ESTIMATION OF FERTILITY RATE WITH OPEN INTERVAL DATA

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1. Introduction

Measurement of fertility changes before and after implementation of family planning is essential for better program planning, management, and evaluation. However, in most of the developing countries in which large scale family planning programs are in operation, poor or non-existent vital statistics and registration systems are the rule rather than the exception.

Various methods and techniques for determining the fertility rates using data of poor quality or from sources other than vital registration and census have therefore been developed by demographers. Such approaches include child-ever-born ratios, the reverse survival method, pregnancy history analysis, and own children living with mother. Manuals prepared by the United Nations present a number of methods for estimation of fertility from incomplete data.(1) Another manual prepared by Bogue and his associate described many of these measures. (2)

Various fertility indicators have also been developed to detect changes in fertility level. These indicators do not measure the fertility of the population; rather, their changes reflect changes in fertility. Examples of such indicators include the age-parity distribution of annual births, age-parenthood status distribution, proportional fertility ratios, cumulative fertility for women over 30; proportion of women who are currently pregnant, live birth pregnancy rate, mean birth intervals, and mean open intervals.

All of these measures or indicator of fertility are useful but their utility depends on the type of populations. Most of these measures need accurate age of mothers and children - data difficult to collect from an illiterate population in the rural areas of developing countries. Moreover, a long recall period is frequently required as, for example, in the pregnancy history analysis technique.

There is pressing need for the development of a simple technique for estimating the fertility of a population. Such a technique would require relatively little information and the information would be of the type that most respondents are able and willing to report. Open interval appears to come close to such requirements.

2. Review of Literature

A number of researchers have discussed the utility of the mean open interval as a fertility indicator. Mohapatra (1966) investigated the relative importance of wife's age at marriage, length of the completed birth intervals, and length of open intervals in explaining the fertility differentials by socio-economic status. He found that among women over 30 years of age, modernization is likely to be more strongly associated with the length of open intervals.(3)

Srinivasan (1966) used the open interval as an index to detect fertility change.(4) In 1967, he further investigated the distribution of open intervals for women under three sets of assumptions concerning the rate of occurrence of births of a specified order and the parity progression ratio, and estimated the first and second moments of the distribution under each of the assumptions.(5) In the same year, he published another article proposing a method for study of interval between live births. Such a study would be applicable to the cases for which data collected in a survey are limited to information about the last two live births. This method of observation yields two kinds of intervals: the birth interval and the open interval. He assumed that the open interval is part of a complete interval from the last live birth to the time immediately proceeding the next birth. Therefore, the open interval is a random segment, which may be assumed to be uniformly distributed within the birth interval. From the rectangular (or uniform) distribution, the first and second moments of the open interval distribution can be obtained.(6)

Leridon (1970) made some comments on the Srinivasan's article, pointing out that the Srinivasan's estimation is based on the assumption that the distribution of open intervals from a survey has a mean equal to one-half of the mean birth interval. However, he proved that the longer the interval from the last live birth to the next, the more likely it is to be included in the survey. Therefore, the mean open interval including the survey point must be greater. In other words, Srinivasan's method under-estimates the mean open interval.(7)

Sheps (1970,1973) et al investigated the truncation effect and problems of interval analysis through computer simulation. They found that the mean open interval does not properly reflect the fertility change, and doubt that the current emphasis on securing such data is justified. (8,9)

Pathak (1971) developed a stochastic model for the study of open interval and reported that by taking account of parity progression variation, the open interval can be shown to predict the current fecundability, and thus, fertility of the women.(10)

Venkatachaya (1972) pointed out the weakness of using the mean open interval as a fertility indicator. His criticism was that the mean open interval does not properly reflect the effect of long-term and continuous use of a less than perfect contraceptive; it will only show the effect of a contraceptive method used since

the last live birth. When the mean open interval is used without adjustment it is not sensitive to changes in fertility. He indicated that the mean open interval standardized by age-parity distribution, might provide a more useful measure of fertility changes.(11)

More recently, Hastings and Robinson replicating and expanding an earlier study of Srinivasan on the open interval reported that "the open interval is more sensitive as an index of marital fertility when marital duration and parity are controlled than when mother's age and parity are controlled."(12)

In spite of some drawbacks, mean open interval is a fertility indicator frequently used in evaluating family planning programs impact. No attempt, however, has been made to convert change in the length of mean open interval into change in fertility rate. Potter (1968) mentioned that if acceptors of programmed contraception exhibit a consistently longer open interval than a matched sample of couples outside the program, then there is little question but that these participants are lowering their fertility. However, he said, "... there is no way to translate a change in mean open interval into an estimate of births averted."(13)

Venkatachaya (1972) also mentioned that the data on open intervals have been collected on a longitudinal basis in some standard fertility surveys in India, but they do not appear to have been used for an analysis of fertility.(11)

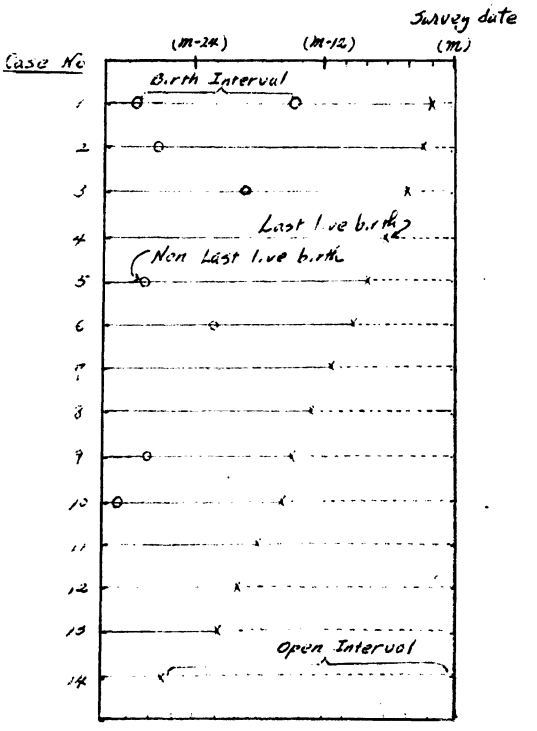
A considerable amount of work has been done on the own children method of estimating fertility. One study by Rindfuss (1976) compared the annual fertility rates obtained from census data on own children and the corresponding rates obtained from the vital statistics data for the United States during 1964 and 1970. He reported that the agreement between the rates obtained from these two sources was greater when own children rates were not adjusted for under-enumeration of women by the census. He also found that the estimated adjusted age-specific rates for the younger age groups were consistently lower than the recorded rates, and the estimated rates for the older age groups were consistently higher than the recorded rates.(14)

3. Rationales for the Current Study

Assume that a random sample of women of childbearing age of size m is drawn, and that a survey is conducted at the end of month m, which includes the following question:

"When was your last child born?" (or,
When did your last live birth occur?)

Assume further that the respondent is requested to answer the question by telling the interviewer the month and year of her last live birth, the following diagram depicts the live births and birth intervals schematically, showing the information obtained from the survey.



The characteristics of the data shown in the diagram may be expressed in different ways. One may compute the number of live births within a specified time interval, which is an essential element in calculating fertility rates. Alternatively, we may compute the duration between two successive live births (i.e., birth interval) or the interval between the date of the last live birth and the date of the survey (i.e., open interval). Since fertility rate and birth or open intervals are derived from a same set of information concerning live births, these three parameters are mutually related to one another. The fundamental rationale of this study is based on the above relationship, which provides a basic converting information on fertility measures.

In other countries where national family planning programs are being implemented, nationwide family planning surveys (or KAP surveys) are usually conducted at two to three year intervals. Questions concerning the respondents' reproductive history are usually asked, and at least one question about the date of the last live birth (or age in months of the last child) will be asked. Open interval information, therefore, is usually available from this type of study.

The advantage of use of open interval data for the estimation of fertility is self-evident; the data are more easily obtainable and with relatively higher accuracy because:

(1) The recall period is shorter, extending only to the last live birth.

(2) The question is asking for a clearly identifiable event, namely a live birth. There may be some ambiguity between stillbirth and

live birth when a baby dies immediately after delivery, but a few supporting questions should minimize the errors.

(3) The information can be obtained by asking a simple and short question taking very little time for the respondents to answer.

(4) The question is essentially non-sensitive, and there is little reason for the respondents to refuse to answer.

(5) The event of last live birth can always be related to a major event which is common to partically all cultures, i.e., a new-year celebration. In a community where most people are illiterate, the question may be modified: e.g., "Was your last child born before or after the last new year festival?" or "Was your youngest son or daughter born before the last new year festival, or the one before the last?".

4. Methods and Procedures

All the live births occurring in any one calendar year may be classified into two mutually exclusive categories: "last live births" and "non-last live births." The number and distribution of last live births occurring in a year is known from the open interval data. The problem of estimation of fertility rate, therefore, is simplified to the estimation of the distribution of "non-last live births" in each calendar year, which is unknown. For this purpose, some assumptions are needed:

(1) First, it is assumed that no two consecutive live births will occur within nine months (we ignore multiple births at this point). In other words, the birth interval must be greater than nine months, or the probability of getting another live birth within nine months after delivery is assumed to be "zero."

(2) Secondly, birth intervals are distributed as a certain function which depends on the fertility at the end of a birth interval. (Retrospective or backward approach rather than perspective or forward approach in estimating fertility.)

Let n_i be the number of last live births month i;

$\bar{n}_i$ be the number of non-last live births at month i;

N_i be the total live births at month i;

T_i be the corresponding number of women at month i; and

f_i be the fertility rate at month i;

then, $N_i = n_i + \bar{n}_i$,

and $f_i = \frac{N_i}{T_i}$

For simplicity, we further assume that within a same birth interval (excluding the duration of gestation), the probability of becoming pregnant in each month is the same. (The distribution of birth intervals is not necessarily restricted to an exponential function. It is also possible to assume an unequal probability of conception during each month.)

Since it is impossible for two consecutive live births to occur within nine-month period, hence,

$$\bar{n}_i = 0 \qquad \text{for } i = m-9, m-8, \ldots m$$

or $N_i = n_i$ for $i = m-9, m-8, \ldots m$, and

and $N_i = n_i + \bar{n}_i$ for $i = 0, 1, 2 \ldots, m-10$

$$f_i = \frac{N_i}{T_i} = \frac{n_i}{T_i} \qquad \text{for } i = m-9, m-8, \ldots m$$

$$\bar{n}_{m-10} = N_m \cdot e^{-f_m}$$

$$N_{m-10} = n_{m-10} + \bar{n}_{m-10}$$

$$f_{m-10} = \frac{N_{m-10}}{T_{m-10}}$$

$$\bar{n}_{m-11} = N_m \cdot e^{-2f_m} + N_{m-1} e^{-f_{m-1}}$$

$$N_{m-11} = n_{m-11} + \bar{n}_{m-11}$$

$$f_{m-11} = \frac{N_{m-11}}{T_{m-11}}$$

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In general,

$$\bar{n}_{m-k} = N_m \cdot e^{-(m-k+9)f_m} + N_{m-1} e^{-(m-k+8)f_{m-1}}$$

$$+ N_{m-k+9} e^{-(2)f_{m-k+9}} + N_{m-k+10} e^{-f_{m-k+10}}$$

$$= \sum_{j=o}^{k-10} N_{m-j} e^{-(m-k+9-j)f_{m-j}} \qquad \text{for } m > k \geq 10$$

$$N_{m-k} = n_{m-k} + \bar{n}_{m-k}$$

and $f_{m-k} = \frac{N_{m-k}}{T_{m-k}}$

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