGH, B.P.; MAURYA, R.K.; SINGH, A.; **Data-curation:** MAURYA, R.K.; SINGH, A.; **Formal analysis:** MAURYA, R.K.; SINGH, A.; **Funding acquisition:** - **Investigation:** TIWARI, A.K.;SINGH, A.; **Methodology:** TIWARI, A.K.;SINGH, B.P.; MAURYA, R.K.; SINGH, A. ; **Project administration:** - **Software:** - **Resources:** MAURYA, R.K.; SINGH, A.; **Supervision:** TIWARI, A.K.; SINGH, B.P. **Validation:** TIWARI, A.K. **Visualization:** - **Writing - original draft:** TIWARI, A.K.; SINGH, B.P.; MAURYA, R.K.; SINGH, A. **Writing - review and editing**: TIWARI, A.K.; MAURYA, R.K.; SINGH, A.

Conflicts ofInterest

The authors declare no conflict of interest.

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