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Estimation of Current Fecundability from Data on Open Status of Women

Introduction

AT the time of survey, reproductive status of woman may be broadly categorised into three states, namely, exposed state (E), pregnant state (P) and amenorrheic state (A), called the open status. Like open birth interval, it has been treated as a sensitive index of current fertility (Pathak, 1969). Information on open status can be obtained with much ease and reliability and its collection involves less cost and time. It also avoids non-sampling errors and non-response biases. Although, it may be difficult to identify the status of pregnancy at its early stages as the woman may not be aware of the pregnancy, it may be rectified through a follow-up survey after a month or two. As a matter of fact, information on the susceptibility status of women may be useful to identify the focus group for implementing the family welfare and Mother and Child Health programmes.

Chaudhury (1971), Goldman and Westoff (1980) have estimated current fertility from the data on pregnancy status of women at the time of survey. The data on pregnancy status have given fairly accurate estimates of fertility for Bangladesh and Indonesia. As expected, if the woman is not aware of pregnancy at its early stage, the current fertility may be underestimated. This is why Sinquefield (1978) found that the level of fertility estimated by using the birth statistics during the last one year was higher than that estimated from the pregnancy status data in the World Fertility Surveys. Therefore, the estimate of fertility based on only pregnancy status is not always reliable as the TFR based on recent births has been found higher than that obtained on the basis of the current pregnancies. However, the estimates of fertility based on all the three states of open status of which pregnancy status is one, would be closer to the reality and would not suffer from any selectivity. Fecundability along with other biological parameters like secondary sterility can easily be estimated by considering an appropriate model describing the distribution of open status of women. An attempt in this direction was earlier made by Pathak (1971) by suggesting a discrete probability distribution of open status of agroup of women with a specific marriage duration.

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The biological parameters like fecundability and secondary sterility were estimated by applying the said distribution to a simulated data obtained by Mukerji and Venkatacharya (1967). The simulated data on open status was generated by considering few empirical inputs, such as age-specific fecundability, chances of secondary sterility, post partum amenorrhea etc. for the women of a specific marriage duration. The estimates so obtained referred to a specific marriage cohort. Therefore, they do not reflect, the period specific experience of the women. The present exercise intends to obtain the distribution of open status conforming to a period specific experience of women.

It may be mentioned that the information on all possible states of reproduction for the women are usually not available from the surveys so far conducted. In such a situation, a simulation experiment may, however, be carried out to obtain the distribution of open status for a cross section of women of a specific age.

It is in this light, we present a simple approach to simulate the distribution of open status of married women at a point of time by using the easily available data on the age specific marital fertility rates (ASMFR). In fact, we have treated ASMFRs as the force of fertility at the particular age and used them to approximate the chance of bearing the child in the particular year. This attempt may be considered as the beginning for generating the distribution of period specific open status commensurate with a specific schedule of ASMFRs. We have applied the theoretical distribution of the open status to obtain some-biological parameters of the distribution, such as fecundability and secondary sterility for 14 major states of India as well as for all India circa the census years of 1971 and 1981. Having used the maximum Likelihood Estimate procedure for estimating the parameters, we have studied the change in these parameters over the intercensul period.

Ascertainment of Open Status: A Simulation Experiment

Assumptions and Inputs

The following assumptions are made for the simulation:

(i) Women of given age are homogeneous with respect to their bilogical parameters; (ii) Gestation and amenorrhea periods are invariant with parity and age of the mothers; (iii) There is explicitly no incidence of secondary sterility; of course the effect of secondary sterility is confounded with ASMFR; (iv) No woman dies during two years for which her reproductive status is simulated.

Obviousely, we ignore the birth order and assume that there is no foetal loss or abortion within a period of two years.

In our simulation excercise, the decision making unit is a married female of a given age within the reproductive span. Number of women of each age is determined according to their observed distribution within (15-49) years of age. The period of simulation is one calendar year. As a matter of fact, it can be termed as simulation of one-step forward and one-step backward Markov process. The reproductive status of women is determined for the women of different ages by determining whether the woman has given a birth in the last one year by drawing a random number and then testing it against their age specific marital fertility rate corresponding to the same age. In case the woman has given birth in the last one year, the month in which she has given birth is again determined by choosing another random number and testing it against a uniform distribution of births. The period of post-partum amenorrhea which is fixed for all the women and all the orders of births is taken as '*h*'. If the time of birth is farther than '*h* - *g*' where 'g' is the gestation period, the woman is atleast not in amenorrhea period. This woman may be either in the exposed state or pregnant state. We test for her pregnancy by ascertaining that whether she will give birth within the next nine months with the help of a random number again. If she is ascertained not to give a live birth next year, certainly she is not in the pregnant state at the time of survey or starting point of simulation. Of course, she will be in the pregnant state only if she gives birth within nine months. Thus, for every woman of each age within the reproductive span (15-49) we have been able to assign the open status.

While the requirement of the input data is quite minimal in the present simulation, the distribution of women according to their reproductive status so generated may be used to ascertain the period specific fecundability of women by age using relevant models. Observed age specific-marital fertility rates available in five yearly age groups are splitted into single year ages by using Sprague' s multipliers. This input has been taken for all India and its major states for the years 1971 and 1981. To take into account the effect of age distribution of the married women in their reproductive ages on their status distribution, we have considered the proportion of women at each age *(Nx)* from the observed data. *(Nx)* corresponds to the number of women at age *x* out of the sample of one thousand women *in* the simulation experiment.

Output

The proportional distribution of the sample of 1000 married women of reproductive ages has been obtained for 1971 and 1981. With the given schedule of ASMFRs for all India as well as its 14 major states, the simulation results as shown in Table 1 are obtained after five runs in the computer. These five different runs are executed with different randon starts in the sirrulatiori model and the final output is considered as the average of five sets of the results. Their variances have also been computed. As a result of declining fertility trend in India and all its major states during 1971 -81, an increase in the proportion of women in the exposed state is clearly exhibited. It may be noticed that the index of exposed women is highly correlated with TMFR values both in 1971 and 1981 (r=-.920 with h = 1.25 years, r=.926 for h = 1.5 years in 1971 and r = -.958 with h = 1.25 years, r = -.964 with h = 1.5 years in 1981). Likewise we can expect a high positive correlation between proportion pregnant and the TMFR values which gives us an idea regarding the sensitivity of the status distribution of women at any point of time in reflecting the change in current fertility. Interestingly, the increases in the proportion exposed are consistent with the quantum decline in TMFR values in all the states except in case of Bihar. The proportion pregnant reflects birth rate of immediate future and therefore it shows a decline with the decline in the level of fertility as indicated by TMFR values of 1971 and 1981 in all the states. Alternatively, the proportion of women in amenorrheic state depicts the birth rate in the immediate past and hence can be considered important to know the short term fluctuations in the level of fertility. So far as the change in the value of *'h' is* concerned, it is bound to affect the proportion of women in the amenorrheic state.

TABLE 1 : SIMULATED PROPORTION OF WOMEN OF REPRODUCTIVE AGES IN DIFFERENT STATES OF REPRODUCTION

Region	*Period*	*Reproductive Status of Women*						*TMFR*
		A (*h* = 1.25 years)	*P*	*E*	*A* (*h — 1.50 years*)	*P*	*E*	
India	1971	.116	.138	.746	.168	.13!	.701	5.74
	1981	.097	.113	.790	.132	.115	.753	4.50
A.P.	1971	.0.98	.116	.786	.139	.117	.744	4.72
	1981	.082	.101	.817	.111	.101	.788	4.00
Bihar	1971	.099	.122	.779	.143	.122	.735	5.17
	1981	.113	.132	.755	.155	.128	.717	5.70
Gujarat	1971	.130	.149	.721	.186	.140	.674	6.26
	1981	.102	.144	.784	.137	.108	.755	4.30
Haiyana	1971	.138	.158	.704	.192	.154	.654	7.16
	1981	.107	.125	.768	.148	.124	.728	5.00
Kamataka	1971	.098	.119	.783	.138	.120	.742	4.57
	1981	.083	.100	.817	.114	.099	.787	3.60
Kerala	1971	.118	.131	.751	.167	.128	.705	4.66
	1981	.081	.092	.827	.110	.089	.801	2.80
M.P.	1971	.129	.146	.724	.178	.142	.680	6.72
	1981	.105	.122	.773	.146	.121	.733	5.20
Maharashtra	1971	.106	.121	.773	.146	.122	.732	4.95
	1981	.087	.097	.822	.107	.096	.797	3.60
Orissa	1971	.097	.199	.784	.139	.120	.741	5.05
	1981	.090	.110	.800	.125	.105	.770	4.30
Punjab	1971	.122	.138	.740	.176	.132	.692	5.77
	1981	.092	.109	.799	.129	.307	.767	4.00
Rajasthan	1971	.130	.154	.716	.182	.149	.667	6.96
	1981	.103	.123	.774	.142	.125	.733	5.20
T.N.	1971	.094	.177	.789	.137	.110	.753,	4.28
	1981	.083	.095	.822	.111	.094	.795	3.40
U.P.	1971	.133	.158	.709	.188	.154	.658	7.36
	1981	.110	.134	.756	.155	.130	.715	5.80
W. Bengal	1971	.121	.143	.736	.174	.132	.694	5.44
	1981	.096	.116	.788	.137	.107	.756	4.20

Considering the proportion of women in the exposed states as an index of fertility, we have compared the quantum of increase in these proportions with the unit of decline in TMFR values during the period 1971-81. In Table 2, we have grouped the states namely, Andhra Pradesh, Kamataka, Orissa and Tamil Nadu which have experienced less than a unit decline in TMFR values and an increase of around 30 per thousand women in the exposed state. Similarly the second group consisting of India, Madhya Pradesh, Maharashtra, Uttar Pradesh and West Bengal shows a decline ranging between 1 to 1.5 units in TMFR and is accompanied with an increase of 45 to 50 women per thousand in the exposed state. Rest of the states which have more than 1.5 units decline in TMFR come in the category of contributing an increase of more than 60 women per thousand women population in the exposed state. Even with an increased value of h = 1.50 years, the grouping of states in Table 2 remains consistent with the quantum decline in TMFR values during the period 1971-81. However, the increase in the value of *'h'* contributes a little more increase in the proportion of women in the exposed state during the said period corresponding to the same quantum of decline in TMFR values. The reproductive status distribution of women is therefore quite sensitive to the value of the parameter 'h'. The variation may be increased if we treat h varying among the women.

TABLE 2 : COMPARISION OF QUANTUM DECLINE IN TMFR WITH INCREASE IN EXPOSED PROPORTION DURING 1971-81

Regions		*Quantum Decline in TMPR*	*Increase in Proportion of Exposed Women*	
			(with h =1.25)	(with h = 1.50)
	A.P.	0.72	.031	.044
Group I	Kamataka	0.97	.034	.045
	Tamilnadu	0.88	.033	.042
	Orissa	0.75	.016	.039
	India	1.24	.044	.052
	M.P.	1.52	.048	.053
Group II	Maharashtra	1.35	.049	.065
	U.P.	1.56	.047	.057
	W.B.	1.54	.052	.062
	Gujarat	1.96	.063	.081
	Kerala	1.86	.076	0.96
Group III	Punjab	1.77	.059	.075
	Rajasthan	1.76	.058	.066
	Haryana	2.66	.064	.074

Theoretical Model

After examining the sensitivity of open status in reflecting the current potential of fertility, we discuss a probability distribution of open status and an estimation procedure for estimating the biological parameters of fecundability and the secondary sterility from the simulated distriubution of open status of married women within the reproductive span.

The probability of remaining in any one of the three mutually exclusive states of reproduction (i.e. exposed, pregnant and amenorrheic) is derived under the following assumptions:

(1) All the women under consideration are within their reproductive ages.
(2) The duration between the *ith* and (i + l)th conceptions for a woman follows a displaced exponential distribution with density function

$$f(t) = m\, e^{-m(t-h)}\ ;\ t > h,\ m > 0$$

where h is the non-susceptible period associated with a live birth and which comprises gestation period 'g' (.75 year) and post-partum amenorrhea period of 'a' year.

(3) $(1 - \alpha)$ is the proportion of women becoming secondarily sterile immediately after the last live birth, and all the conceptions result into live births.

Under the above assumptions, if the period of marriage duration is sufficiently large, then the asymptotic birth rate is given by $m/(1 + mh)$. Hence, the probability that a woman gives birth at any point of time between $(x, x + dx)$ is given by $[m/(1 + mh)]\, dx$. A woman can be found in amenorrheic state at the point of observation 'T only when she has given birth between $(T - a, T)$. Hence, if S denotes the State of Reproduction, we have

$P(S = R)$ = Probability that the woman is in amenorrhea following the last live birth, i.e.

$$P[S = R_0] = \int_{T-a}^{T} \frac{m}{1+mh}\, dx \qquad \text{for } (T - a) < x < T \tag{1}$$

$$= \frac{ma}{1+mh}$$

A woman will be found in the state of pregnancy at the point ot observation if she has conceived again following the last live birth and the point of conception is within nine months or 'g' period away from the observation point. Hence

$P(S = R_1)$ = Probability that the woman is in the state of pregnancy at the survey *point,* i.e.

$$P[S = R_1] = \alpha \frac{mg}{1+mh} \tag{2}$$

Hence, probability that a woman is in exposed slate at the point of survey is,
$P(S = R_2) = 1 - P(S = R_0) - P(S = R_1)$

$$= \frac{(1-\alpha)\,mg+1}{1+mh} \qquad (3)$$

Estimation of Parameters

In the model discussed above, the parameters a and m can be estimated from the data on open status of women. We derive here a procedure to obtain maximum likelihood estimates of these parameters. Let M), $N1$ and N2 be the number of women observed in states $S = Ro$, $S = R1$ and $S = R2$ respectively at the time of survey. Then from the logarithm of the joint density of S's given N, we have

$$\log L = N_0\{\log(ma) - \log(1+mh)\} + N_1\{\log\alpha + \log(mg) - \log(1+mh)\} = N_2\{\log(1+(1-\alpha)\,mg)\} - \log(1+mh). \qquad (4)$$

After solving the M.L. equations, we get,

$$\hat{\alpha} = 1 - \frac{N_2\ mh - N'}{N\,mg} \qquad (5)$$

and $$\hat{m} = \frac{N N_1 - N_1 N' - N_2 N'}{N_2 N g - N_1\ N_2 h\ - N_2^2 h} \qquad (6)$$

where, $N' = N_0 + N_1$

Application

In practice, sometimes difficulty may arise in ascertaining the number of women in some specific state of reproduction at the time of survey. As for example, the state of pregnancy may not be properly ascertained by the woman in its early stages. On the other hand, women may report themselves as amenorrheic if they are continuing breastfeeding to the last born baby. Therefore, special care needs to be taken in ascertaining the proper biological status of the woman at the time of survey. Anyhow this kind of information is not available from the surveys or censuses. We have therefore simulated this kind of information from the available schedule of Age Specific Marital Fertility Rates (see Table 1).

We have simulated the distribution of married women by age and biological status from the observed schedule of ASMFRs for All India and its fourteen major states at two points of time, namely 1971 and 1981 assuming two different values of 'ft'. Though the simulation results provide the status distribution of a sample of 1000 currently married women over each five year age groups, the estimates of *"m'* and 'α' have been obtained only for the women aged above 25 years. The married women below age of 25 years may not satisfy the steady state assumptions regarding their reproduction process as some of them must have married only recently. The steady state model can only be applied if the women have atleast four to five years of marital duration (see, Perrin and Sheps, 1963). The, estimates of fecundability obtained from the status distribution of women at different ages are shown in

TABLE 3 AGE SPECIFIC ESTIMATES OF *m* AND *c* FOR ALL INDIA AND FOURTEEN MAJOR STATES FOR 1971 AND 1981

Region	*Year*	*Ages* 25-29 $\hat{m}$	25-29 $\hat{\alpha}$	30-34 $\hat{m}$	30-34 $\hat{m}$.	35-39 $\hat{m}$	35-39 $\hat{\alpha}$	40+ $\hat{m}$	40+ $\hat{\alpha}$
India	1971	.507	.805	.424	.754	.264	.571	.069	.778
	1981	.392	.747	.289	.706	.130	.750	.051	.400
A.P.	1971	.358	.778	.247	.800	.180	.600	.448	.333
	1981	.321	.758	.177	.848	.095	.889	.021	*
Bihar	1971	.329	.952	.416	.725	.231	.556	.057	.800
	1981	.422	.880	.400	.758	.272	.571	.077	.762
Gujarat	1971	.587	.813	.469	.720	.240	.718	.088	.667
	1981	.403	.744	.214	.857	.098	.778	.020	.667
Hatyana	1971	.773	.706	.527	.750	.292	.524	.091	.750
	1981	.437	.821	.346	.704	.158	.583	.042	.500
Kamataka	1971	.343	.861	.237	.844	.194	.606	.073	.667
	1981	.327	.722	.202	.821	.111	.762	.032	.667
Kerala	1971	.511	.736	.354	.767	.248	.583	.048	.800
	1981	.306	.722	.125	.741	.088	.556	.018	.667
M.P.	1971	.632	.687	.424	.754	.283	.619	.099	.750
	1981	.414	.806	.360	.702	.139	.750	.041	.667
Maharashtra	1971	.394	.846	.364	.730	.184	.606	.045	.667
	1981	.337	.754	.162	.788	.073	.933	.019	
Orissa	1971	.462	.759	.244	.875	.181	.606	.069	.778
	1981	.338	.833	.198	.923	.118	.750	.029	.667
Punjab	1971	.577	.771	.505	.718	.223	.718	.065	.571
	1981	.438	.782	.232	.792	.126	.750	.017	
Rajasthan	1971	.725	.762	.498	.693	.311	.571	.111	.741
	1981	.376	.812	.374	.737	.347	.556	.078	.571
T.N.	1971	.399	.805	.226	.844	.146	.733	.031	.666
	1981	.423	.879	.171	.722	.087	.571	.017	.666
U.P.	1971	.694	.765	.602	.714	.368	.628	.115	.733
	1981	.448	.800	- .402	.825	.267	.619	.082	.666
W.B.	1971	.452	.762	.379	.818	.242	.564	.063	.667
	1981	.318	.812	.206	.923	.114	.762	.044	.500

Table 3. The estimates of fecundability show a similar age pattern as age specific marital fertility rates. The estimates of secondary sterility show an increasing trend over the ages for the year 1971 which does not hold good when we observe the same for the year 1981. One of the reasons for the secondary sterility estimates not following a consistent pattern may be the use of contraception by die younger women in 1981. In this sense we can interpret the secondary sterility parameter confounded with decision of the parents to stop reproduction in future.

Remarks

The simulation technique used here is a simple one as it needs minimum input for generation of open status distribution of the married women. It is different from simulation exercises available in literature, because it is using vital rates directly as inputs and generating a period specific open status distribution of the married women conforming to a period schedule of fertility. Analysis of the output of the proposed model gives credence for open status to be a sensitive index of current fertility level. Further refinements, however, can be brought in by introducing a distribution of duration of non-susceptible period in the said model. Such an exercise may help in ascertaining the birth rate of immediate future with the proportion of pregnant women and can reveal the current fertility level in terms of women in the exposed state of reproduction. But as we make the model more and more elaborate, determination of the empirical distribution of the inputs required for simulation increase and the model becomes more complex. Also, the model applied here is only a steady state model. The model of open status distribution for the fixed marital duration may also be utilised to estimate the various bio-cultural parameters of fertility from the corresponding simulated data. The purpose of this exercise has been quite limited because our focus is on the simplicity of the model and minimum requirement of input for simulating open status distribution. Neverthless, it has succeeded in showing the importance of open status data in studying fertility.

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