

## ON THE ESTIMATION OF PARITY PROGRESSION RATIOS

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### Abstract

The paper deals with estimation of parity progression ratios utilizing the data on open and closed birth intervals. For illustration, the procedure has been applied to the data from National Family Health Survey 1998-99 (NFHS-2). The significance of the technique lies essentially due to the fact that in this approach, data requirements for estimation of the same, are simple and the values itself may be less liable to be affected by various kinds of errors of data collection.

**Key words :** Parity, Parity progression ratio, Open birth interval, Closed birth interval, Post-partum amenorrhoea.

### INTRODUCTION

Total fertility rate, the most popular index of fertility, gives an idea about the average completed family size of a female during her entire reproductive span ignoring her mortality upto that period. It does not, however, reveal about the proportion of females in that population who after having a specified number of children do not proceed to the next birth. This proportion plays a very important role on the overall fertility performance of any population because of the fact that it not only reflects the extent of family limitation practices that are being followed in that population but also determines total fertility of that population. Infact, after knowing about this proportion, TFR can be determined. Hence, the knowledge of this proportion is of particular importance in context of developing countries like India in order to asses the impact on fertility of various family planning programmes that are being currently undergoing on an unprecedented scale. Its knowledge is also quite useful in differentiating populations with regard to their fertility levels.

Parity Progression Ratio (PPR), as it is normally referred to in the literature, is the chance that a woman after delivering her  $i^{th}$  child will ever proceed to the next parity i.e. will have an additional child in future. As a useful measure of fertility the concept of PPR was introduced by Henry (1953). It did not, however, gain wide applicability because of various problems associated with its measurement, data needs and also with its conceptualization with

respect to period and cohort measures. Initially Henry, while proposing a procedure to estimate PPRs from the reproductive experience of a cohort of married women with completed fertility, latter tried to transform them into period measures following a method similar to the Lexis diagram. Afterwards, Bhrolchain (1987), Feeney and Jingyuan (1987) advanced the latter part of Henry's work for estimating period PPRs with suitable modifications. However, their procedure was based on a synthetic cohort of women and required a large amount of data on the maternity history of women. A few other attempts have also been made to estimate PPRs from the data available in vital statistics. Lutz and Feichtinger (1985) used life table approach of Chiang and van den Berg (1982) to estimate PPRs, from the data on average age of mothers at the occurrences of births of different orders and their parity specific fertility rates, by replacing the characteristic of age by parity. A similar attempt was also made by Pandey and Suchindran (1989) but this was also derived with life-table assumptions.

Srinivasan (1968), independent of the above, has given a procedure to estimate the Instantaneous Parity Progression Ratio (IPPR) from the observed data on open birth intervals (OBI) and knowledge of few other intervals. His procedure needs among other things, information about the interval between the date of birth of last child and the terminal point of reproductive period for the females who have completed their reproductive period. This information can only be obtained if in the survey, the data have been collected on age at last birth for those females who have crossed their reproductive span. However, since in most of the surveys, the data are collected from only those women who are within the reproductive period, such data are usually not available. Even if they are available, they usually are affected by different kinds of errors of age reporting and hence may not be reliable. Moreover, as in any survey, number of females of completed fertility is usually small and also, occurrence of last birth to female of such type is a distant event, this information may also suffer from recall lapse. Further this procedure provides an estimate of IPPR rather than PPR which are two different concepts, although of similar nature. Infact, PPR as defined above is the probability that a woman after delivering her  $i^{th}$  birth will ever proceed to the next birth whereas IPPR is the probability that a woman of parity  $i$  at the time of survey will ever proceed to the next birth. Yadava and Saxena (1989) have investigated the difference between the two in detail and have also provided a procedure to convert IPPR to PPR and vice versa.

Srinivasan's procedure of estimating IPPR, though requires more data, nevertheless it has paved the way for further research in this direction. Hence a majority of work in this area afterwards have mainly been concerned with developing new methods which overcome some of the limitations of

Srinivasan's procedure.

Yadava and Bhattacharya (1985) have proposed an alternative procedure for estimating PPRs from the data on open and last closed birth intervals for the females who are in the reproductive period. This is actually a modification of Srinivasan's (1968) procedure which provides estimates of PPRs rather than IPPRs and it also does not require data on the age at last birth for females who have completed their reproductive period. The procedure includes only those females whose open birth interval is less than a pre-assigned period  $C$  where  $C$  is such that the probability of the closed birth interval exceeding  $C$  is almost zero. Hence if  $F_i(t)$  denotes the distribution function of closed birth interval (CBI) of females of parity  $i$  then above assumption implies that

$$\int_0^C [1 - F_i(t)] dt = E_c(T_i^*)$$

$$\int_0^C 2t[1 - F_i(t)] dt = E_c(T_i^{*2})$$

where,  $E_c(T_i^*)$  and  $E_c(T_i^{*2})$  are the mean and second moment of  $i^{th}$  order CBI, both of which can be computed from the observed set of data. This assumption however, seems to be strong in the sense that a proper choice of  $C$  is needed and  $C$  will also be generally large.

Yadava et al. (1992) have modified Yadava and Bhattacharya (1985) procedure in order to estimate PPRs considering smaller values of  $C$  also. This procedure not only avoids information about the date of last birth and the terminal point of the reproductive period for woman of completed fertility but also avoids the information on the longer open and closed birth intervals. However, for such choice of  $C$ ,

$$\int_0^C [1 - F_i(t)] dt \neq E_c(T_i^*) \quad \text{and}$$

$$\int_0^C 2t[1 - F_i(t)] dt \neq E_c(T_i^{*2})$$

and computation of above integrals becomes a problem. Consequently, for evaluating the above integrals, they have suggested to use appropriate quadrature formulae and used *Trapezoidal Rule* for this purpose. Yadava et al. (1992) expression for computation of PPRs is given as follows

$$\alpha_i = \frac{C^2 - 2CE_c(U_i^*)}{C^2 - 2J - 2E_c(U_i^*)(C - I)} \quad \text{where}$$

$I = \int_0^C [1 - F_i(t)] dt$ ,  $J = \int_0^C t [1 - F_i(t)] dt$ ,  $E_c(U_i^*)$  is the mean open birth interval for all females of  $i^{\text{th}}$  parity (both fertile and sterile), included in the study. Later Yadava and Kumar (2002) modified Yadava et al. (1992) technique and gave explicit expressions for the two integrals  $I$  and  $J$  in terms of  $E_c(T_i^{*2})$ ,  $E_c(T_i^*)$  and  $F_i(C)$ , the values of which can be easily obtained from the observed set of data for any given value of  $C$ .

The objective of present paper is to propose a new approach for computation of PPRs using data on open and last closed birth intervals. The method appears to be more simpler and may be less likely to be affected by various kinds of errors of data collection, in comparison to the earlier methods.

### THE PROPOSED PROCEDURE

In the Yadava et al. (1992) procedure of estimation of PPRs we need computation of the values of the integrals  $I$  and  $J$  as well as the value of  $E_c(U_i^*)$ . Apart from other requirements the computation of the value of  $E_c(U_i^*)$  involves the whole set of data on open birth interval for females involved in the study and any errors (digit preference or memory bias) are likely to affect the computed values of  $E_c(U_i^*)$ . Further, such errors may also affect the values of the integrals  $I$  and  $J$  and thereby affecting the estimate of PPR.

Yadava et al. (1992) procedure is essentially based on the concept that the mean open birth interval of the females included in the study is the weighted mean of means of open birth intervals of fertile and sterile females of parity  $i$  at the time of survey, the weights being  $\alpha_i^*$  and  $(1 - \alpha_i^*)$ . The values of  $\alpha_i^*$  and  $(1 - \alpha_i^*)$  are given by

$$\alpha_i^* = \frac{\alpha_i \int_0^C [1 - F_i(t)] dt}{\alpha_i \int_0^C [1 - F_i(t)] dt + (1 - \alpha_i).C}$$

and

$$(1 - \alpha_i^*) = \frac{(1 - \alpha_i).C}{\alpha_i \int_0^C [1 - F_i(t)] dt + (1 - \alpha_i).C}$$

However, if instead of considering the mean open birth interval of the females included in the study, we consider the proportion of females of  $i^{\text{th}}$  parity with open birth interval in the range  $(0, C)$ , then the proportion say,  $p_i^{(0, C)}$  is given as

$$p_i^{(0,C_1)} = \frac{\alpha_i \int_0^{C_1} [1 - F_i(t)] dt + (1 - \alpha_i) \cdot C_1}{\alpha_i \int_0^C [1 - F_i(t)] dt + (1 - \alpha_i) \cdot C}$$

If  $C_1$  is chosen such that  $F_i(t)$  is zero for  $0 < t < C_1$  then  $p_i^{(0,C_1)}$  becomes

$$p_i^{(0,C_1)} = \frac{C_1}{\alpha_i \int_0^C [1 - F_i(t)] dt + (1 - \alpha_i) \cdot C} \quad (2.1)$$

It is true that for an extended range,  $F_i(t) = 0$  due to involvement of gestation period as well as post-partum amenorrhoea period associated with the birth. Thus with a suitable choice of the value of  $C_1$  and the computed values of  $p_i^{(0,C_1)}$ , and  $\int_0^C [1 - F_i(t)] dt$  from observed data on open birth interval and closed birth interval, the estimate of  $\alpha_i$  can be easily obtained by equation (2.1). The explicit solution for  $\alpha_i$  is

$$\alpha_i = \frac{C_1 - p_i^{(0,C_1)} \cdot C}{p_i^{(0,C_1)} [E_c(T_i^*) - C]} \quad (2.2)$$

where,  $E_c(T_i^*) = \int_0^C [1 - F_i(t)] dt$

If  $g$  is the gestation period associated with the  $i^{\text{th}}$  birth, then for  $0 < t < g$ ,  $F_i(t) = 0$ . Normally, the value of  $g$  is 9 months. However, due to presence of post-partum amenorrhoea period associated with the birth, the value of  $F_i(t)$  is almost zero for  $t$  less than one year (or 12 months).

Theoretically the choice of  $C_1$  is arbitrary with the only condition that  $F_i(t) = 0$  for  $0 < t < C_1$ , but if  $C_1$  is chosen very small, then  $p_i^{(0,C_1)}$  will also be quite small, which may be more affected by sampling error due to smaller number of observations involved in its calculation. Thus the choice of  $C_1$  should be such that it is as large as possible with the condition that  $F_i(t) = 0$  for  $0 < t < C_1$ . On this consideration, the value of  $C_1$  may be taken near to 12 months or almost 12 months. With  $C_1$  equal to 12 months, estimate of  $\alpha_i$  is

$$\alpha_i = \frac{12 - p_i^{(0,12)} \cdot C}{p_i^{(0,12)} [E_c(T_i^*) - C]} \quad (2.3)$$

which can easily be obtained utilizing observed data on open birth interval and closed birth interval corresponding to a pre-determined value of  $C$ .

### THE ILLUSTRATION

For illustration the procedure is applied on the same data set as was used by Yadava and Kumar (2002) taking the same values of  $C$  viz. 120 months, 96 months and 84 months. Here also the computation of  $\alpha_i$ 's are restricted to parity 8 or less because of the smaller number of observations associated with higher parity. The Table given, presents the estimated values of  $\alpha_i$  obtained from both the procedures viz. the present and Yadava and Kumar (2002), for each parity. From the table, it is evident that the results from the two procedures are in close vicinity.

It must be mentioned that the proportion  $p_i^{(0,12)}$  has been computed by considering the open birth intervals between 0 to 11 months since it is assumed that the data on open birth intervals are in completed months. Thus this proportion excludes the females who have reported their open birth interval as 12 months. Also it is expected that there is likelihood of digit preference for 12 months. Consequently, it is likely that the computed proportion  $p_i^{(0,12)}$  might be slightly underestimated because of this digit preference which might have resulted in getting slightly lower estimates of  $\alpha_i$ . It may be also remarked that the estimates of  $\alpha_i$  obtained by this procedure are based on the estimated value of  $E_c(T_i^*)$  also. Hence an error either sampling or non sampling in its estimate may affect the values of the estimates of  $\alpha_i$ . Further, if the assumptions of the model are true and there is no error in the estimates of the values of  $E_c(T_i^*)$  and the computed value of  $p_i^{(0,12)}$  the estimates of  $\alpha_i$  should be the same for different values of  $C$ . however, in practice there may be variations in the estimates of  $\alpha_i$  for different values of  $C$  and one may choose the median of these estimates as the estimate of  $\alpha_i$ .

The data used in this paper are the National Family Health Survey 1998-99 (NFHS-2) data for the state of Uttar Pradesh. The brief description of the survey is as follows.

The National Family Health Survey (NFHS) was carried out as the principal activity of a collaborative project to strengthen the research capabilities of the Population Research Centers (PRCs) in India, initiated by the Ministry of Health and Family Welfare (MOHFW), Government of India, and coordinated by the International Institute for Population Sciences (IIPS), Mumbai. The first round of NFHS (known as NFHS-1) was conducted in India in 1992-93 and after a gap of six years in 1998-99, second round of NFHS (NFHS-2) was also conducted. NFHS-1 and NFHS-2 were designed along the lines of the Demographic and Health Surveys (DHS) that have been conducted

worldwide in many developing countries during the past two decades. The primary objective of the NFHS is to provide national level and state level data on various health and demographic characteristics. Apart from providing other types of data, the two rounds of the NFHS give the complete birth histories of each eligible female included in the sample. Details about the survey are given in the published reports of the NFHS.

A review of the PPR values in Table indicates that parity progression ratio for parity one is almost near to one showing that in general none of the females stop bearing children after the birth of first child. So it can be said that the one child family norm is almost absent in the context of females of Uttar Pradesh. However, the value of  $\alpha_2$  has been found to be in the vicinity of 0.90 indicating that around 10 percent of the females after delivering their second child stop bearing children. Although not analyzed, such females may be largely from highly educated segment and belonging to upper stratum of the society. The values of  $\alpha_i$  for  $i = 3$  onwards although show a declining trend but the rate of decline is not as much fast as desired. This shows that the efforts are needed to educate and persuade the couples in favor of small family norm and until and unless this is achieved the fertility of this most populous state of the country will continue to remain higher. Since around 1/6<sup>th</sup> of the population of the country lives in Uttar Pradesh and hence its level of fertility would definitely play a major role in shaping the future fertility level of the country as a whole.

**Table :** Estimates of PPRs for different parities from proposed procedure and Yadava and Kumar (2002) according to three different values of C, NFHS-2 Uttar Pradesh.

Parity	Parity Progression Ratios					
	C = 10 years		C = 8 years		C = 7 years	
	Yadava and Kumar (2002)	Proposed Procedure	Yadava and Kumar (2002)	Proposed Procedure	Yadava and Kumar (2002)	Proposed Procedure
1	.9892	.9680	.9935	.9538	1.0000	.9439
2	.9116	.8727	.8948	.8444	.8910	.8201
3	.8731	.8234	.8493	.7937	.8319	.7709
4	.7741	.7507	.7164	.7168	.6987	.7041
5	.7832	.6676	.7581	.6248	.7270	.5786
6	.7021	.6043	.6644	.5653	.6062	.5175
7	.6325	.5827	.4776	.5212	.4108	.5046
8	.5343	.5325	.4482	.5048	.3195	.4690

**REFERENCES**

- Bhrolchain, M.N. (1987) : *Period parity progression ratios and birth intervals in England and Wales. 1941-71: A synthetic life table analysis*, Population Studies, 41: 103-126.
- Chiang, C.L. and Van den Berg, B. J. (1982) : *A fertility table for the analysis of human reproduction*, Mathematical Biosciences, 62: 237-251.
- Feeney, G. and Jingyuan, Yu. (1987) : *Period parity progression measures of fertility in China*, Population Studies, 41: 77-102.
- Henry, L. (1953) : *Fertility of marriages: A new method of measurement*, Population Studies Translation Series No. 3, United Nations, 1980 (French Edition Published in 1953).
- Lutz, W. and Feichtinger, G. (1985) : *A life table approach to parity progression and marital status transitions*, Paper presented in the session on Family Demography at IUSSP, General Conference in Florence, Italy.
- Pandey, A. and Suchindran, C.M. (1989) : *Pace, speed and quantum of fertility: A model based estimation*, in Dynamics of Population and Family Welfare, K. Srinivasan and K. B. Pathak, eds., Ser.6, 268-279. Himalaya Publishing House, Mumbai.
- Srinivasan, K. (1968) : *A set of analytical models for the study of open birth intervals*, Demography, 5, 34-44.
- Yadava, R. C. and Bhattacharya, M. (1985) : *Estimation of parity progression ratios from closed and open birth interval data*, Mimeo, Centre of Population Studies, Banaras Hindu University, Varanasi, India.
- Yadava, R. C. and Kumar, A. (2002) : *A modified procedure of computation of parity progression ratios from birth interval data*, Janasamkhya, Vol. XX, 33-40.
- Yadava, R. C. and Saxena, N. C. (1989) : *The estimation of parity progression and instantaneous parity progression ratios*, in Population Transition in India, Vol.1, 357-362., S. N. Singh et. al., eds., B. R. Publishers, New Delhi.
- Yadava, R. C., Pandey, A. and Saxena, N. C. (1992) : *Estimation of parity progression ratios from the truncated distribution of closed and open birth intervals*, Mathematical Biosciences, 110, 181-190.